FINAL
Technical Memorandum

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To:	Herrera Environmental Consultants Inc.	**CC:**	
From:	Rod DenHerder, P.E., Martin McCabe, P.E.	**Date:**	September 30, 2013
RE:	White River Countyline Levee Setback Project Seepage, Stability, Design and Construction Recommendations		

In partial fulfillment of Task 400.3 of the Herrera contract with King County for analysis and design of the proposed White River Countyline Levee Setback project (Contract #E00187E10), this technical memorandum outlines the approach, analytical methods, and results of geotechnical-related evaluations for the setback levee. This memo furthermore presents recommendations regarding geotechnical design and construction aspects of the project.

1.0 PROJECT DESCRIPTION

1.1 SETBACK LEVEE ALIGNMENT

The White River at Countyline Levee Setback (Countyline) project is a salmon recovery and flood risk reduction project located on the left (east) bank of the White River between river mile (RM) 5.00 and RM 6.33. Implementation of the Countyline project will reconnect approximately 124 acres of forested wetland and historical floodplain to the main stem of the White River by removing most of an existing left bank levee and constructing a new setback levee and biorevetment along the eastern edge of the project boundary. The site location is shown on Figure 1. The proposed setback levee alignment and locations of subsurface investigation borings are shown on Figure 2. Figure 2 also shows the locations of Sections AA', BB', CC', and DD' that are discussed repeatedly in this memo, as representative locations for the geotechnical analyses conducted.

1.2 SETBACK LEVEE CROSS SECTION

URS and King County agreed upon the following proposed general levee configuration for the cross sections evaluated in detail:

- Levee top width 15 feet.
- Levee side slopes 2.5H:1V (horizontal to vertical).
- River-side water level is 3 feet below the levee crest.

The proposed levee consists of a zoned embankment consisting of the following materials:

- Core – low permeability fill material.
- Shell – native alluvium surrounding the core.
- Outer surface - topsoil.
- Top – gravel driving surface.

2.0 SCOPE OF SERVICES

The scope of services for the analyses presented in this memo is described in the December 6, 2010 Professional Services Agreement signed between Herrera Environmental Consultants and URS Corporation, which includes providing geotechnical services for levee setback seepage analysis. Specific elements of this scope of services are:

- Compare river stages to measured groundwater level data to assess the linkage between river water level and the groundwater elevation response to it, using river stage data from the USGS gauging station at the A Street Bridge in Auburn and groundwater data loggers deployed by King County in the wetland on-site.
- Characterize the general foundation conditions along the setback levee alignment and provide concept level and design-level geotechnical analysis of the proposed levee, and provide construction recommendations addressing compaction; preload requirements; and potential modes of failure, including slope stability, settlement, levee underseepage, and seismic considerations in general accordance with the following: US Army Corps of Engineers (USACE) Design and Construction of Levees Manual EM 1110-2-1913, dated April 30, 2000, USACE Slope Stability Manual EM 1110-2-1902, dated October 31, 2003, and ETL 1110-2-569 Design Guidance for Levee Underseepage, dated May 1, 2005.
- Prepare a geotechnical analysis technical memorandum (this memo) that documents water level monitoring in wells along the setback levee alignment, addresses the static stability and settlement of the new setback levee, the need for seepage cutoff within and below the new levee, erosion protection of the new levee, use of on-site soils (if available) for construction of the new levee, and seepage cutoff key (if required).
- Provide geotechnical analyses using SLOPE/W and SEEP/W, including design recommendations, for up to two setback levee footprints and up to 3 levee cross-section configurations prepared by King County.

3.0 SITE CONDITIONS

3.1 SURFACE DESCRIPTION

The proposed setback levee site is on the perimeter of active farmland with a small area of commercial/industrial property along the southern 1,500 lineal feet of the setback alignment. The ground surface in the setback levee project area is relatively flat and gently sloping upward from the southwest to the northeast end, with a mean surface elevation of approximately 70 to 80 feet (NAVD 88). The setback floodplain area west of the setback levee alignment encompasses approximately 124 acres of forested wetland and upland wetland buffer.

3.2 GEOLOGIC SETTING

The valley of the White River is underlain by Holocene alluvium (USGS, 1995). During the Holocene Epoch, erosion and deposition occurred primarily along major river valleys and marine embayments. Holocene deposits include peat, mass wasting debris, mudflow sediments generated on the volcanic peaks of the Cascade Range, and fluvial and deltaic sediments. Alluvium found in the valley of the White River is designated as geologic unit "Qal", and this unit is considered to be an important aquifer. Few wells fully penetrate the Qal unit in the study area, so the thickness of the unit generally is not known. Near the steep slopes of each valley, Qal is interbedded with and sometimes overlain by mass-wasting debris (USGS, 1995). The liquefaction potential of the area is indicated as "moderate to high" in the most recent liquefaction susceptibility mapping (Palmer et al, 2004).

The project area is part of the alluvial fan laid down over the past 5,000 years by the erosion and deposition of lahar (volcaniclastic mudflow, such as the 5,700-year-old Osceola mudflow) sediment deposited in the White River canyon. The river was historically considered the Stuck River, an overflow distributary channel of the White River. Prior to a major flood in 1906, most of the White River water and sediment exited the White River canyon near RM 8 and flowed north to join the present-day Green River near Auburn (Herrera, 2012). During the 1906 flood, the main flow of the White River was diverted down the old Stuck River channel. The construction of the Auburn Wall in 1915 made the change permanent.

3.3 SUBSURFACE CONDITIONS

Subsurface conditions at the project site were investigated by King County by drilling 16 soil borings, excavating six test pits and excavating three shallow surface scrapings on the waterward face of the existing levee, performing laboratory testing of selected soil samples, and performing conductivity testing at two wells at the locations indicated on Figure 2. A list of the borings and a brief summary of soil layers encountered are presented in Table 2 below. It should be noted that when a water level monitoring well was installed in the boring, an additional name was assigned to the boring to reflect the presence of the well. For example a monitoring well was installed in boring KCB-2, so the boring is also designated as KCMW-2. Boring logs and laboratory data are provided in Appendix A, and are also in Appendix A of the *County Line to A Street Geotechnical Investigation* memo prepared by the King County Department of Transportation (2012).

<u>STRATIGRAPHY</u>

The general stratigraphy along the proposed setback levee alignment as indicated by the subsurface descriptions in the boring logs is roughly illustrated on Figure 3. The figure reflects the substantial variation of subsurface conditions in this alluvial fan setting and may not accurately portray the stratigraphy at locations between borings. About one foot of cultivated sandy topsoil was encountered at the surface along the proposed setback levee alignment at borings KCB-1 and KCB-2 and in borings KCB-4 to KCB-9. Uncontrolled fill (mixed natural and man-made materials without obvious compaction controls) and road fill were encountered at the surface in borings KCB-16 and KCB-3 in thicknesses of about 11 feet and 1 foot, respectively. In general, the native stratigraphy below the topsoil or fill surface is poorly graded fine to medium sand to silty sand interbedded with silt and scattered lenses of peat and organics. In the upper 25 feet, the granular material zones tend to be medium dense to occasionally loose, while the fine grained material zones (silt, clay, and peat) tend to be medium stiff to soft.

GROUNDWATER

Groundwater was encountered in all of the borings drilled for this project at depths ranging from 1.6 to 6 feet below the ground surface (see Figure 3 and Appendix A). Water level measurements from six (6) shallow groundwater monitoring wells installed for this project were provided by King County. Of the six groundwater wells installed for the project, four are located in the wetland area on the landward side of the existing levee, and two are located in borings drilled on the floodplain surface above the wetland along the alignment of the proposed setback levee. The locations of the wells (Figure E-1) and the associated water level data are included in Appendix E. A summary of the wells is shown in Table 1.

Groundwater levels generally follow the slope of the river and alluvial fan surface and are higher in the northeast and lower in the southwest (see Figures 3 and E-2). The time-series plots for the wells shown on Figure E-2 illustrate that the upper wetland in the vicinity of groundwater wells GW1, GW2, and GW3 is hydraulically disconnected from the river (USGS gage #12100496 – White River near Auburn, WA, located at the A Street bridge crossing). King County personnel have reportedly observed static water levels in the wetland several feet lower than the river stage even when the river level is near the top of the existing left bank levee. In contrast, groundwater at GW4, KCMW-2, and KCMW-4 in the lower portion of the wetland is hydraulically connected to the river and responds to water entering the wetland near the county line (for flows greater than 3,500 cfs) and returning back to the river near GW4. The two-foot drop in water levels at GW4 between September and October 2011 corresponds to repair work performed on the culvert at the wetland outlet, whereby a beaver dam was dismantled, the culvert unclogged, and a ford cut in the access road. Reconstruction of the beaver dam restored groundwater levels at GW4 by spring 2012.

Table 1: Summary of Groundwater Well Measurements

	GROUNDWATER WELLS					
	GW1	GW2	GW3	GW4	KCMW-2	KCMW-4
Ground Elevation	unknown	unknown	unknown	unknown	70.2	73.3
Sensor Elevation (ft)	72.15	68.15	66.19	71.57	59.32	61.99
Start Date	5/22/11	5/22/11	5/22/11	5/22/11	11/17/11	11/17/11
End Date	5/23/12	5/23/12	5/23/12	5/23/12	5/9/12	5/9/12
Highest Water Surface Elevation (ft)	75.63	74.02	73.53	72.14	70.77	72.89
Lowest Water Surface Elevation (ft)	72.15	68.15	66.19	71.57	66.53	69.94

Figure E-2 and Table 1 also show that groundwater levels measured in KCM-2 were higher than the ground surface at the well location during peaks in the White River hydrograph. This indicates groundwater movement originating from upland areas on the alluvial fan in addition to the shallow groundwater connection with the river described above. This interpretation is consistent with saturated ground observed by King County personnel in the fields near KCM-2 during periods of low river levels in July 2012.

LABORATORY TESTING

To aid in classifying the subsurface materials and to estimate general material characteristics, laboratory tests were performed on selected representative samples. The following tests were performed by the King County Materials Laboratory: moisture content, grain size distribution, fines content and Atterberg limits. The results of the laboratory testing are presented in Appendix A and on the boring logs.

4.0 METHODS AND RESULTS

4.1 SOIL PROFILES AND SOIL PARAMETERS FOR DESIGN

Figure 3 shows a conceptual stratigraphic profile along the proposed setback levee alignment based on an interpretation of the boring logs. The estimated material parameters for each of the soil strata encountered at the site are provided in Table 2 for use in the levee seepage and stability analyses. The values provided in the table have been estimated using a combination of field and laboratory data together with published data on similar materials. It should be noted that in most cases the values listed in Table 2 are intended to represent average or slightly conservative field conditions.

The estimated material parameters for the proposed setback levee core fill material are also listed in Table 2. Topsoil is not specifically listed but the value for permeability used in the seepage modeling was 0.02 centimeters per second (cm/sec). The permeability value of 0.10 cm/sec was used to model alluvium.

Natural variations in stratigraphy and soil parameters are expected throughout the site, and thus the values listed in Table 2 may not be strictly representative of all locations. The definitions of the soil types used in Table 2 are listed in ASTM D-2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System).

Table 2: Summary of Characteristics and Estimated Material Properties

Section * or Boring No.	Fill or Stratum Modeled **	Top Depth (ft)	Thick-ness (ft)	Raw SPT (blows per foot)	Unit Weight (lbs/ft^3)	Friction Angle (degrees)	Cohesion (lbs/ft^2)	Perm-eability (cm/s)
2	Riprap	n/a	n/a	n/a	140	40	0	0.200
1, 2	Core Fill (25% fines)	n/a	n/a	n/a	130	35	50	0.003
	Core Fill (20% fines)	n/a	n/a	n/a	130	37	0	0.020
3a, 3b	Narrow Core Fill (25% fines)	n/a	n/a	n/a	130	35	50	0.003
KCB-1	Existing. Fill (SP)	0	4	18	128	33	0	0.003
	ML,PT	4	2.5	6	110	28	50	0.00001
	SP-SM	6.5	10.5	7-31	125	35	0	0.0003
	ML	17	4	10-23	115	30	50	0.00001
KCB-2 / KCMW-2	ML,OR	0	4	2	110	28	50	0.00001
	SM	4	1.5	14	125	35	0	0.0003
	ML	5.5	6.5	14-19	115	30	50	0.00001
	ML-PT	12	2	2	110	28	50	0.00001
	SP-SM	14	14	21-29	130	35	0	0.0003
KCB-3	Road Fill (SM)	0	1.5		128	33	0	0.0003
	ML,PT	1.5	5.5	3-4	110	28	50	0.00001
	SP-SM	7	2.5	8	125	32	0	0.0003
	ML	9.5	2	3	110	28	50	0.00001
	SP-SM	11.5	10	13-28	130	35	0	0.0003
KCB-6	ML,PT	0	4	9	110	28	50	0.00001
	SP-SM	4	13	7-31	125	35	0	0.0003
	ML,PT	17	8.5	4-8	110	28	50	0.00001
KCB-7	SM	0	4	8	128	33	0	0.0003
	ML	4	5	13-15	115	30	50	0.00001
	SP	9	3.5	11-18	125	35	0	0.003
	ML	12.5	2	5-17	115	30	50	0.00001
	SP	14.5	5	11	125	35	0	0.003
KCB-9	SM	0	9	4-16	128	33	0	0.0003
	ML,PT	9	3	3	110	28	50	0.00001
	SP	12	5	12-21	125	35	0	0.003
	ML	17	1	3	110	28	50	0.00001
	SM	18	3	8	125	32	0	0.0003

* Sections as shown on Figures 4 and 5

** 20% or 25 % fines is that percentage of fill material that passes the #200 sieve

SPT – standard penetration test

4.2 LEVEE CROSS SECTIONS

Several different setback levee cross-section configurations were modeled (simulated). Section 1 and Section 2 are shown on Figure 4. Sections 3a and 3b are preferred by King County and are shown on Figure 5.

Section 1 was analyzed at locations AA', CC', and DD' shown on Figure 2. Section 1 was assumed applicable for all portions of the setback levee except where the levee encroaches into the wetland. This section consists entirely of imported low permeability material with a top width of 15 feet and 2.5H:1V side slopes (Figure 4).

Section 2 is located in the area where the levee encroaches on the wetland as shown at cross-section BB' on Figure 2 (approximately Station 12+00 to 16+50 as shown on the 60% Plans). Section 2 is shown on Figure 4 and is similar to Section 1 except that it has a 3-foot layer of heavy loose riprap with a filter layer on the riverward side and an engineered logjam with wood piles built into the levee toe on the river side.

Sections 3a and 3b have a smaller impermeable core, and were evaluated at locations AA' and DD' shown on Figure 2. These sections include an outer shell of gravelly material representative of on-site alluvium. Section 3a consists of a core of imported low permeability material with the top at the future 100-year recurrence interval water surface elevation, 2.5H:1V side slopes, and on-site alluvium for the outer shell around the core ranging in thickness from 18 inches on the slopes to 3 feet on the top of the levee. The shell is covered with 18 inches of topsoil on both slopes of the levee. Section 3b is similar to Section 3a, with a narrower core constructed to the same height as section 3a but with 1H:1V side slopes. On-site alluvium was assumed for the outer shell around the core ranging in thickness from 3 feet on the top of the levee to approximately 5 feet on the side slopes. Both slopes of the levee in Section 3b are covered with 18 inches of topsoil.

4.3 SEEPAGE ANALYSES

Seepage analyses were performed using the computer program SEEP/W (2007) to obtain pore water pressures in the soil elements for both steady state and transient state flow conditions. The steady state pore pressures are used for the evaluation of exit hydraulic gradients at the toe of the levee for long-term conditions. Similarly, the transient pore pressures are used to evaluate hydraulic gradients for rapid drawdown conditions. The pore pressure values were also used in the slope stability analyses using SLOPE/W (2007).

SEEP/W is a commercially available (Geo-Slope International Ltd) finite element software product for analyzing groundwater seepage and excess pore-water pressure dissipation problems within porous materials such as soil and rock. SEEP/W provides analyses and results that comply with the USACE guidelines in EM 1110-2-1913 and ETL 1110-2-569. SEEP/W can model both saturated and unsaturated flow, a feature that greatly broadens the range of problems that can be analyzed. In addition to traditional steady-state saturated flow analysis, the saturated/unsaturated formulation of SEEP/W makes it possible to analyze seepage as a function of time and to consider such processes as the infiltration of precipitation.

The seepage models were developed for the proposed setback levee using soil conditions encountered at borings KCB-1, KCB-2/KCMW-2, KCB-7 and KCB-9, and assumed material properties for the imported material to be used in the proposed levee. These borings were considered the most critical for seepage considerations because of the presence of relatively higher permeability materials directly beneath the ground surface under the proposed embankment compared to the other borings. Seepage analyses were conducted for the steady state condition and for a transient rapid drawdown condition. A total head boundary condition was applied for the seepage model cases discussed below.

URS used available King County hydraulic modeling data showing the timing of flood water rise and fall (see Appendix B) to develop a rapid drawdown rate for the seepage analysis. A drawdown rate of 0.42 feet per hour (ft/hr) was calculated from the drawdown curves provided by the County for the future conditions scenario. This value was conservatively rounded up to 0.50 ft/hr for the seepage analysis.

The phreatic surface across the levee was developed based on the following total head boundary conditions for the following model cases:

- Long-term Condition:
  - Riverward side of the levee – 100-year flood peak water surface elevation (Section AA' - EL. 80 feet, Section BB'- EL. 80 feet, Section CC' - EL. 82 feet, Section DD' - EL. 85 feet),
  - Landward side of the levee – ground surface elevation (Section AA' - EL. 72 feet, Section BB' - EL. 73 feet, Section CC' - EL. 79 feet, Section DD' - EL. 81 feet).
- Rapid Drawdown Condition:
  - Riverward side of the levee – drop from 100-year flood level elevation to landward side ground elevation at a rate of 0.5 inches per hour in 6 to 12 hours;
  - Landward side of the levee - ground surface elevation.

For underseepage conditions, the current USACE criterion for the average vertical exit hydraulic gradient through a levee's landward side blanket was used. This criterion is to be less than or equal to 0.5 for the design floodwater level condition (see USACE, 2000 and USACE, 2005).

Table 3 shows results of the seepage analyses for long-term steady seepage conditions. An exit vertical gradient contour output figure was generated using SEEP/W for each case as shown on Figures C1 to C5 included in Appendix C. The results of the seepage analysis are summarized in Table 3. The analyses were performed on the four different sections with different core fill soil types as follows:

- Fill with an estimated 25 percent fines with a conservative estimate of permeability equal to 0.003 cm/sec (Section 1 at locations AA,' CC', and DD'; Section 2 at location BB'). In this case a "conservative" permeability is one that is in the high end of the expected range.

- Fill with an estimated 25 percent fines with typical estimate of permeability equal to 0.003 cm/sec (Sections 3a and 3b).
- Fill with an estimated 20 percent fines passing the #200 sieve and higher permeability of 0.020 cm/sec (Section 1 at Location AA; Section 2 at BB).

Topsoil was not modeled as a separate layer from the levee fill in Section 1 and Section 2. However, both of these sections were modeled using permeability of 0.02 cm/sec for the levee

fill, which is the same permeability used in modeling topsoil in Sections 3a and 3b. Therefore, 12 inches of topsoil placed as part of the section at AA and BB would not be inconsistent with the modeled results.

It should be noted that the estimates of permeability for levee core material having 20 to 25 percent fines were made assuming that these fines are non-plastic to low plasticity silt and/or clay to account for the potential difficulty in obtaining borrow fill containing higher plasticity fines that would also have lower permeabilities.

Table 3: Summary of Seepage Gradient Estimates at Setback Levee Toe

Analyzed Location	Levee Core Material		Maximum Vertical Exit Gradient (i_{max})	Figure No.
	Passing #200 Sieve * (%)	Permeability (cm/sec)		
SECTION 1				
AA'	25	0.003	0.38	C1
	20	0.020	0.43	C1a
CC'	25	0.003	0.35	C3
DD'	25	0.003	0.35	C4
SECTION 2				
BB'	25	0.003	0.45	C2
	20	0.020	0.46	C2a
SECTION 3a				
AA'	25	0.003	0.40	C5
SECTION 3b				
AA'	25	0.003	0.41	C5a
DD'	25	0.003	0.39	C6

* Percent fines passing the #200 sieve.

The vertical exit gradients listed in Table 3 are less than the maximum acceptable value of 0.5 that is the current USACE criterion for the levee design floodwater level condition (see USACE, 2000 and USACE, 2005). The results of the seepage analysis indicate that the exit gradients are considered acceptable according to USACE criteria, and therefore a seepage cutoff trench, core or blanket is not required if soils encountered during construction are consistent with the values used in the analysis.

The analysis of core material with an estimated 20 percent fines was performed only at location AA' for Section 1 and location BB' for Section 2 to show the relative difference if fill is imported with lesser fines than assumed for the modeling.

The results of this comparative analysis show that soils with higher permeability consistent with lesser fines content (assumed 20 percent) would have greater exit gradients than soils with permeability corresponding to 25 percent fines. However, the difference in exit gradients for location BB' and Section 2 is insignificant, which may be related to the thinner impermeable section with the rock face on the waterward side of levee in this section.

A transient analysis was performed to simulate the phreatic surface (including groundwater levels on the landward side of the proposed levee) during a 100-year flood event in the White River. The results of the transient analysis indicate that groundwater is high enough to be at or above the ground surface during extreme flood events with associated high river stages lasting 48 hours or more. The high groundwater levels would not be from seepage through the levee but would occur from the surcharge of deeper pervious layers that would transmit groundwater to shallower alluvium near the surface. This is in contrast to existing conditions during moderate flood flows less than the 100-year flood event, in which the field areas south of the proposed setback levee would be inundated with floodwaters. Although the proposed setback levee will provide protection from flood inundation, the high groundwater levels that currently exist in the field areas south of the proposed setback levee will not be alleviated by the levee. The presence of near-surface moisture for 48 hours or more under existing and proposed conditions could have adverse impacts on the existing pavements near the toe of the future levee at the south end of the alignment. With or without the setback levee, consideration should be given to adding fill in areas where roads and buildings will be constructed immediately adjacent to the proposed setback levee toe.

4.4 STABILITY ANALYSES

URS performed a static slope stability analysis for long-term conditions and for rapid drawdown conditions using SLOPE/W (2007), a commercially available computer program for the general solution of slope stability problems by two-dimensional limit equilibrium methods. SLOPE/W provides analyses and results that comply with the USACE guidelines in EM 1110-2-1913 and ETL 1110-2-1902. The calculation of the factor of safety (FS) against instability of a slope can be performed using one of the following methods: Bishop Simplified Method (applicable to circular shaped failure surfaces), Ordinary Method, Janbu Simplified Method (applicable to failure surfaces of general shape), or Spencer's Method (applicable to any type of surface).

SLOPE/W features unique random techniques for generation of potential failure surfaces for subsequent determination of the more critical surfaces and their corresponding factors of safety. These techniques generate circular failure surfaces, surfaces of sliding block character, or more general irregular surfaces of random shape. For the purposes of these analyses, URS utilized Spencer’s Method. The pore pressure generated in the SEEP/W model run was used in the SLOPE/W program during stability analysis. The analysis incorporated the following options:

1. Analysis method: Spencer
2. Slip surface option: entry and exit
3. Directions of movement: left to right for landward side of levee; right to left for riverward side of levee
4. Tension crack option: no tension crack
5. Minimum slip surface depth: 5 feet

The minimum FS for static conditions required by the USACE (2000) are shown in Table 4.

Table 4: Minimum Factors of Safety Required by the USACE (2000) for Levees under Static Conditions

Design Condition	Minimum FS
Rapid Drawdown	1.0 to 1.2 *
Long Term (Steady Seepage)	1.4**

* Sudden drawdown analysis. F.S. = 1.0 applies to pool levels prior to drawdown conditions where these water levels are unlikely to persist for long periods preceding drawdown. F.S. = 1.2 applies to pool level likely to persist for long periods prior to drawdown.

** For existing slopes where either sliding or large deformation have occurred previously and back analyses have been performed to establish design shear strengths, lower factors of safety may be used. In such cases probabilistic analyses may be useful in supporting the use of lower factors of safety for design.

Cross sections for evaluation were selected based on levee height and the presence of the most critical foundation soil conditions and strata depths. Selected locations for stability analyses are as follows:

- Location AA' (near KCB-1) .
- Location BB' (near KCB-2/KCMW-2). *
- Location CC' (near KCB-7) .
- Location DD' (near KCB-9).

*Note that KCB-2 and KCMW-2 are the same boring with different names to designate that the boring is also used as groundwater monitoring well.

Static factors of safety were estimated for long-term and rapid drawdown conditions.

The results of the long-term and rapid drawdown stability analyses are summarized in Tables 5 and 6, respectively. These tables show that the calculated FS met the minimum acceptable FS specified by the USACE (2000) in all cases. The stability calculation output figures are attached in Appendix D.

Table 5: Summary of Simulated Long-term Condition Factors of Safety

Analyzed Locations	Levee Core Material				FS		Figure No.
	Passing #200 Sieve (%)	Friction Angle (degrees)	Cohesion (lbs/ft^2)	Perm-eability (cm/sec)	Land-ward Side	River-ward Side	
AA'	20	37	0	0.020	1.52	1.96	D1, D2
	25	35	50	0.003	1.64	2.15	D1a, D2a
BB'	20	37	0	0.020	1.40	2.00	D5, D6
	25	35	50	0.003	1.46	2.19	D5a, D6a
CC'	20	37	0	0.020	1.88	2.13	D9, D10
DD'	20	37	0	0.020	1.68	2.03	D13, D14

Table 6: Summary of Simulated Rapid Drawdown Condition Factors of Safety

Analyzed Sections	FS*		Figure No.
	Landward Side	Riverward Side	
Section AA'	1.62	1.52	D3, D4
Section BB'	1.56	1.91	D7, D8
Section CC'	1.91	1.90	D11, D12
Section DD'	1.74	1.74	D15, D16

* ϕ = 37 °, c = 0 lbs/ft^2 , permeability = 0.02 cm/s, assumed 20% fines passing the #200 sieve for the modeled fill .

As in the seepage analyses, the stability analyses were performed for two separate hypothetical levee fill soil types, one having 20 percent fines and an assumed zero cohesion value but higher friction angle than a fill having 25 percent fines. In general, the use of the higher fines fill resulted in a slightly higher long-term factor of safety. The rapid drawdown case was only examined with 20 percent fines in the fill soil (zero cohesion), because the likelihood of obtaining a factor of safety less than the required 1.2 value was judged to be remote for the higher fines fill.

All FS values listed in Table 5 and Table 6 are greater than or equal to the minimum for static conditions (FS =1.4) and rapid drawdown conditions (FS = 1.2) required by the USACE (2000), as shown in Table 4.

5.0 CONCLUSIONS

The analyses conducted for the proposed setback levee along the alignment shown in Figure 2 indicate that all configurations modeled will meet the requirements of the USACE for slope stability. The analyses also indicate that the sections modeled meet the USACE seepage guidelines at the locations as follows:

- The proposed sections using a narrow core as shown for Sections 3a and 3b on Figure 5 can be used for the entire proposed setback levee except near location BB'.
- Location BB' requires a core section with rock riprap facing on the waterward side as shown in Section 2 on Figure 4.

Calculations indicate that for soil conditions at most borings, the estimated settlement magnitude for the new levee embankments is relatively small at 2 to 4 inches, most of which is expected to occur during construction. At a few locations where peat or organic silt have been encountered, such as at borings KCB-6 and KCB-7 , the settlement could increase to as much as approximately 6 inches, and could occur over an extended period of time.

Existing groundwater levels will not be lowered by installation of the setback levee. The transient modeling predicts that there may be low-gradient seepage beneath the levee during prolonged periods of high river flows that could result in shallow groundwater conditions landward of the setback levee that would otherwise be inundated with flood water if the project was not constructed. With or without the setback levee, roads or structures may experience saturated subgrades due to existing shallow groundwater conditions.

6.0 RECOMMENDATIONS AND CONSTRUCTION CONSIDERATIONS

The soil encountered within the area to be occupied by the new levee is suitable as a foundation for the new levee fills without preload or extensive modification. Total settlements ranging up to 6 inches could occur at the center of the levee during and after construction in locations overlying peat deposits. The settlement will be generated by consolidation of the silt and peat zones under the weight of the new embankment fill.

The permeability of potential on-site or imported embankment fill could vary naturally by a substantial amount. Accordingly, URS is recommending minimum fines content of 25 percent for the levee core so that portions of the fill that do not meet the assumed permeability will still meet the requirement for the maximum allowable seepage gradient.

Recommended fill materials for the core of the levee embankment are silts, clays, sands with silt, sands with clay, or a mixture thereof. The plasticity of the fines content of levee fill materials should be as high as possible to decrease permeability. The fill material should have a maximum particle size of 3 inches with a minimum of 25 percent of the material passing the #200 sieve (considering only material less than 3 inches) measured in accordance with ASTM D-1140. Organic and foreign substances should not be allowed in the earthfill material. URS recognizes that the minimum fines recommendation may be difficult to achieve given the available borrow sources, and accordingly has examined the seepage and stability assuming a coarser levee fill.

Zoned fills as shown on Figure 5 meet minimum seepage and stability guidelines as described in the Conclusions section above. The existing levee materials (alluvium) are gravels with minimal fines and are not acceptable for the core of the setback levee. For the zoned levee section, the core should contain soils with a minimum of 25 percent of the material passing the #200 sieve and it should be constructed up to the future 100-year flood peak water surface elevation. The portion of the levee above the 100-year flood level (freeboard) may be constructed of fill having less than 25 percent fines, including on-site alluvium.

The impervious core of the levee embankment fill should be placed in continuous, homogenous lifts with a maximum layer thickness of 8 inches before compaction. The alluvium may be placed with a maximum layer thickness of 12 inches before compaction. The recommendations for the degree of compaction made here consider that no specific numerical compaction requirement is contained in the latest guidance on levee construction (EM 1110-2-1913, Design and Construction of Levees) published by the USACE (2000). Given the above considerations, URS recommends that fill placed for construction of the setback levee be compacted to a minimum density of 95 percent of the maximum dry density as measured using ASTM Test Method D-698.

The moisture content of the fine-grained fill matrix should not be less than 2 percent below the optimum moisture content, and no more than 3 percent above optimum moisture content as determined by ASTM D-698.

The fill in the wetland (location DD') can be started by removing fine and organic material and filling with approved riprap as a base within the footprint of the riprap as shown in the design drawings. Levee fill behind the riprap should be placed in the dry, meeting all levee criteria described above, after the foundation has been stripped and proof rolled (compact foundation layer prior to initial fill placement).

A clubfoot or sheepsfoot roller is recommended for foundation subgrade preparation and levee compaction for fine-grained soils (e.g., silts, clay, sandy silt, and sandy clay) or soils that have a high fines component (e.g., silty sand), to be used for construction of the new levee. This type of roller is expected to minimize the potential for creating a preferred pathway for seepage at the interface between lifts of fill soil. If a smooth surface occurs during placement, the top of each lift should be scarified to a depth of approximately 1 inch before placement of the next lift to avoid development of a preferred pathway for seepage. If rainfall is expected during the construction period, the levee surface should be sloped to drain and "sealed" with a smooth drum roller to allow surface water runoff. The smooth surface should be scarified when fill placement is resumed. Vibratory compaction should be avoided for fine-grained soils or soils with high fines content. Rubber tire or smooth drum vibratory compactors can be used on coarser soils used in the zone identified as alluvium.

Fill soils immediately below the riprap blanket placed on the waterward face of the setback levee may be susceptible to erosion and washing from behind the riprap unless a filter is placed between the riprap blanket and the levee fill. The filter should consist of a 9-inch minimum thickness of well-graded sand and gravel meeting the gradation requirements in Appendix D of EM 1110-2-1913.

Before starting earthwork, site preparation should begin with stripping any surficial grass, roots, and topsoil from within the limits of fill placement. URS expects surface stripping will be necessary to a minimum depth of 1 foot.

One typically adverse existing soil condition that was not encountered in the soil borings, but if encountered during construction would likely result in an unacceptable seepage exit gradient is the presence of a clean sand (SP or SW) at the subgrade level of the new setback levee embankment. While it appears that the possibility of encountering such a condition is low, URS recommends that if the clean sand is present for a distance of at least 15 feet along the setback levee alignment, the low permeability core soil should be extended downward in the form of a keyway into the foundation to a depth of at least 4 feet. The final dimensions should be assessed according to the nature of conditions encountered.

Topsoil obtained from the foundation preparation may be stockpiled and placed on the setback levee prior to revegetation of the levee slopes. Prior to placing topsoil, the setback levee should be constructed to its full cross section using approved levee fill material. The setback levee side slopes should be “track-walked” by a tracked vehicle running up and down the slopes of the fill. The topsoil should be compacted by the same track-walking method leaving the final surface with horizontal indents from the tracks to collect rain and prevent erosion of the newly completed levee.

The soils expected to be exposed at the subgrade level for the setback levee are considered moderately to highly erodible in a disturbed condition. Erosion control efforts during construction should be diligently implemented in this large area of disturbance, and Best Management Practices (BMPs) applied as necessary to protect the nearby wetlands and river. Protection of compacted soil embankment slopes should be selected considering the velocity of the water that may be flowing towards or along the sloping surface.

7.0 LIMITATIONS

The recommendations and descriptions presented in this report are based on the soil conditions encountered in the field exploration conducted by King County at the site in 2010. The subsurface information referred to herein does not constitute a direct or implied warranty that the soil conditions between boring locations can be directly interpolated or extrapolated or that subsurface conditions and soil variations different from those encountered in the County’s explorations will not be revealed. If, during construction, subsurface conditions different from those described herein are observed, or if the structures and loading conditions described here are modified, URS Corporation should review such conditions and the recommendations given herein should be revised, as necessary.

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APPENDICES

Appendix A - Logs of Borings, Results of Laboratory Testing
Appendix B - King County Modeling Data for Drawdown Analysis
Appendix C - Vertical Exit Gradient SEEP/W Output
Appendix D - Stability Analyses SLOPE/W Output
Appendix E - King County Groundwater Well Data

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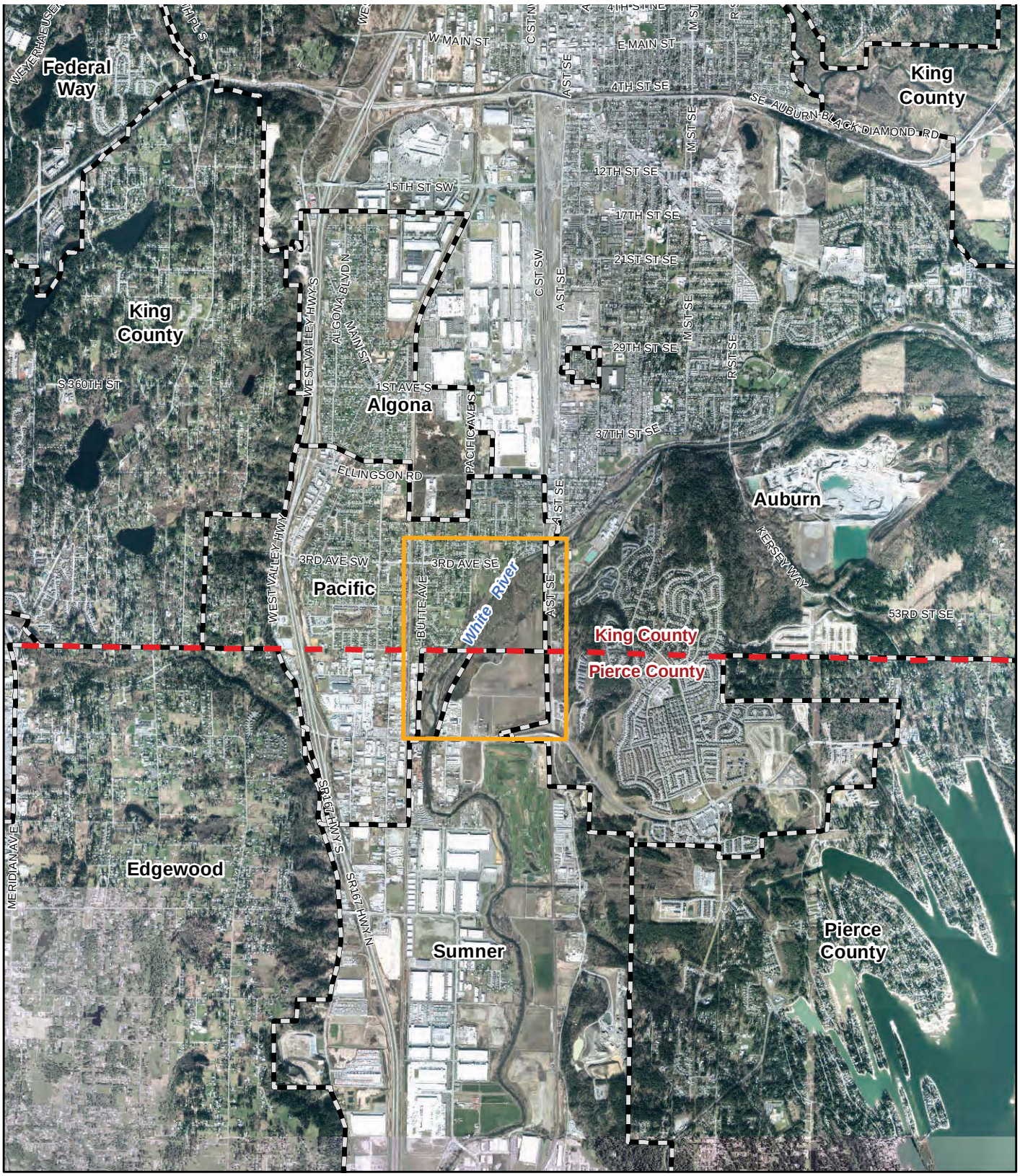


Source: King County, Department of Natural Resources and Parks, Water and Land Resources Division

Figure 2 Location
City Boundary
County Boundary

0 2,000 4,000 6,000
Feet

Figure 1
Site Location

Job No. 33762798

URS

White River Countyline Levee Project
King County, Washington

33762798_02.ai

Source: King County, Department of Natural Resources and Parks, Water and Land Resources Division

City Boundary
County Boundary
A A' Cross Section Location
Boring Sites
Test Pits
Scrapes

0 600 1,200
Feet

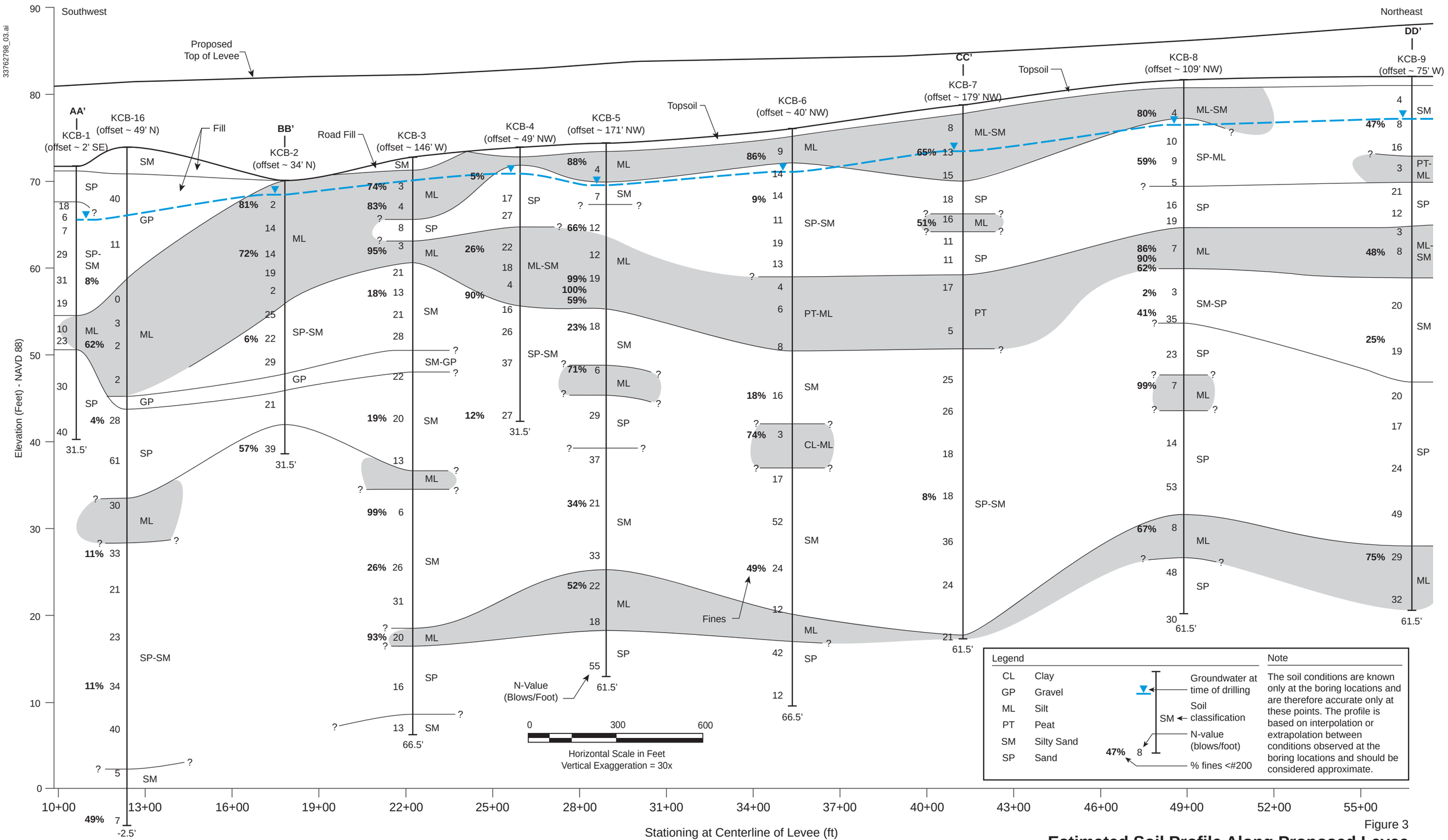
Figure 2

Site Plan, Boring Locations and Cross Sections

Job No. 33762798

URS

White River Countyline Levee Project
King County, Washington



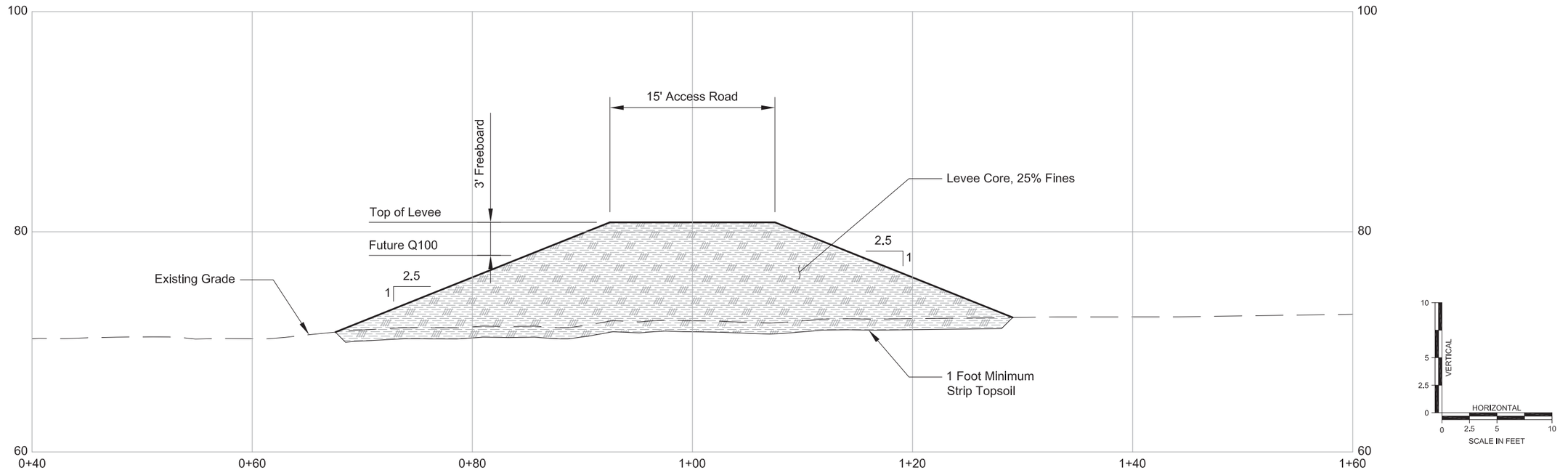
Job No. 33762798

Figure 3

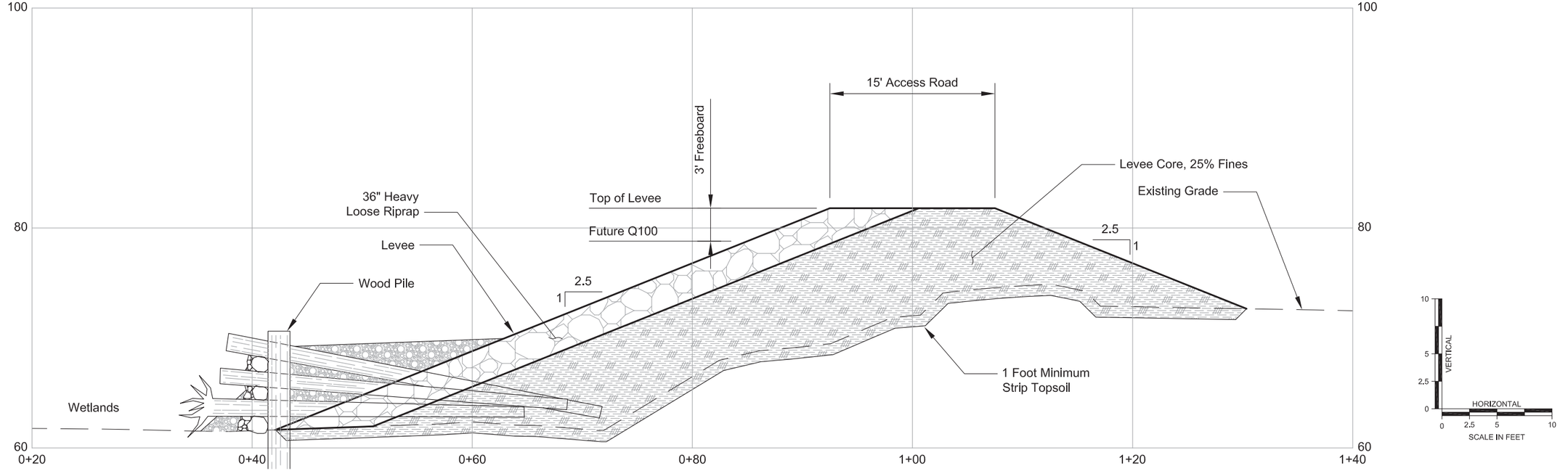
Estimated Soil Profile Along Proposed Levee

URS

White River Countyline Levee Project
King County, Washington



Typical Section 1 at A, C, and D



Section 2 at B

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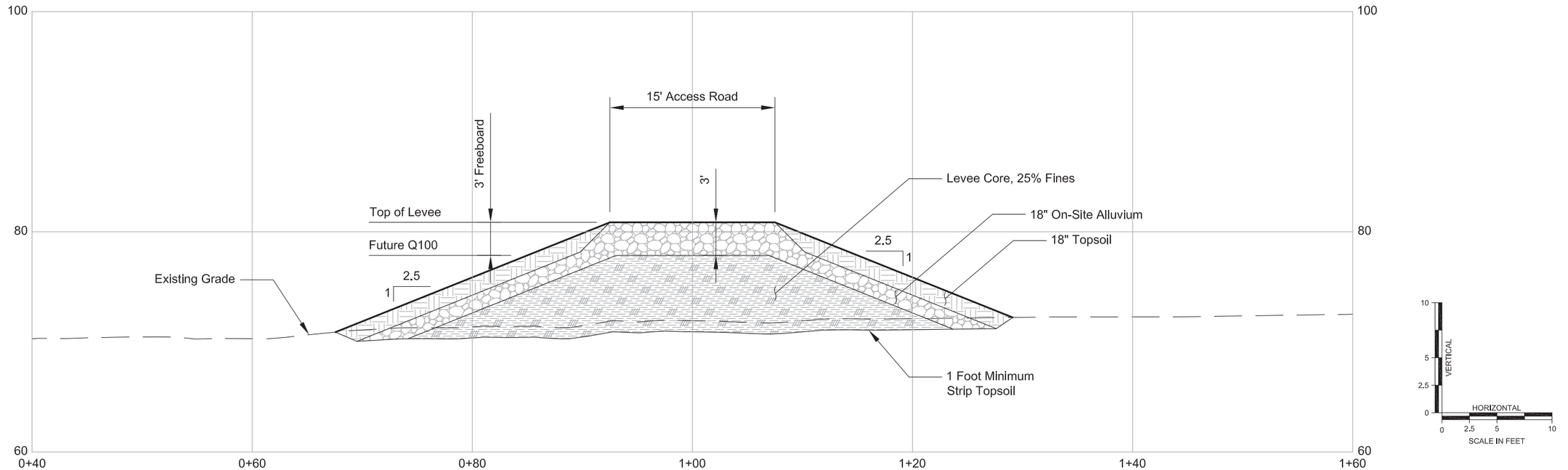
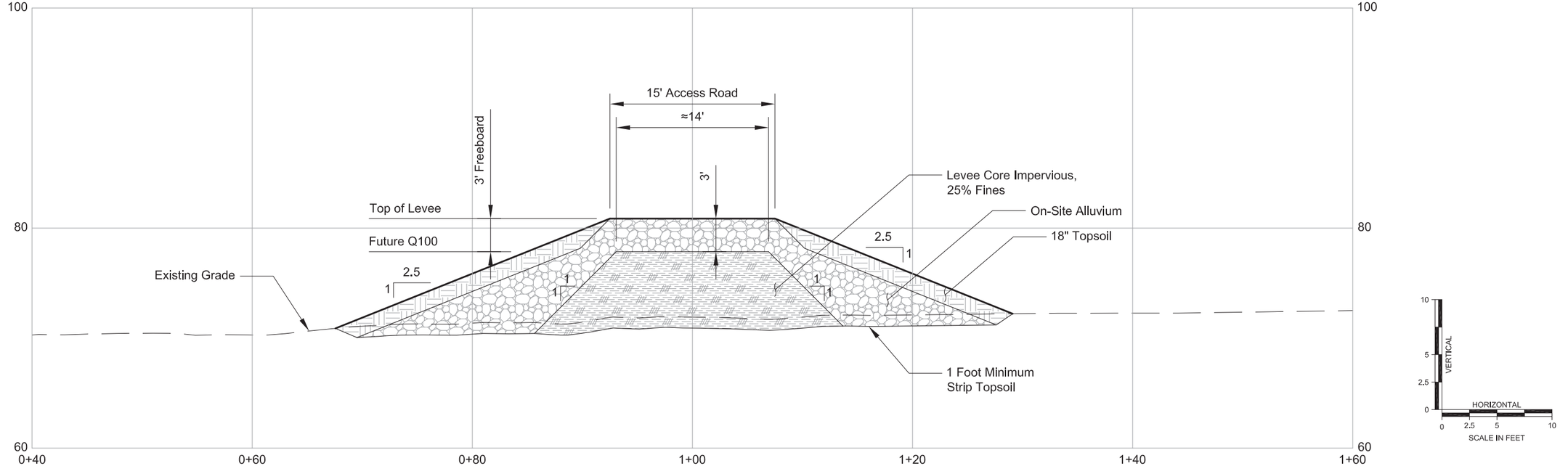
URS

Figure 4
Typical Sections

White River Countyline Levee Project
King County, Washington



Alternate Section 3a at A, C and D



Alternate Section 3b at A, C and D

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Figure 5
Alternate Sections

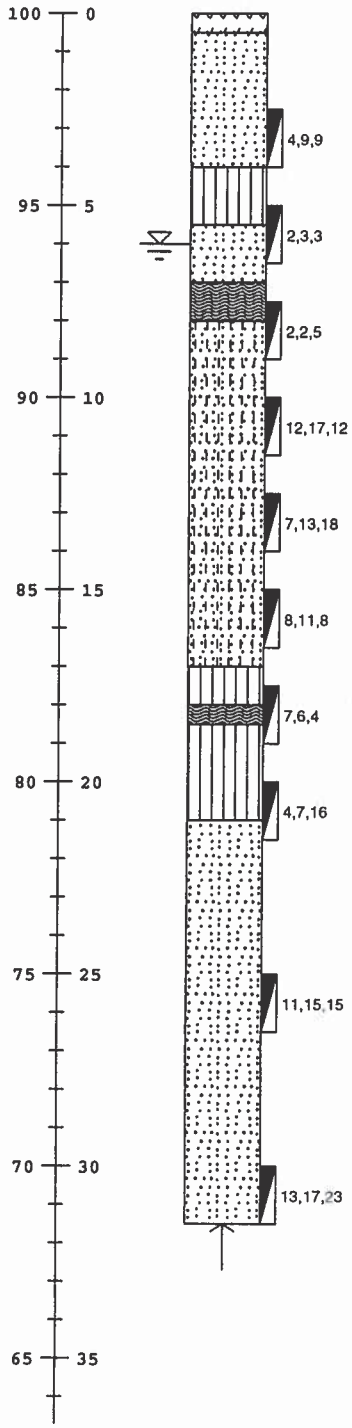
White River Countyline Levee Project
King County, Washington

Appendix A: Borings and Laboratory Test Results

BORING LOG
BORING KCB-1

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Setback Levee Location 1**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **6 ft** Caving: **N. A.**

DATE: **September 28, 2010**
START: **12:00 PM 9/28/2010**
FINISH: **2:00 PM 9/28/2010**
LOGGER: **DA**
DATE CHECKED: **During**



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
		SP	Sod and sandy topsoil.			
		ML	Dark brown poorly graded fine to medium grained sand with silt, gravel, and occasional cobbles, moist, medium dense. (Fill)			
		SP	Gray silt with sand, moist, loose. The silt contains a few fragments of decaying vegetation.			
		PT		168.0		
		SP-SM	Black poorly graded fine to medium sand, wet, loose.			
			Peat.			
			Black poorly graded fine to medium grained sand with silt, wet, loose to dense.	26.4	7.9	The sample contained scattered gravel.
		ML	Black silt, wet, medium dense.			
		PT	Peat.	168.1		
		ML	Dark gray sandy silt, wet, medium dense.	35.4	61.7	The silt was found to be non-plastic.
		SP	Black poorly graded fine to medium grained sand, wet, medium dense to dense.			
			The sample contained scattered tephra granules.			

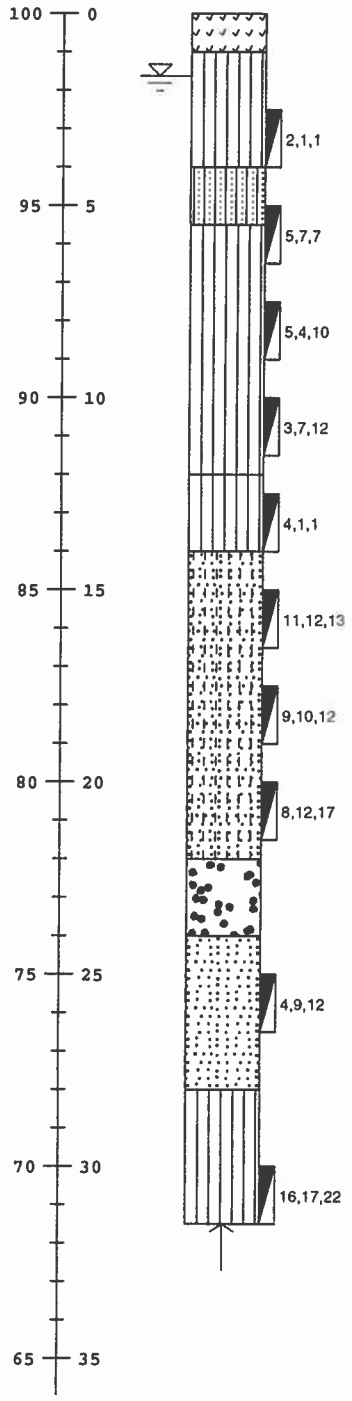
Boring KCB-1 was located in the field by GPS. The approximate boring location is provided in Figure 2.

PLATE NUMBER **A1**

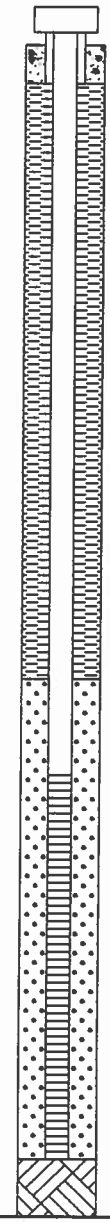
LOG OF MONITOR WELL INSTALLATION
WELL NO. KCB-2

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Setback Levee Location 2**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **1.62 ft**

DATE: **September 22 2010**
START: **12:00 PM 9/22/2010**
FINISH: **2:00 PM 9/22/2010**
LOGGER: **DA**
DATE CHECKED: **7:30 AM 9/30/**



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
			Cultivated sandy topsoil.				
		ML	Gray mottled silt with sand, moist to wet, very loose. Sample also contained scattered organic material.	53.0	80.6	The silt was found to be non-plastic.	
		SM					
		ML	Black silty sand, wet, medium dense. The sand contains thin lenses of fine sand and silt.	31.6	72.2	The silt was found to be non-plastic.	
			Black silt with sand, wet, loose to medium dense.				
		ML	Gray silt, wet, very loose. The sample also contained a 6 inch thick lense of peat.				
		SP-SM					
			Black poorly graded fine to medium sand with silt, wet, medium dense.	29.5	5.5		
		GP	Poorly graded gravel with sand, wet, medium dense.			The gravel was detected by the action of the drill.	
		SP	Black poorly graded fine to medium grained sand, wet, medium dense to dense.			Sample contained scattered decomposed wood debris and root fibers.	
		ML	Dark gray sandy silt, wet, dense.	30.0	56.6	The silt was found to be non-plastic.	



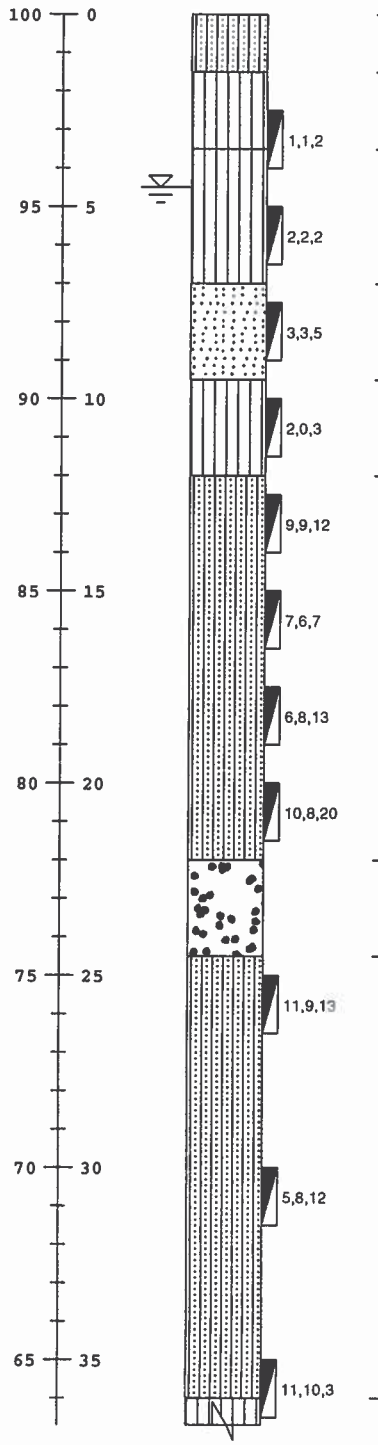
Well KCB-2 was located in the field by GPS. The approximate well location is provided in Figure 2. Well KCB-2 is identified by Washington State Department of Ecology discrete well tag number BCJ 225.

PLATE NUMBER **A2**

BORING LOG
BORING KCB-3

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Setback Levee Log Jam Location 3**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **4.5 ft** Caving: **N.A.**

DATE: **September 22, 2010**
START: **9:00 AM 9/22/2010**
FINISH: **2:00 PM 9/22/2010**
LOGGER: **D. A.**
DATE CHECKED: **During**

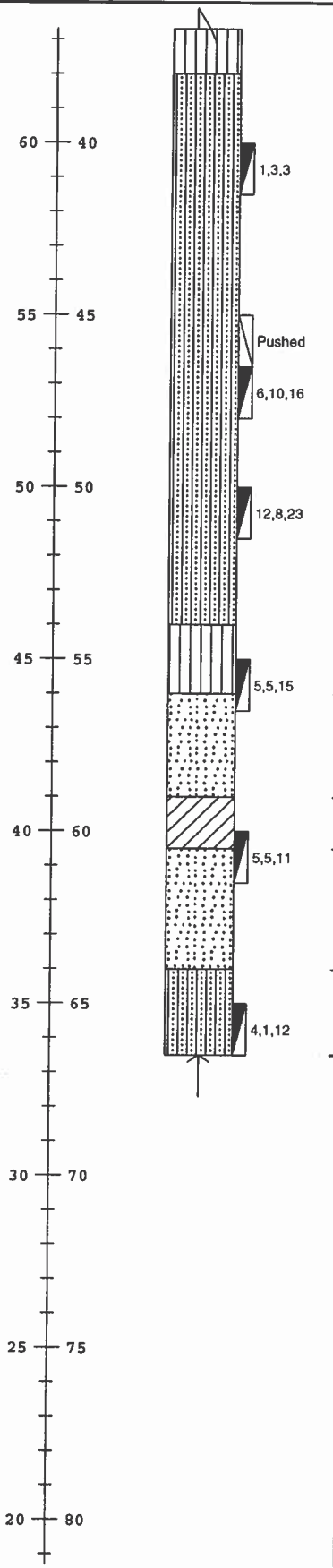


USCS	Description	Moist (%)	-200 (%)	Remarks
SM	Brown silty sand with gravel, moist, medium dense. (Road fill)			
ML	Gray silt with sand, wet, very loose.	42.9	73.8	The silt was found to be non-plastic.
ML	Gray silt with fine grained sand, wet, very loose. The sample contained roots and traces of decomposed wood debris.	36.5	82.5	The silt was found to be non-plastic.
SP	Black poorly graded fine to medium grained sand, wet, loose.			
ML	Gray silt, wet, loose.	45.5	95.3	The silt was found to be non-plastic.
SM	Black silty fine to medium grained sand, wet, medium dense.	28.4	17.9	
GP	Black poorly graded gravel with sand, wet, dense.			The gravel was detected by the action of the drill.
SM	Black silty fine grained sand with scattered gravel, wet, medium dense.	26.2	18.7	A 1-foot thick gravel lense was detected during drilling.
SM				
ML				

Boring KCB-3 was located in the field by GPS. The approximate boring location is provided in Figure 2.

PLATE NUMBER **A3**

LOG OF Boring
BORING KCB-3
(continued)

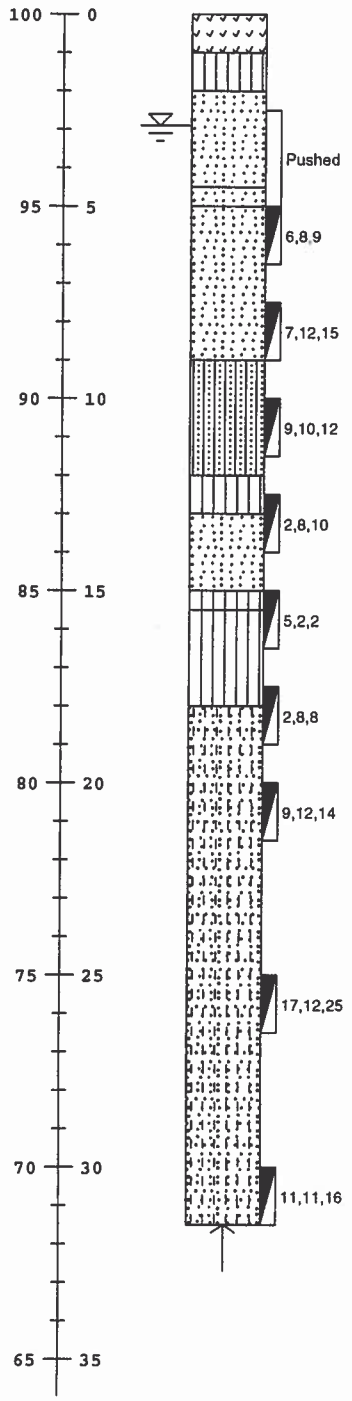


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
		SM	Brown silt, wet, loose. A 1 inch thick peat lens was found on the surface of the silt.			
			Black silty fine to medium grained sand, wet, loose to medium dense. The soil zone from 38 to 54 feet also contains scattered thin silt and peat lenses with occasional decomposed wood.	45.9	98.5	Liquid Limit 35 Plastic Index 2. The testing at 40 feet was performed on one of the intermittent silt lenses.
				24.2	25.6	A sampler containing rings was pushed at this elevation resulting in no sample recovery.
		ML	Peat and dark brown silt, wet, loose.	51.3	92.7	Liquid Limit 42 Plastic Index 8
		SP	Black poorly graded fine to medium sand, wet, medium dense.			
		CL	Gray silty lean clay, wet, stiff.			
		PT	Peat	112.9		
		SP	Black poorly graded fine to medium sand, wet, medium dense.			
		SM	Dark gray silty fine grained sand, wet, medium dense.			

LOG OF MONITOR WELL INSTALLATION
WELL NO. KCB-4

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Set Back Levee Location 4**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **2.90 ft**

DATE: **September 22, 2010**
START: **2:00 PM 9/22/2010**
FINISH: **9:00 AM 9/23/2010**
LOGGER: **DA**
DATE CHECKED: **7:30 AM 9/30/10**



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks	Monitor Well Construction Schematic
			Cultivated sandy topsoil.				
		ML	Gray mottled sandy silt, moist to wet, very loose. The sample also contained scattered organic material.	26.7	4.5	Brown fine sand observed in the tip of the shelby.	
		SP					
		SP	Black poorly graded fine to medium grained sand, wet, medium dense.				
		SP					
		SM	Brown poorly graded fine grained sand, wet, medium dense.				
			Black poorly graded fine to medium grained sand with 1 to 2 inch thick lenses of fine sand and silt, wet, medium dense.	28.3	26.1		
		ML					
		SP					
			Dark gray silty sand, wet, medium dense. Slight bedding visible.	62.5	89.8		
		ML					
		ML					
			Gray silt, wet, very loose. The sample also contained a 3 inch thick lens of peat at the bottom of the silt.				
		SP-SM					
			Black poorly graded fine to medium grained sand, wet, medium dense.				
			Gray silt, wet, very loose. The sample also contained a 3-inch thick lens of peat at the bottom of the silt.	26.7	11.8		
			Black poorly graded fine to medium grained sand with silt, wet, medium dense to dense.				

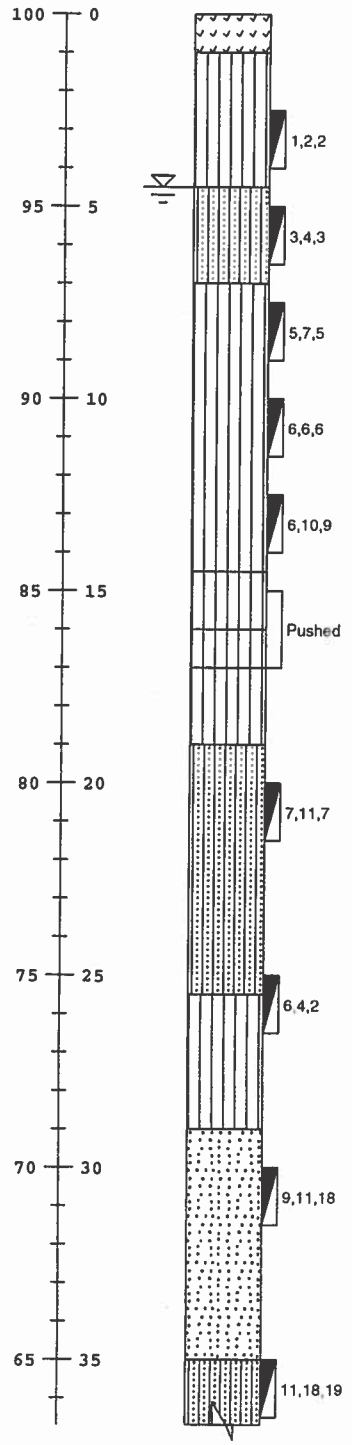
Well KCB-4 was located in the field by GPS. The approximate well location is provided in Figure 2. Well KCB-4 is identified by Washington State Department of Ecology discrete well tag number BCJ 226.

PLATE NUMBER **A4**

BORING LOG
BORING KCB-5

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Setback Levee Log Jam Location 5**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **4.5 ft** Caving: **N.A.**

DATE: **September 23, 2010**
START: **1:45 PM 9/23/2010**
FINISH: **10:AM 9/24/2010**
LOGGER: **D. A.**
DATE CHECKED: **During**

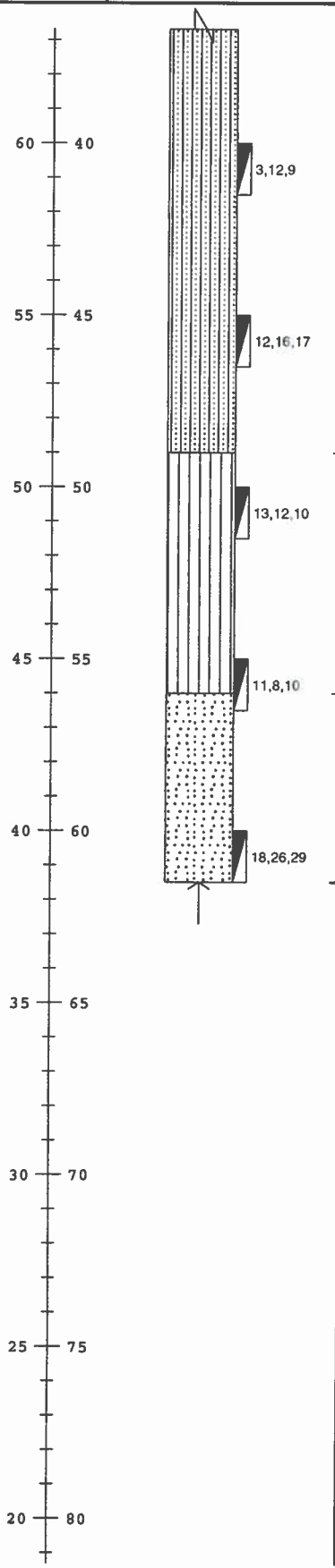


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Cultivated sandy topsoil.			
		ML	Gray brown mottled silt, wet, loose. The sample contained scattered root fragments.	49.0	87.9	
		SM	Dark gray silty sand, wet, loose.	29.1		
		ML	Black fine to medium grained sandy silt, wet, medium dense.	48.6	66.2	The silt was found to be non-plastic.
		ML	Brown silt, wet, medium dense.	52.6	98.6	The silt was found to be non-plastic.
		ML	Gray silt, wet, medium stiff to stiff.	49.6	99.6	Liquid Limit 44
		ML	Black sandy silt, wet, medium dense.	36.4	59.0	Plastic Index 10 The silt was found to be non-plastic.
		SM	Dark gray silty sand, wet, medium dense.	29.1	23.0	The mud level in the boring at 7:45 AM on 9/24/10 was 4 feet below the surface.
		ML	Dark gray silt with a 4-inch thick peat lens, wet, loose. The silt also contained scattered decomposed wood debris.	40.2	71.3	Scattered decomposed wood debris observed in the drill fluid. The silt was found to be non-plastic.
		SP	Black poorly graded fine to medium grained sand, wet, medium dense to dense.			
		SM	Dark gray silty sand, wet, medium dense			Silt noted in the drill cuttings

Boring KCB-5 was located in the field by GPS. The approximate boring location is provided in Figure 2.

PLATE NUMBER **A5**

LOG OF Boring
BORING KCB-5
(continued)

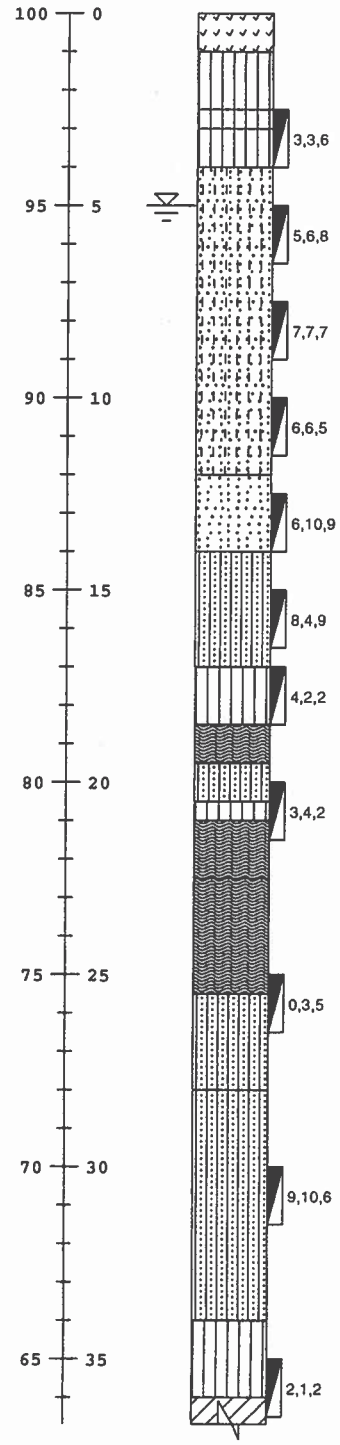


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			to dense.			between 38 and 40 feet below the surface.
	3,12,9			32.3	33.6	
	12,16,17					Sloping thin lenses of fine sand in the sample.
		ML	Dark gray sandy silt, wet, medium dense.			
	13,12,10			29.1	52.1	A thin volcanic ash lens was found overlying a minor layer of peat in the tip of the sampler. The silt was found to be non-plastic.
	11,8,10					
		SP	Black poorly graded fine to medium sand, wet, medium dense to very dense.			
	18,26,29					Silt was observed in cuttings during drilling.

BORING LOG
BORING KCB-6

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Setback Levee Location 6**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **5 ft** Caving: **N.A.**

DATE: **September 24, 2010**
START: **11:00 AM 9/24/2010**
FINISH: **3:30 PM 9/24/2010**
LOGGER: **D. A.**
DATE CHECKED: **During**

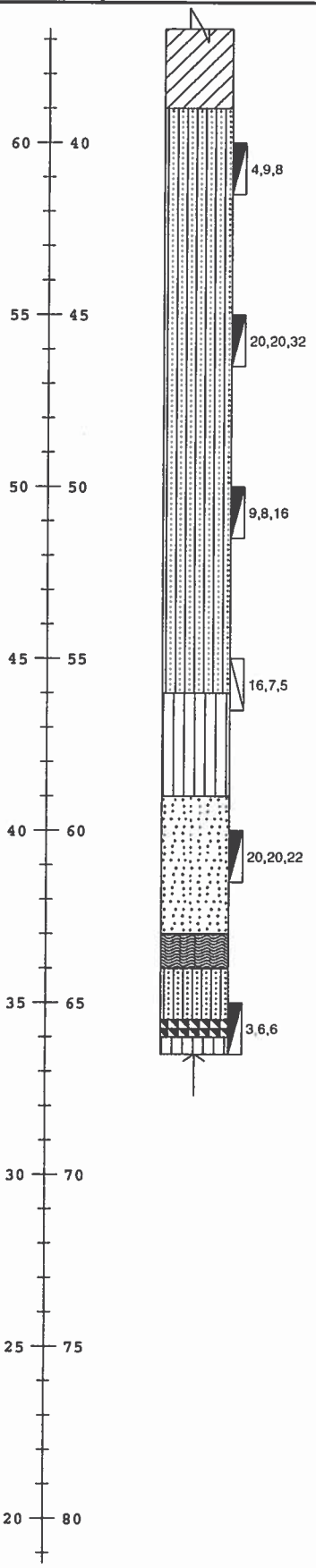


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Cultivated sandy topsoil.			
		ML	Brown mottled poorly graded fine grained sand with silt, wet, loose.			
		ML		35.3	86.4	The silt was found to be non-plastic.
		ML	Tan mottled silt, wet, loose. The sample also contained a few iron stained joints.			
		SP-SM	Black poorly graded fine to medium grained sand with silt, wet, medium dense. Lenses of fine sand and silt are 1 to 2 inches thick.	26.1	8.5	
		SP	Black poorly graded fine grained sand, wet, loose. This unit contains lenses of fine sand and silt 1 to 2 inches in thickness.			Sample contained scattered decomposed wood fragments.
		SM	Dark gray silty sand, wet, loose.			
		ML	Gray silt with sand, wet, loose.			
		PT	Peat.			
		SM	Dark gray silty sand, wet, loose.			
		ML	Gray silt, wet, loose.	134.7		
		PT	Tan sedimentary peat, wet, soft.			
		PT	Peat with alternating layers of organic silt and sand, wet, loose.			
		SM	Dark gray silty sand, wet, loose.			
		SM	Black silty sand, wet, medium dense. Tephra pebbles noted in the cuttings.	24.0	18.0	
		ML	Dark gray silt with sand and a thin lens of sedimentary peat, wet, loose.	88.9	74.2	The silt was found to be non-plastic.
		CL				

Boring KCB-6 was located in the field by GPS. The approximate boring location is provided in Figure 2.

PLATE NUMBER **A6**

LOG OF Boring
BORING KCB-6
(continued)

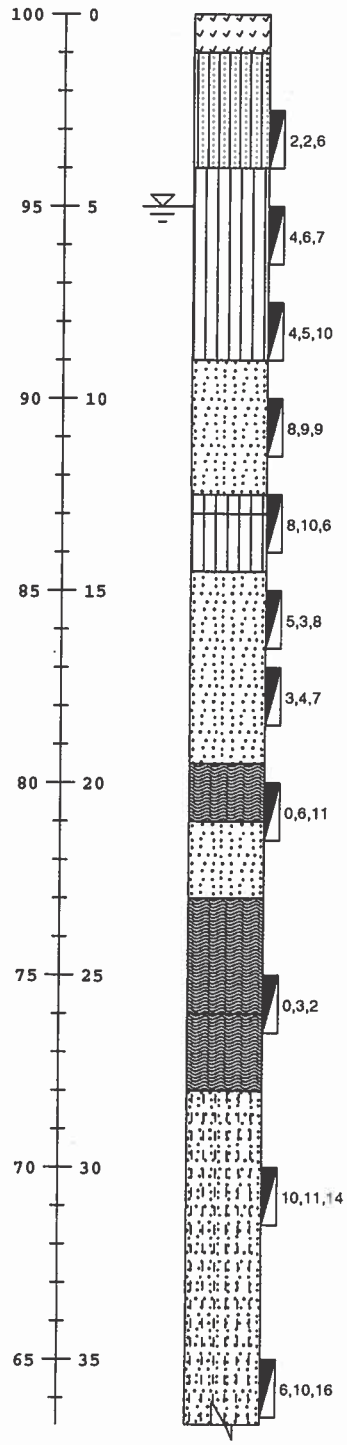


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Green lean clay, wet, soft.			
		SM	Black silty fine to medium grained sand, wet, medium dense to very dense.			
						Sloping thin lenses of fine sand in the sample.
				36.7	49.7	Scattered decomposed wood in the sample.
		ML	Dark gray silt, wet, medium dense.			Silt observed in the drill cuttings between 56 and 59 feet below the surface.
		SP	Black poorly graded fine to medium sand, wet, dense.			
		PT	Peat and organic silt, wet, loose.			Material composition based on drill cuttings.
		SM	Dark gray silty sand, wet, loose.			
			Decomposed wood.			
		ML	Dark gray silt with scattered wood debris, wet, medium dense.			

BORING LOG
BORING KCB-7

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Setback Levee Log Jam Location 7**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **5 ft** Caving: **N.A.**

DATE: **September 27, 2010**
START: **7:30 AM 9/27/2010**
FINISH: **10:30 AM 9/27/2010**
LOGGER: **D. A.**
DATE CHECKED: **During**



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Cultivated sandy topsoil.			
		SM	Brown mottled silty sand, moist, loose.			
		ML	Dark brown sandy silt, wet, medium dense.	29.8	65.3	The silt was found to be non-plastic.
		SP	Black poorly graded fine to medium grained sand, wet, medium dense.			
		ML	Dark gray sandy silt, wet, medium dense.	27.4	50.8	The sample contained scattered decomposed wood fragments. The silt was found to be non-plastic.
		ML				
		SP	Brown silt, wet, medium dense. The silt contains scattered organic material.			
		PT	Black poorly graded fine to medium grained sand with scattered 1 to 2 inch thick lenses of fine sand and silt, wet, medium dense.	166.0		
		SP	Peat and lenses of organic silt.			
		PT	Black poorly graded fine to medium sand, wet, medium dense.			
			Brown peat with lenses of gray organic silt, wet, soft.	201.6		
		PT	Yellow sedimentary peat, wet, soft.			
		SP-SM	Black poorly graded fine to medium grained sand with silt, wet, medium dense. Fine sand in the form of 1 to 2 inch thick lenses throughout this section.			

Boring KCB-7 was located in the field by GPS. The approximate boring location is provided in Figure 2.

PLATE NUMBER **A7**

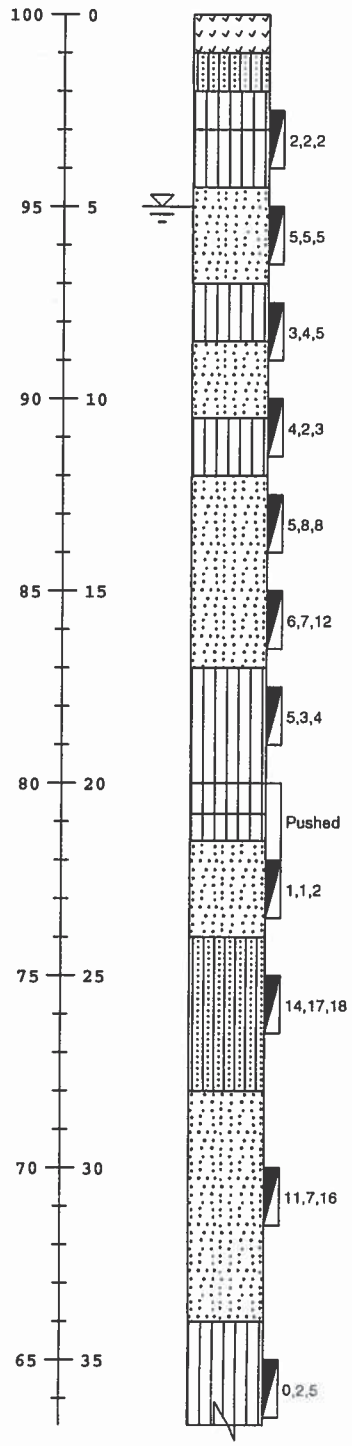
LOG OF Boring
BORING KCB-7
(continued)

ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
60 — 40	11,5,13					
55 — 45	5,3,15			39.3	8.2	
50 — 50	12,14,22					
45 — 55	8,11,13					Scattered decomposed wood in the sample.
40 — 60	22,12,9					
		ML	Dark gray silt with scattered wood debris, wet, medium dense.			
35 — 65						
30 — 70						
25 — 75						
20 — 80						

BORING LOG
BORING KCB-8

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Set Back Levee Log Jam Location 8**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **5 ft** Caving: **N.A.**

DATE: **September 27, 2010**
START: **11:30 AM 9/27/2010**
FINISH: **3:30 PM 9/27/2010**
LOGGER: **D. A.**
DATE CHECKED: **During**

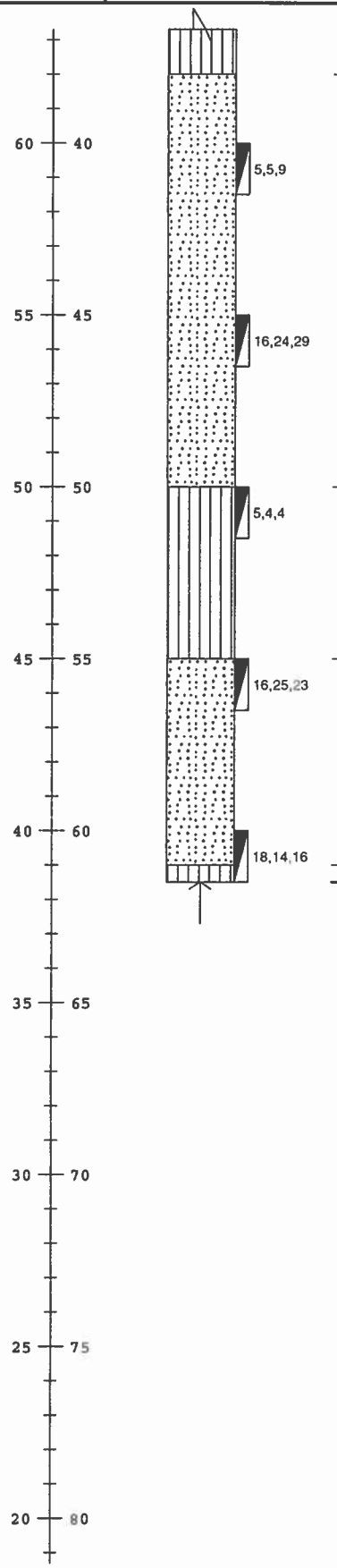


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Cultivated sandy topsoil.			
		SM	Brown mottled silty sand, moist, loose.			
		ML	Tan mottled silt, moist, loose.	35.7	80.4	The silt was found to be non-plastic.
		ML	Dark gray silt with scattered organic material, wet, loose.			
		SP	Brown mottled poorly graded fine grained sand, wet, loose to medium dense.			
		ML	Gray mottled sandy silt, wet, loose.	38.6	58.8	The silt was found to be non-plastic.
		SP	Black poorly graded fine to medium grained sand, wet, loose.			
		ML	Gray mottled silt with scattered organic material, wet, loose.			
		SP	Black poorly graded fine to medium grained sand with 1 to 2 inch thick silt and fine grained sand lenses, wet, medium dense.			
		ML	Dark gray silt with scattered organic material, wet, loose.	42.7	86.2	The silt was found to be non-plastic.
		ML		32.8	90.1	
		ML	Dark gray sandy silt, wet, loose.	33.3	62.1	The silt was found to be non-plastic.
		SP	Black poorly graded fine to medium sand, wet, medium dense.	30.7	1.9	
		SM	Dark gray silty sand, wet, dense.	29.0	40.5	
		SP	Black poorly graded fine to medium grained sand, wet, medium dense. Fine sand in the form of 1 to 2 inch thick lenses throughout this section.			
		ML	Green silt, wet, loose.	54.3	99.4	Liquid Limit 45 Plastic Index 8

Boring KCB-8 was located in the field by GPS. The approximate boring location is provided in Figure 2.

PLATE NUMBER **A8**

LOG OF Boring
BORING KCB-8
(continued)

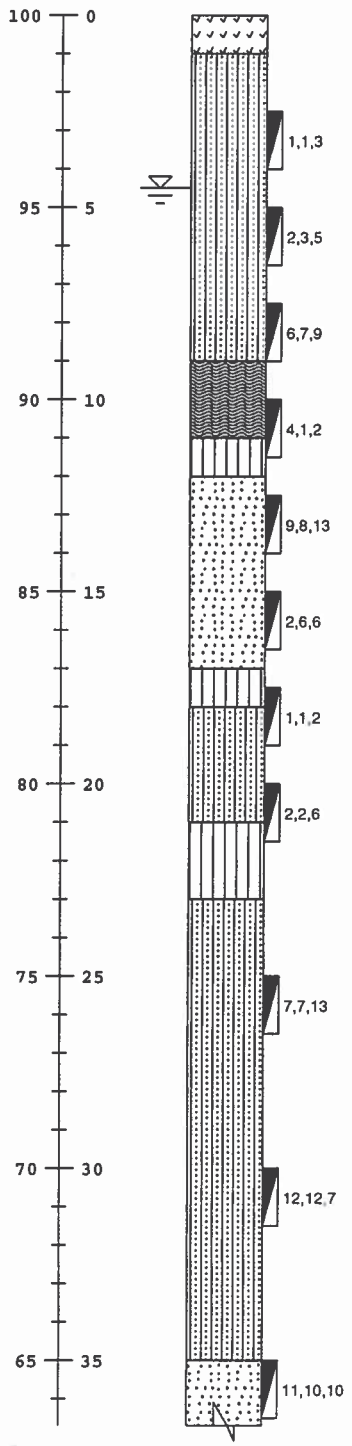


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
		SP	Black poorly graded fine to medium grained sand, wet, loose to very dense. The fine sand and silt is in the form of 1 to 2 inch to thick lenses throughout out this section.			
		ML	Gray sandy silt, wet, dense to very dense.	33.2	66.7	The silt was found to be non-plastic.
		SP	Black poorly graded fine to medium grained sand, wet, loose to very dense. The fine sand and silt is in the form of 1 to 2 inch to thick lenses throughout out this section.			
		ML	Dark gray silt with scattered wood debris, wet, dense.			

BORING LOG
BORING KCB-9

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Setback Levee Log Jam Location 9**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **4.5 ft** Caving: **N.A.**

DATE: **September 28, 2010**
START: **8:00 AM 9/28/2010**
FINISH: **10:30 AM 9/28/2010**
LOGGER: **D. A.**
DATE CHECKED: **During**

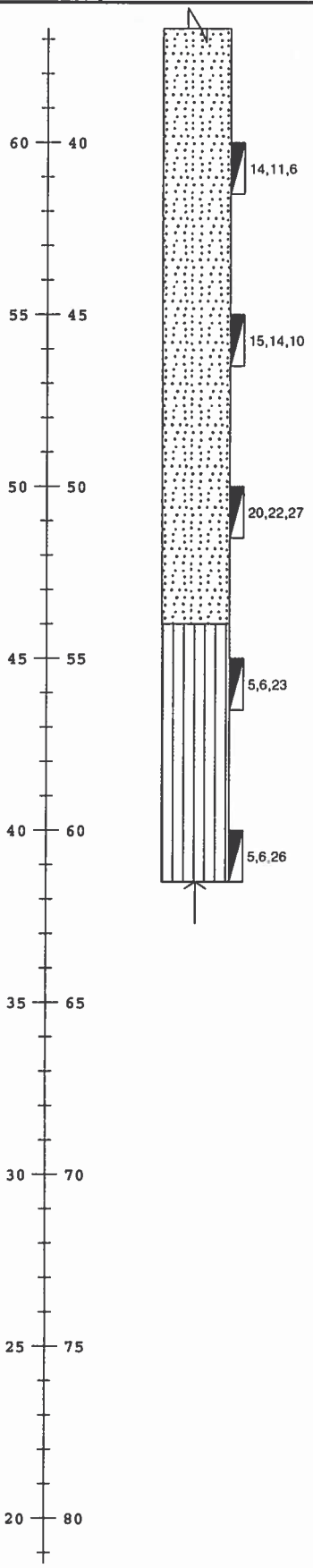


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			Cultivated sandy topsoil.			
		SM	Brown mottled poorly graded fine to medium grained sand, moist, loose.	32.6	47.1	
		PT	Brown peat.	47.1		
		ML	Gray mottled silt with scattered organic material, wet, loose.			
		SP	Black poorly graded fine to medium grained sand with 1 to 2 inch thick silt and fine grained sand lenses, wet, medium dense.			
		ML	Dark gray silt with scattered organic material, wet, loose.			A thin peat lens was found at the base of the silt in the sampler.
		SM	Dark gray silty fine grained sand, wet, loose.	39.2	48.2	
		ML	Dark gray silt with thin fine sand lenses, wet, loose. A thin peat lens 1/4 inch thick was found on the surface of the silt.			
		SM	Black silty fine to medium grained sand, wet, medium dense to dense. Silt and fine sand are in the form of 1 to 2 inch thick lenses throughout this section.	26.6	24.6	
		SP	Black poorly graded fine to medium			

Boring KCB-9 was locate in the field by GPS. The approximate boring location is provided in Figure 2.

PLATE NUMBER **A9**

LOG OF Boring
BORING KCB-9
(continued)

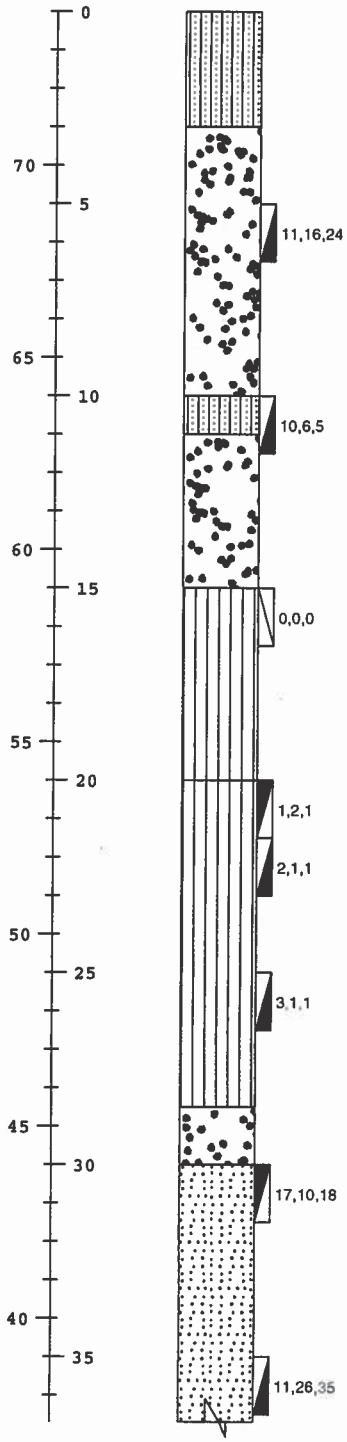


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
			grained sand, wet, medium dense to dense. Silt and fine sand are in the form of 1 to 2 inch thick lenses throughout this section.			
		ML	Dark gray silt with sand, wet, medium dense to dense.	30.3	75.3	The silt was found to be non-plastic.

BORING LOG
BORING KCB-16

PROJECT: **Countyline to A-Street Geotechnical Study**
BORING LOCATION: **Fairweather Property**
DRILL METHOD: **Mud Rotary**
DRILLER: **Holocene Drilling Inc.**
DEPTH TO - Water: **N/A** Caving: **N/A**

DATE: **October 4, 2011**
START: **7:45 AM 10/4/2011**
FINISH: **2:15 PM 10/4/2011**
LOGGER: **DW**
DATE CHECKED: **N/A**

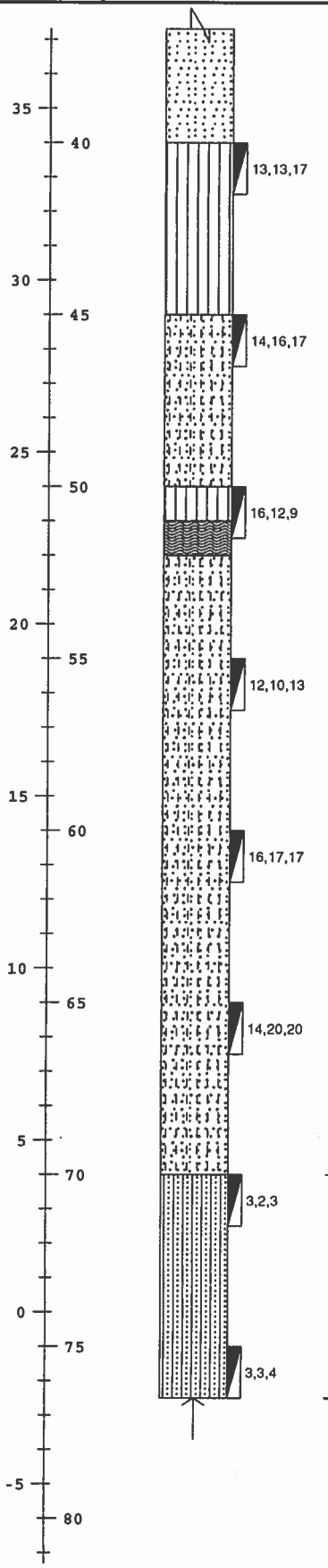


ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
		SM	Brown silty sand with gravel, occasional cobble, scattered concrete debris, moist to wet, medium dense. (Fill)			
		GP	Black poorly graded gravel with sand and cobble, scattered concrete debris, trace paper, moist to wet, medium dense to dense. (Fill)			Dames and Moore sample.
		SM	Brown silty sand with gravel, trace concrete debris, moist to wet, medium dense. (Fill)	26.2	29.6	Dames and Moore sample.
		GP	Black poorly graded gravel with sand, wet, medium dense. (Native contact?)			
		ML	Gray sandy silt, wet, very loose?			Weight of hammer dropped sampler 18 inches. No sample recovery.
		ML	Wood debris with gray sandy silt, wet, very loose?			No sample recovery at 20 or 21.5 feet. Description based on minor sample recovery at 25 feet. Heavy mud loss between 20 and 30 feet. Dames and Moore sample.
		GP	Black poorly graded gravel with sand, occasional cobble, wet, dense.			Dames and Moore sample.
		SP	Black poorly graded sand with gravel, wet, dense.	39.0	3.8	Minor recovery of wood debris (twigs) and gray sandy silt. Installed casing to 35 feet. Black sand at tip of sampler.

Boring KCB-16 was drilled in the Fairweather Propery south of the wetland. The boring location is provided in Figure 2. No water level was determined for the boring due to use of mud rotary methodology. However, the water level is anticipated to be at the approximate depth of the adjacent wetland.

PLATE NUMBER **A16**

LOG OF Boring
BORING KCB-16
(continued)



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
		ML	Dark gray sandy silt, wet, medium dense to dense.			
		SP-SM	Black poorly graded fine to medium sand with silt, wet, dense.	19.2	11.0	
		ML	Gray sandy silt, wet, medium dense.			
		SP-SM	Dark brown fibrous peat, wet, medium dense.			
			Black poorly graded fine grained sand with silt, trace gravel, wet, medium dense to dense.	28.9	10.8	
		SM	Gray silty sand to sandy silt, scatterd organics and wood debris, wet, loose.	69.3	49.2	LL=29, PL=29, PI=0, KCB-16 terminated at 76.5 feet.

KEY TO SYMBOLS

Symbol	Description
Strata symbols	
	Silty sand
	Silt
	Poorly graded sand
	Poorly graded gravel
	Low plasticity clay
	Topsoil
	Peat
	Poorly graded sand with silt
	Decomposed wood
	Poorly graded gravel with silt
	Elastic silt
Misc. Symbols	
	Water table during drilling
	End of boring

Symbol	Description
	Boring continues
Soil Samplers	
	Standard penetration test
	No recovery
	Undisturbed thin wall Shelby tube
	Dutch cone test
Monitor Well Details	
	riser with cover and protective casing
	protective casing set in concrete
	bentonite pellets
	silica sand, blank PVC
	slotted pipe w/ sand
	no pipe, filler material

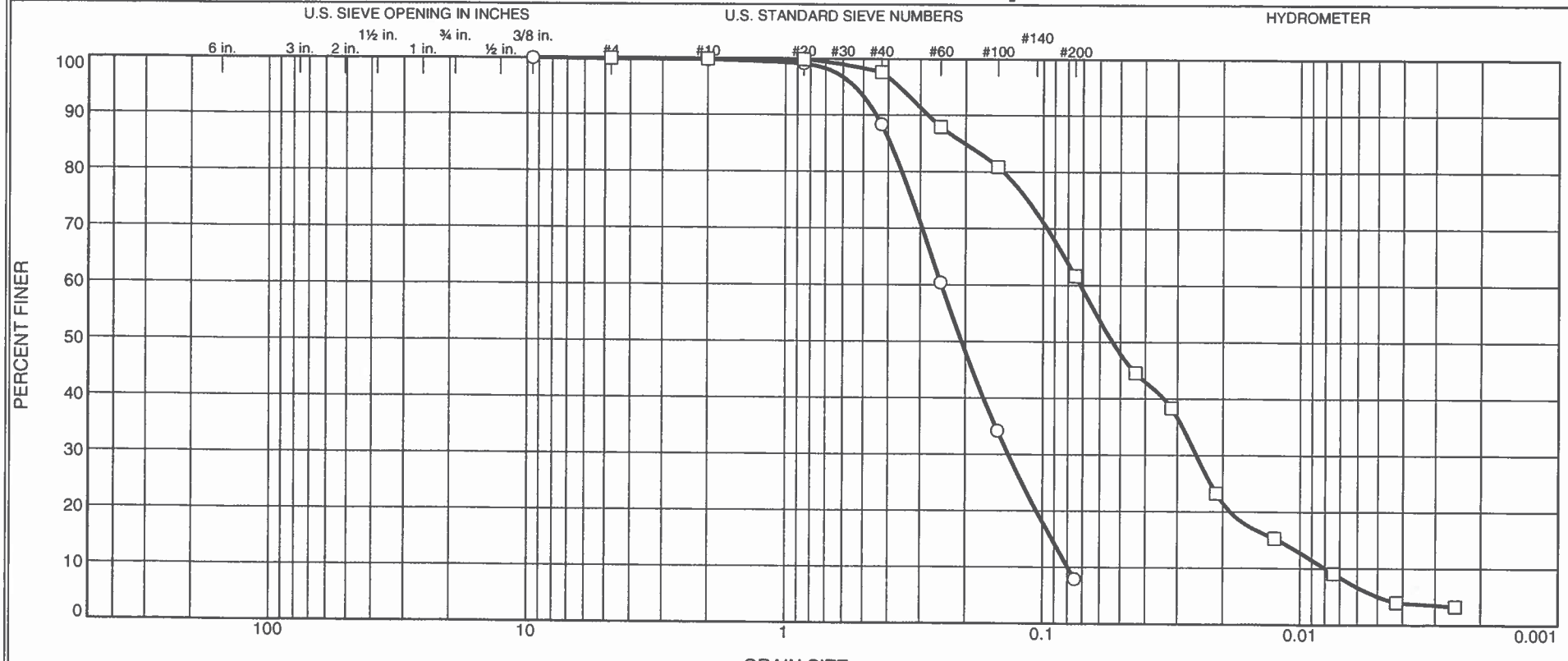
Notes:

1. KCB-1 through KCB-12 were drilled between September 22, 2010 and October 1, 2010. KCB-13 through KCB-16 were drilled between September 28, 2011 and October 4, 2011. All borings were drilled using a CME-850 track mounted drill utilizing mud rotary methodology.

2. Results of tests conducted on samples recovered are reported on the logs.

3. These logs are subject to the limitations, conclusions, and recommendations in this report.

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.1	0.1	11.4	80.5	7.9	
□	0.0	0.0	0.0	0.0	2.4	35.9	56.7	5.0

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-1	KC-10-971	12.5	10/8/10	SP-SM	Poorly graded sand with silt	26.4	NV	NP
□	KCB-1	KC-10-973	20	10/8/10	ML	Sandy silt	35.4	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

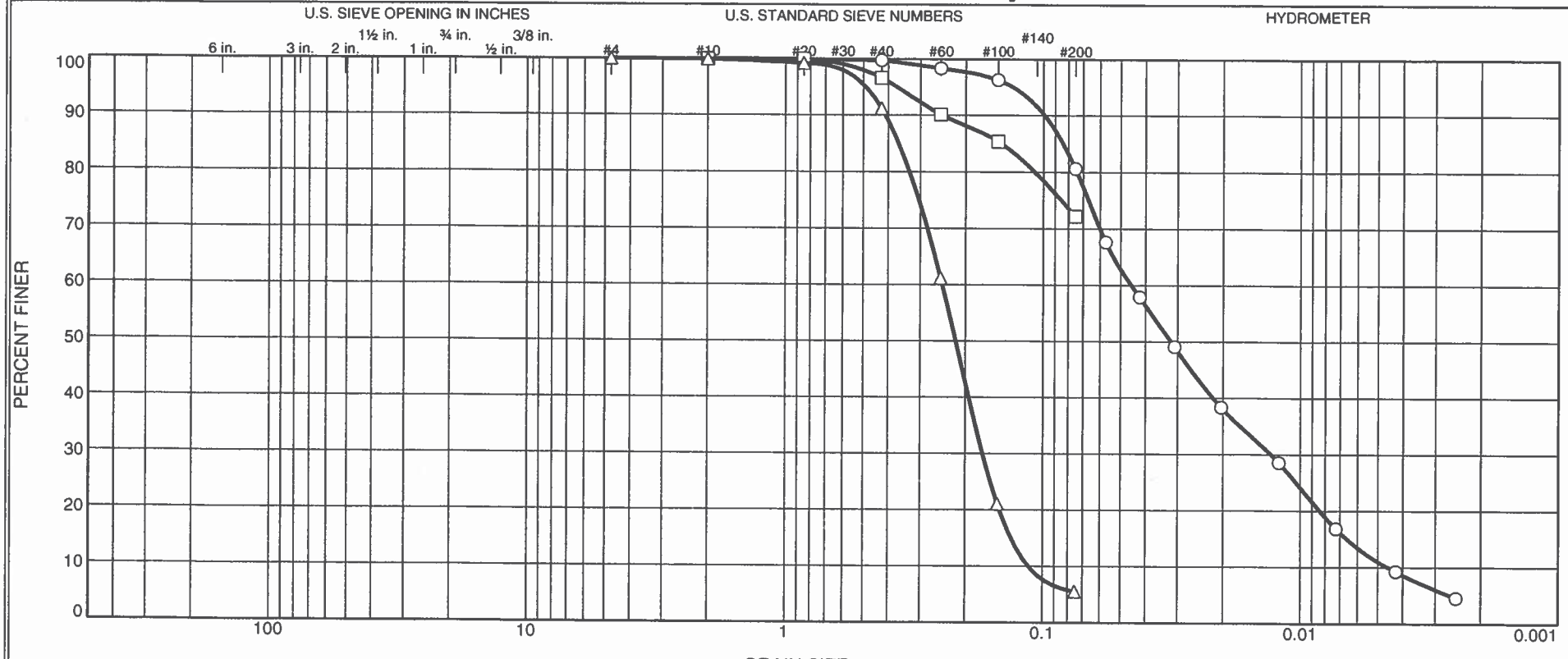
Project No. FL9001 Figure A1

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.3	19.1	69.6	11.0
□	0.0	0.0	0.0	0.0	3.4	24.4	72.2	
△	0.0	0.0	0.0	0.1	8.7	85.7	5.5	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-2	KC-10-974	2.5	10/8/10	ML	Silt with sand	53.0	NV	NP
□	KCB-2	KC-10-975	7.5	10/8/10	ML	Silt with sand	31.6	NV	NP
△	KCB-2	KC-10-976	17.5	10/8/10	SP-SM	Poorly graded sand with silt	29.5	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

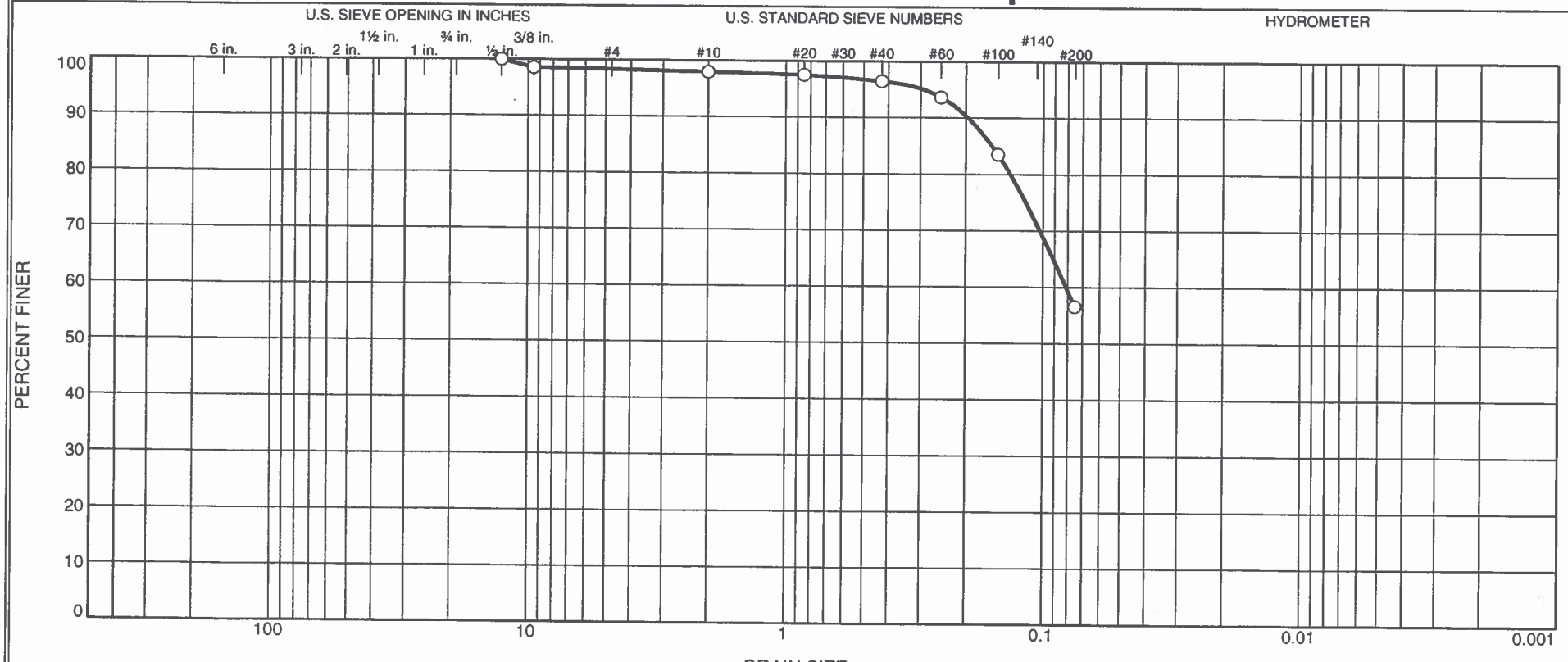
Project No. FL9001 Figure A2

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
O	0.0	0.0	1.7	0.4	1.4	39.9	56.6	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
O	KCB-2	KC-10-977	30	10/8/10	ML	Sandy silt	30.0	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

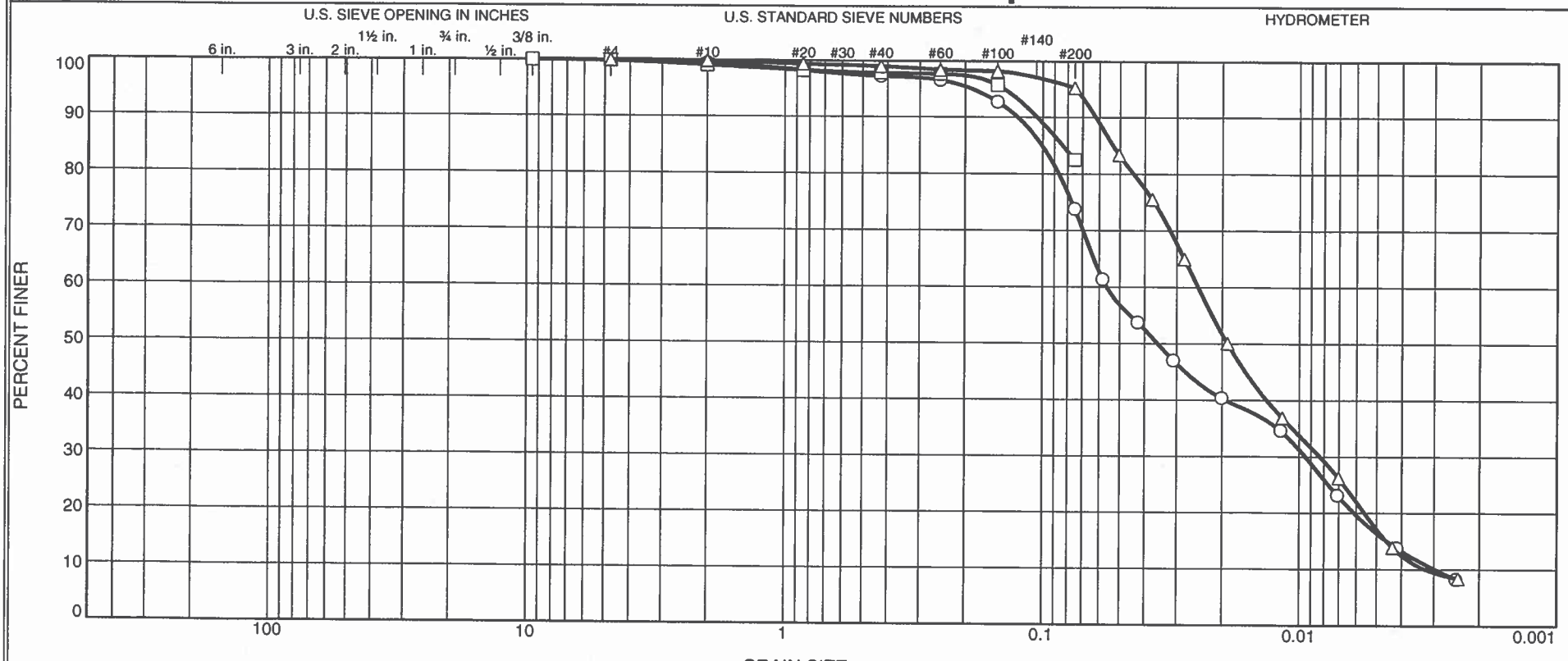
Project No. FL9001 Figure A3

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.5	2.2	23.5	57.4	16.4
□	0.0	0.0	0.1	0.7	1.4	15.3	82.5	
△	0.0	0.0	0.0	0.1	0.9	3.7	78.2	17.1

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-3	KC-10-978	2.5	10/8/10	ML	Silt with sand	42.9	NV	NP
□	KCB-3	KC-10-979	5	10/8/10	ML	Silt with sand	36.5	NV	NP
△	KCB-3	KC-10-980	10	10/8/10	ML	Silt	45.5	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

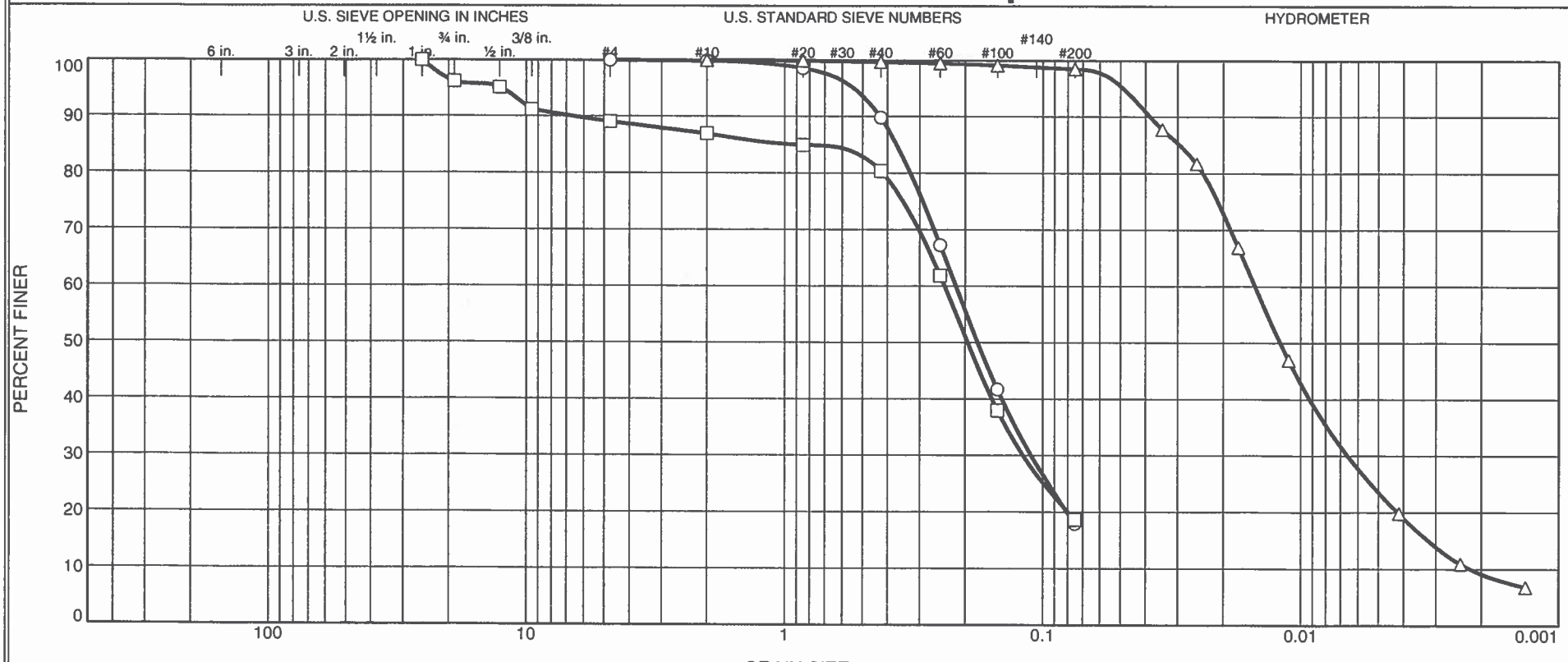
Project No. FL9001 Figure A4

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	10.1	71.9	17.9	
□	0.0	3.8	7.1	2.1	6.6	61.7	18.7	
△	0.0	0.0	0.0	0.0	0.3	1.2	74.9	23.6

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-3	KC-10-981	15	10/8/10	SM	Silty sand	28.4	NV	NP
□	KCB-3	KC-10-982	30	10/8/10	SM	Silty sand	26.2	NV	NP
△	KCB-3	KC-10-983	40	10/8/10	ML	Silt	45.9	35	33

Client WLRD

Project Countyline to A-Street Geotechnical Study

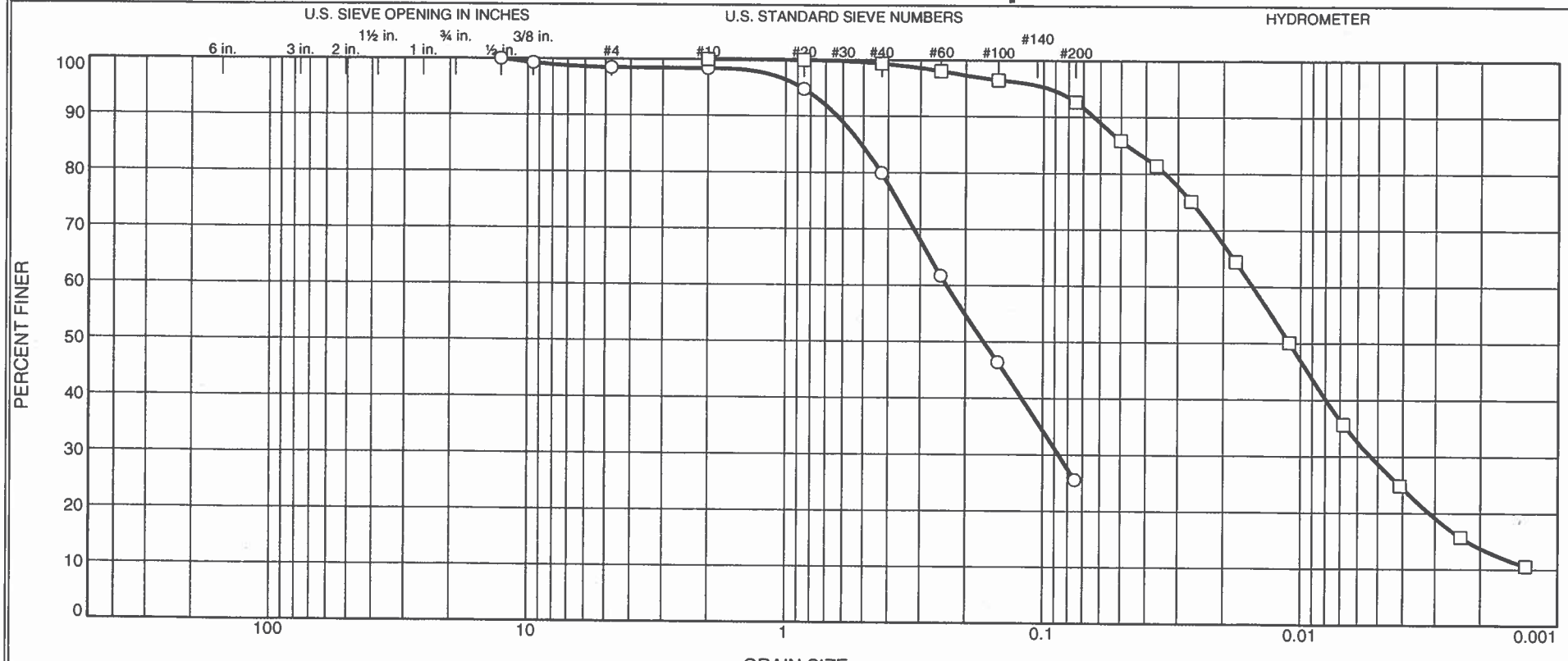
Project No. FL9001 Figure A5

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	1.5	0.1	18.5	54.3	25.6	
□	0.0	0.0	0.0	0.0	0.6	6.7	64.0	28.7

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-3	KC-10-984	46.5	10/8/10	SM	Silty sand	24.2	NV	NP
□	KCB-3	KC-10-985	55	10/8/10	ML	Silt	51.3	42	34

Client WLRD

Project Countyline to A-Street Geotechnical Study

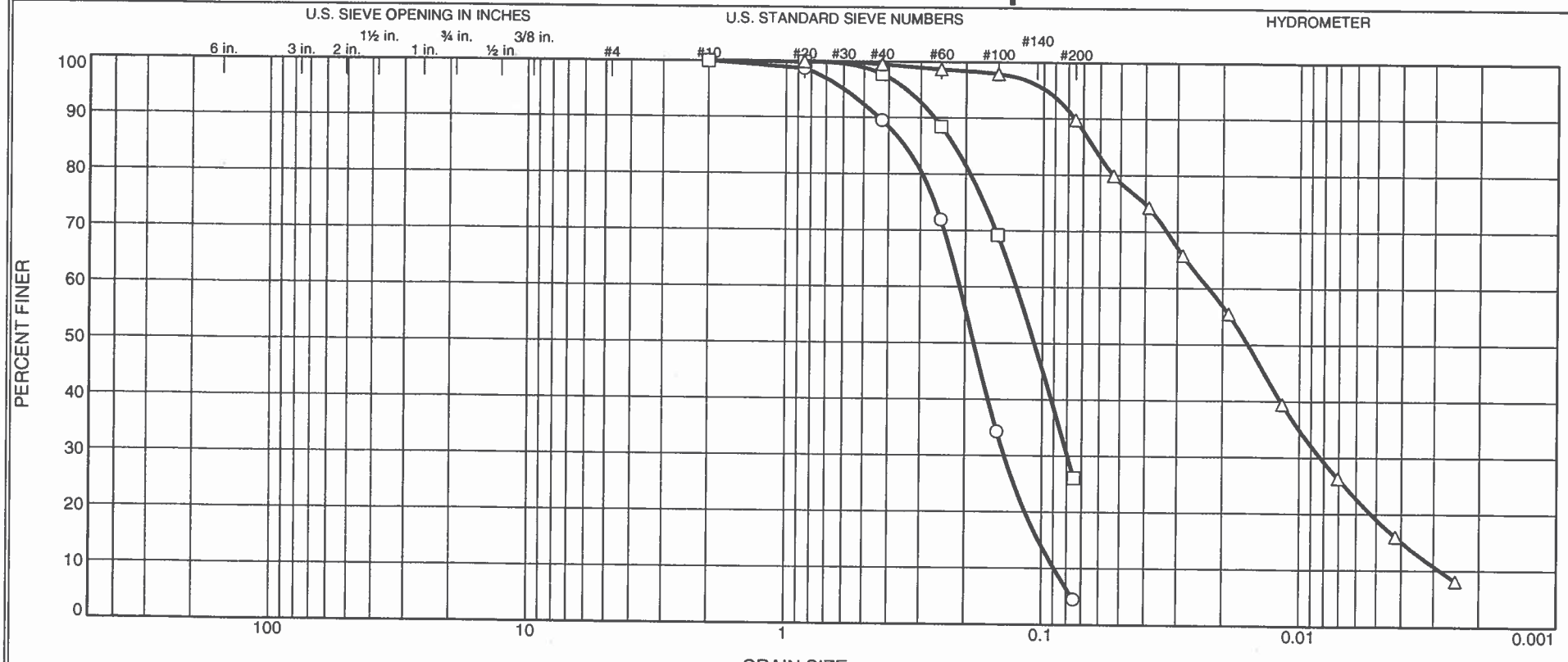
Project No. FL9001 Figure A6

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	10.5	85.0	4.5	
□	0.0	0.0	0.0	0.0	2.2	71.7	26.1	
△	0.0	0.0	0.0	0.0	0.5	9.7	70.7	19.1

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-4	KC-10-1025	2.5	10/8/10	SP	Poorly graded sand	26.7	NV	NP
□	KCB-4	KC-10-987	10	10/8/10	SM	Silty sand	28.3	NV	NP
△	KCB-4	KC-10-988	15	10/8/10	ML	Silt	62.5	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

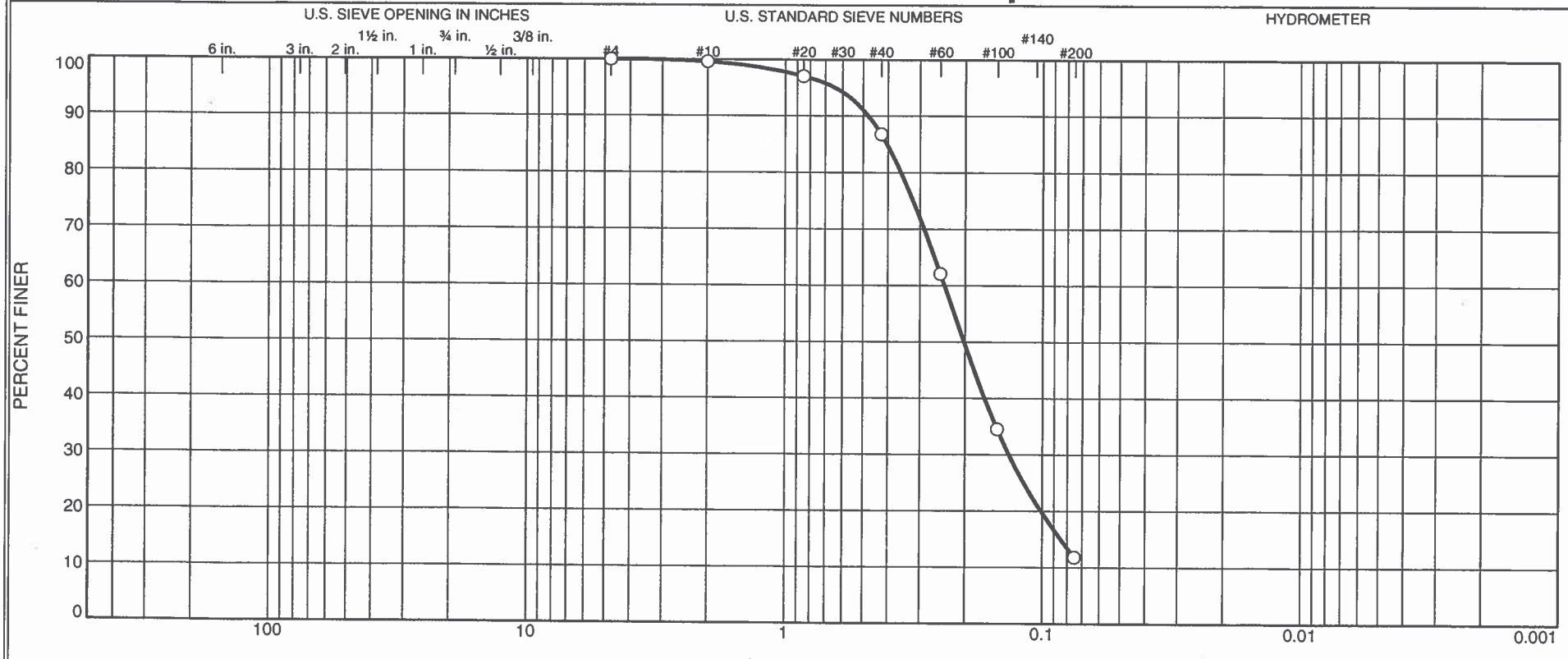
Project No. FL9001 Figure A7

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.4	12.8	75.0	11.8	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-4	KC-10-989	25	10/8/10	SP-SM	Poorly graded sand with silt	26.7	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

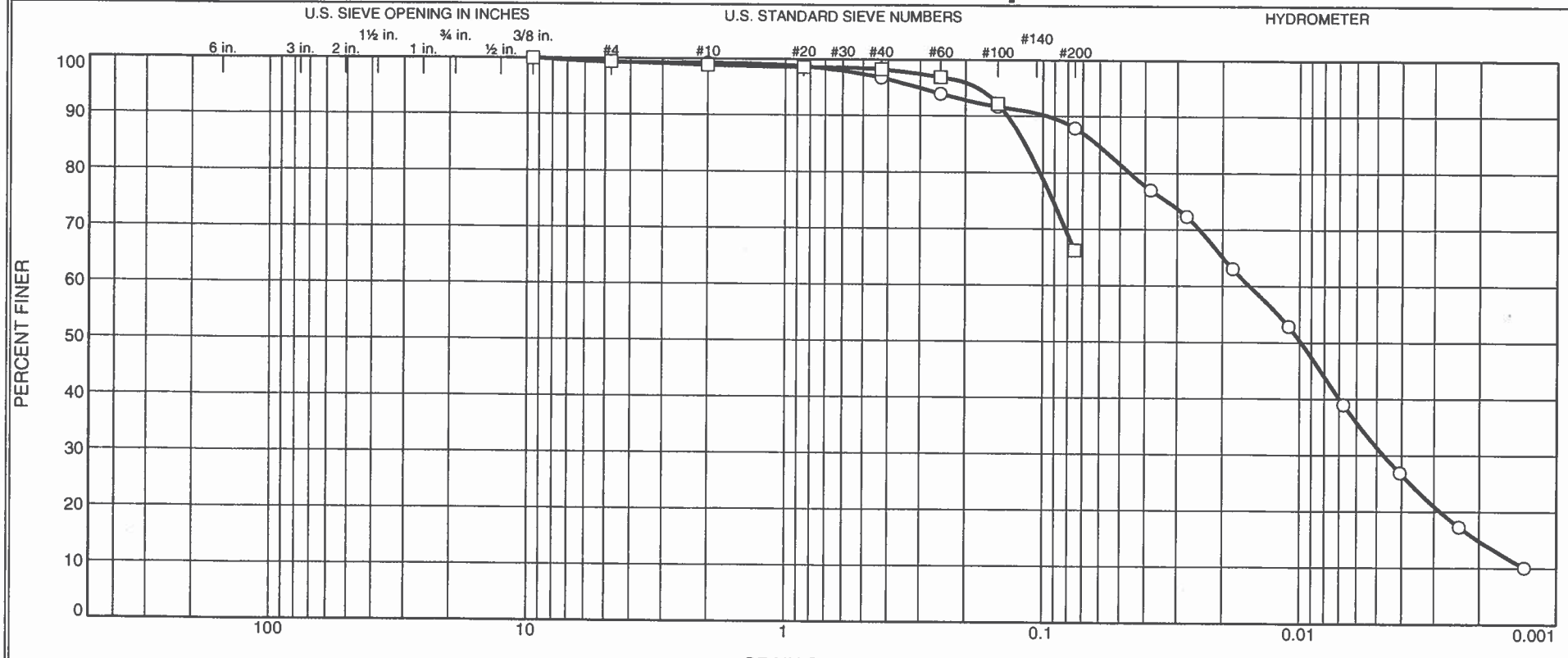
Project No. FL9001 Figure A8

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.7	0.1	2.5	8.8	56.5	31.4
□	0.0	0.0	0.6	0.5	0.6	32.1	66.2	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-5	KC-10-990	2.5	10/8/10	ML	Silt	49	35	30
□	KCB-5	KC-10-991	10	10/8/10	ML	Sandy silt	48.6	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

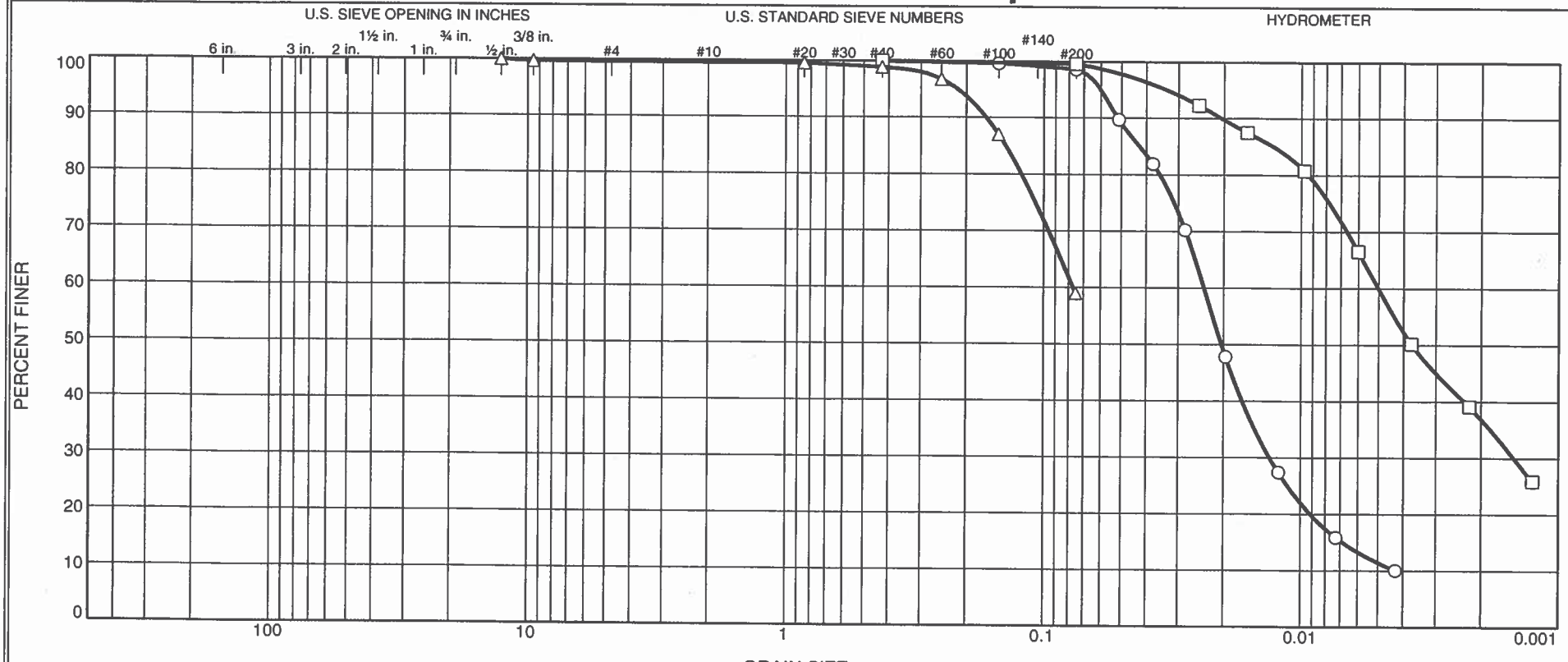
Project No. FL9001 Figure A9

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.0	1.4	87.1	11.5
□	0.0	0.0	0.0	0.0	0.0	0.4	39.7	59.9
△	0.0	0.0	0.4	0.0	0.7	39.9	59.0	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-5	KC-10-1026	15	10/8/10	ML	Brown silt	52.6	NV	NP
□	KCB-5	KC-10-1026	16	10/8/10	ML	Gray silt	49.6	44	34
△	KCB-5	KC-10-1026	17	10/8/10	ML	Sandy silt	36.4	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

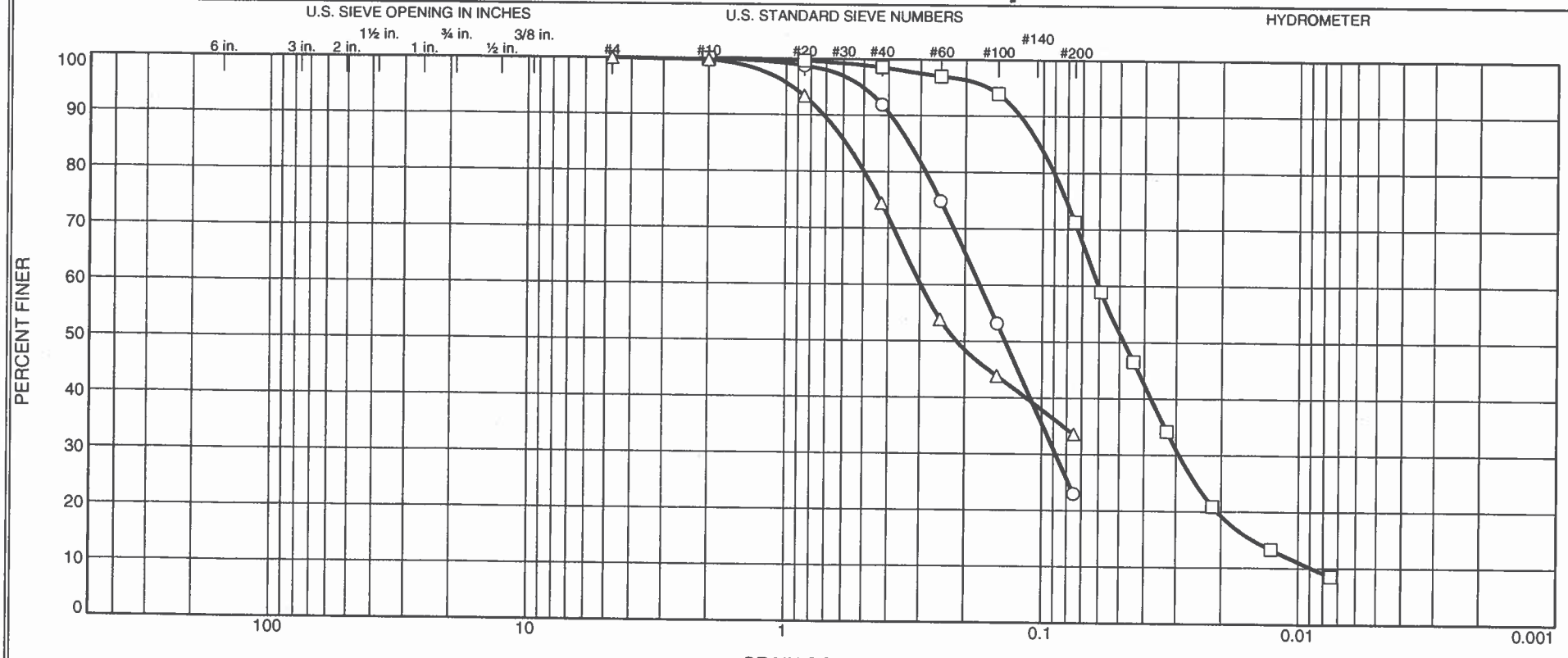
Project No. FL9001 Figure A10

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	8.1	68.9	23.0	
□	0.0	0.0	0.0	0.0	1.4	27.3	71.3	
△	0.0	0.0	0.0	0.2	25.3	40.9	33.6	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-5	KC-10-992	20	10/8/10	SM	Silty sand	29.1	NV	NP
□	KCB-5	KC-10-993	25	10/8/10	ML	Silt with sand	40.2	NV	NP
△	KCB-5	KC-10-994	40	10/8/10	SM	Silty sand	32.3	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

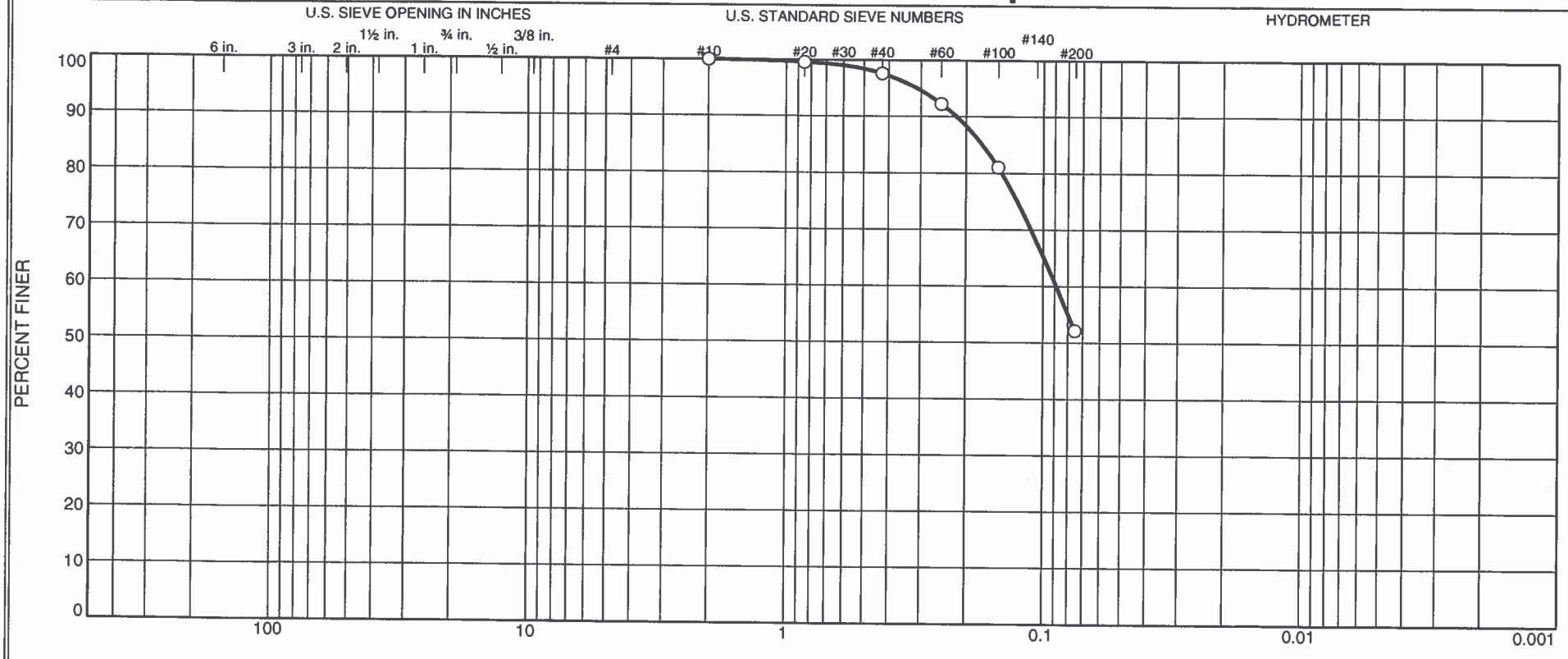
Project No. FL9001 Figure A11

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
O	0.0	0.0	0.0	0.0	2.4	45.5	52.1	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
O	KCB-5	KC-10-995	50	10/8/10	ML	Sandy silt	29.1	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

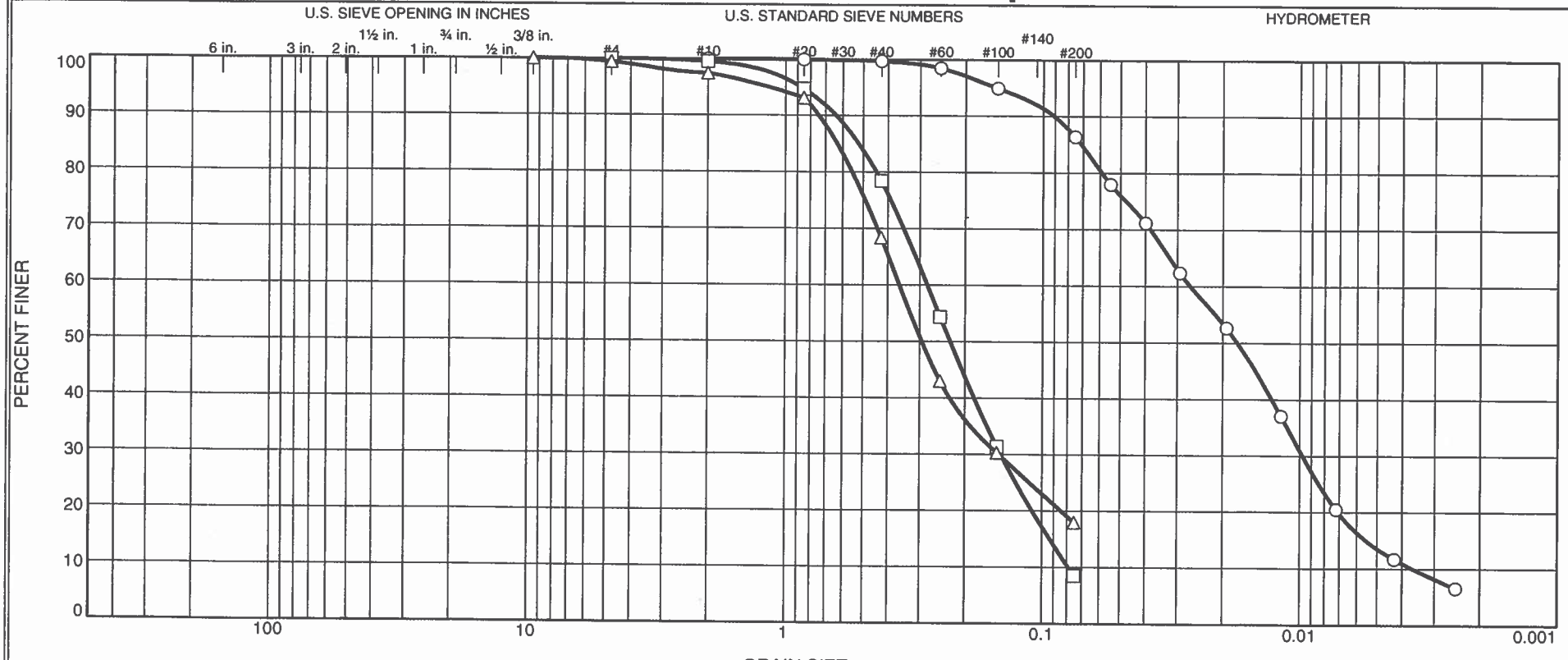
Project No. FL9001 Figure A12

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.3	13.3	72.8	13.6
□	0.0	0.0	0.0	0.5	21.1	69.9	8.5	
△	0.0	0.0	0.6	1.9	29.1	50.4	18.0	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-6	KC-10-996	2.5	10/8/10	ML		35.3	NV	NP
□	KCB-6	KC-10-997	7.5	10/8/10	SP-SM	Poorly graded sand with silt	26.1	NV	NP
△	KCB-6	KC-10-999	30	10/8/10	SM	Silty sand	24	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

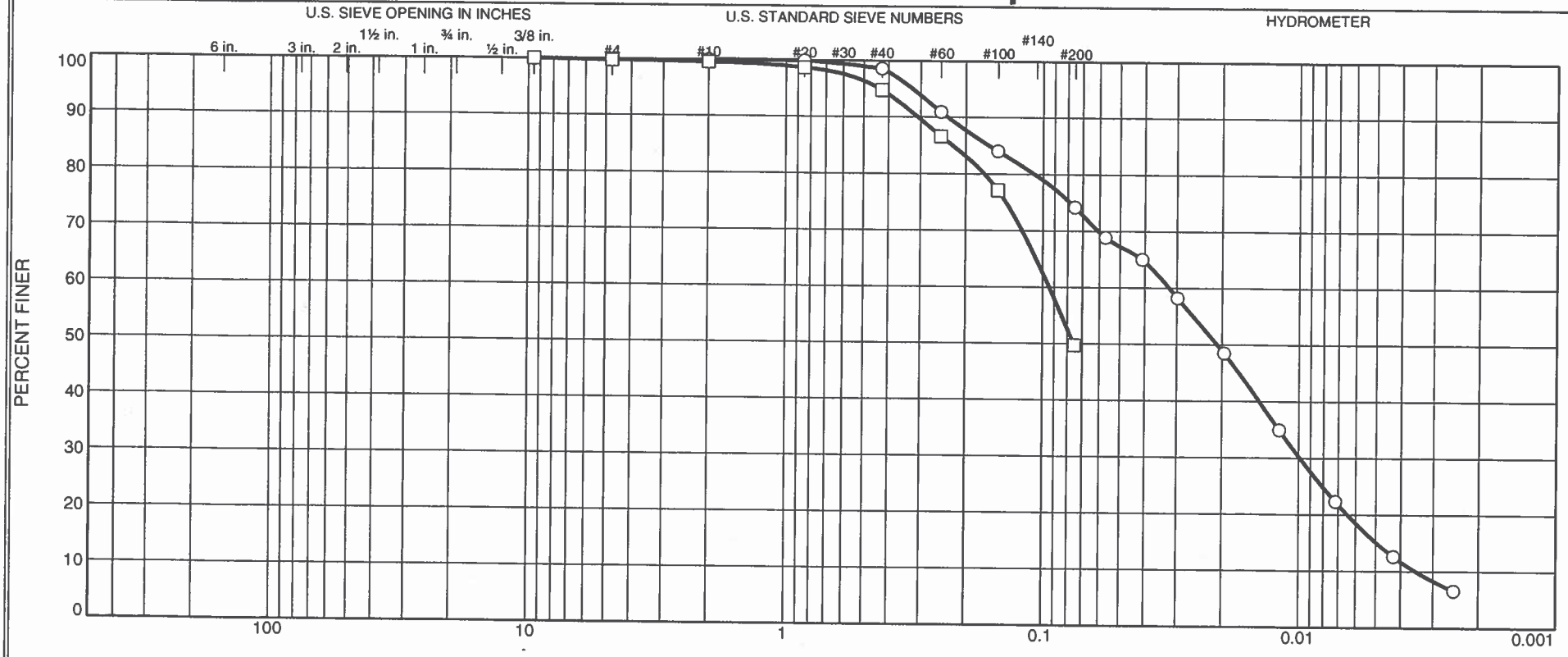
Project No. FL9001 Figure A13

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	1.4	24.4	59.1	15.1
□	0.0	0.0	0.2	0.2	4.8	45.1	49.7	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-6	KC-10-1000	35	10/8/10	ML	Silt with sand	88.9	NV	NP
□	KCB-6	KC-10-1001	50	10/8/28	SM	Silty sand	36.7	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

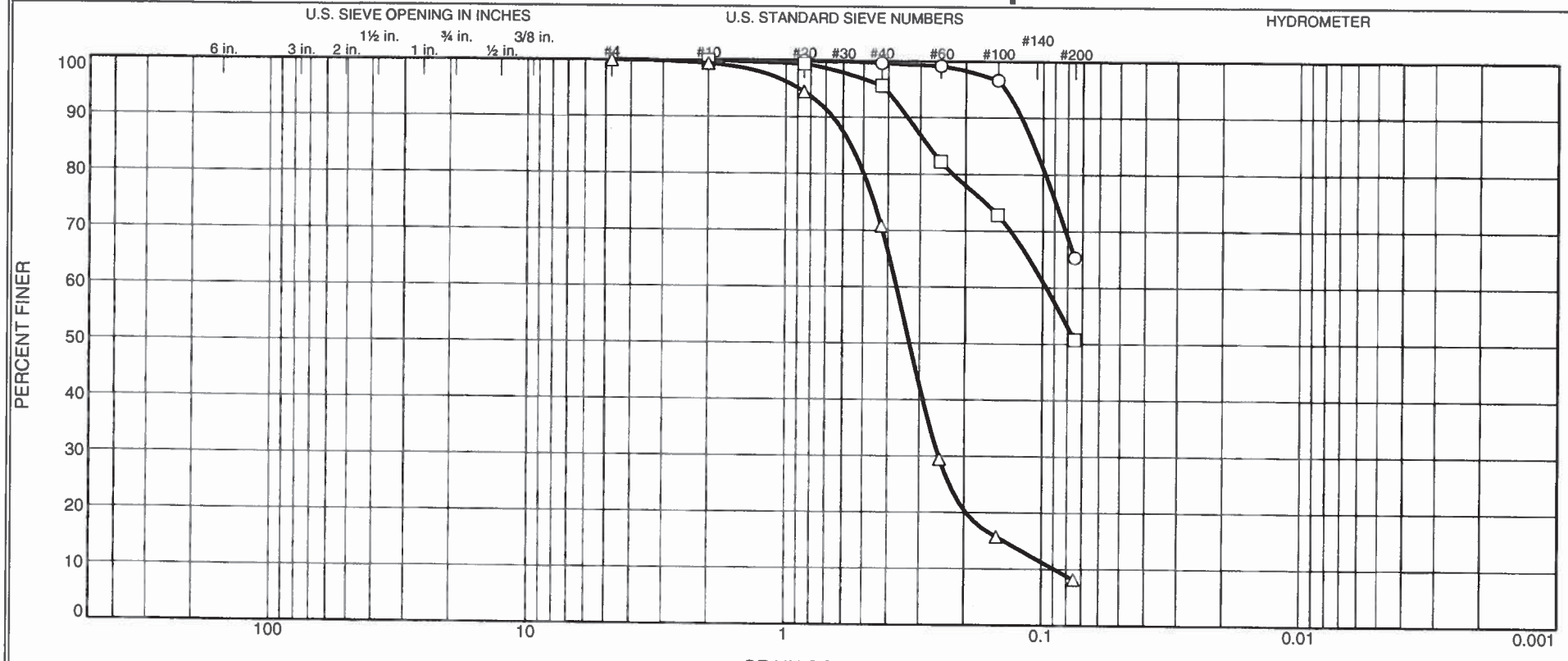
Project No. FL9001 Figure A14

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.4	34.3	65.3	
□	0.0	0.0	0.0	0.0	4.3	44.9	50.8	
△	0.0	0.0	0.0	0.5	28.6	62.7	8.2	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-7	KC-10-1002	5	10/8/10	ML	Sandy silt	29.8	NV	NP
□	KCB-7	KC-10-1003	12.5	10/8/10	ML	Sandy silt	27.4	NV	NP
△	KCB-7	KC-10-1006	45	10/8/10	SP-SM	Poorly graded sand with silt	39.3	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

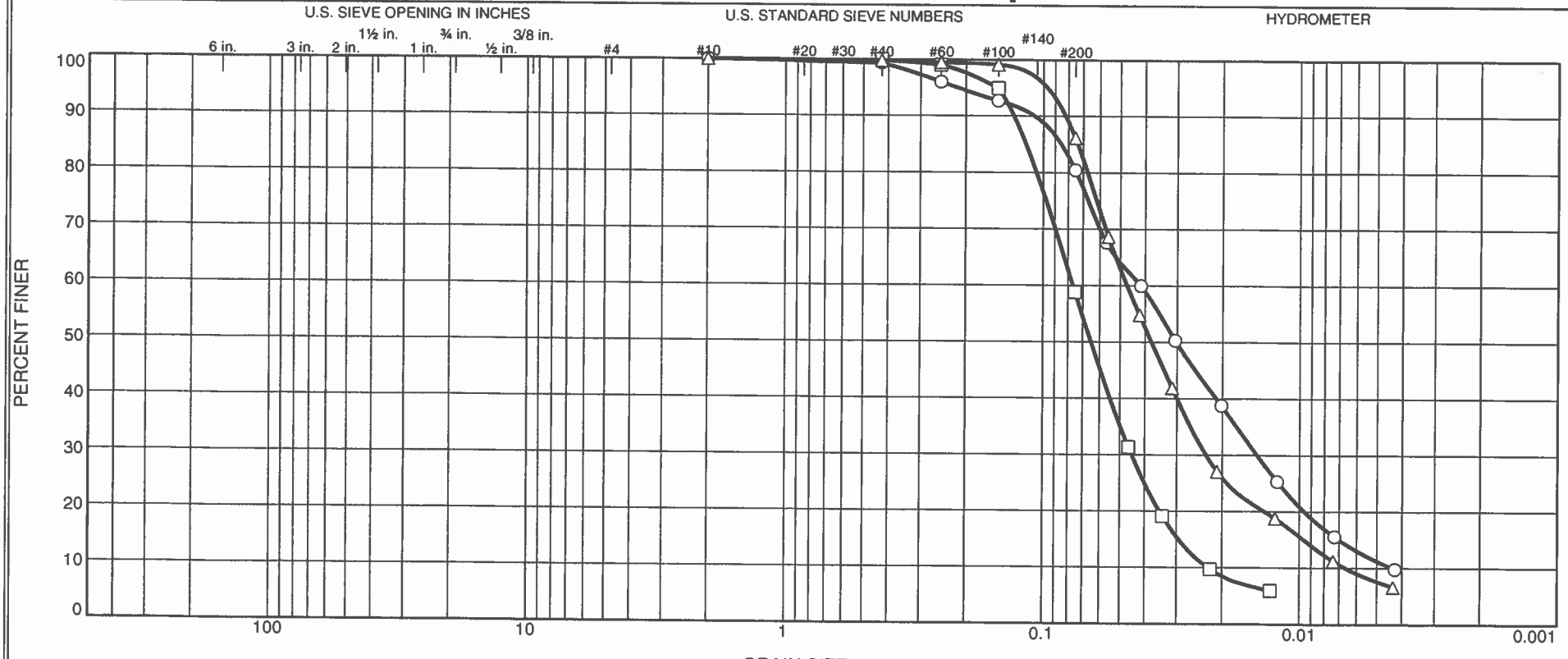
Project No. FL9001 Figure A15

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.6	19.0	69.2	11.2
□	0.0	0.0	0.0	0.0	0.0	41.2	58.8	
△	0.0	0.0	0.0	0.0	0.2	13.6	78.6	7.6

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-8	KC-10-1007	2.5	10/8/10	ML	Silt with sand	35.7	NV	NP
□	KCB-8	KC-10-1008	7.5	10/8/10	ML	Sandy silt	38.6	NV	NP
△	KCB-8	KC-10-1009	17.5	10/8/10	ML	Silt	42.7	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

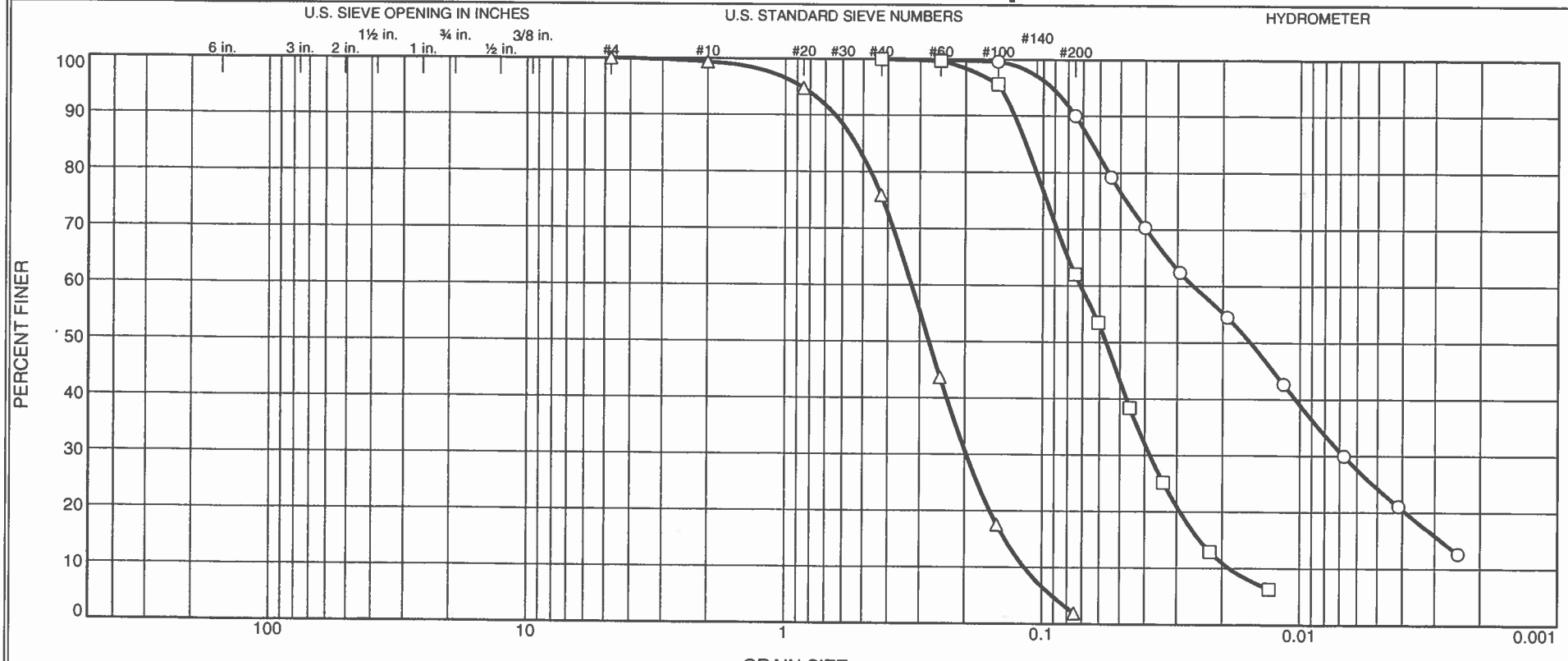
Project No. FL9001 Figure A16

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.0	9.9	65.8	24.3
□	0.0	0.0	0.0	0.0	0.0	37.9	62.1	
△	0.0	0.0	0.0	0.6	23.5	74.0	1.9	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-8	KC-10-1027	20	10/8/10	ML	Silt	32.8	NV	NP
□	KCB-8	KC-10-1027	20.8	10/8/10	ML	Sandy silt	33.3	NV	NP
△	KCB-8	KC-10-1027	21.5	10/8/10	SP	Poorly graded sand	30.7	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

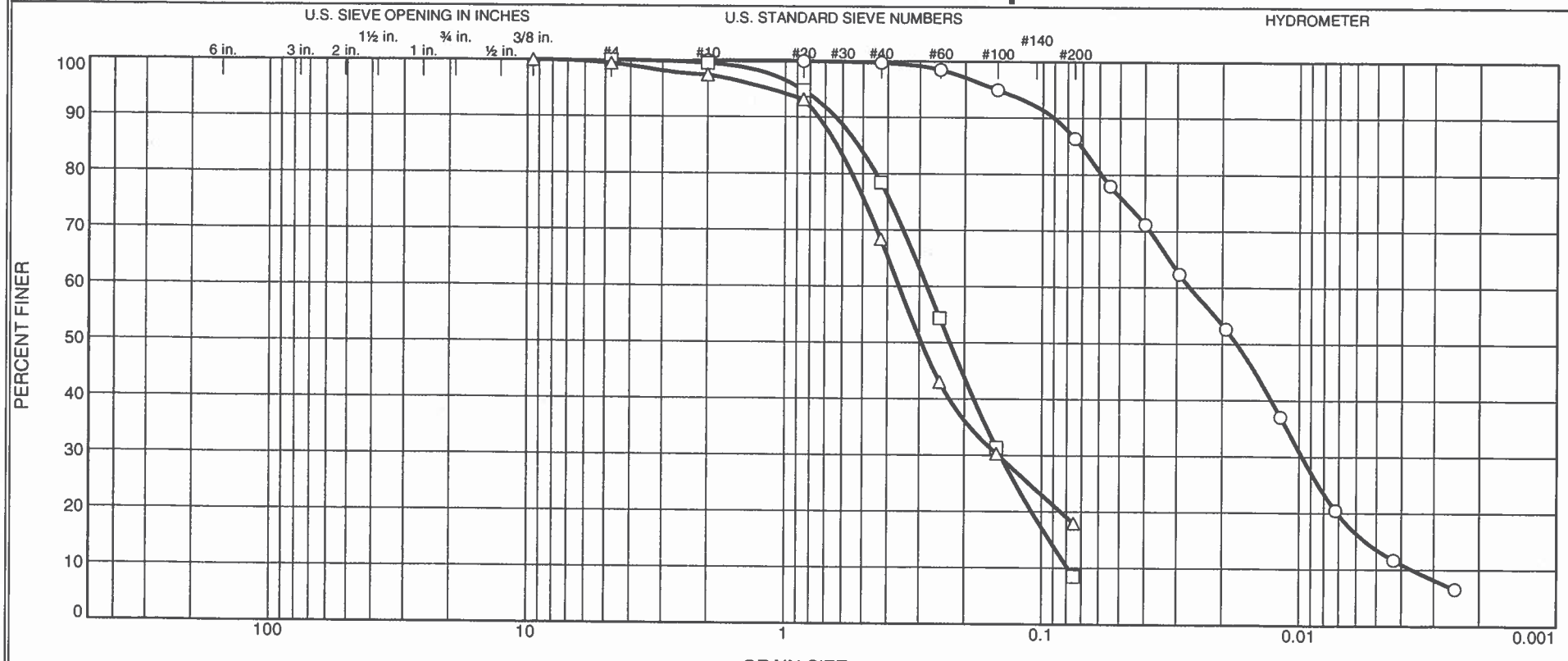
Project No. FL9001 Figure A17

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.3	13.3	72.8	13.6
□	0.0	0.0	0.0	0.5	21.1	69.9	8.5	
△	0.0	0.0	0.6	1.9	29.1	50.4	18.0	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-6	KC-10-996	2.5	10/8/10	ML		35.3	NV	NP
□	KCB-6	KC-10-997	7.5	10/8/10	SP-SM	Poorly graded sand with silt	26.1	NV	NP
△	KCB-6	KC-10-999	30	10/8/10	SM	Silty sand	24	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

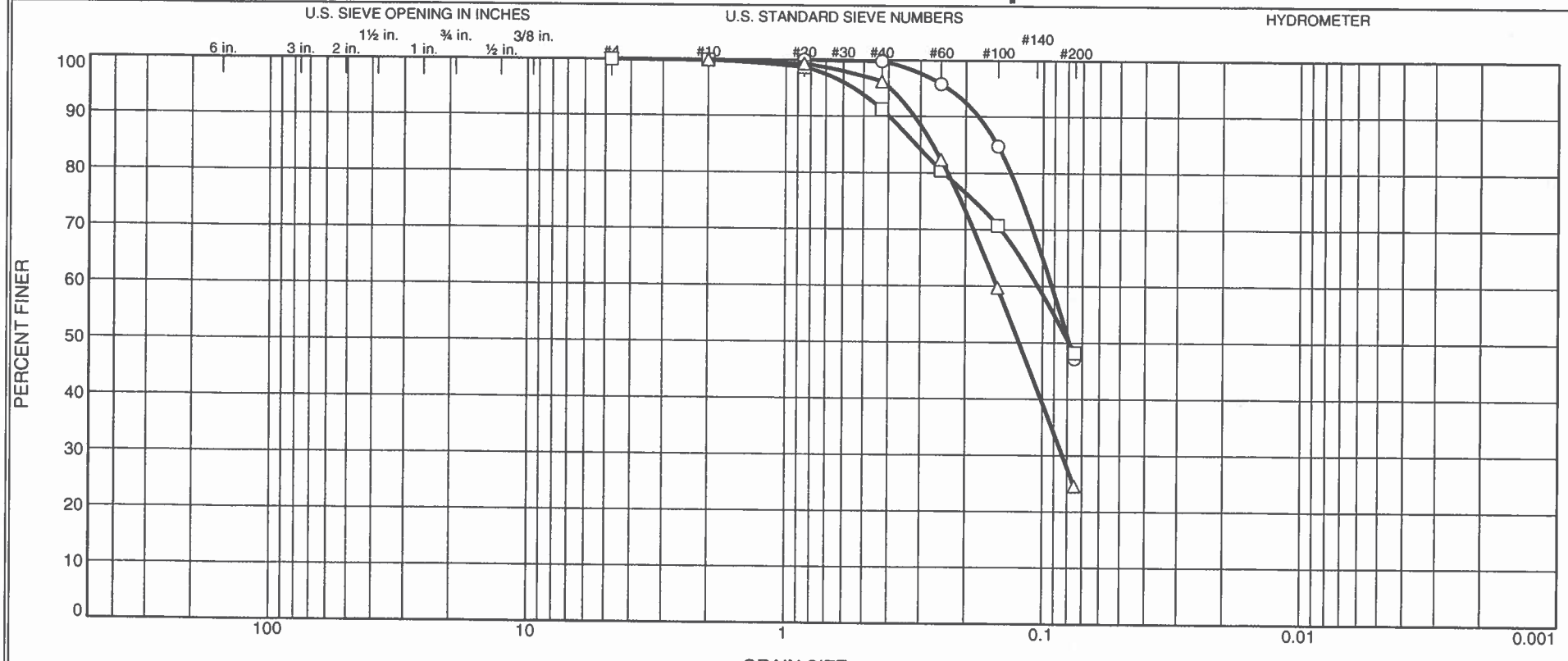
Project No. FL9001 Figure A18

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.2	52.7	47.1	
□	0.0	0.0	0.0	0.1	8.6	43.1	48.2	
△	0.0	0.0	0.0	0.0	3.8	71.6	24.6	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-9	KC-10-1013	5	10/8/10	SM	Silty sand	32.6	NV	NP
□	KCB-9	KC-10-1015	20	10/8/10	SM	Silty sand	39.2	NV	NP
△	KCB-9	KC-10-1016	30	10/8/10	SM	Silty sand	26.6	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

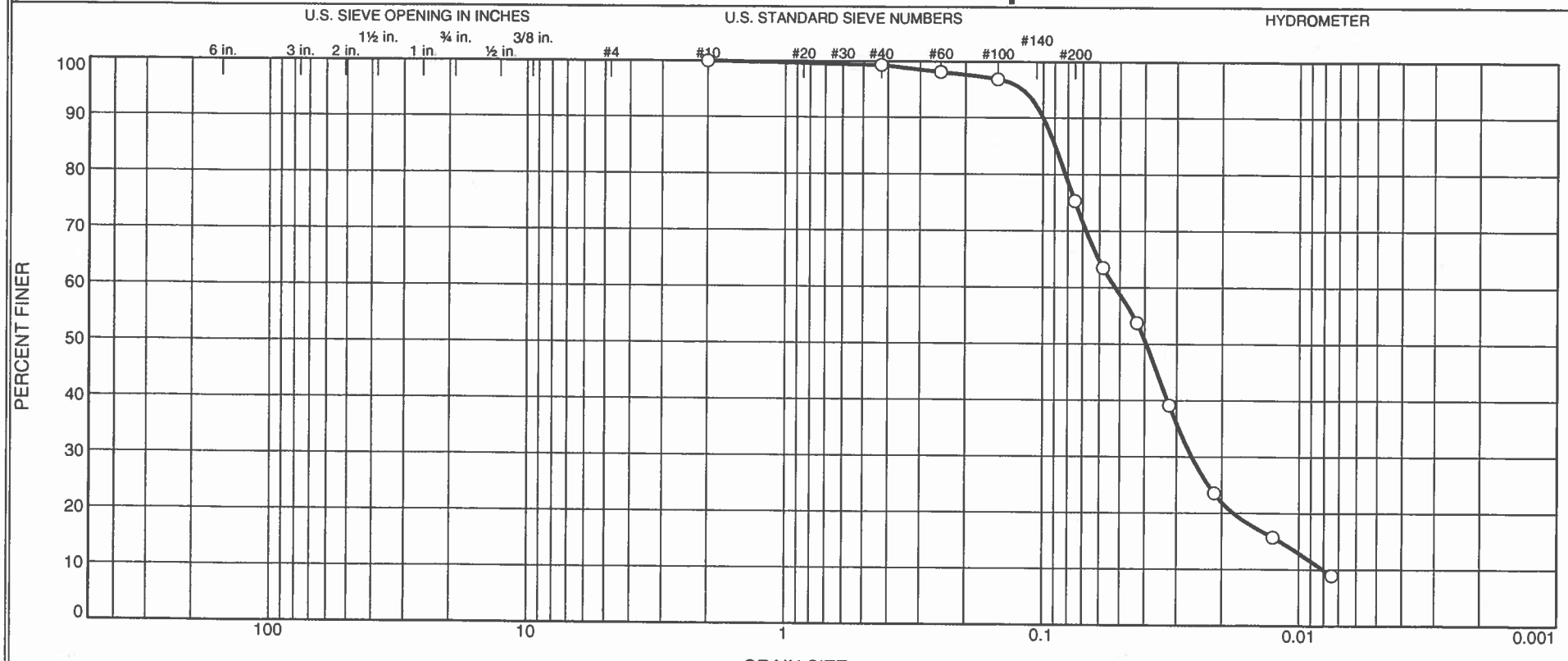
Project No. FL9001 Figure A19

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
O	0.0	0.0	0.0	0.0	0.7	24.0	75.3	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
O	KCB-9	KC-10-1017	55	10/8/10	ML	Silt with sand	30.3	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

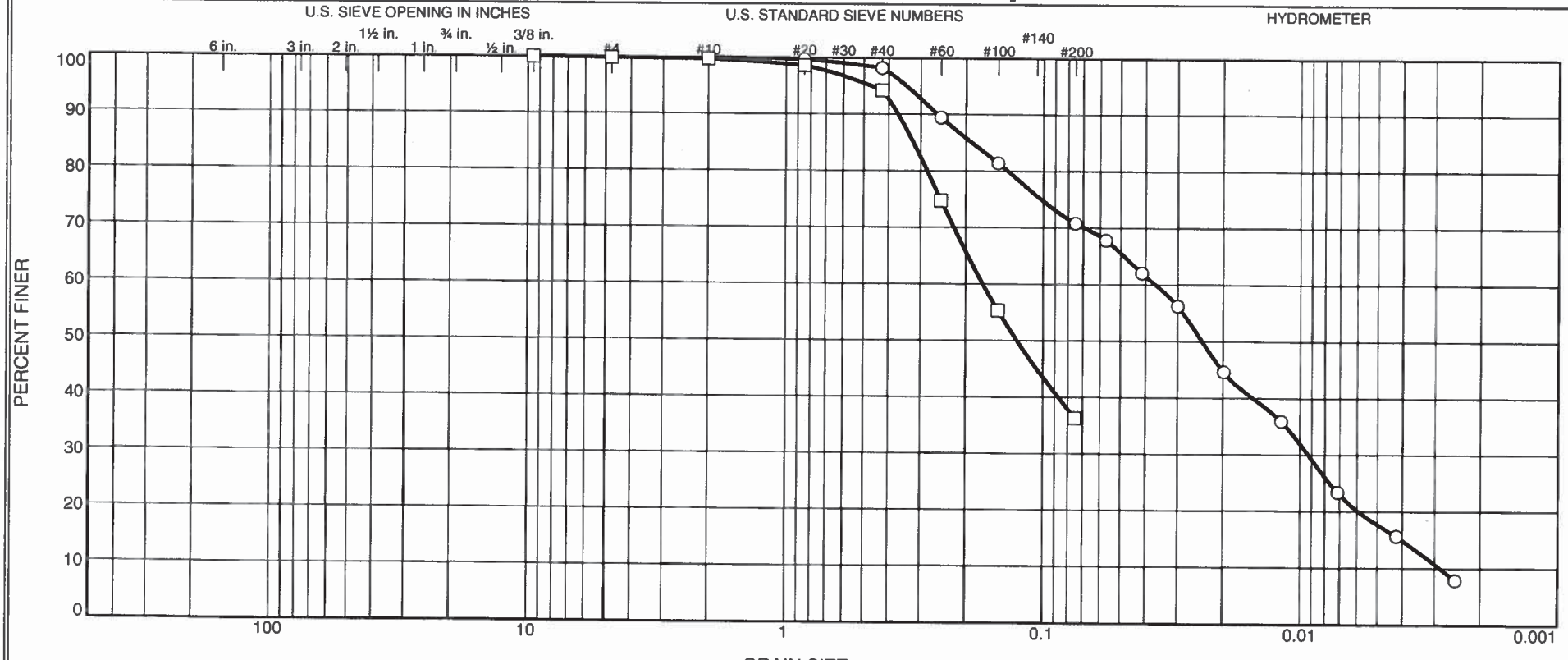
Project No. FL9001 Figure A20

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	1.8	27.4	53.1	17.7
□	0.0	0.0	0.1	0.2	5.5	57.9	36.3	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-10	KC-10-1018	40	10/8/10	ML	Silt with sand	46.6	NV	NP
□	KCB-10	KC-10-1019	55	10/8/10	SM	Silty sand	36.1	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

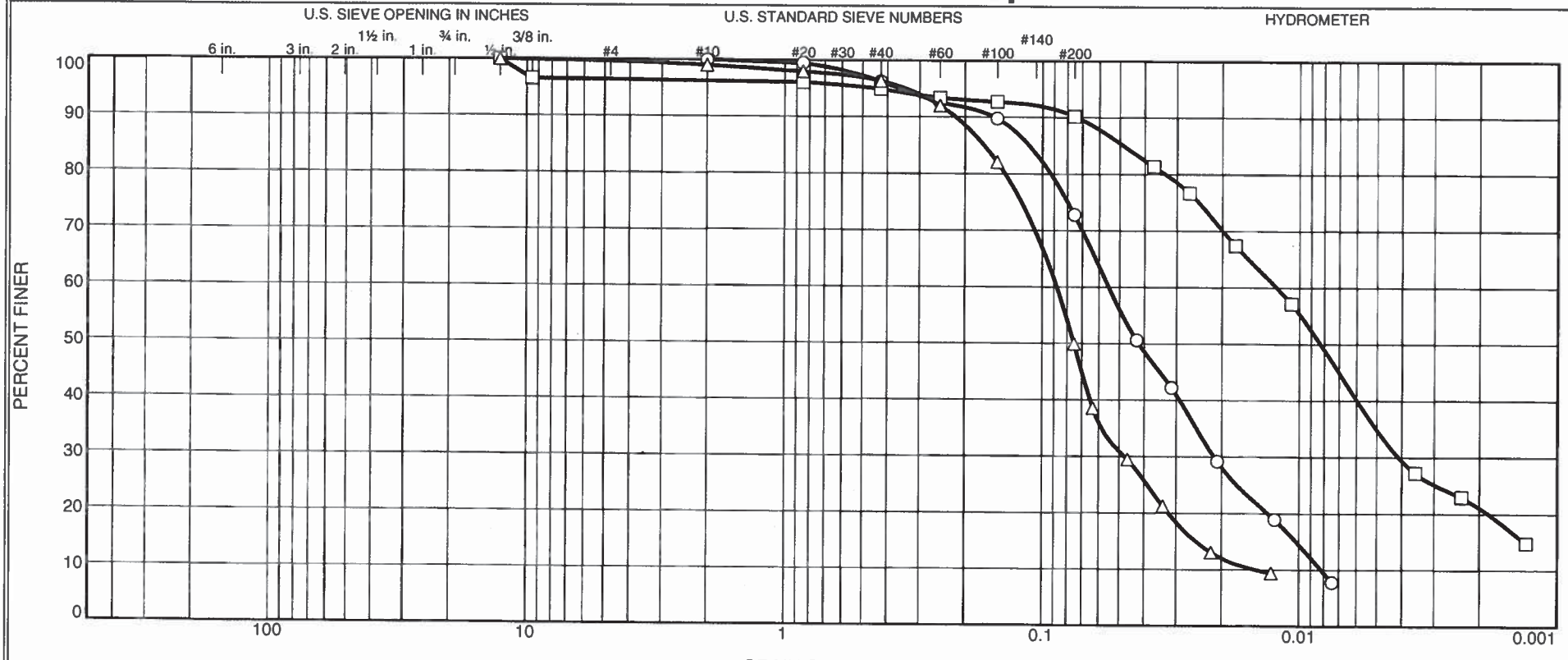
Project No. FL9001 Figure A21

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	3.7	23.5	72.8	
□	0.0	0.0	3.6	0.1	1.4	4.7	55.4	34.8
△	0.0	0.0	0.3	0.7	2.6	46.5	49.9	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-11	KC-10-1020	40	10/8/10	ML	Silt with sand	33.9	NV	NP
□	KCB-11	KC-10-1021	60	10/8/10	ML	Silt	43.6	40	31
△	KCB-11	KC-10-1022	65	10/8/10	SM	Silty sand	31.5	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

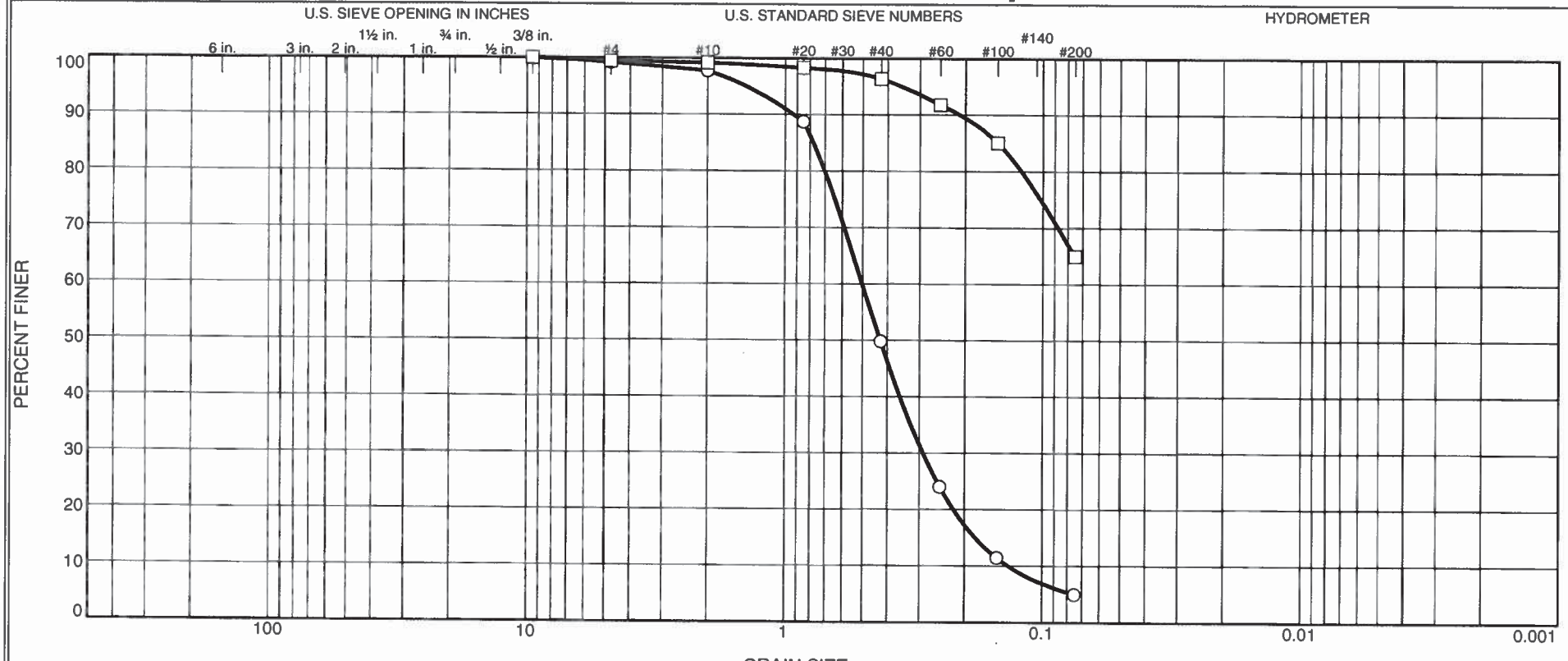
Project No. FL9001 Figure A22

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.8	1.4	48.0	44.8	5.0	
□	0.0	0.0	0.5	0.3	2.8	31.4	65.0	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-12	KC-10-1023	25	10/8/10	SP-SM	Poorly graded sand with silt	24.4	NV	NP
□	KCB-12	KC-10-1024	50	10/8/10	ML	Sandy silt	45.5	NV	NP

Client WLRD

Project Countyline to A-Street Geotechnical Study

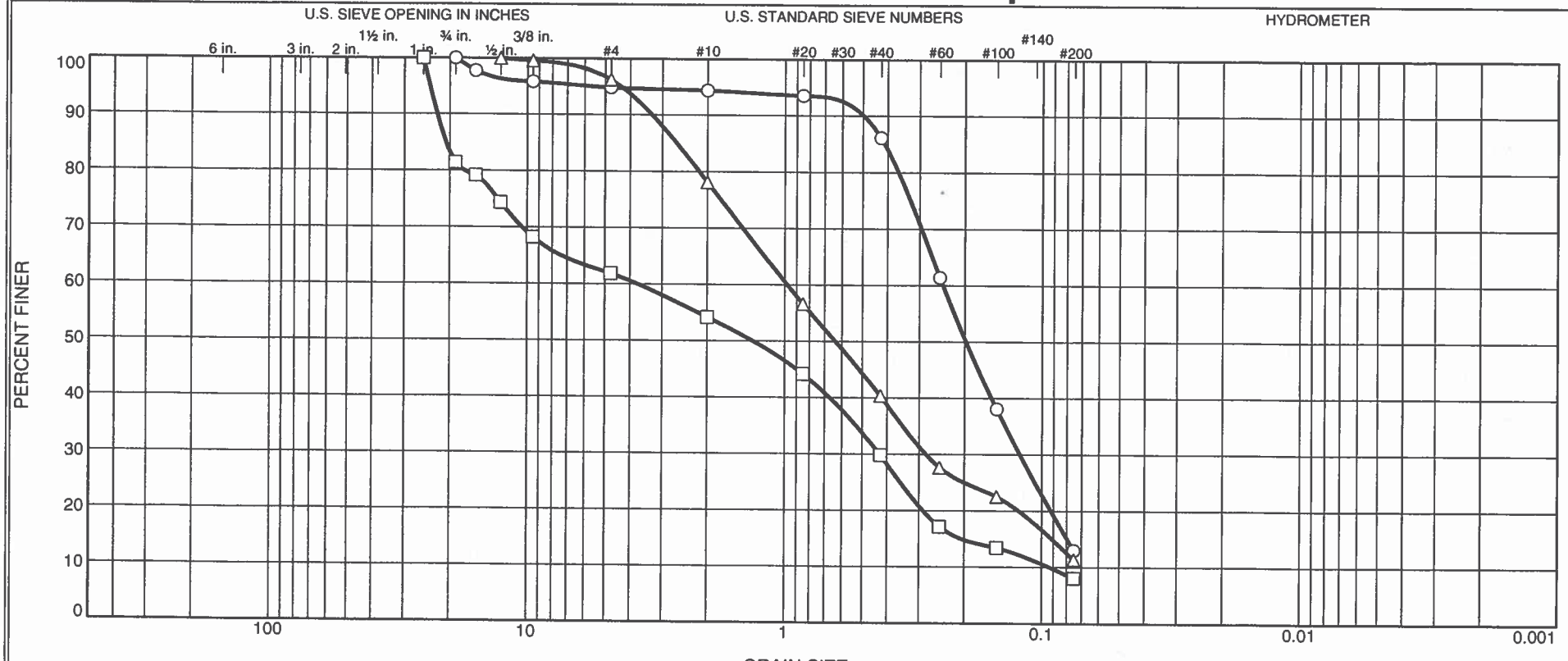
Project No. FL9001 Figure A23

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	5.2	0.4	8.2	73.2	13.0	
□	0.0	18.6	19.5	7.7	24.4	21.7	8.1	
△	0.0	0.0	3.8	18.1	37.8	28.9	11.4	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-13	KC-11-1361	5.0-6.5	10/6/11	SM	Silty sand	27.0		
□	KCB-13	KC-11-1362	20.0-21.5	10/6/11	SP-SM	Poorly graded sand with silt and gravel	17.6		
△	KCB-13	KC-11-1363	30.0-31.5	10/6/11	SP-SM	Poorly graded sand with silt	16.2		

Client King County

Project County Line Levee Relocation

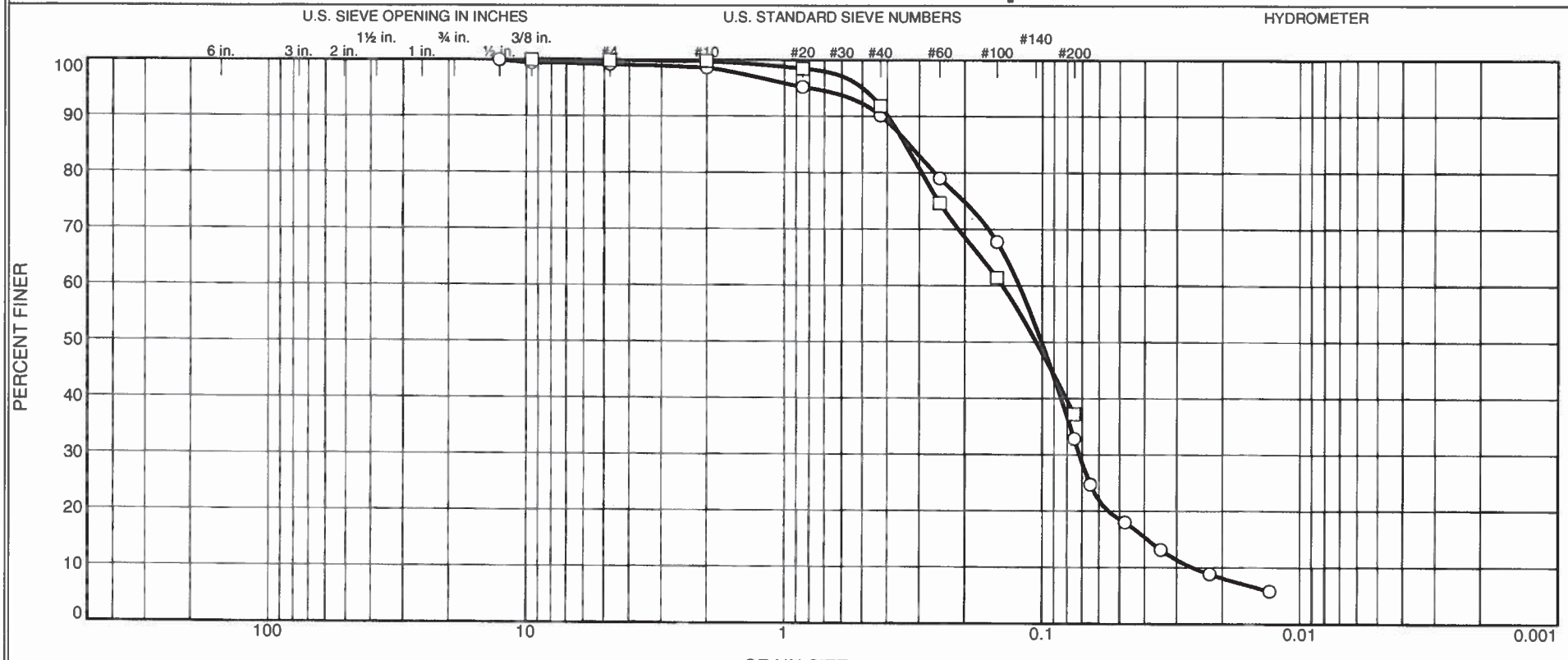
Project No. FL9001 Figure A24

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.8	0.6	8.4	57.4	32.8	
□	0.0	0.0	0.1	0.1	7.9	54.7	37.2	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-13	KC-11-1364	40.0-41.5	10/6/11	SM	Silty sand	27.3		
□	KCB-13	KC-11-1365	50.0-51.5	10/6/11	SM	Silty sand	24.9		

Client King County

Project County Line Levee Relocation

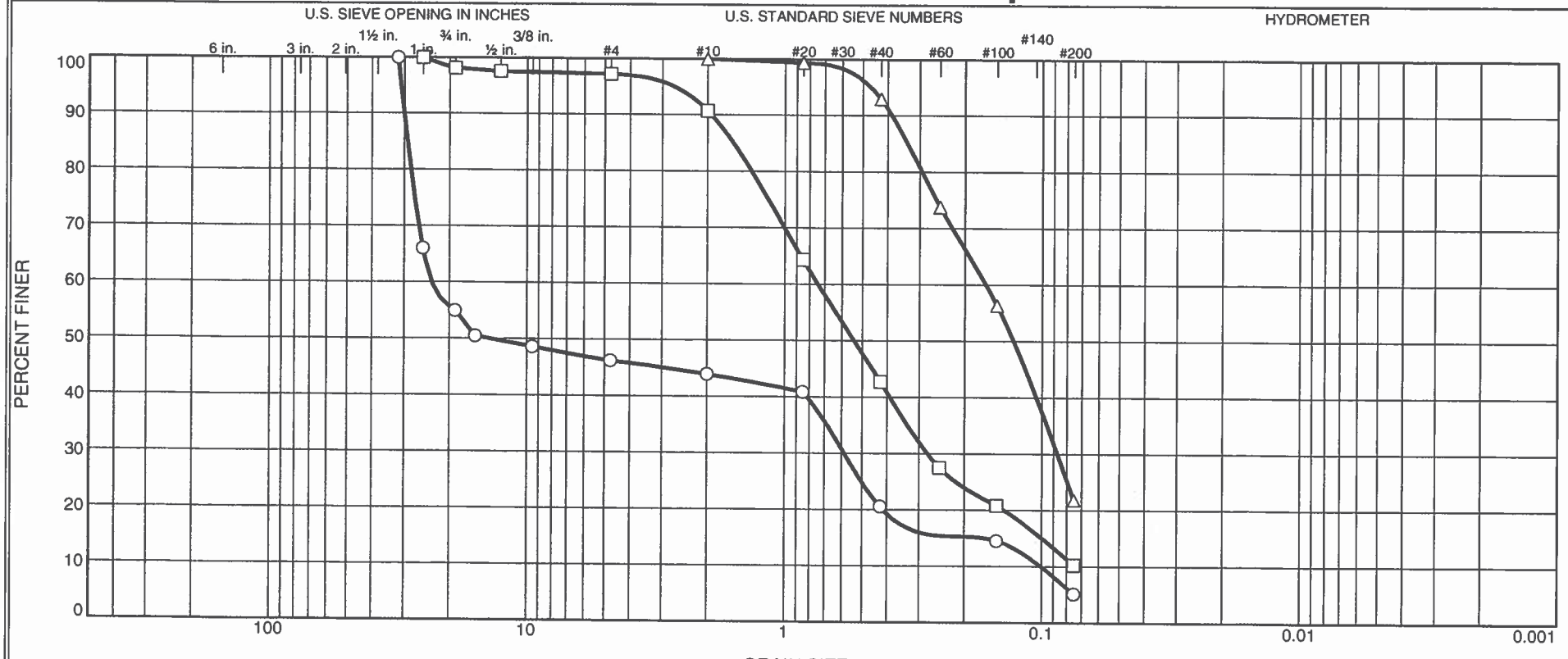
Project No. FL9001 Figure A25

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	45.1	8.7	2.3	23.3	15.5	5.1	
□	0.0	1.9	0.9	6.5	48.0	32.4	10.3	
△	0.0	0.0	0.0	0.0	7.1	71.1	21.8	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-14	KC-11-1366	15.0-16.5	10/6/11	GP-GM	Poorly graded gravel with silt and sand	12.1		
□	KCB-14	KC-11-1367	35.0-36.5	10/6/11	SP-SM	Poorly graded sand with silt	16.3		
△	KCB-14	KC-11-1368	50.0-51.5	10/6/11	SM	Silty sand	28.2		

Client King County

Project County Line Levee Relocation

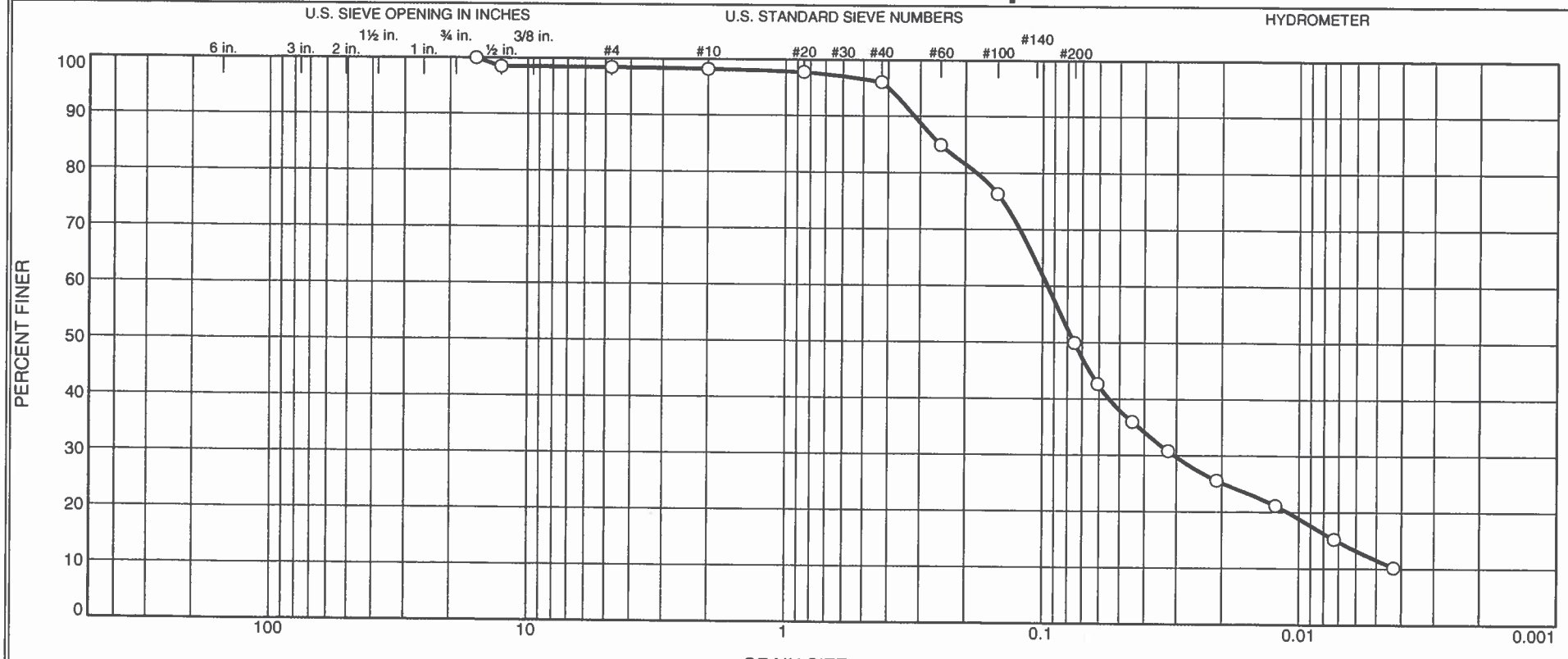
Project No. FL9001 Figure A26

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
O	0.0	0.0	1.6	0.2	2.1	46.2	38.3	11.6

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
O	KCB-14	KC-11-1369	70.0-71.5	10/6/11	SP	Sandy silt	36.5		NP

Client King County

Project County Line Levee Relocation

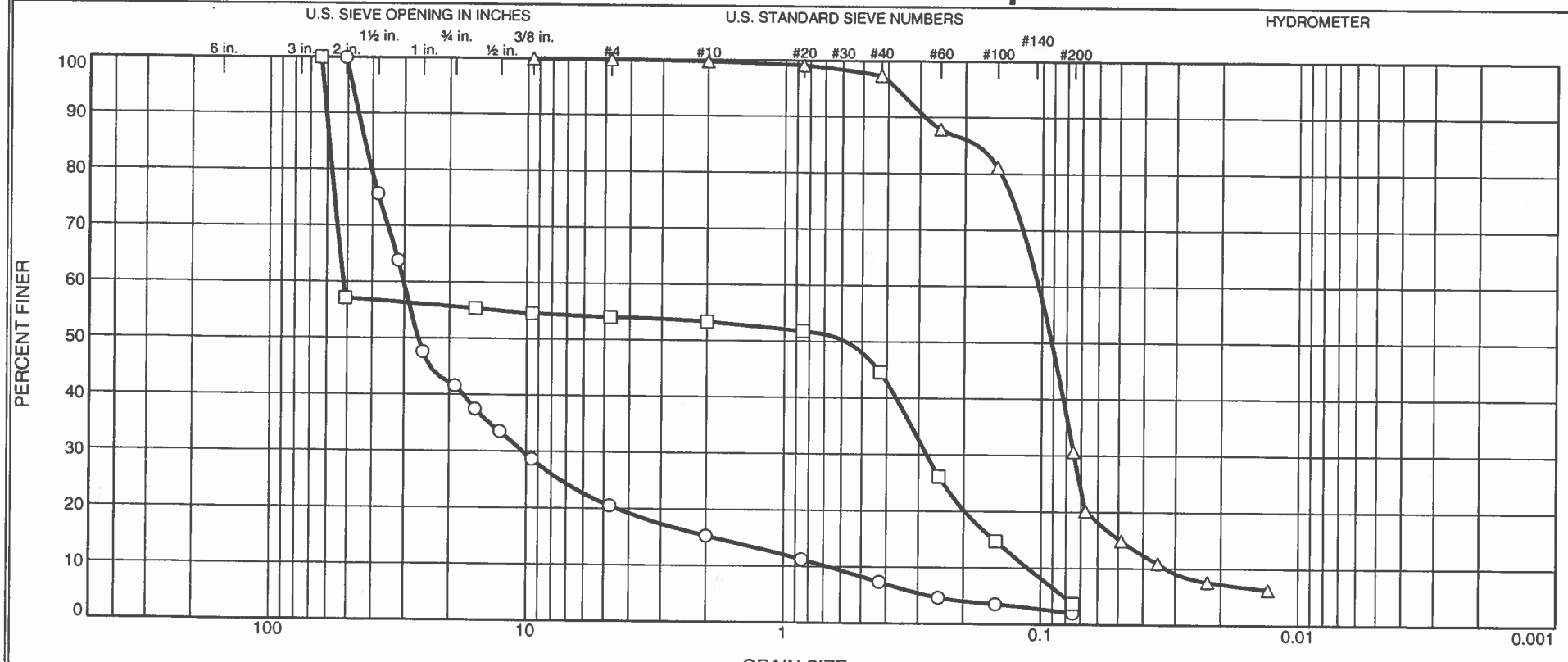
Project No. FL9001 Figure A27

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	58.4	21.1	5.2	7.9	5.4	2.0	
□	0.0	44.3	1.7	0.6	8.8	40.9	3.7	
△	0.0	0.0	0.1	0.2	2.3	66.7	30.7	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-15	KC-11-1370	10.0-11.5	10/6/11	GP	Poorly graded gravel with sand	8.9		
□	KCB-15	KC-11-1371	20.0-21.5	10/6/11	SP	Poorly graded sand with gravel	17.4		
△	KCB-15	KC-11-1372	30.0-31.5	10/6/11	SM	Silty sand	26.7		

Client King County

Project County Line Levee Relocation

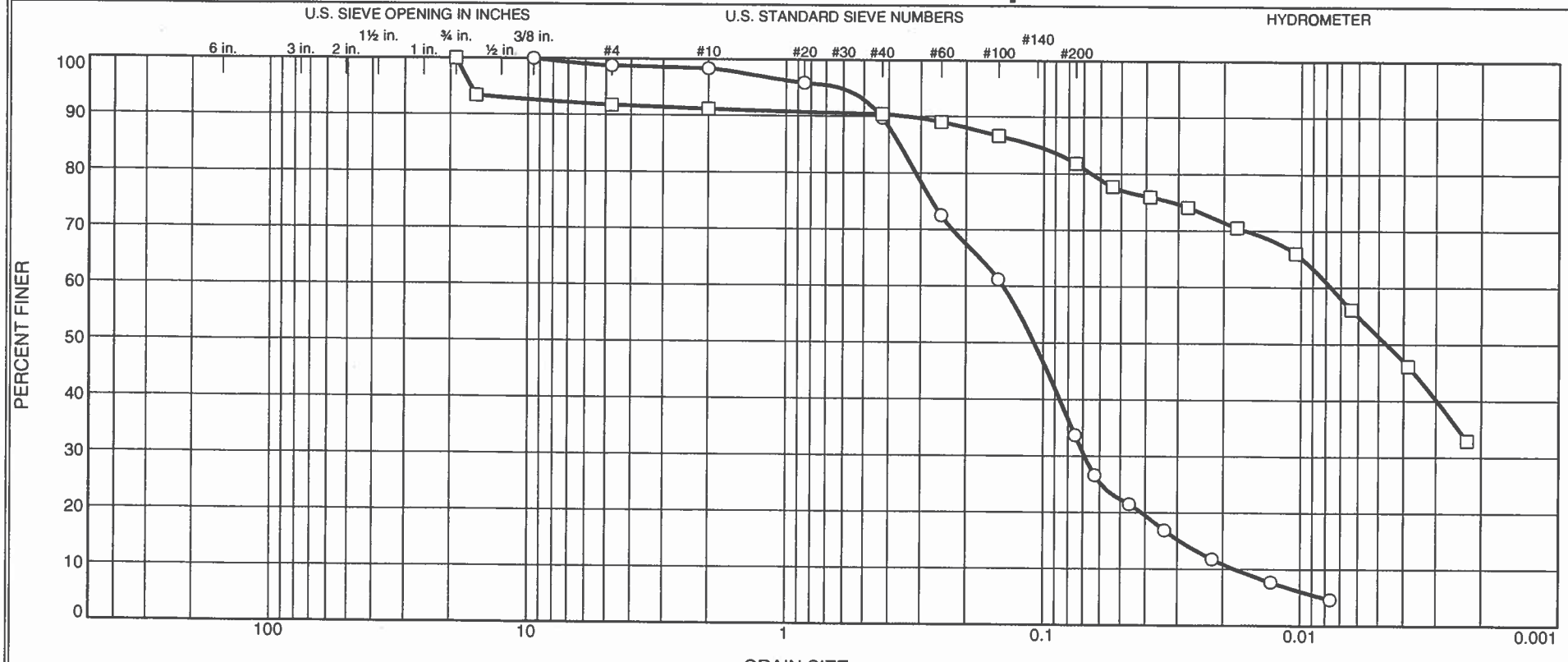
Project No. FL9001 Figure A28

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	1.2	0.4	8.6	56.1	33.7	
□	0.0	0.0	8.2	0.6	0.8	8.6	30.4	51.4

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-15	KC-11-1373	45.0-46.5	10/6/11	SM	Silty sand	26.6		
□	KCB-15	KC-11-1374	60.0-61.5	10/6/11	MH	Elastic silt with sand	76.8	59	42

Client King County

Project County Line Levee Relocation

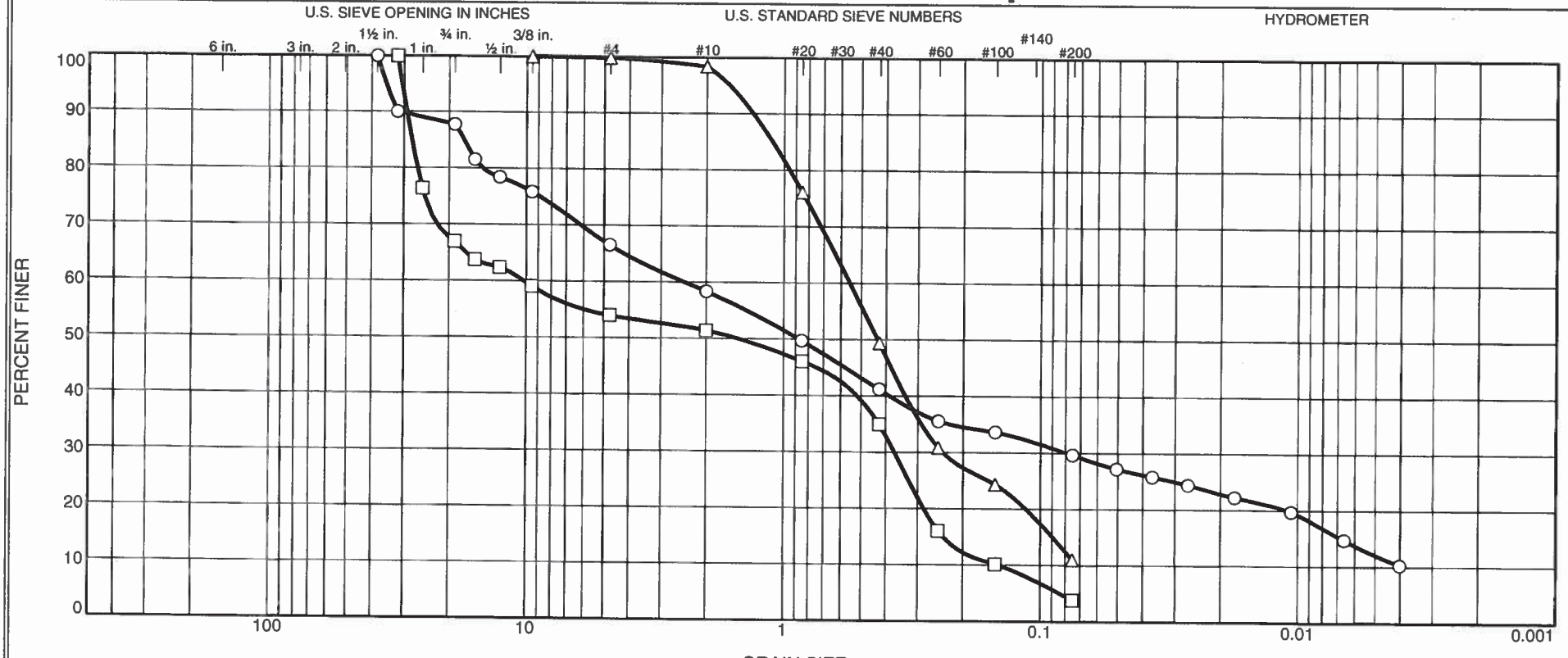
Project No. FL9001 Figure A29

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	12.2	21.3	8.1	17.2	11.6	17.5	12.1
□	0.0	33.1	12.9	2.6	16.5	31.1	3.8	
△	0.0	0.0	0.1	1.5	49.0	38.4	11.0	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-16	KC-11-1375	10.0-11.5	10/6/11	SM	Silty sand with gravel	26.2		
□	KCB-16	KC-11-1376	30.0-31.5	10/6/11	SP	Poorly graded sand with gravel	39.0		
△	KCB-16	KC-11-1377	45.0-46.5	10/6/11	SP-SM	Poorly graded sand with silt	19.2		

Client King County

Project County Line Levee Relocation

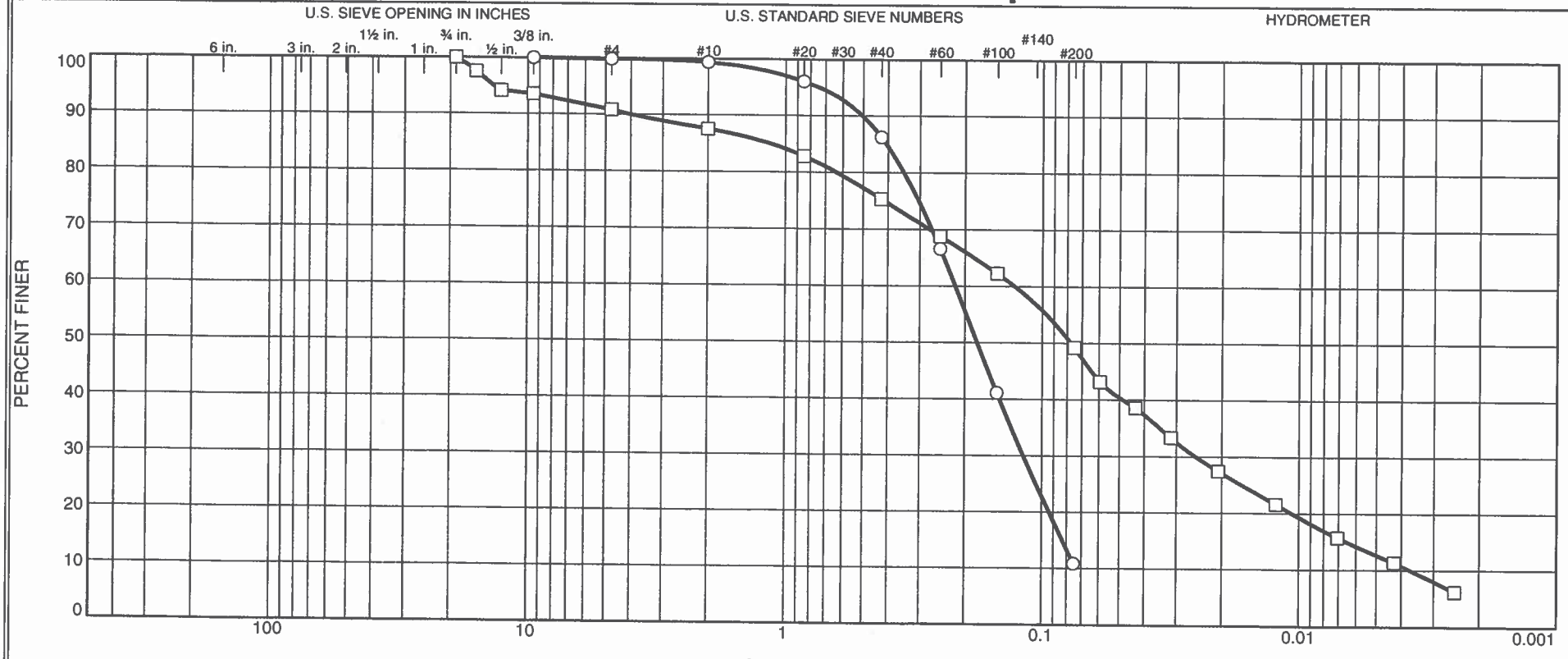
Project No. FL9001 Figure A30

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.1	0.5	13.1	75.5	10.8	
□	0.0	0.0	9.2	3.3	12.2	26.1	36.5	12.7

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-16	KC-11-1378	60.0-61.5	10/6/11	SP-SM	Poorly graded sand with silt	28.9		
□	KCB-16	KC-11-1379	75.0-76.5	10/6/11	SM	Silty sand	69.3	29	29

Client King County

Project County Line Levee Relocation

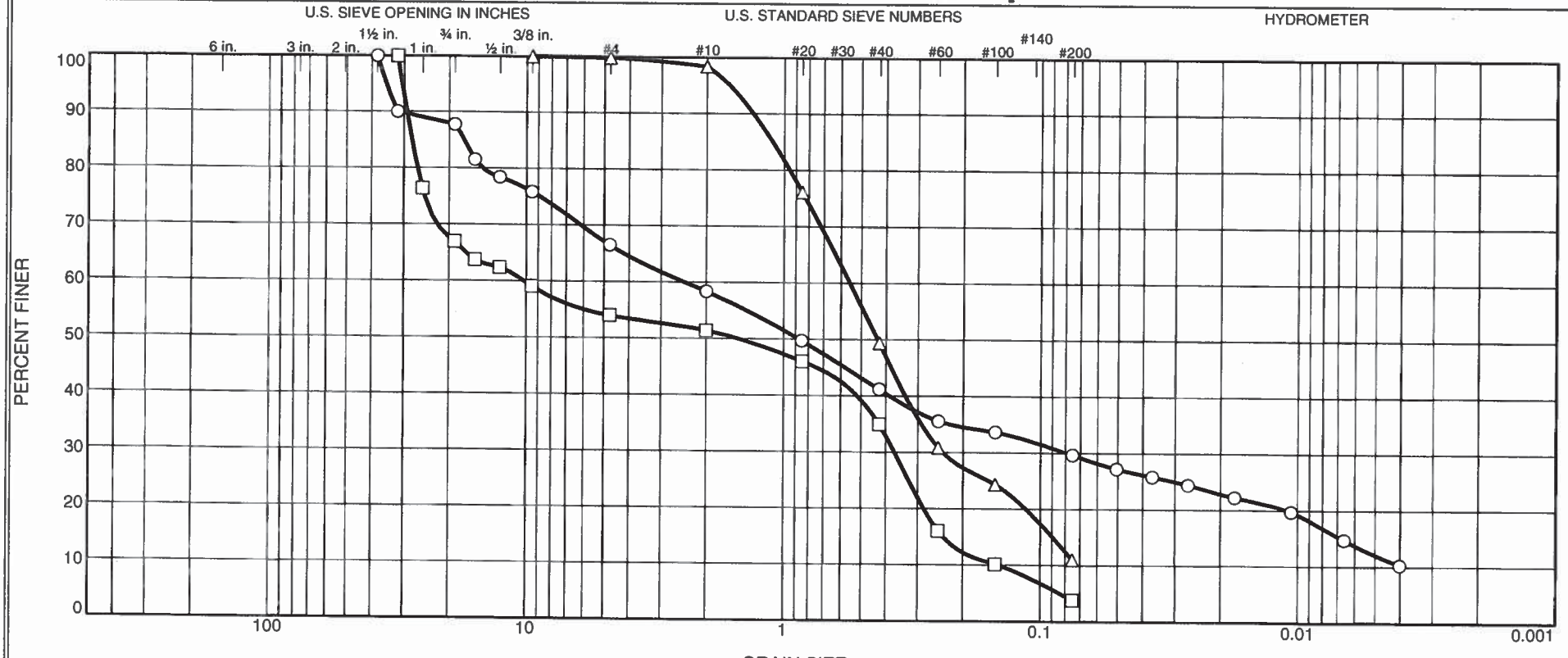
Project No. FL9001 Figure A31

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	12.2	21.3	8.1	17.2	11.6	17.5	12.1
□	0.0	33.1	12.9	2.6	16.5	31.1	3.8	
△	0.0	0.0	0.1	1.5	49.0	38.4	11.0	

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-16	KC-11-1375	10.0-11.5	10/6/11	SM	Silty sand with gravel	26.2		
□	KCB-16	KC-11-1376	30.0-31.5	10/6/11	SP	Poorly graded sand with gravel	39.0		
△	KCB-16	KC-11-1377	45.0-46.5	10/6/11	SP-SM	Poorly graded sand with silt	19.2		

Client King County

Project County Line Levee Relocation

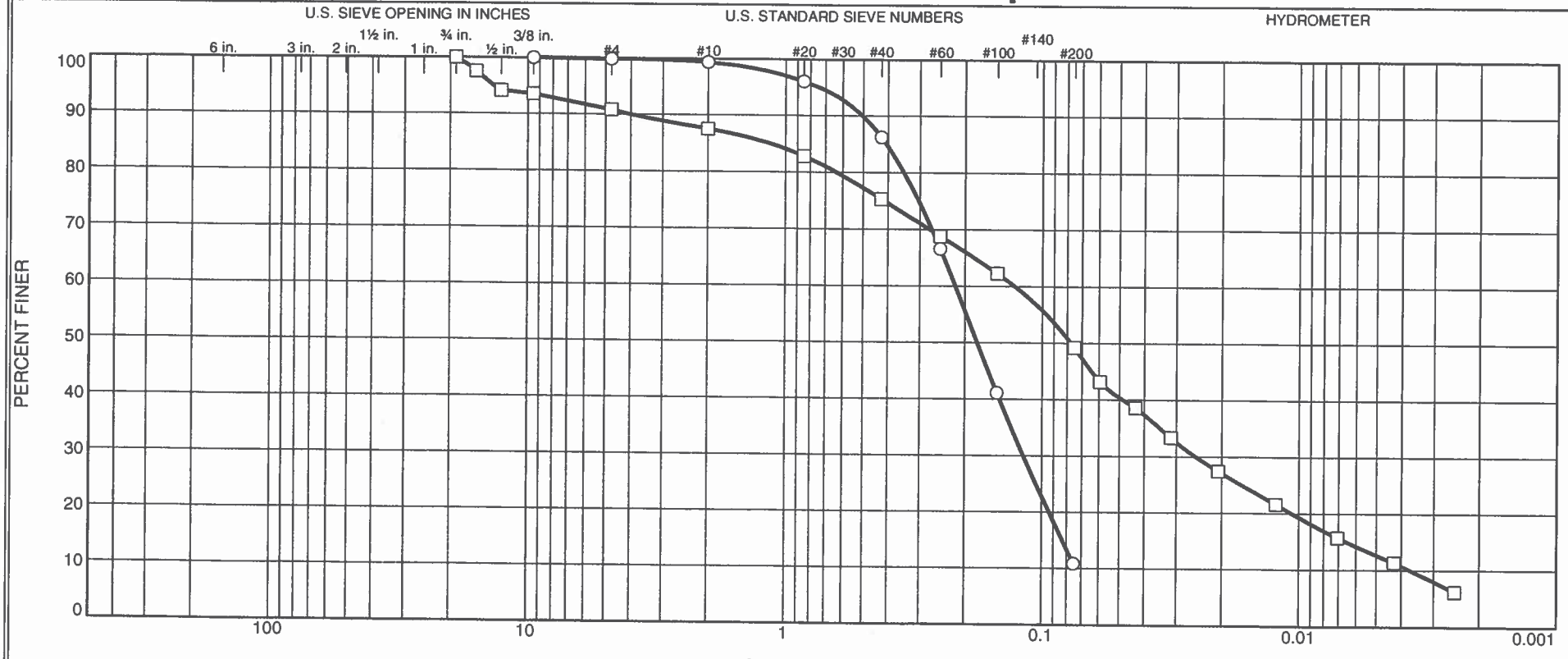
Project No. FL9001 Figure A30

KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.1	0.5	13.1	75.5	10.8	
□	0.0	0.0	9.2	3.3	12.2	26.1	36.5	12.7

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○	KCB-16	KC-11-1378	60.0-61.5	10/6/11	SP-SM	Poorly graded sand with silt	28.9		
□	KCB-16	KC-11-1379	75.0-76.5	10/6/11	SM	Silty sand	69.3	29	29

Client King County

Project County Line Levee Relocation

Project No. FL9001 Figure A31

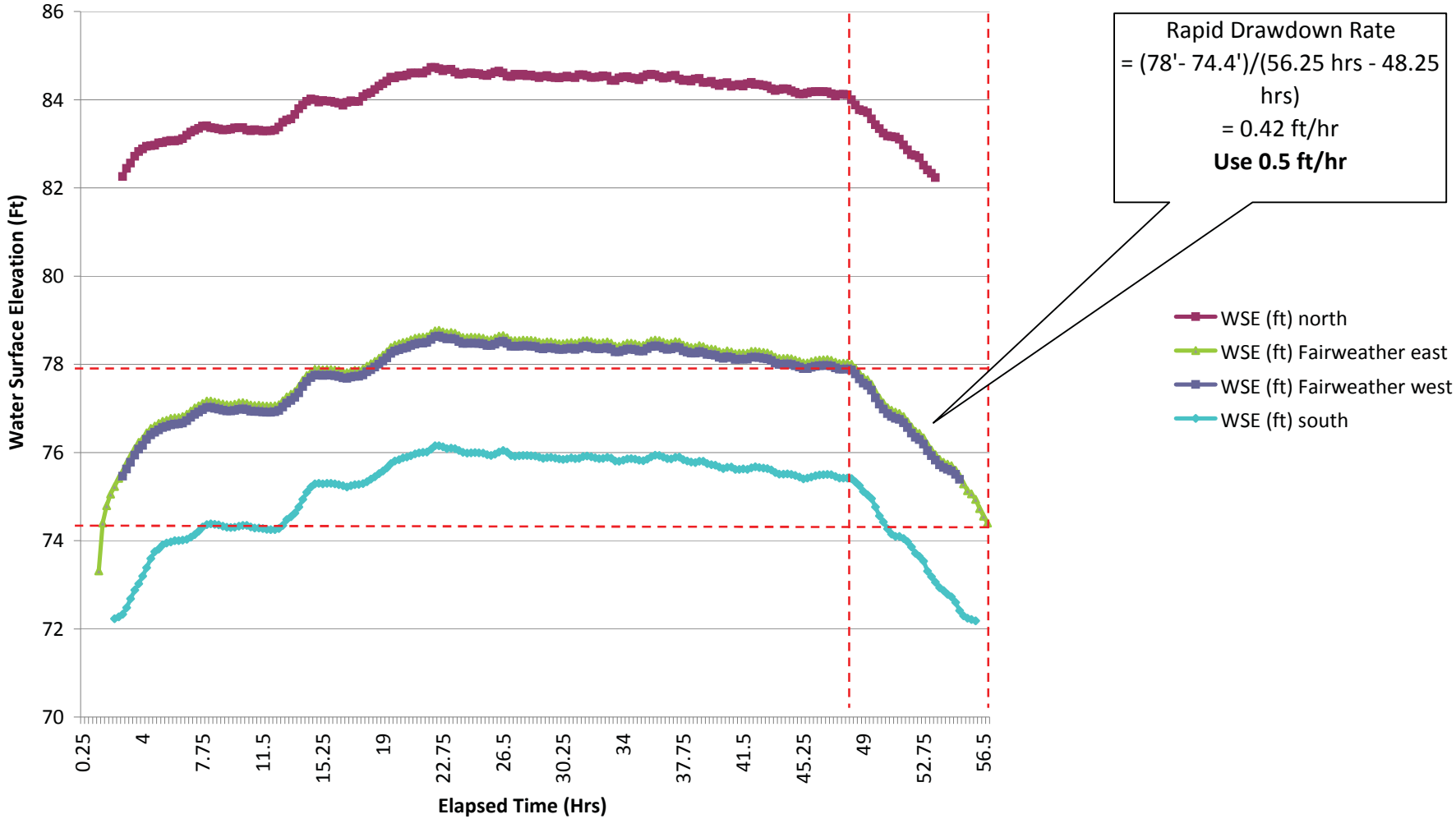
KING COUNTY

MATERIALS LABORATORY

Tested By: vw

Appendix B: King County Rapid Drawdown Data

Water Surface Elevation Along Levee in S1d 100 year Model



Appendix C: Vertical Exit Gradient SEEP/W Output

Name: Proposed Fill Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: 2-Silt,Peat Model: Saturated Only K-Sat: 3.281e-007 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.8425e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 1-Existing Fill Model: Saturated / Unsaturated K-Function: Stratum 1-Fill Vol. WC. Function: Sand K-Ratio: 0.25 K-Direction: 0

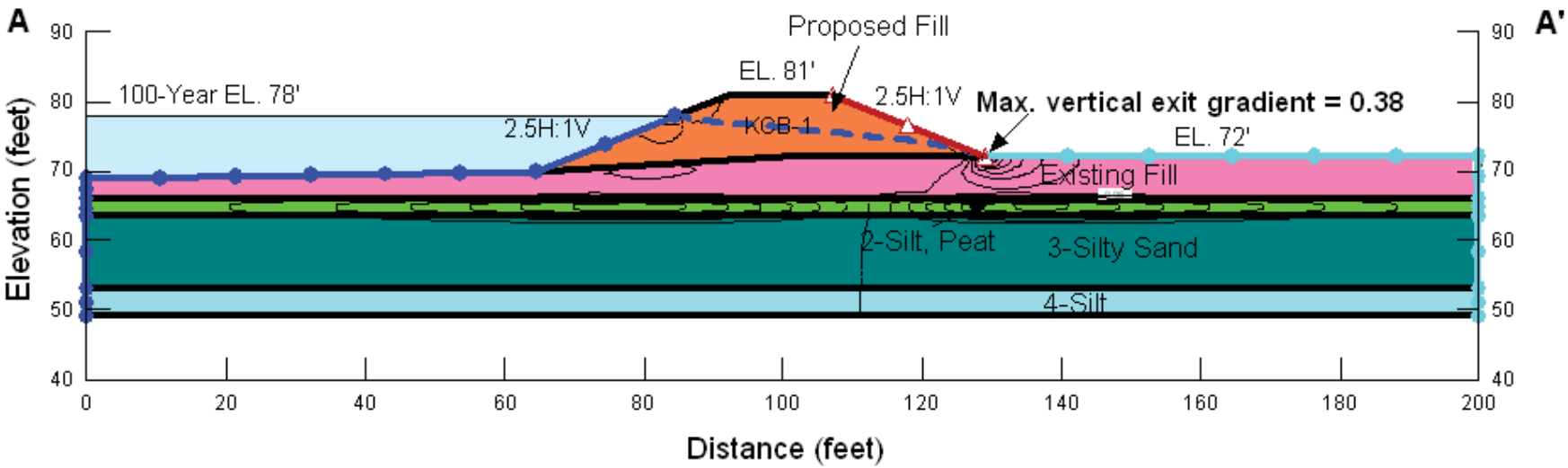


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Figure C1

Job No. 33762798

Vertical Gradient Contours, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Permeability for Proposed Fill is 0.02 cm/s = 6.5616798E-4 ft/s

Name: Proposed Fill Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: 2-Silt,Peat Model: Saturated Only K-Sat: 3.281e-007 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.8425e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 1-Existing Fill Model: Saturated / Unsaturated K-Function: Stratum 1-Fill Vol. WC. Function: Sand K-Ratio: 0.25 K-Direction: 0

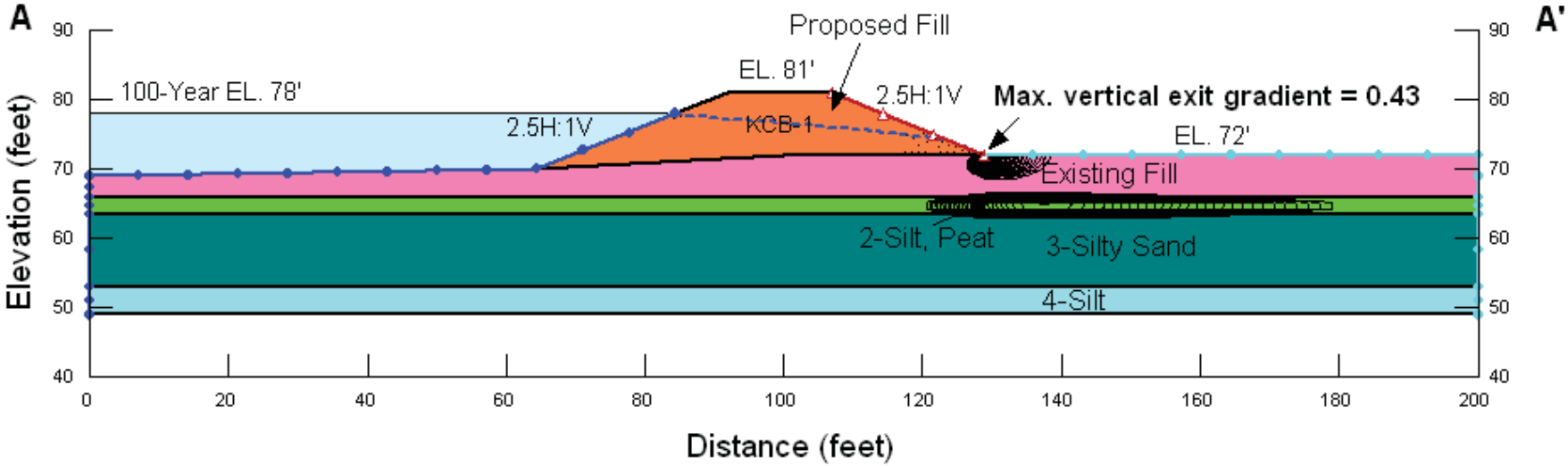

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Figure C1a

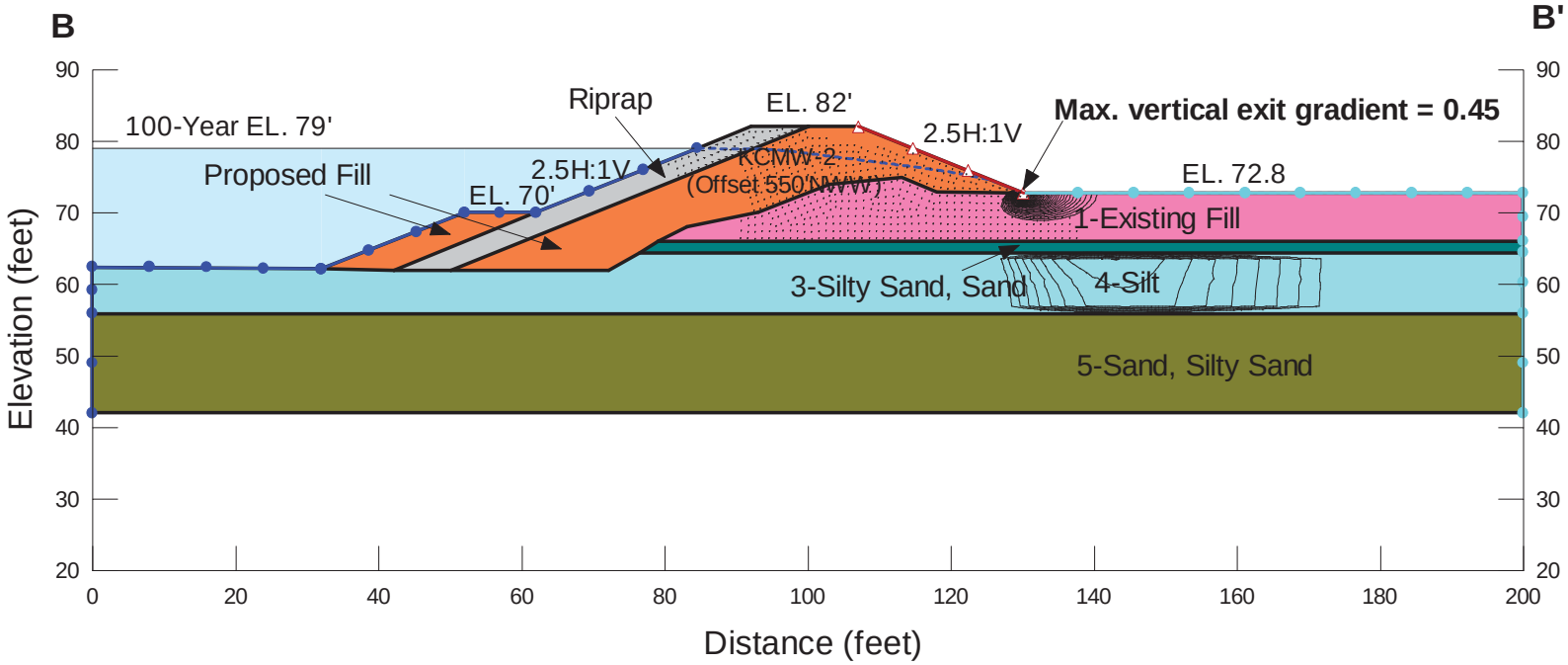
Vertical Gradient Contours, Section AA'

Job No. 33762798

URS

White River Countyline Levee Project
King County, Washington

Name: Proposed Fill Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: Riprap Model: Saturated / Unsaturated K-Function: Riprap Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.84252e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.84252e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 5-Sand, Silty Sand Model: Saturated Only K-Sat: 9.84252e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 1-Existing Fill Model: Saturated / Unsaturated K-Function: Stratum 1-Fill Vol. WC. Function: Sand K-Ratio: 0.25 K-Direction: 0



G:\King County White River\04 - Calculations\SeepW, SlopeW\Revised Dec 10-14, 2012\Section KCB-2 qaqc.gsz

Figure C2

Job No. 33762798

Vertical Gradient Contours, Section BB'

URS

White River Countyline Levee Project
King County, Washington

Permeability for Proposed Fill is 0.02 cm/s = 6.5616798E-4 ft/s

Name: Proposed Fill Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: Riprap Model: Saturated / Unsaturated K-Function: Riprap Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.84252e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.84252e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 5-Sand, Silty Sand Model: Saturated Only K-Sat: 9.84252e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 1-Existing Fill Model: Saturated / Unsaturated K-Function: Stratum 1-Fill Vol. WC. Function: Sand K-Ratio: 0.25 K-Direction: 0

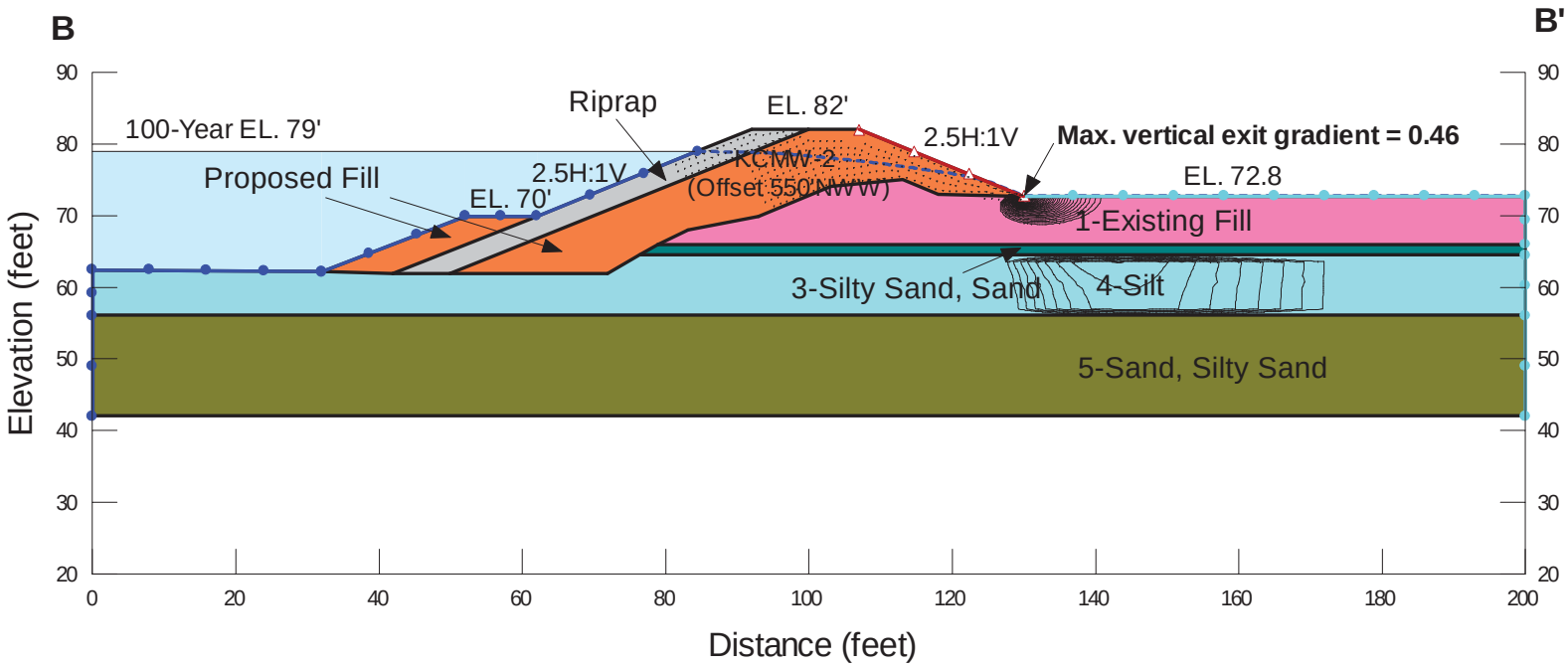


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Figure C2a

Job No. 33762798

Vertical Gradient Contours, Section BB'

URS

White River Countyline Levee Project
King County, Washington

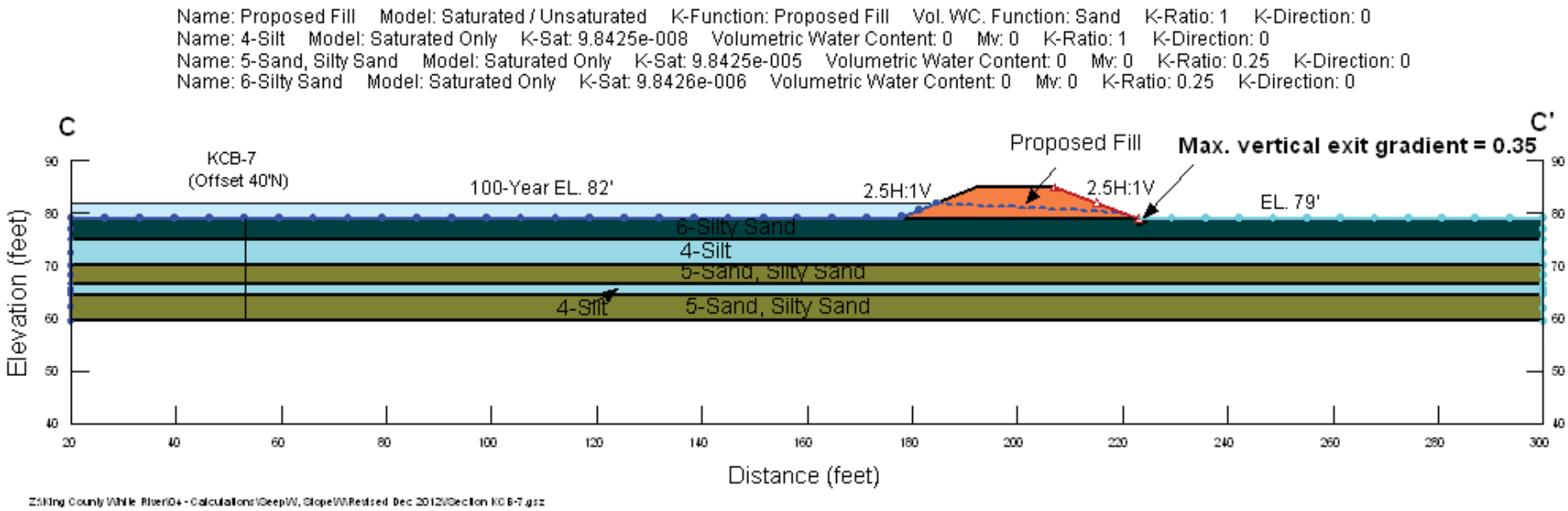

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Figure C3

Vertical Gradient Contours, Section CC'

White River Countyline Levee Project
King County, Washington

Job No. 33762798

URS

Name: Proposed Fill Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: 2-Silt,Peat Model: Saturated Only K-Sat: 3.28084e-007 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.8425e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 5-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-005 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0

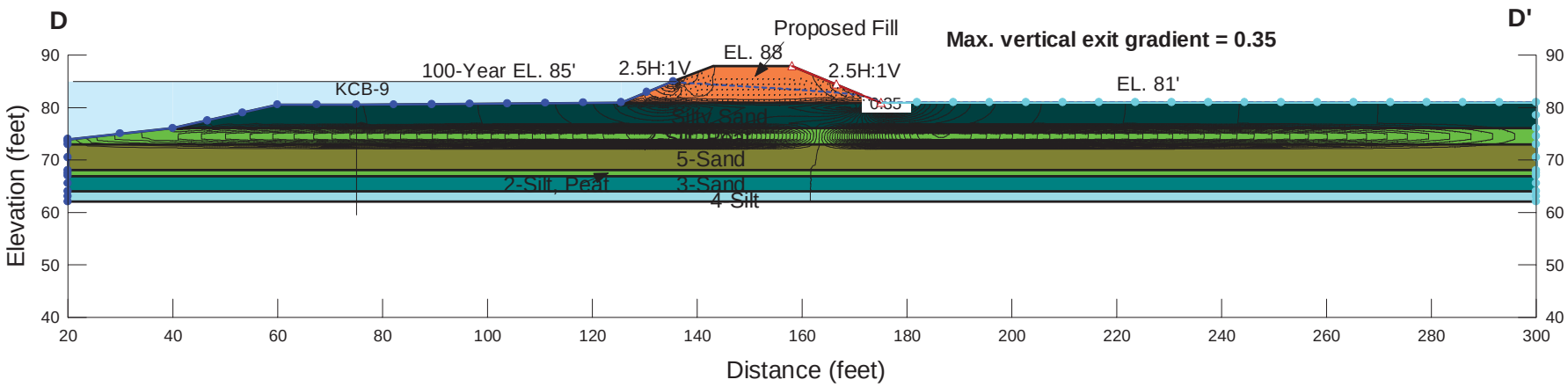

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Figure C4

Vertical Gradient Contours, Section DD'

Job No. 33762798

URS

White River Countyline Levee Project
King County, Washington

Name: Proposed Imported Fill (Fines.=25%) Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Silty Sand K-Ratio: 1 K-Direction: 0
Name: 2-Silt,Peat Model: Saturated Only K-Sat: 3.281e-007 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.8425e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 1-Existing Fill Model: Saturated / Unsaturated K-Function: Stratum 1-Fill Vol. WC. Function: Sand K-Ratio: 0.25 K-Direction: 0
Name: On-Site Alluvium Model: Saturated / Unsaturated K-Function: On-Site Alluvium Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: Topsoil Model: Saturated / Unsaturated K-Function: Topsoil Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0

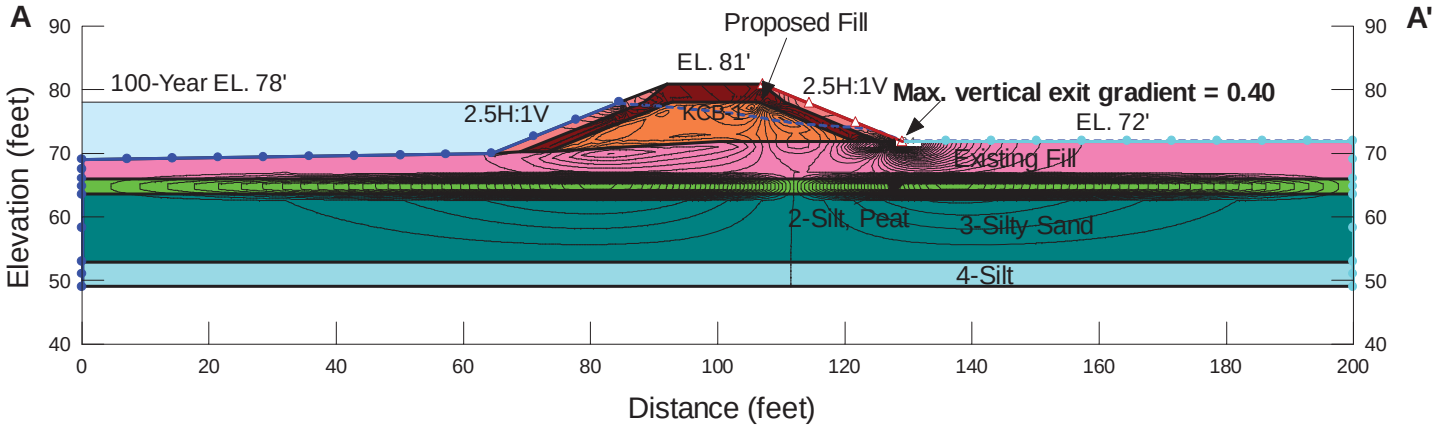

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Figure C5

Job No. 33762798

Vertical Gradient Contours, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Name: Proposed Imported Fill (Fines.=25%) Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Silty Sand K-Ratio: 1 K-Direction: 0
Name: 2-Silt,Peat Model: Saturated Only K-Sat: 3.281e-007 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.8425e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 1-Existing Fill Model: Saturated / Unsaturated K-Function: Stratum 1-Fill Vol. WC. Function: Sand K-Ratio: 0.25 K-Direction: 0
Name: On-Site Alluvium Model: Saturated / Unsaturated K-Function: On-Site Alluvium Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: Topsoil Model: Saturated / Unsaturated K-Function: Topsoil Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0

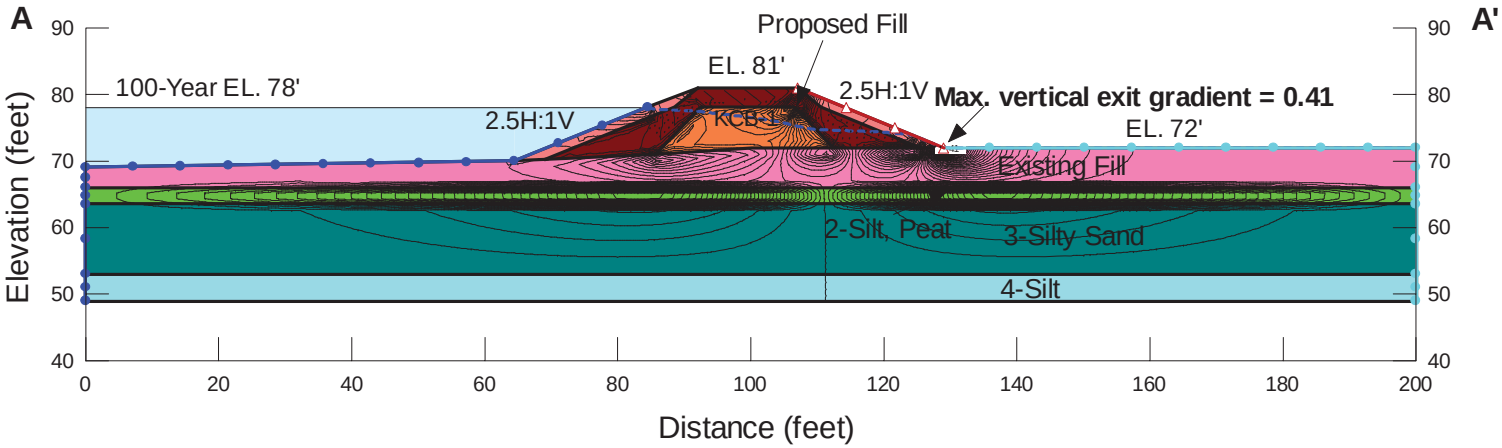

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Figure C5a

Job No. 33762798

Vertical Gradient Contours, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Name: Proposed Imported Fill (Fines.=25%) Model: Saturated / Unsaturated K-Function: Proposed Fill Vol. WC. Function: Silty Sand K-Ratio: 1 K-Direction: 0
Name: 2-Silt,Peat Model: Saturated Only K-Sat: 3.28084e-007 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 3-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: 4-Silt Model: Saturated Only K-Sat: 9.8425e-008 Volumetric Water Content: 0 Mv: 0 K-Ratio: 1 K-Direction: 0
Name: 5-Sand, Silty Sand Model: Saturated Only K-Sat: 9.8425e-005 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: Silty Sand Model: Saturated Only K-Sat: 9.8425e-006 Volumetric Water Content: 0 Mv: 0 K-Ratio: 0.25 K-Direction: 0
Name: Topsoil Model: Saturated / Unsaturated K-Function: Topsoil Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0
Name: On-Site Alluvium Model: Saturated / Unsaturated K-Function: On-Site Alluvium Vol. WC. Function: Sand K-Ratio: 1 K-Direction: 0

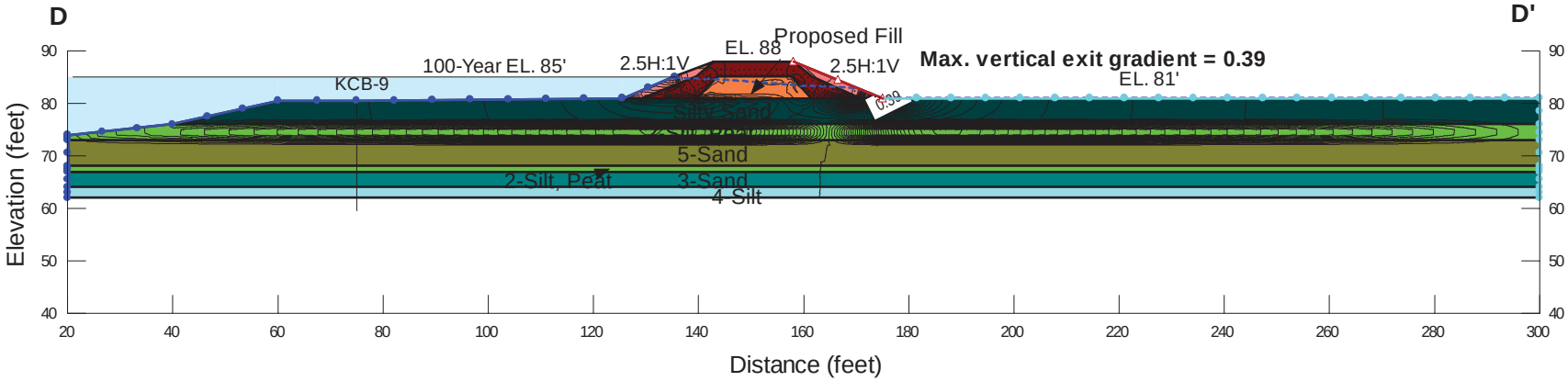

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Figure C6

Job No. 33762798

Vertical Gradient Contours, Section DD'

URS

White River Countyline Levee Project
King County, Washington

Appendix D: Stability Analyses SLOPE/W Output

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.52

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

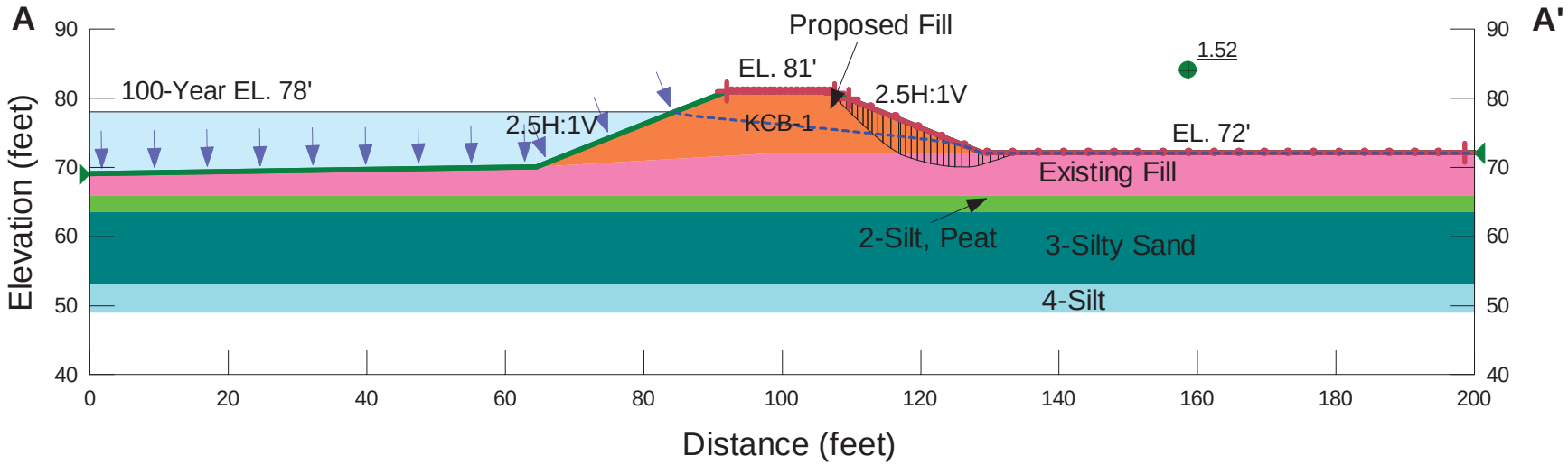

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Figure D1

Job No. 33762798

Slope Stability – Static, Steady State, Land Side, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.64

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 50 Phi: 35
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

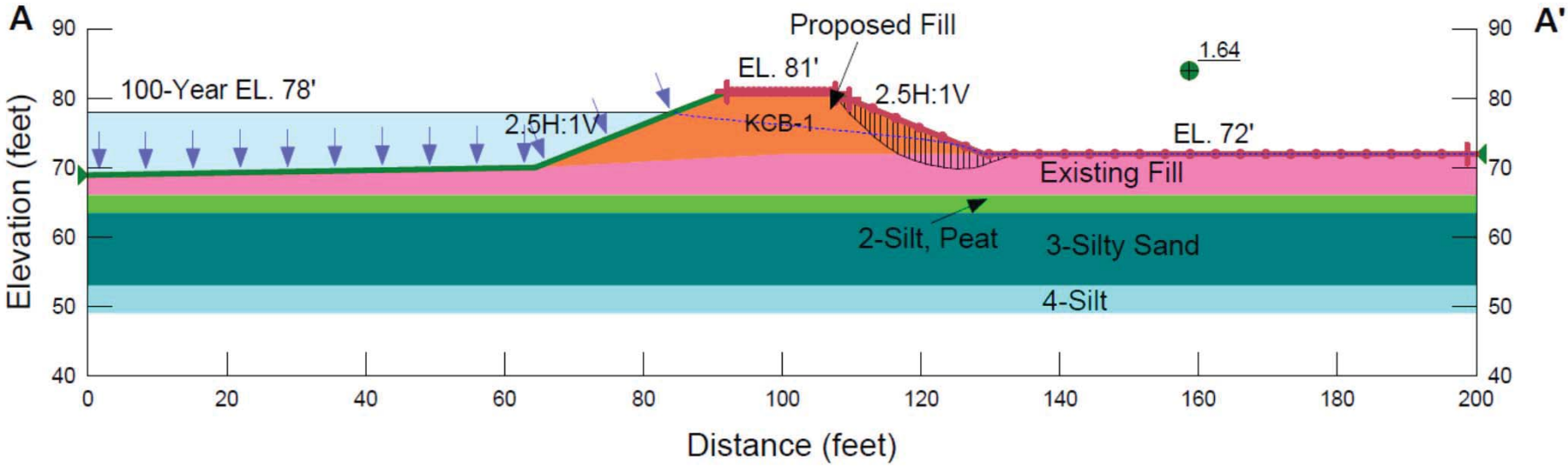

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Figure D1a

Job No. 33762798

Slope Stability – Static, Steady State, Land Side, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.96

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

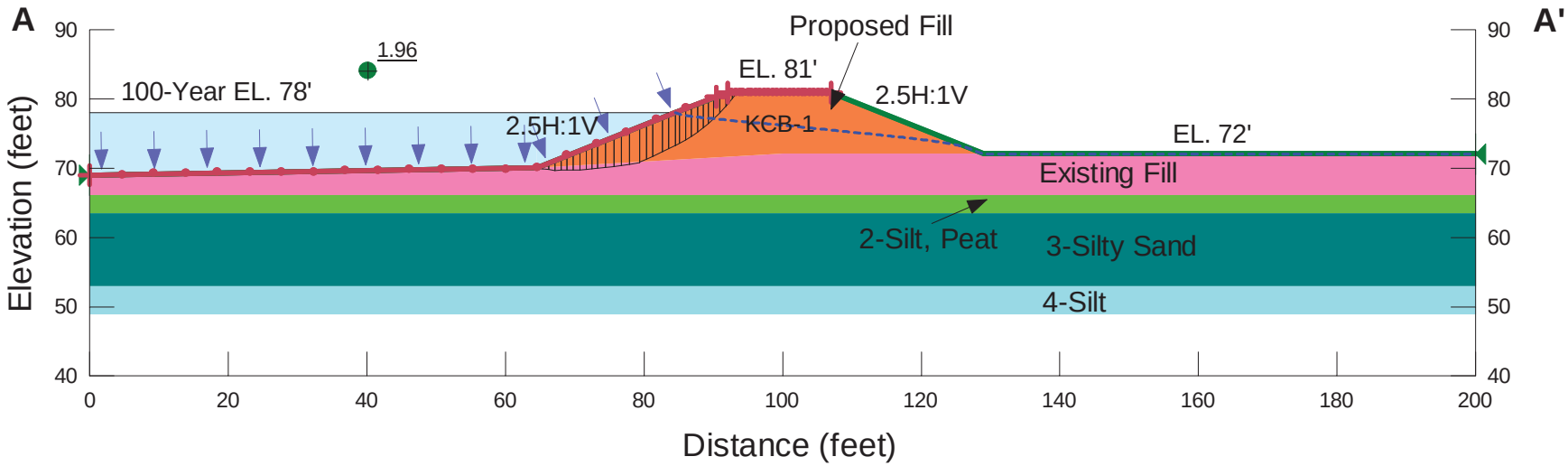

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Figure D2

Job No. 33762798

Slope Stability – Static, Steady State, River Side, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 2.15

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 50 Phi: 35
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

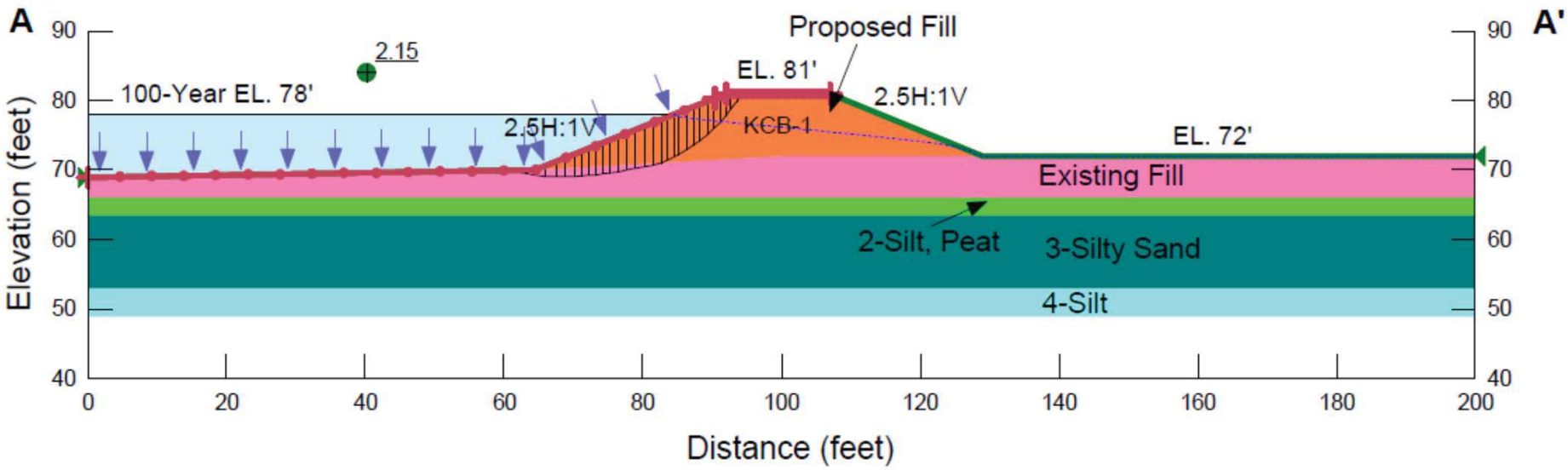

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Figure D2a

Job No. 33762798

Slope Stability – Static, Steady State, River Side, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.62

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

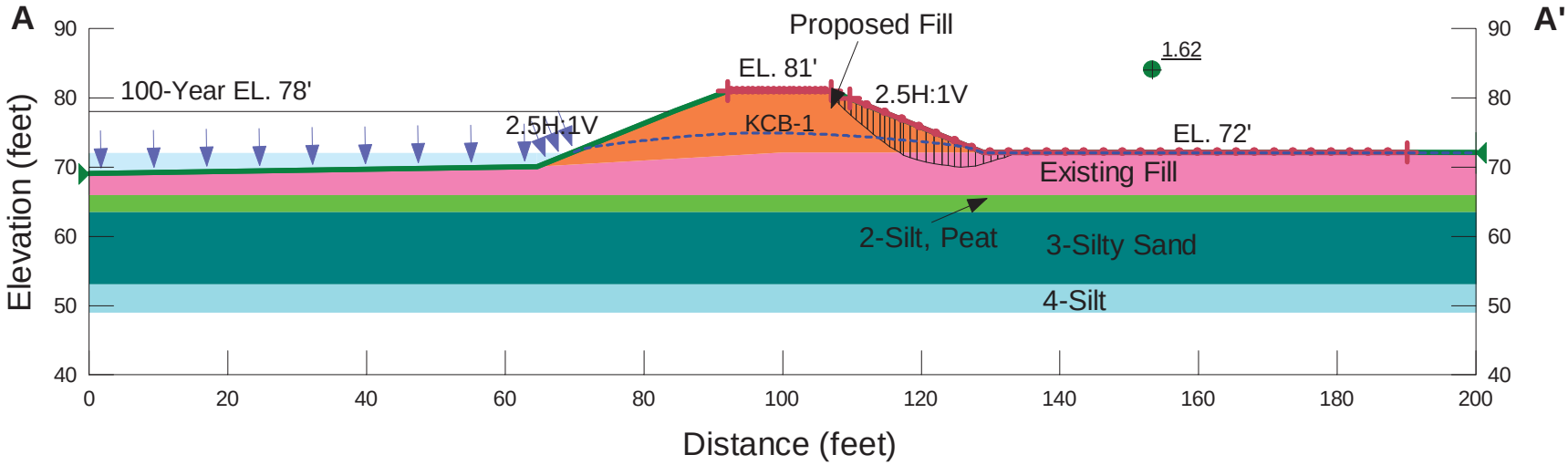

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Figure D3

Job No. 33762798

Slope Stability – Static, Transient Seepage at 43200 Sec, Land Side, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.52

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

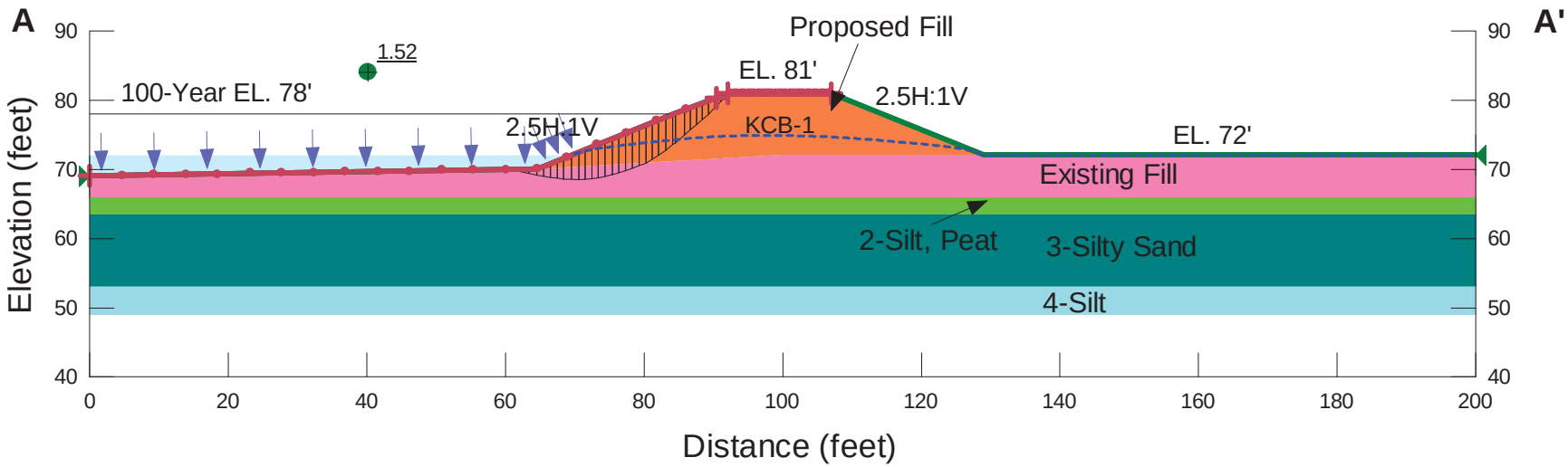

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Figure D4

Job No. 33762798

Slope Stability – Static, Transient Seepage at 43200 Sec, River Side, Section AA'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.40

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: Riprap Model: Mohr-Coulomb Unit Weight: 140 Cohesion: 0 Phi: 40
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35

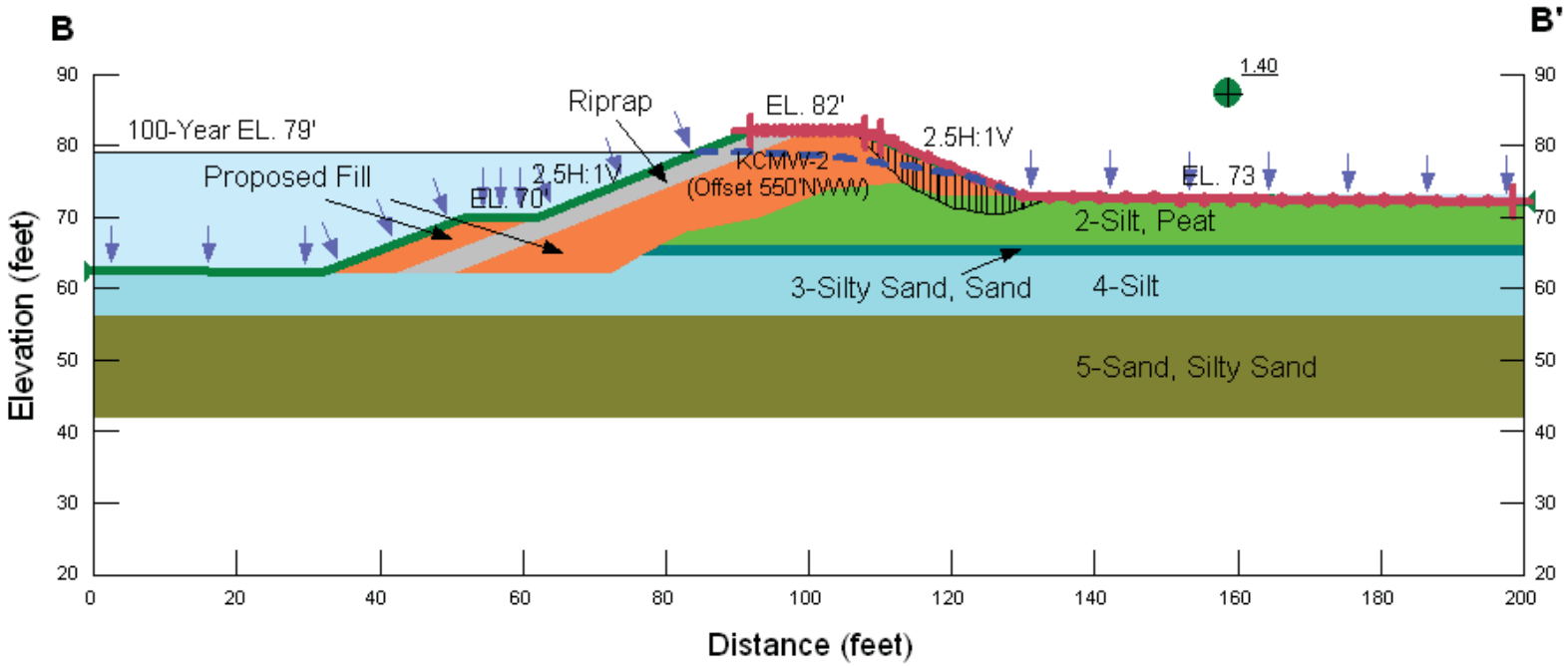

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Figure D5

Job No. 33762798

Slope Stability – Static, Steady State, Land Side, Section BB'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.46

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 50 Phi: 35
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: Riprap Model: Mohr-Coulomb Unit Weight: 140 Cohesion: 0 Phi: 40
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35

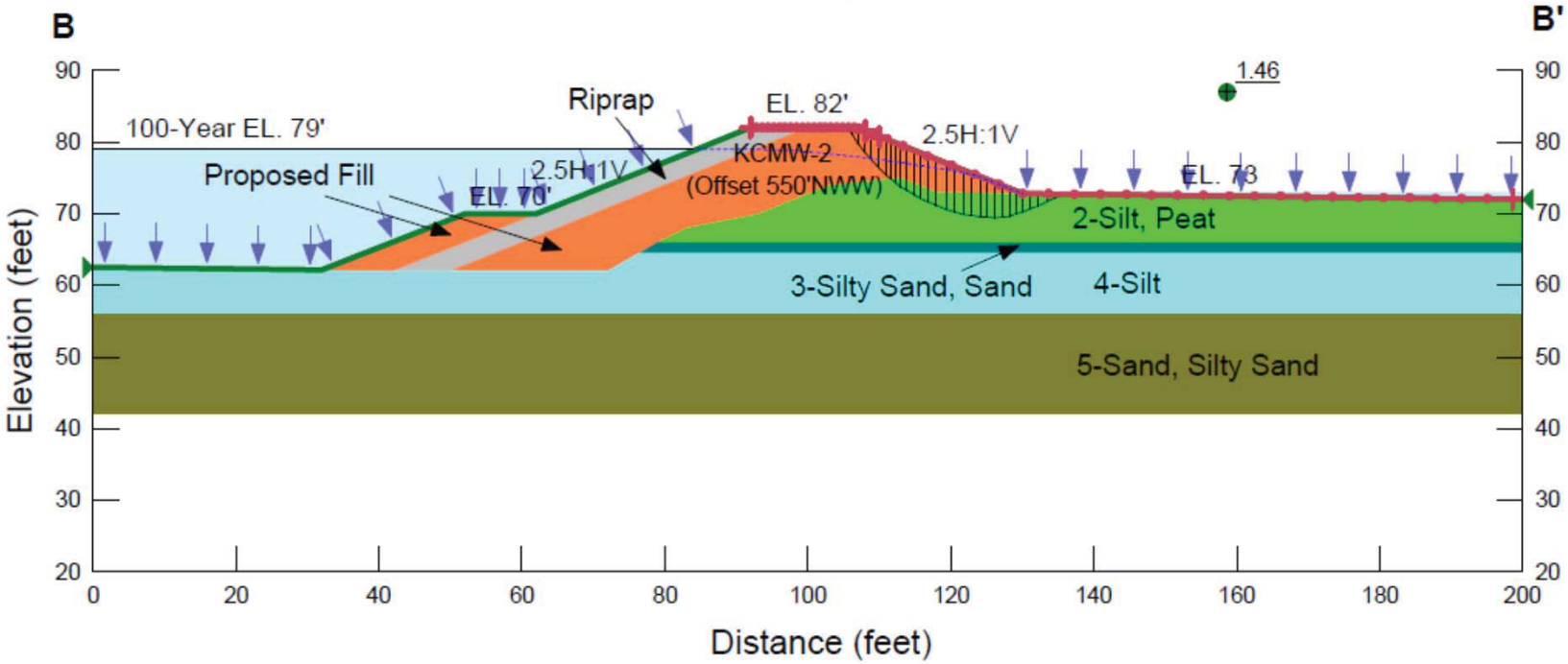

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Figure D5a

Job No. 33762798

Slope Stability – Static, Steady State, Land Side, Section BB'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 2.00

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: Riprap Model: Mohr-Coulomb Unit Weight: 140 Cohesion: 0 Phi: 40
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35

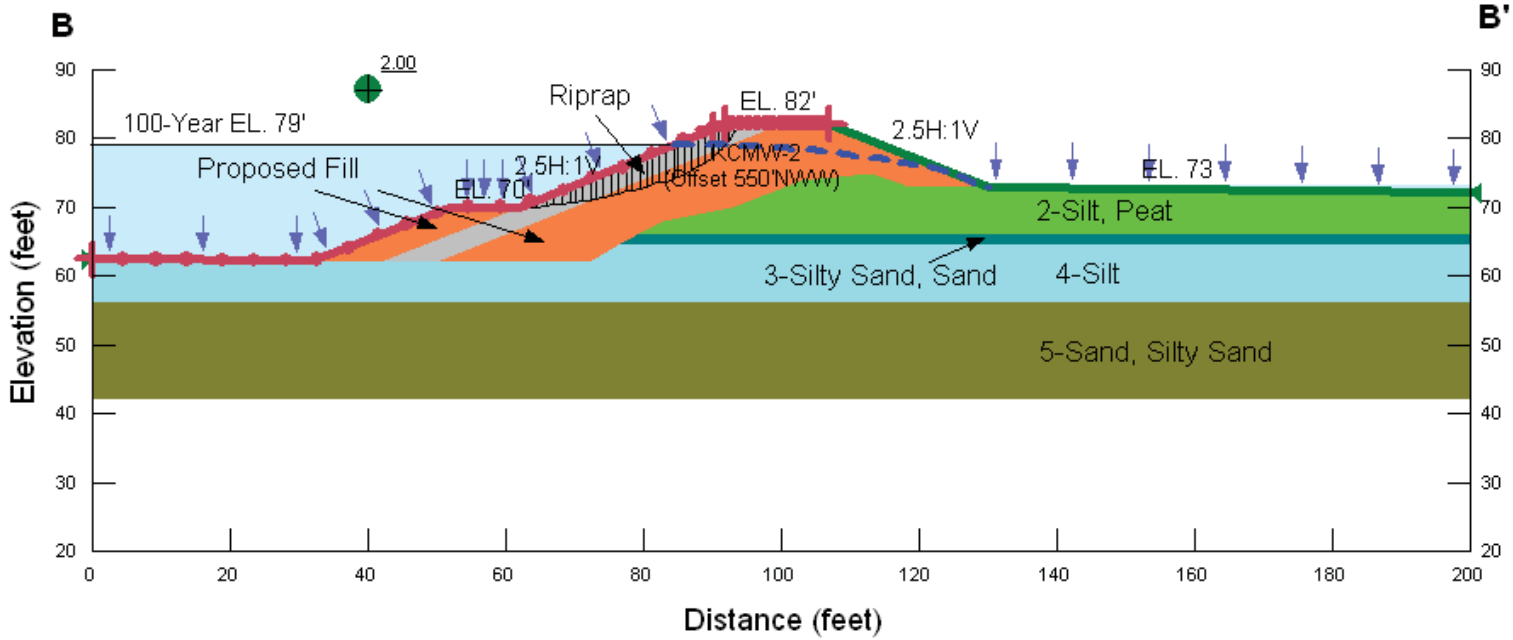

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Figure D6

Slope Stability – Static, Steady State, River Side, Section BB'

Job No. 33762798

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 2.19

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 50 Phi: 35
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: Riprap Model: Mohr-Coulomb Unit Weight: 140 Cohesion: 0 Phi: 40
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35

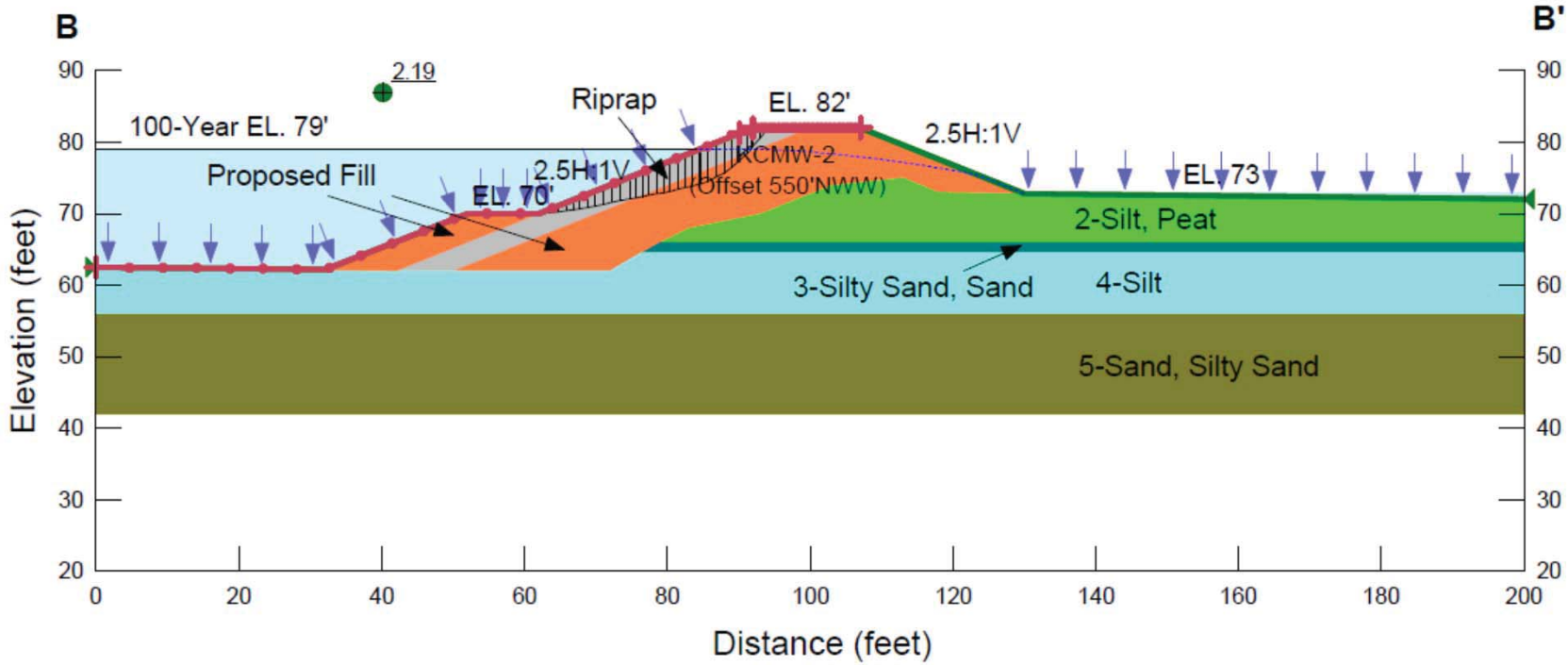

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Figure D6a

Job No. 33762798

Slope Stability – Static, Steady State, River Side, Section BB'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.56

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: Riprap Model: Mohr-Coulomb Unit Weight: 140 Cohesion: 0 Phi: 40
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35

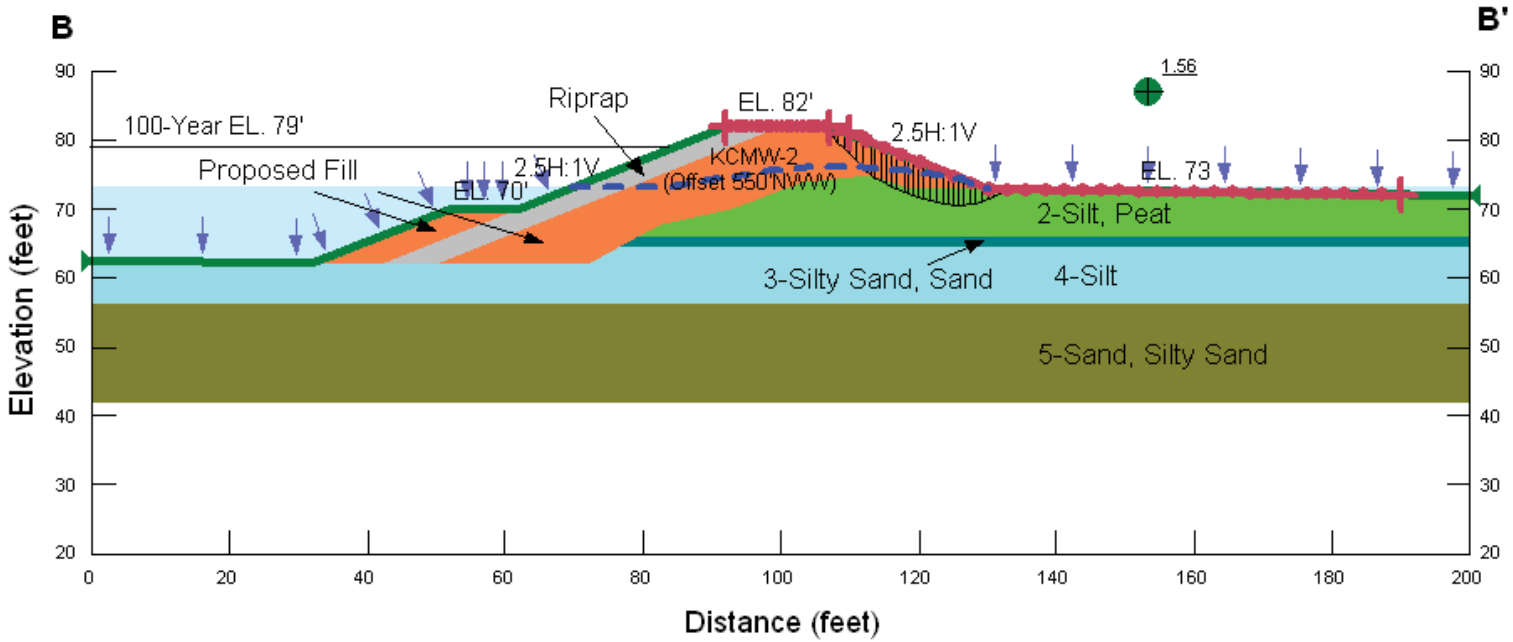

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Figure D7

Job No. 33762798

Slope Stability – Static, Transient Seepage at 43200 Sec, Land Side, Section BB'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.91

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: Riprap Model: Mohr-Coulomb Unit Weight: 140 Cohesion: 0 Phi: 40
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35

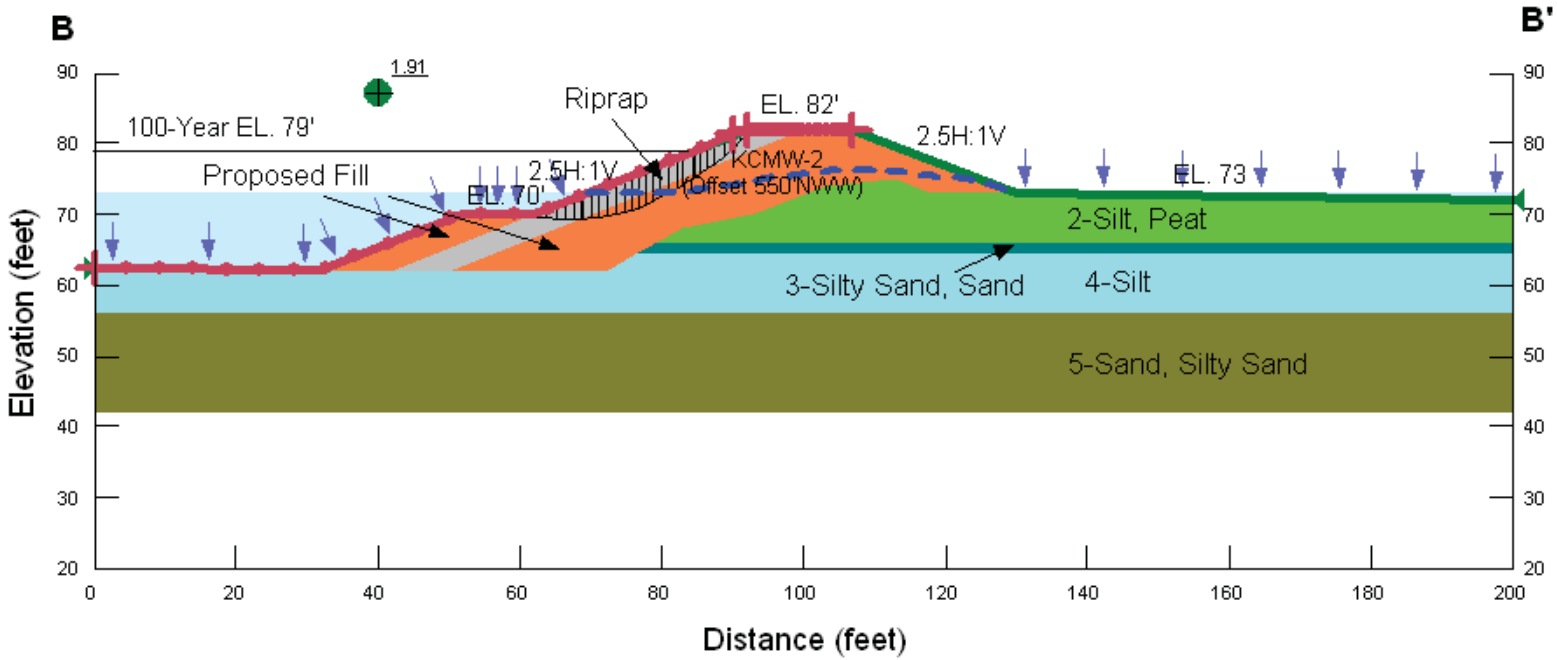

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Figure D8

Job No. 33762798

Slope Stability – Static, Transient Seepage at 43200 Sec, River Side, Section BB'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.88

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

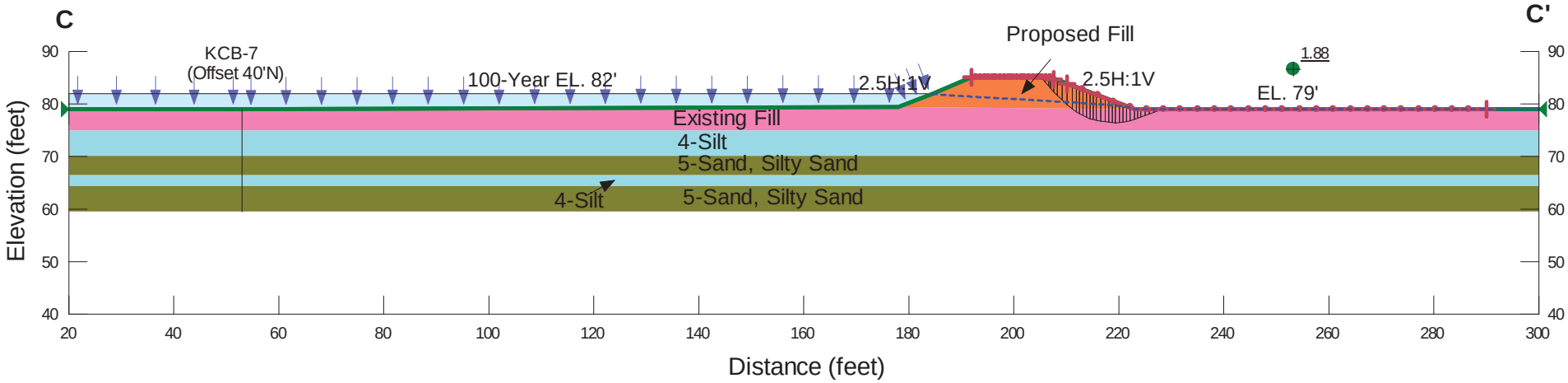

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Figure D9

Job No. 33762798

Slope Stability – Static, Steady State, Land Side, Section CC'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 2.13

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

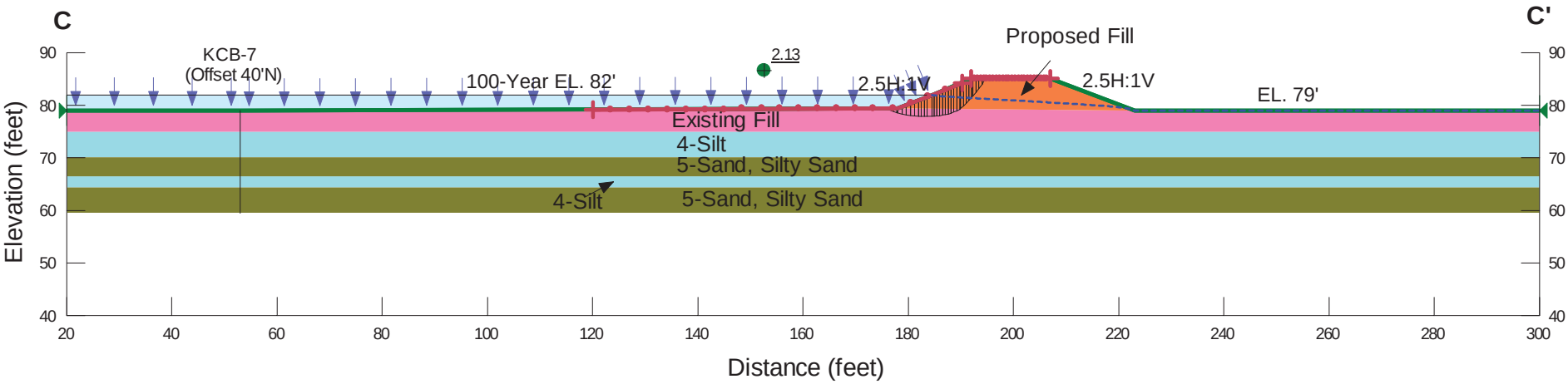

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Figure D10

Job No. 33762798

Slope Stability – Static, Steady State, River Side, Section CC'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.91

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

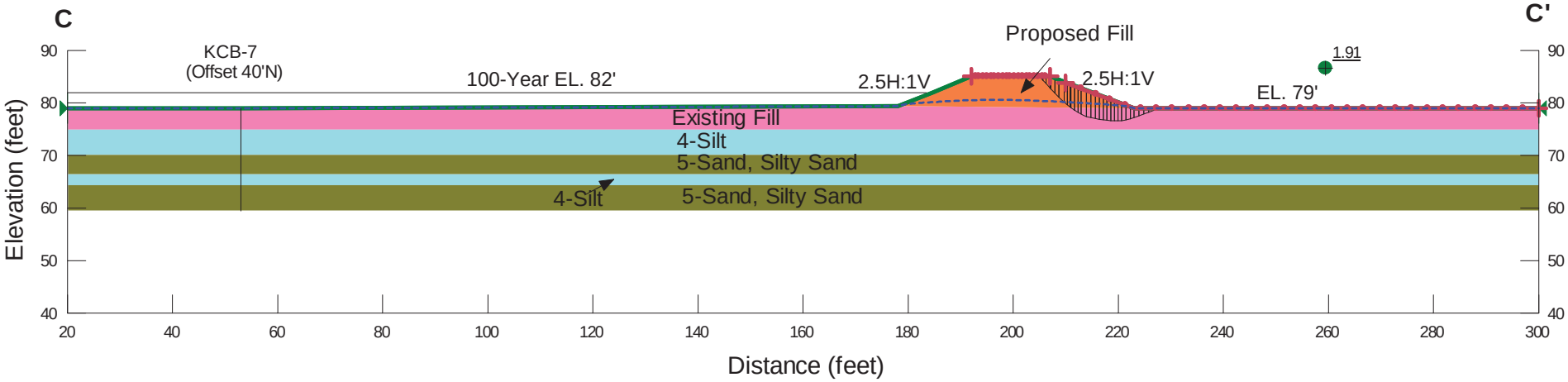

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Figure D11

Job No. 33762798

Slope Stability – Static, Transient Seepage at 21600 Sec, Land Side, Section CC'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.90

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

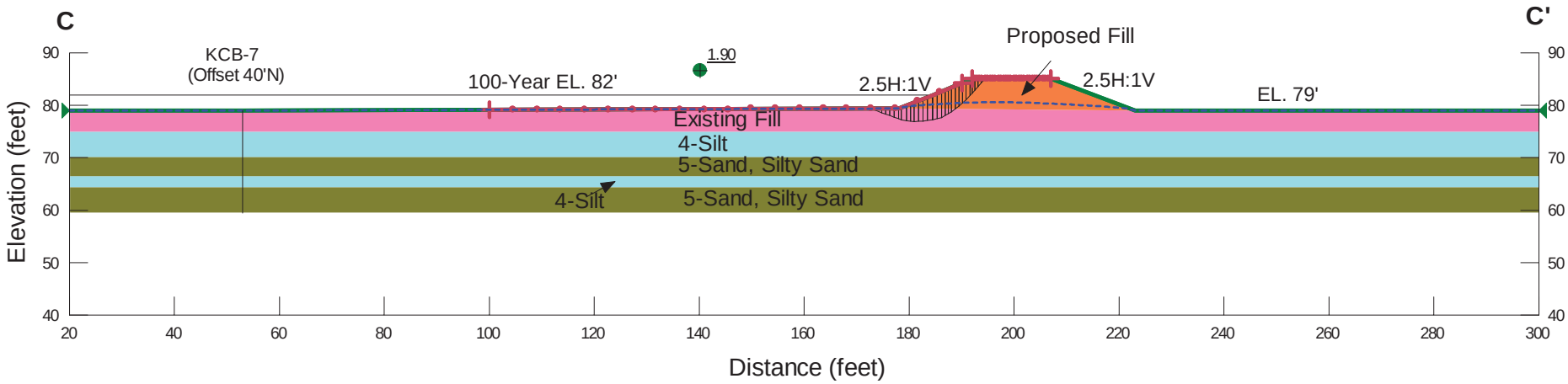

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Figure D12

Job No. 33762798

Slope Stability – Static, Transient Seepage at 21600 Sec, River Side, Section CC'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.68

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

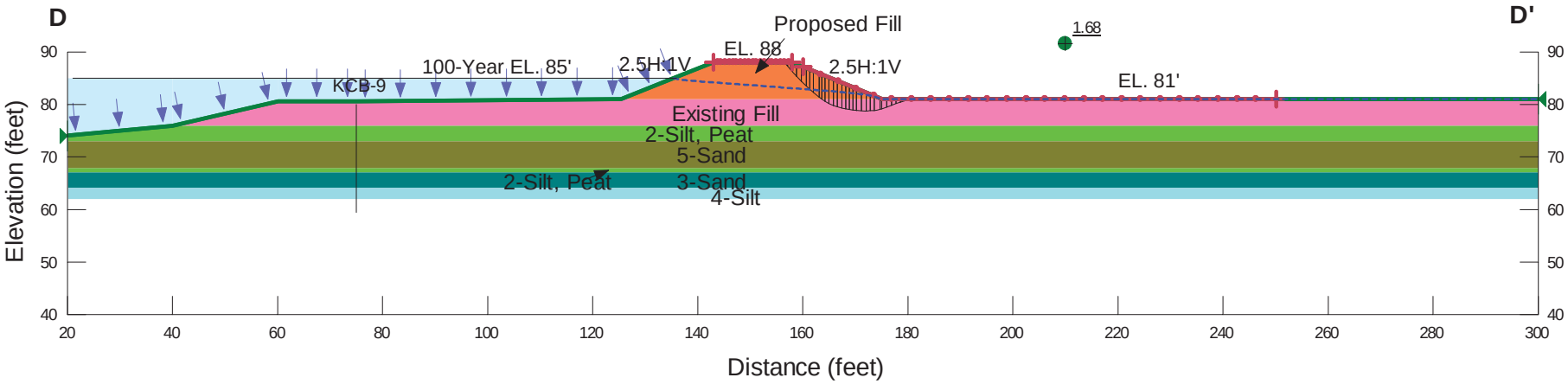

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Figure D13

Job No. 33762798

Slope Stability – Static, Steady State, Land Side, Section DD'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 2.03

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

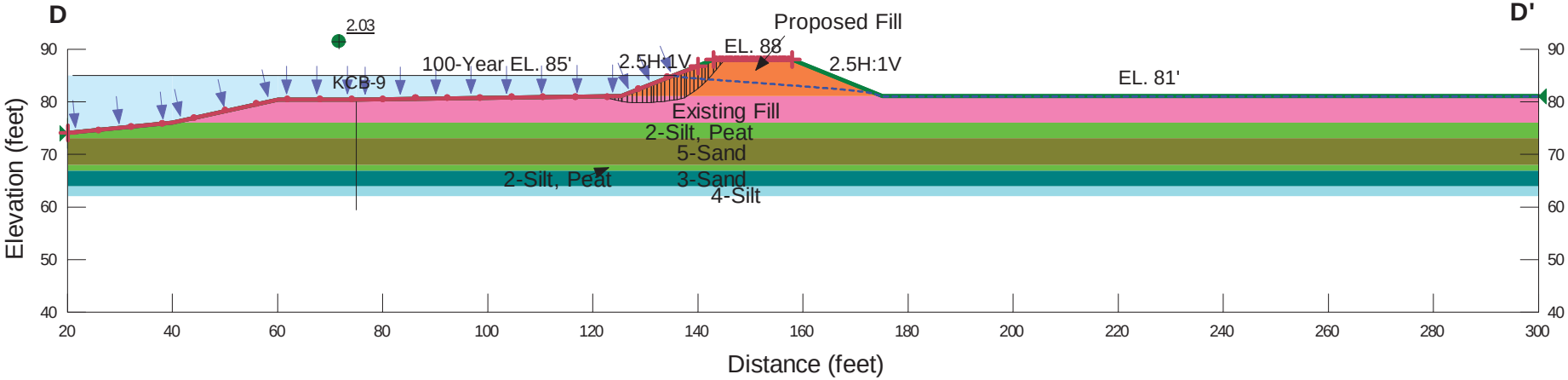

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Figure D14

Job No. 33762798

Slope Stability – Static, Steady State, River Side, Section DD'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.74

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

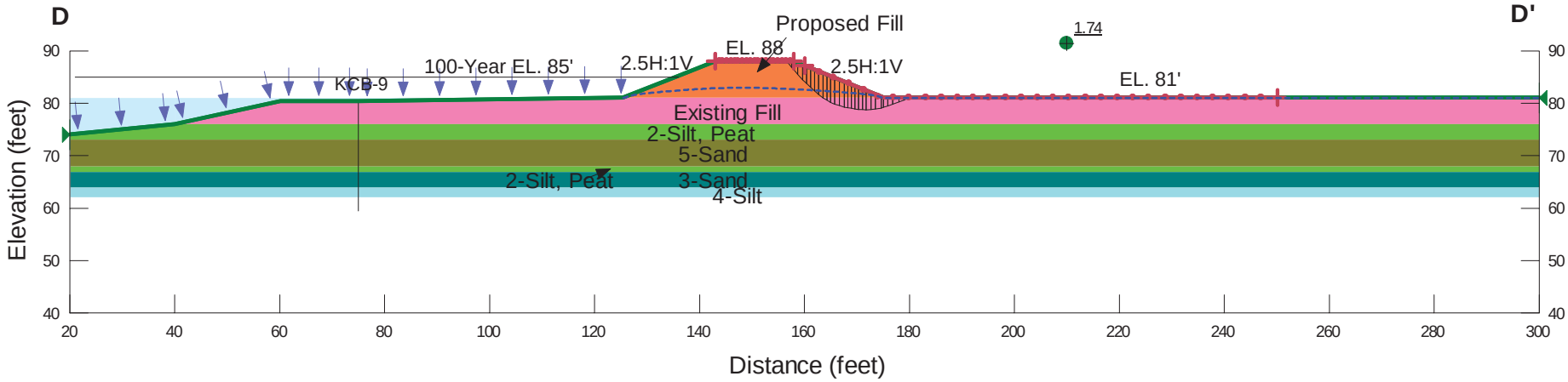

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Figure D15

Job No. 33762798

Slope Stability – Static, Transient Seepage at 28800 Sec, Land Side, Section DD'

URS

White River Countyline Levee Project
King County, Washington

Slip Surface Option: Entry and Exit
Analyses State: Static
Factor of Safety: 1.74

Name: Proposed Fill Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 37
Name: 2-Silt,Peat Model: Mohr-Coulomb Unit Weight: 110 Cohesion: 50 Phi: 28
Name: 3-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 125 Cohesion: 0 Phi: 35
Name: 4-Silt Model: Mohr-Coulomb Unit Weight: 115 Cohesion: 200 Phi: 30
Name: 5-Sand, Silty Sand Model: Mohr-Coulomb Unit Weight: 130 Cohesion: 0 Phi: 35
Name: 1-Existing Fill Model: Mohr-Coulomb Unit Weight: 128 Cohesion: 0 Phi: 33

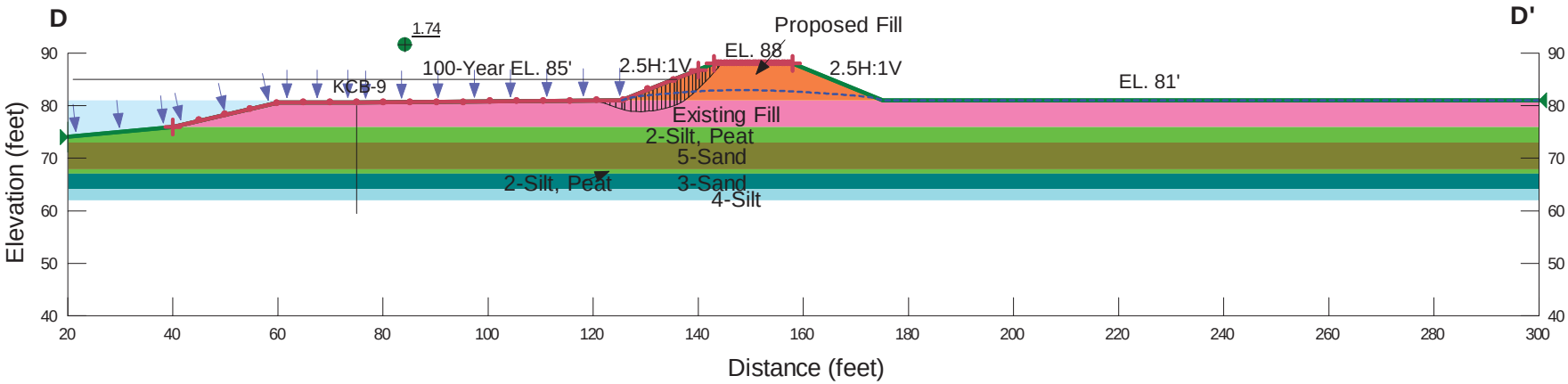

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Figure D16

Job No. 33762798

Slope Stability – Static, Transient Seepage at 28800 Sec, River Side, Section DD'

URS

White River Countyline Levee Project
King County, Washington

Appendix E: Groundwater Analysis

Figure E-1: Groundwater Well Location Map

See Figure 2 for location of proposed setback levee and drill holes.

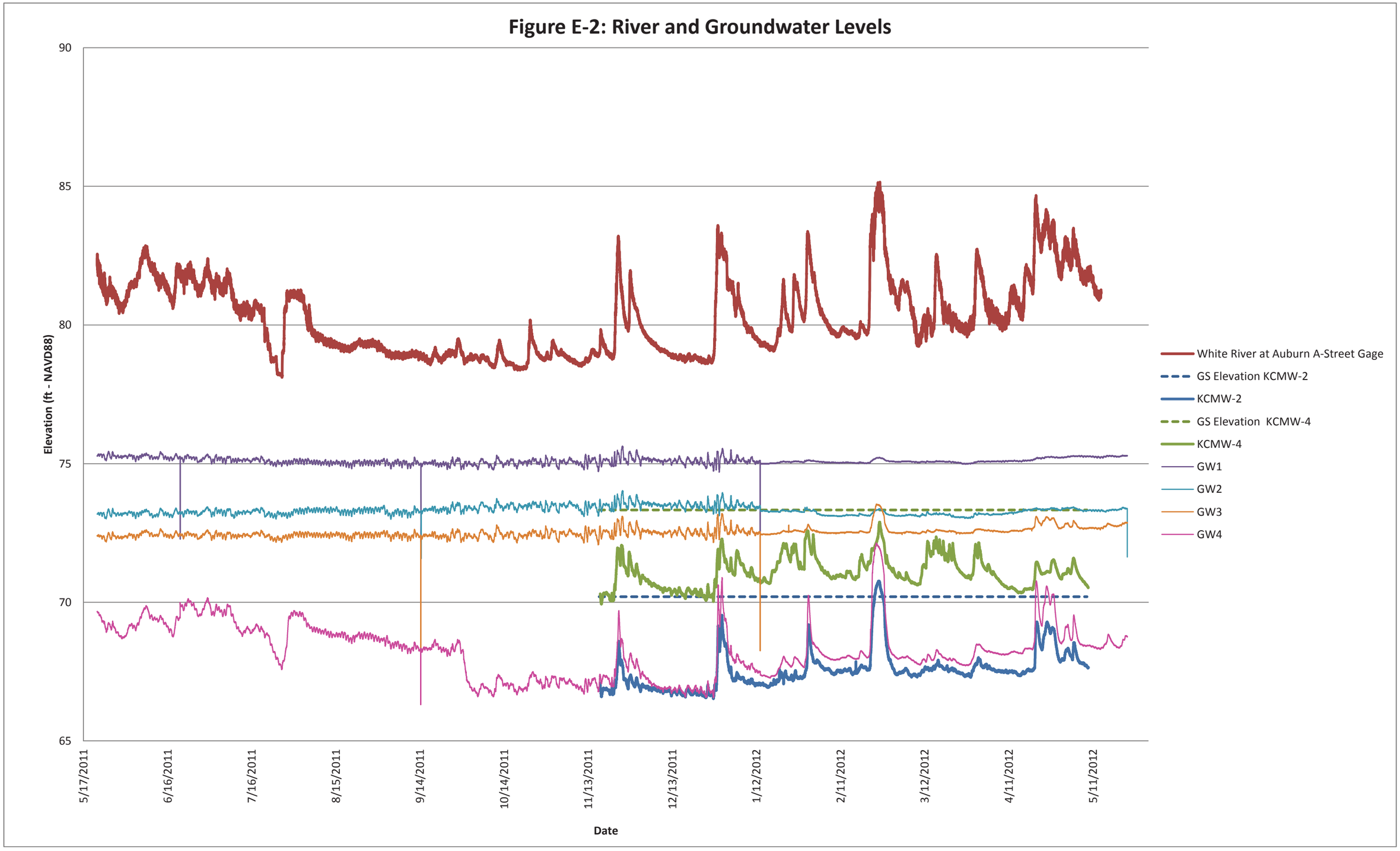
Figure E-2: River and Groundwater Levels
90
85
80
75
70
65
Elevation (ft - NAVD88)
5/17/2011
6/16/2011
7/16/2011
8/15/2011
9/14/2011
10/14/2011
11/13/2011
12/13/2011
1/12/2012
2/11/2012
3/12/2012
4/11/2012
5/11/2012
Date
White River at Auburn A-Street Gage
GS Elevation KCMW-2
KCMW-2
GS Elevation KCMW-4
KCMW-4
GW1
GW2
GW3
GW4