
Report

**Sunnyside Canal
Improvement Project
FY 2011 Check Structures
Geotechnical Report**

Prepared for
Sunnyside Valley Irrigation District

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Introduction

As part of the Sunnyside Canal Improvement Project in FY 2011, six new canal check structures are proposed at Milepost (MP) 4.30, 5.98, 7.33, 9.01, 10.18, and 12.01. These canal check structures are also known as Drops 2, 3, 4, 5, 6, and 7 on the Sunnyside Canal system. Existing check structures at these locations will be replaced by new check structures during the winter of 2011 to 2012. Drop 1 (MP 2.93) may be replaced in 2012, but was investigated as a part of the 2011 field investigation for efficiency of the field exploration program. A field exploration program was conducted in December 2010 to evaluate subsurface conditions and provide/obtain data for use in developing design recommendations for the proposed check structures. This report describes the field exploration program, summarizes the subsurface conditions, presents the laboratory and field test data, summarizes the results of engineering analyses, and provides geotechnical recommendations to be used in designing the check structures.

Limitations

This report has been prepared for the exclusive use of the Sunnyside Valley Irrigation District—for specific application to the FY2011 Check Structures project—in accordance with generally accepted geotechnical engineering practice. No other warranty, express or implied, is made.

The information and findings presented in this report are based on data obtained from soil borings and resistivity surveys conducted in December 2010 by CH2M HILL and subcontractors. Soil borings and resistivity data indicate subsurface conditions only at specific locations and times, and only to the depths penetrated. They do not necessarily reflect strata and water level variations that may exist between exploration locations or over time. If variations in subsurface conditions from those described are noted during construction, CH2M HILL should be notified and given an opportunity to review the design assumptions. In the event that any changes in the nature, design, or location of the components of this project are planned, the findings contained in this report should not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by CH2M HILL.

CH2M HILL is not responsible for any claims, damages, or liability associated with interpretation of subsurface data or for the reuse of subsurface data, without the express written authorization of CH2M HILL.

Subsurface Exploration and Conditions

This section summarizes the exploration program including the drilling program, site-specific subsurface soil conditions, and groundwater conditions.

Geologic Setting

Unconsolidated geologic deposits underlie the Sunnyside Canal between mileposts 2.93 and 12.01, and consist primarily of catastrophic outburst flood deposits, continental sedimentary deposits (sedimentary rocks), and possibly alluvial deposits underlying the flood deposits. Schuster (1994) and Reidel and Fecht (1994) describe these deposits in more detail:

The outburst flood deposits consist primarily of silt, sand, and minor gravel. The outburst flood deposits were deposited by catastrophic floods from glacial Lake Missoula and other ice-margin lakes, and are found along the Snake, Columbia, and Yakima rivers. The mineralogy of these materials is predominantly quartz and feldspar, with basalt in coarser sands. Stratigraphic features include rhythmically-bedded silt layers with stringers of coarse sand and gravel, clastic dikes, small-scale cross-bedding, ice-rafted clasts, and ice-melt structures present locally. The sand-dominated facies are typically planar laminated and sporadic channel-fill sequences. The silt-dominated facies are planar laminated and ripple cross-laminated, commonly displaying normal graded rhythmites. Discrete ash and tephra layers are also common throughout the flood deposits.

Based on observations of local exposures and soil boring information, the flood deposits along this reach of the canal consist primarily of interbedded fine sandy silt to fine silty sand, with layers of lean clay, and poorly graded silty sand and occasional gravels. The thickness of these deposits along this reach of the canal is not known and is likely to vary.

The continental sedimentary deposits consist of fluvial sand, silt, and clay with local gravel lenses, diatomite, and lahars. This unit is white to reddish-brown, weakly to moderately indurated, and occurs as interbeds between units of Columbia River basalt. These sedimentary rocks are exposed along the canal banks in the vicinity of Drops 2 and 3 and form cliffs on the uphill sides of the canal.

The alluvium consists of silt, sand, and gravel deposits along valley bottoms and was deposited by the Yakima River. Although the Sunnyside Canal does not cross through alluvium, the gravelly alluvial deposits may underlie the flood deposits in the vicinity of Drop 1.

The site-specific subsurface conditions, based on the drilling information, are described below.

Drilling Program

The subsurface exploration program consisted of drilling seven soil borings on December 8, 9, and 10, 2010, to depths 45 to 51.5 feet below ground surface (ft bgs). The borings were drilled along the canal access road near the locations of each proposed replacement check structure (see Site Plans in Appendix A). Drilling was conducted by Haz-Tech Drilling of Meridian, Idaho, under subcontract to CH2M HILL. A CME-75 truck-mounted rig with a 140-pound autohammer advanced the borings, using hollow-stem auger drilling techniques and split-spoon standard penetration test (SPT) sampling. The boring logs are included in Appendix B. The borings are summarized in Table 1.

TABLE 1
CH2M HILL Soil Boring Summary

Boring ID	Location	Depth Drilled (ft bgs)	Easting	Northing	Approximate Ground Surface Elevation (feet)
SCB-1-10	On canal access road upstream from existing check structure at MP 2.93	45.3			895 ^a
SCB-2-10	On canal access road approximately 1/2 mile upstream from existing check structure at MP 4.30	50.6			891.2
SCB-3-10	On canal access road upstream from existing check structure at MP 5.98	51.3			892.12
SCB-4-10	On canal access road upstream from existing check structure at MP 7.33	51.5			889.27
SCB-5-10	On canal access road upstream from existing check structure at MP 19.01	51.5			887.47
SCB-6-10	On canal access road upstream from existing check structure at MP 10.18	51.5			885.14
SCB-7-10	On canal access road upstream from existing check structure at MP 12.01	51.5			882.24

Note: Horizontal coordinates based on Washington State Plane Coordinates—Washington South. Elevations are based on NGVD 29 vertical datum, and shown on the Site Plan for each check structure.

^a Drop 1 location (or SCB-1-10) was not surveyed. Elevation listed is approximated from existing mapping.

Laboratory Testing Program

A limited laboratory testing program was performed to confirm field classifications, evaluate compaction characteristics, and evaluate corrosion properties. Laboratory tests performed on samples collected from the borings are as follows:

- ASTM D 2216, Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock
- ASTM D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils
- ASTM D 1140, Standard Test Method for Amount of Material in Soils Finer Than the No. 200 (75 μ m) Sieve
- AASHTO T-288, 289 pH and Resistivity of Soils
- EPA 300, Chloride and sulfates

A summary of the laboratory test results is provided in Table 2. The original laboratory test results are provided in Appendix C.

TABLE 2
Summary of Laboratory Test Results

Borehole/Sample ID	Depth (ft)	Soil Type (USCS)	Moisture Content (%)	Atterberg Limits (%)		Gradation			pH	Chloride (mg/kg)	Sulfate (mg/kg)
				LL	PI	% Gravel	% Sand	% Fines			
SCB-1-10, SS-2	10.0	ML	20.8			0	31	69			
SCB-1-10, SS-3	15.0	CL-ML		26	21						
SCB-1-10, SS-5	25.0	ML	33.0	27	1						
SCB-1-10, SS-6	30.0	GP				58	33	9			
SCB-2-10, SS-2,3	10.0-15.0	ML/CL	23.0						6.3		
SCB-2-10, SS-5	25.0	SM				38	42	20			
SCB-3-10, SS-3,4	15.0-20.0	ML/CL	27.4							ND	7.90
SCB-3-10, SS-7	37.0	SC				3	71	26			
SCB-3-10, SS-9	45.0	SC	24.1	31	2			33.8			
SCB-4-10, SS-5	25.0	SM		38	3						
SCB-5-10, SS-2,3	10.0-15.0	ML	20.6						6.0	ND	22.4
SCB-5-10, SS-4,5	20.0-25.0	ML	27.2	23	1						
SCB-6-10, SS-3	15.0	ML/CL	29.0								
SCB-6-10, SS-4	20.0	CL-ML		24	4	0	0	88			
SCB-6-10, SS-8	40.0	SP				41	49	10			
SCB-7-10, SS-2	10.0	ML							6.8		
SCB-7-10, SS-3	15.0	ML/SP/SM	13.4							ND	21.7
SCB-7-10, SS-7	35.0	SM				0	72	28			

Notes:

ND = Non-Detect

LL = Liquid Limit

PL = Plastic Limit

PI = Plasticity Index

CL = Lean Clay

ML = Silt

SP = Poorly-Graded Sand

SM = Silty Sand

SC = Clayey Sand

GP = Poorly-Graded Gravel

USCS = Unified Soil Classification System

The relative percentages for gravel, sand, and fines were noted in Table 2. Gravel is defined as material with a particle size ranging from approximately 4.75 mm (3/16 inch, or U.S. #4 sieve size) up to 75 mm (3 inches) in diameter. Sand-sized particles range in diameter from 0.075 mm (U.S. #200 sieve) up to the U.S. #4 sieve. Fines are silt and clay particles smaller than the U.S. #200 sieve.

Subsurface Conditions

The subsurface materials observed during the field exploration varied somewhat between each proposed check structure location. Subsurface materials encountered during the investigation included primarily sandy silts, silty sands, clay, caliche-like material, and gravels. The subsurface conditions found at each proposed check structure are described below. Because the borings were drilled on the canal access road, the depths to the layers are below the elevation of the access road.

Standard Penetration Tests (SPT) were conducted at 5-foot intervals during the exploration. As part of this test, the SPT N-value is logged and noted on the boring logs (Appendix B). N-values are measured as the number of blows required to drive the sampler the last 12 inches in each 18-sample interval. Refusal is noted as "R," and is the condition in which the sampler is driven less than 6 inches after 50 blows, or greater than 6 inches but less than 12 inches after 100 blows.

The boring logs are included in Appendix B. The Site Plan for each structure shows the locations of the borings relative to the proposed check structures. A general description and tabular summary of subsurface conditions (along with N-values) are provided in the tables for each check structure.

MP 2.93 (Drop 1)

Boring SCB-1-10 was drilled to a depth of 45.3 feet on the south side of the canal near the existing check structure. The upper silt layer was used to construct the canal berm. Field resistivity testing indicated that the soils beneath the canal bottom in this vicinity are non-corrosive to mildly corrosive. The following is a description of the soil layers:

TABLE 3
MP 2.93 (Drop 1) Soil Layers

Depth (feet)	Soil Description	N-Value	Density/Consistency
0 - 27	Brown, moist, low-plasticity silt	4 - 10	Soft to stiff
27 - 45.3	Gray, wet, poorly-graded gravel with silt and sand	50/3"	Very dense

Note: contacts between soil layers that are between SPT samples are approximate.

MP 4.30 (Drop 2)

Boring SCB-2-10 was drilled to a depth of 50.6 ft on the south side of the canal approximately 1/2 mile upstream from the existing check structure, since it is proposed to construct the new structure at this location. The canal berm was constructed from the upper silt and clay layers. Field resistivity testing indicated that the soils beneath the canal bottom in this vicinity are moderately corrosive. The following shows a description of the soil layers:

TABLE 4
MP 4.30 (Drop 2) Soil Layers

Depth (feet)	Soil Description	N-Value	Density/Consistency
0 - 8	Brown, moist, low-plasticity clay	5	Firm
8 - 18	Brown, moist, stratified silt with sand and lean clay	5	Firm
18 - 23	Brown, moist, silty fine sand	9	Loose
23 - 28	Brown, moist, silty and sandy gravel	25	Medium dense
28 - 33	Gray to brown, moist, silt	17	Very stiff
33 - 43	Gray to brown, moist, interbedded silt and clayey sand with gravel	30 - 36	Very stiff to dense
43 - 50.6	Brown to gray, wet, sand, silt and gravel	48, R	Dense to very dense

Note: contacts between soil layers that are between SPT samples are approximate.

MP 5.98 (Drop 3)

Boring SCB-3-10 was drilled to a depth of 51.3 feet on the south side of the canal near the existing check structure. The canal berm was constructed from the upper silty material. The clayey residual soil is either caliche or continental sedimentary rock. Field resistivity testing indicated that the soils beneath the canal bottom in this vicinity are highly corrosive. The following shows a description of the soil layers:

TABLE 5
MP 5.98 (Drop 3) Soil Layers

Depth (feet)	Soil Description	N-Value	Density/Consistency
0 - 18	Brown, moist to wet, non-plastic silt	8 - 15	Firm to stiff
18 - 28	Mottled white to brown, moist, lean clay with residual blocky soil texture	40 - R	Hard
28 - 43	Brown, moist to wet lean clay with sand with blocky structure and slight induration	R	Hard
43 - 51.3	Brown, moist to wet, clayey sand with sandy interbeds	48 - R	Dense to very dense

Note: contacts between soil layers that are between SPT samples are approximate.

MP 7.33 (Drop 4)

Boring SCB-4-10 was drilled to a depth of 51.5 feet on the south side of the canal near the existing check structure. The canal berm was constructed from the upper silty material. The clayey residual soil is either caliche or continental sedimentary rock. Field resistivity testing indicated that the soils beneath the canal bottom in this vicinity are moderately to highly corrosive. The following is a description of the soil layers:

TABLE 6
MP 7.33 (Drop 4) Soil Layers

Depth (feet)	Soil Description	N-Value	Density/Consistency
0 - 24.5	Brown, moist non-plastic silt, rapid dilatancy	9 - 20	Stiff to very stiff
24.5 - 35	Mottled white to tan, moist, caliche that breaks down into silty sand to lean clay	55	Very dense to hard
35 - 43	Brown, wet low-plasticity sandy lean clay	34 - 35	Hard
43 - 51.5	Tan to brown, moist, lean clay with clayey sand layers	31 - 33	Hard

Note: contacts between soil layers that are between SPT samples are approximate.

MP 9.01 (Drop 5)

Boring SCB-5-10 was drilled to a depth of 51.5 feet on the south side of the canal near the existing check structure. The canal berm was constructed from the upper silty material. Field resistivity testing indicated that the soils beneath the canal bottom in this vicinity are moderately to extremely corrosive, due to the presence of fat clay. The following is a description of the soil layers:

TABLE 7
MP 9.01 (Drop 5) Soil Layers

Depth (feet)	Soil Description	N-Value	Density/Consistency
0 - 27	Brown, moist, non-plastic to low-plasticity silt with rapid dilatancy	6 - 11	Firm to stiff
27 - 34	White to tan, wet, weathered caliche that breaks down into silty sand	20	Medium dense
35 - 51.5	Tan-brown, moist to wet, medium- to high-plasticity lean clay to fat clay	19 - 21	Very stiff

Note: contacts between soil layers that are between SPT samples are approximate

MP 10.18 (Drop 6)

Boring SCB-6-10 was drilled to a depth of 51.5 feet on the south side of the canal near the existing check structure. The canal berm was constructed from the upper silty material. Field resistivity testing indicated that the soils beneath the canal bottom in this vicinity are moderately corrosive. The following is a description of the soil layers:

TABLE 8
MP 10.18 (Drop 6) Soil Layers

Depth (feet)	Soil Description	N-Value	Density/Consistency
0 - 39	Interbedded and stratified brown, moist to wet, non-plastic to low-plasticity sandy silt, silt, and lean clay	9 - 19	Stiff to very stiff
39 - 50	Dark gray, wet, gravel with sand to clayey gravel	38 - R	Medium dense to very dense
50 - 51.5	Brown, wet, low-plasticity silt	22	Very stiff

Note: contacts between soil layers that are between SPT samples are approximate

MP 12.01 (Drop 7)

Boring SCB-7-10 was drilled to a depth of 51.5 feet on the southeast side of the canal near the existing check structure. The canal berm was constructed from the upper silty material. Field resistivity testing indicated that the soils beneath the canal bottom in this vicinity are non-corrosive to moderately corrosive. The following is a description of the soil layers:

TABLE 9
MP 12.01 (Drop 7) Soil Layers

Depth (feet)	Soil Description	N-Value	Density/Consistency
0 - 31	Brown, moist to wet, nonplastic to low plasticity silt with interbedded sandy silt and silty sand, with a thin caliche layer at 31 feet bgs	11 - 30	Stiff to very stiff
31 - 50	Brown, moist to wet, silty sand	20 - 44	Medium dense to very dense

Note: contacts between soil layers that are between SPT samples are approximate

Groundwater Conditions

Preliminary groundwater levels were measured in the boreholes at the completion of drilling. In general, during the time of the field exploration, groundwater levels measured in the boreholes ranged from approximately 20 to 40 feet bgs. These depths should only be regarded as preliminary information because water levels in boreholes can vary significantly from the static water level in the subsurface. No piezometers or standpipes were installed in the borings to measure long-term static groundwater levels. Also, water levels vary at different times of year. In irrigated areas, groundwater levels typically rise with the onset of irrigation season, and then fall during non-irrigated periods. At the time of the subsurface exploration, the canal was dry, and during irrigation season leakage from the canal may influence the groundwater level by recharging shallow groundwater. In addition, irrigation water that percolates in the vicinity is likely to have an influence on local shallow groundwater levels.

Corrosion Potential

Corrosion of buried steel usually results from an electrochemical reaction between the metal and water or moist soil. The reaction is referred to as electrochemical because electrical currents and chemical reactions occur simultaneously. Corrosion in the form of pitting or thinning of the metal surface occurs when atoms of solid metal ionize and dissolve in the environment. An electrical current flows between the anodic (corroding) areas and cathodic (non-corroding) areas. The probable intensity of corrosion can be estimated by measuring the electrical conductance of the soil.

The electrical conductance of the soil is commonly measured as its inverse, which is known as resistivity. Low resistivity values are interpreted as corrosive to exposed metal surfaces. In general, the relationship between soils and resistivity values are presented in Table 10.

TABLE 10
Relationship between Soils and Resistivity Values

Soil Resistivity (ohm-cm)	Corrosivity Rating
>20,000	Essentially non-corrosive
10,000 to 20,000	Mildly corrosive
5,000 to 10,000	Moderately corrosive
3,000 to 5,000	Corrosive
1,000 to 3,000	Highly corrosive
<1,000	Extremely corrosive

Concrete is normally deteriorated by reaction with acidic soils or soils with high concentrations of sulfate in the groundwater. The pH value is a measure of the soil acidity. The corrosivity of the soil increases as the pH decreases. Low pH soils (less than 5) can be corrosive to concrete and cement mortar coatings. The potential for corrosion decreases as the soil pH increases (pH greater than 7).

The check structure sites were field tested for soil resistivity and laboratory tested for pH in order to evaluate corrosion potential – in particular to evaluate concerns of corrosion of the steel sheet pile cutoff walls that will be constructed as part of the check structures. The field resistivity tests were conducted using a Nilsson Model 400 4-Pin Soil Resistance Meter. The 4-pin method measures the voltage drop across a distance, and thus provides an average resistance at a depth based on the spacing of the pins.

Field Electrical Resistivity Measurements

The site conditions at the time of the field investigation were excellent for field resistivity measurements. The canals were dry at the time and therefore the measurements were conducted along the bottom of the canal, in a direction parallel with the canal. Some of the test locations had partial snow cover or areas of standing water. The underlying silty and sandy soils were moist to wet; which helped to provide optimal contact between the pins and the soil. The field resistivity measurements were conducted by inserting the pins into the bottom of the canal at typical spacings of 5, 10, 15, and 20 feet. Using this spacing; the average resistivity values were calculated from ground surface to the depth equal to the pin spacing, and also resistivity for individual 5-foot soil layers.

The results of the 2011 field resistivity measurements indicate that the *average* soil resistivity in the upper 20 feet ranges from around 1,600 to 8,800 ohm-cm, which indicates the soils could be characterized as moderately corrosive, with layers of corrosive soils. Because of disturbance, rock armoring and sediment deposition along the canal bottom, the uppermost layer (0 - 5 feet) was not used in the averages.

Table 10 shows a summary of the field resistivity measurements. Figure 1 shows a plot of soil resistivity versus depth for each of the drop sites. The highest resistivity values (lowest corrosion potential) were seen at Drops 1 and 7, which corresponds to more granular subsurface conditions observed, including gravelly materials. The lowest resistivity values were observed at Drops 3, 4, and 5, which correspond with observed fine-grained, clayey soils at depth. The resistance of individual layers corresponds well with soil classifications, that is, the finer-grained soils typically exhibit lower resistivity and thus higher corrosion potential.

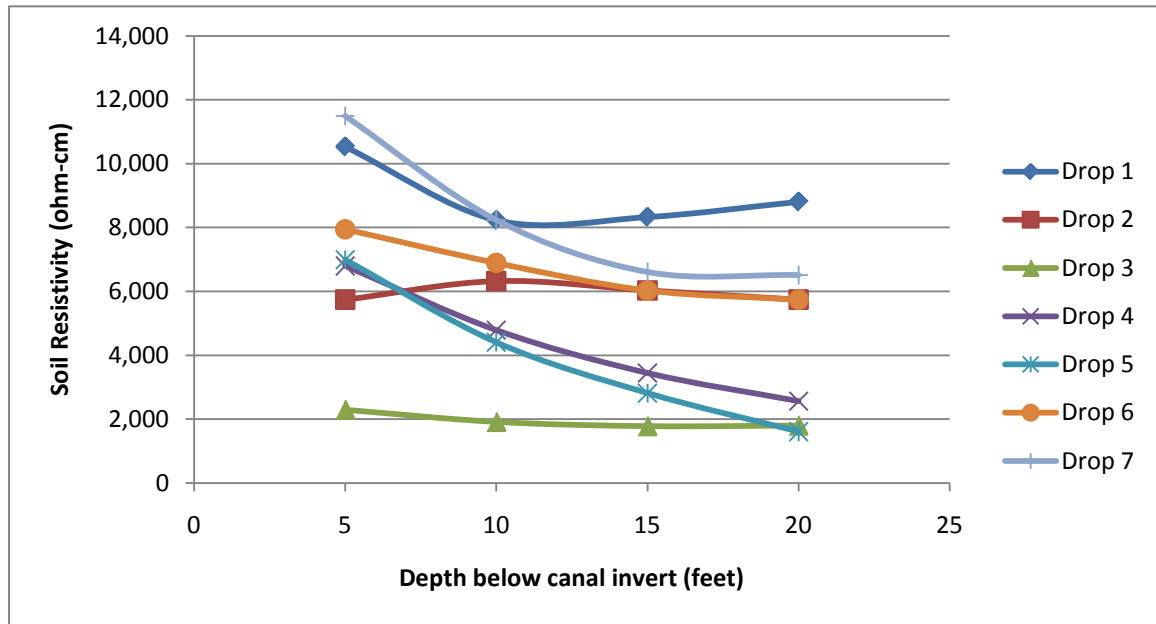


FIGURE 1
Soil Resistivity Versus Depth

The resistivity of the individual 5-foot soil layers was relatively consistent throughout the depth of the soil profile, indicating relatively consistent soil conditions. Homogenous soils tend to be less corrosive. However, the soils at check structures 4 and 5 exhibited a decrease in resistivity with depth, indicating higher corrosive potential with depth in addition to change in soil characteristics. This change in soil resistivity could increase the potential for corrosion if the soils are disturbed. The soil samples from the borings indicated moist to wet conditions. The canals were dry at the time of the field testing, with occasional pools of standing water. During irrigation season, leakage from the canals may increase saturation of the underlying soils which could increase the corrosion potential.

Laboratory testing of chloride and sulfate content indicates that the soil exhibits negligible to low potential for corrosion of concrete. The pH of the soils ranged from 6.0 to 6.8.

Conclusions

Disturbed soils are known to be corrosive at the resistivity values measured at the site. However, previous studies have shown that sheet piles driven into undisturbed soils do not experience corrosion, apparently due to more uniform corrosion conditions along the metal surface. Previous studies in similar conditions show corrosion rate of less than 1 mil/year (NBS Monograph 127, NBS Papers on Underground Corrosion of Steel Piling). These corrosion rates are usually associated with metal in the water table fluctuation zone, where oxygen is introduced to the metal surface. Surfaces below the water table exhibit even lower corrosion rates.

The design life of the check structures is 50 years. Given that the sheet piles will be approximately ½ inch thick (500 mils), and assuming a loss of 1 mil/year, this equals a loss of approximately 50 mils over the design life, or approximately 10 percent of the steel. Therefore, based on the findings from the field and pH testing, and considering that the steel sheet piles will be driven into undisturbed soils and should experience minimal

corrosion losses, corrosion protection of the sheet piles is not considered necessary. It should also be noted that the sheet piles serve the primary purpose to limit seepage beneath the structures, and are not intended to provide structural support.

Seismic Conditions

This section summarizes seismicity for the area of the check structure sites. This is a cursory summary and the reader is referred to the report titled, *Geotechnical Canal Improvement Project, MP 59.29 Reservoir*, by CH2M HILL (2004) which provides more detail of the regional seismic setting, historical seismicity, and seismic source zones for central Washington.

Seismic Hazards

Seismic hazard areas are defined by Washington State Department of Community, Trade and Economic Development (2003) as those that include areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, or surface faulting. One indicator of potential for future earthquake damage is a record of earthquake damage in the past. In Washington, ground shaking is the primary cause of earthquake damage and the strength of ground shaking is primarily affected by the following:

- The magnitude of an earthquake
- The distance from the source of an earthquake
- The type and thickness of geologic materials at the surface
- The type of subsurface geologic structure

Settlement and soil liquefaction conditions occur in areas underlain by cohesionless soils of low density, typically in association with a shallow groundwater table.

Area Seismicity

The check structures are located in a region of relatively little historic seismic activity (CH2M HILL, 2004) with few significant earthquakes having occurred within a 100-kilometer (km) (62-mile) radius of Sunnyside in recent history. There are nine historic earthquakes with a magnitude greater or equal to 4.0 that have occurred within 100-km of the site since 1973 (USGS, 2011a). The largest of these had a magnitude of 4.9 and occurred southeast of Mount Rainier, Washington in 1974, approximately 90 km northwest of the project site.

The Yakima County Critical Areas Ordinance (CAO) reports that earthquake activity in Yakima County is mostly marked by low magnitude events and thus has a low seismic risk. The earthquake potential in Yakima County is considered low to moderate. One exception is an area along Toppenish Ridge (located approximately 12 miles south of the site) where Holocene faulting may have produced earthquakes of a magnitude as great as 7. The rest of the county is relatively low risk for earthquake related damage.

Design earthquake accelerations have been determined from the probabilistic seismic hazard modeling conducted by the United States Geologic Survey (USGS) (USGS, 2011b) and adopted by the Federal Emergency Management Agency (FEMA) (FEMA, 2003), and the International Building Code (IBC) (IBC, 2009). The modeling considers known seismic sources

and the maximum credible earthquake and return interval associated with each source, including the Seattle Fault and subduction earthquakes similar to the Nisqually Earthquake.

Site-Specific Seismic Parameters

For new construction, the sites should be designed for the maximum considered earthquake, or MCE, according to the International Building Code (IBC, 2009). This earthquake event corresponds to an event having a 2 percent probability of exceedance in 50 years (or 2,500-year return period). The MCE has a peak ground acceleration (PGA) of approximately 0.21g at the bedrock surface. This value of PGA on rock is an average representation of the acceleration most likely to occur at the site for all seismic events (crustal, intraplate, or subduction). The corresponding short-period (0.2-second) spectral acceleration, S_s , is approximately 0.52g. The 1-second period spectral acceleration, S_1 , is 0.17g. The mean moment magnitude associated with these return periods is approximately magnitude 6.2. Fault sources for each type of seismic event are summarized in Table 11.

TABLE 11
MCE Source Characterization Parameters

Earthquake Source	Moment Magnitude	Epicentral Distance (miles [km])
Crustal (Including Mill Creek Thrust Fault)	5.9 - 6.9	5 - 19 [8 - 30]
Intraslab	6.9	90 [145]
Interplate	9.0	164 [264]

Note: the magnitude and distance parameters for all events are for a frequency that corresponds to the PGA.
km = kilometers

Based on IBC code, the acceleration at the surface should be amplified based on soil type and consistency. For the current subsurface information available, the check structure sites should be designed for Site Class D (stiff soil profile), according to IBC requirements for a weighted average of the soil properties (shear wave velocity or standard penetration resistance) in the upper 100 ft. This site classification results in a short period soil amplification factor, F_a , of 1.39 for Site Class D. The corresponding 1-second period soil amplification factor, F_v is 2.12.

Seepage Analysis

This section describes the methods used to analyze seepage and seepage cutoff walls.

Seepage cutoff walls are recommended for Drops 2-7 (the check structures at MP 4.30, 5.98, 7.33, 9.01, 10.18, and 12.01). Seepage and the required depth of the cutoff walls were analyzed using the flow net method. The seepage analyses are based on design maximum water levels upstream of the structures (as indicated on the preliminary drawings and design criteria) with the gates closed and a drained canal downstream. However, it should be noted that this condition is encountered infrequently and is expected to occur for a short period of time (2 or 3 days), and only in the rare event of a downstream canal dike failure.

The predominant soil type encountered at most of the check structures is non-plastic silt with sand and silty sand. Soils of these types are particularly susceptible to piping (internal erosion).

Protection against piping can be provided by seepage cutoff walls. Steel sheet piles, rather than a deep concrete cutoff wall, are recommended for seepage and piping protection under the check structures because of the presence of saturated soils in the canal bottom.

Excavation of a narrow, deep trench for a cutoff wall and placement of concrete for a cutoff wall would be difficult given these conditions. By comparison, steel sheet piles can easily be driven using a vibratory pile driver. It is recommended that the steel sheet piles for each check structure should be driven to depths adequate to achieve partial seepage cutoff as discussed below.

Flow nets were developed for the check structures using SLIDE, a two-dimensional finite element program by Rocscience, Inc., and a utility for groundwater analysis.

Analyses were performed using flow nets to check the exit gradient and uplift pressures under the structures for a variety of cutoff lengths assuming full differential head across the structure. Table 12 shows a summary of calculated exit gradient for sheet pile depths of 20 feet for the check structures.

If the soil were unconfined or unprotected (with no properly graded filter material), piping and quick conditions can begin to develop at exit gradients of about 1.0. At the point where seepage water discharges from under the structure, the exit gradient should be kept less than about 0.5.

The flow net analysis also allows uplift pressures due to seepage flow to be calculated beneath the check structures. A summary of the maximum uplift pressures beneath each check structure for the given sheet pile depth is presented in Table 12, along with estimated hydraulic exit gradient. For the check structure at MP 4.30, although the estimated exit gradient is greater than 0.5, additional measures to prevent erosion at the toe of the apron are not considered necessary. The exit gradient at this location is not significantly large (greater than 1.0) to expect piping under the limited period of time (2 or 3 days) of the design condition.

TABLE 12
Calculated Uplift Pressures and Exit Gradients

Check Structure	Cutoff Depth (feet)	Maximum Uplift (psf)	Hydraulic Exit Gradient
MP 4.30	20	328	0.675
MP 5.98	20	391	0.05
MP 7.33	20	83	0.01
MP 9.01	20	37	0.01
MP 10.18	20	124	0.01
MP 12.01	20	437	0.45

Notes:

The check structure at MP 2.93 (Drop 1) was not analyzed

Maximum uplift pressure occurs beneath the structure downstream and directly adjacent to the sheet pile and moves towards zero closer to the toe of the structure.

Geotechnical Recommendations

This section provides geotechnical recommendations for the design and construction of the check structures for the Sunnyside Canal. These recommendations include the items listed below.

- Foundation Subgrade Preparation
- Earthwork and Grading
- Allowable Bearing Pressures
- Lateral Earth Pressures for Buried Structures

Foundation Subgrade Preparation

The new check structure sites should be cleared prior to construction by removing riprap, concrete, and debris, and removing all vegetation, organic soils, and any other deleterious materials.

Site subgrade material exposed will vary depending on location and depth of excavations. Based on the borings, the native subgrade should consist of silt and sand. Foundation excavations for structures should be deep enough to expose a subgrade that is hard and non-yielding.

In general, concrete should be placed directly against native undisturbed earth. Soft areas should be excavated to firm bearing soils and replaced with suitable backfill material. Under the check structures, suitable backfill should possess low permeability to help control seepage. If a cavity must be backfilled with soil, the zone should be backfilled with densely compacted native silt or clay soils having a minimum of 50 percent passing the No. 200 sieve size and should possess a minimum compacted permeability of 1×10^{-6} cm/sec.

Earthwork and Grading

Fill material for access roads and backfill of utilities should consist of granular fill meeting the *WSDOT Standard Specifications for Gravel Borrow*, Section 9-03.14(1) with gradation altered to limit maximum particle size to 2 inches. The backfill should be placed in uniform loose layers not exceeding 10 inches in thickness prior to compaction. In areas where small hand compaction equipment is required, the backfill should be placed in lifts not exceeding 4 inches prior to compaction. The fill should be compacted to a minimum of 95 percent of the maximum dry density and within 2 percent of optimum moisture content, as determined according to ASTM D1557, and should be non-yielding.

Allowable Bearing Pressures

The recommended allowable bearing pressures are based on soil types expected to be present at the canal invert at the various check structure locations. These allowable bearing pressures are derived from presumptive bearing pressures presented in NAVFAC DM-7.2 and engineering judgment. For all check structure locations, the recommended allowable bearing pressure is 1,500 psf.

Lateral Earth Pressures for Buried Structures

Below-grade structures must be designed to resist lateral earth pressures. Three states of static soil pressure can develop on structures, based in general on the amount and direction of movement:

- At-rest state—structures that are restrained from yielding at their tops
- Active state—structures that are free to yield at their tops and that freely move away from the backfill
- Passive state—structures that are free to yield at their tops and that can move toward the backfill

For compacted backfill, structures should be designed to resist the lateral earth pressures given as equivalent fluid pressures in psf per foot (psf/ft) of height (H) in either Tables 13 or 14, depending on backfill material type. Structures should be designed to resist surcharge loads of any nearby at-grade structures, material stockpiles, or vehicles. Lateral earth pressure coefficients and equivalent fluid pressures were estimated for imported clean, free-draining crushed rock, and for the native silt material. Imported crushed rock was assumed to have a total unit weight of 135 pcf and a friction angle of 34 degrees. The silt (native material) was assumed to have a unit weight of 115 pcf and a friction angle of 28 degrees. Imported backfill may not be needed during construction, but its properties are provided here nonetheless.

TABLE 13
Imported Backfill—Lateral Earth Pressure Summary

Condition	Coefficient ^a	Horizontal Ground		Sloping Ground (2H:1V)	
		Drained (psf/ft)	Undrained (psf/ft)	Drained (psf/ft)	Undrained (psf/ft)
At-rest	0.44/0.69	60	94	93	112
Active	0.28/0.45	38	83	61	95
Passive	3.54/2.20	478	320	297	222

^a Coefficients are listed for horizontal ground/sloping ground. Rankine's method was used to determine earth pressure coefficients.

TABLE 14
Native Silt—Lateral Earth Pressure Summary

Condition	Coefficient ^a	Horizontal Ground		Sloping Ground (2H:1V)	
		Drained (psf/ft)	Undrained (psf/ft)	Drained (psf/ft)	Undrained (psf/ft)
At-rest	0.50/0.78	61	90	95	106
Active	0.33/0.60	42	81	83	100
Passive	3.0/1.67	318	208	159	135

^a Coefficients are listed for horizontal ground/sloping ground. Rankine's method was used to determine earth pressure coefficients.

Where softer silt and clay soils are encountered, they should be overexcavated and replaced with compacted low permeability material, or granular backfill if approved by the Owner.

Substantial movement must take place before the total available passive pressure is mobilized. A value of passive pressure one-third to one-half of the total passive pressure should be used when calculating resistance to thrust or sliding to limit the amount of movement. The reduced value depends on the amount of movement allowed by the structural designer.

Active earth pressures should be used only when the structure is free to move by translation or rotation at least $0.002 \cdot H$, where H is the total height of soil above the bottom of the wall. Where the wall cannot move, at-rest earth pressures should be used. Movement of about $0.02 \cdot H$ is required to mobilize full passive resistance. Buoyant unit weights for soils pressures should be used in computing lateral earth pressures, and full hydrostatic pressures should be applied.

Coefficient of Friction

For cast-in-place concrete bearing on compacted granular backfill (assuming an internal friction angle equal to 34 degrees), a friction coefficient of 0.55 should be used to calculate sliding resistance to lateral loads. For footings cast directly on compacted native soil, the friction coefficient is summarized in Table 15 by structure location.

TABLE 15
Coefficients of Interface Friction of CIP Concrete on Native Soil

Check Structure	Soil Type	Coefficient of Interface Friction ($\tan \delta$)
MP 2.93	Silt	0.35
MP 4.30	Clay	0.30
MP 5.98	Silt	0.35
MP 7.33	Silt	0.35
MP 9.01	Silt	0.35
MP 10.18	Silt and Clay	0.30
MP 12.01	Silt	0.35

At locations where the sliding friction is too low to resist forces, overexcavation of the silt or clay and replacement with compacted granular backfill may be preferable to improve the coefficient of friction and passive lateral resistance. Granular backfill must include 10 to 15 percent fines, in order to limit the permeability of this material as much as possible, and it should not be used continuously beneath any structure from an upstream face to a downstream face. If this approach is used in the design analysis, the potential for shearing and sliding along the granular backfill/native soil interface should be checked to ensure structural stability. An angle of internal friction of 28° may be assumed for analyzing shearing and sliding at the granular backfill/native soil interface, or within the native soil (that is, the coefficient of friction is equal to 0.53).

Construction Considerations

Construction Sequence

Construction of the FY 2011 check structures is anticipated to occur in the winter of 2011 to 2012. The following items generally define the critical path.

- Mobilization by Contractor.
- Demolition of the existing check structures, by the Owner.
- Excavation of the trench for sheet pile installation, by the Owner.
- Drive in steel sheet pile cutoff wall, by the Owner.
- Excavate downstream cutoff wall trench, by the Contractor.
- Place concrete for sheet pile cutoff wall and downstream cutoff wall, by the Contractor.
- Grading of the area between the cutoff walls by slight removal or filling, by the Contractor.
- Placing a concrete slab between the two cutoff trenches, by the Contractor.
- Placement of the concrete walls.
- Installation of the Langeman gate, by the Owner.
- Construction of the walkway, by the Owner.
- Gate control box installation, electrical wiring and installation of controls, by the Owner.
- Canal grading and shaping, by the Contractor.
- Canal lining and erosion protection, by the Owner.

Dewatering

Dewatering of the construction zones is recommended at sites where saturated fine-grained soils, particularly silts, exist at or near the surface. Previous experience in the area has shown that fine-grained soils may be seasonally saturated and at a natural moisture content that is twice as much as the optimum moisture content for compaction. The soils are expected to be saturated with perched water for several weeks to months following the end of irrigation season. If the soils are saturated or near saturation, the soils are expected to soften and “pump” when disturbed; trafficking and earthwork, particularly compaction, will become virtually impossible. In order to work on or in these saturated soils, they must first be dewatered, and possibly disked, aerated, dried, or replaced before attempting to achieve compaction.

The least expensive method of dewatering the soils is by excavating dewatering trenches to a depth of 5 or 6 feet upstream and downstream of the work zone. If perched groundwater migrates into the work zone from the canal banks, additional trenches along the banks are recommended. It is recommended that these trenches be shown on the construction drawings in order to ensure the contractor is aware of the need. If it turns out that the soils are not saturated at the time of construction, excavation of the dewatering trenches can be waived by the construction manager. The drawing notes or specifications should also require sufficient time (up to several weeks) in the construction schedule to allow the soils in the construction zone to drain.

Sheet Pile Driving

Driving tips are recommended for driving sheet piles to construct the cut-off walls, particularly at locations where gravel or cobbles are present (refer to the boring logs). Some

relatively thin layers of caliche were also encountered at MP 9.01 and MP 12.01 which may damage sheet piles. The determination of whether to drive the sheet piles with a vibratory hammer or an impact hammer, and selection of the appropriate sheet pile section for the subsurface conditions should be considered.

Construction Access

Construction access to each of the check structures will be from the Sunnyside Canal road.

Stockpile and Staging Areas

Stockpile and staging areas are available near each of the check structures. Additional staging areas should be identified if needed for construction.

Waste Area

The Contractor will be responsible for locating suitable disposal sites as required to perform the work. The waste concrete resulting from Owner's demolition of the existing structures will be handled by the Owner.

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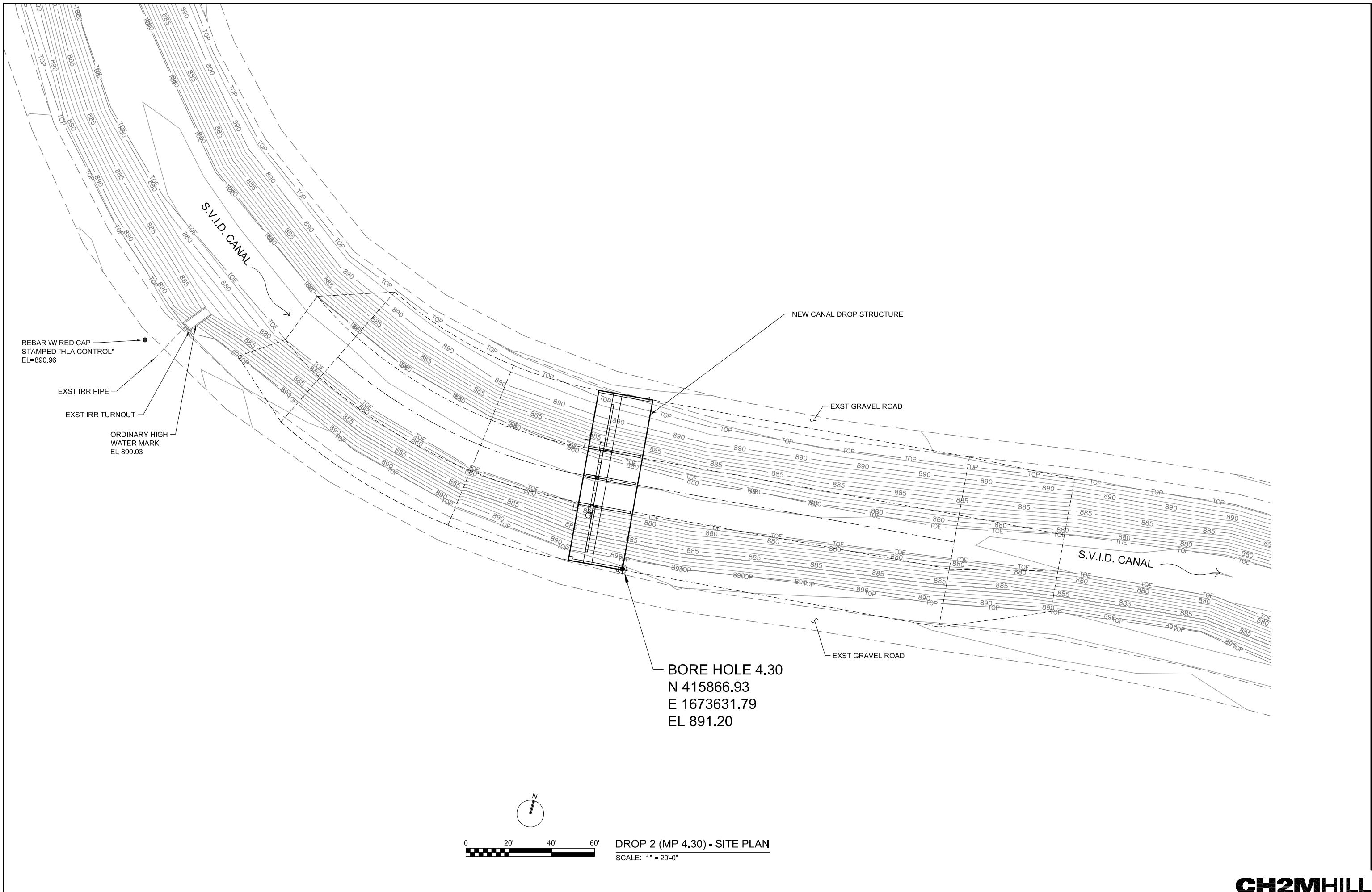
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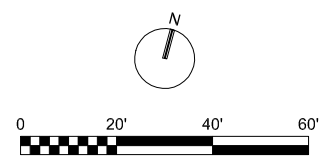
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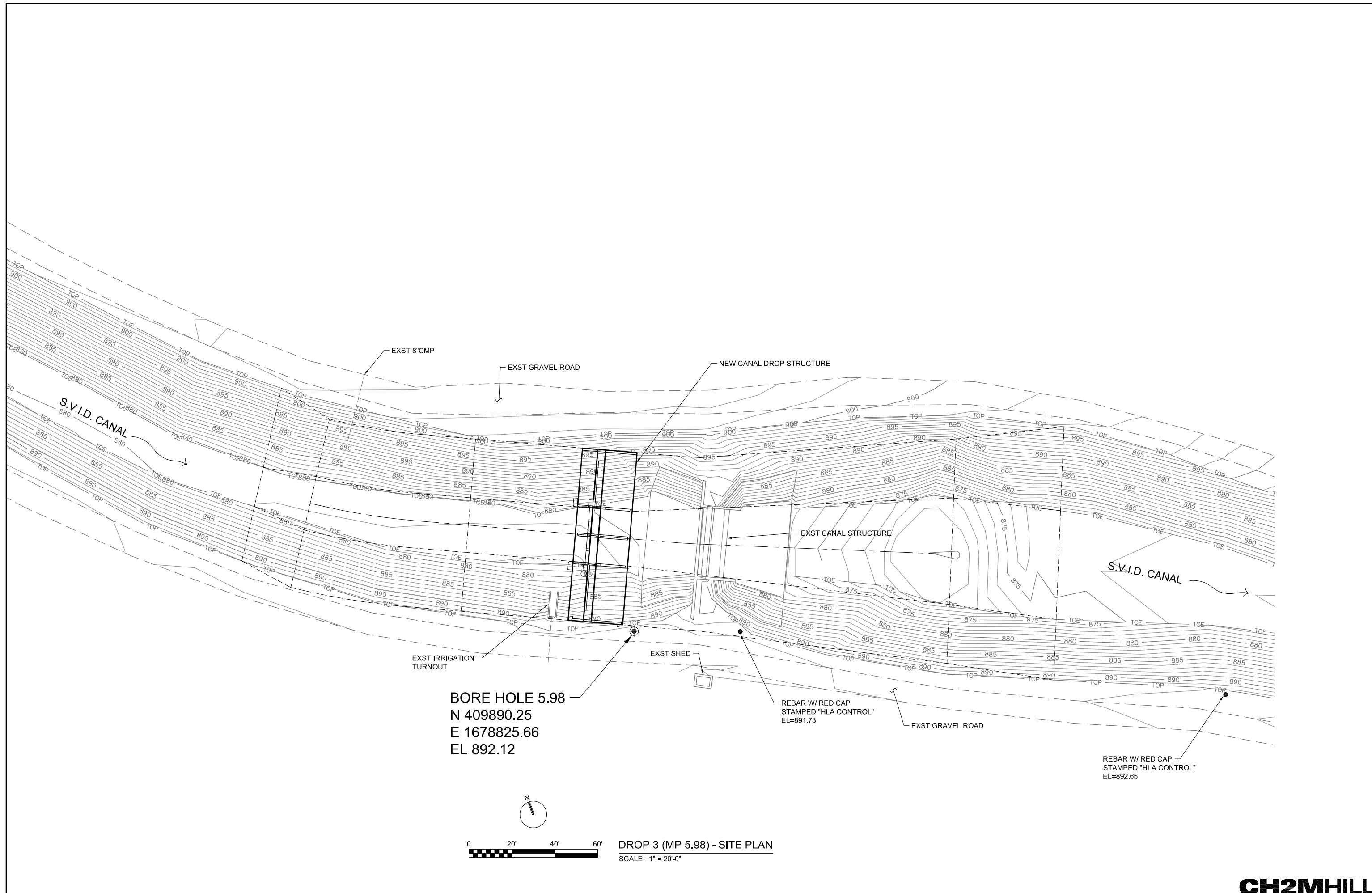
Appendix A
Site Plans



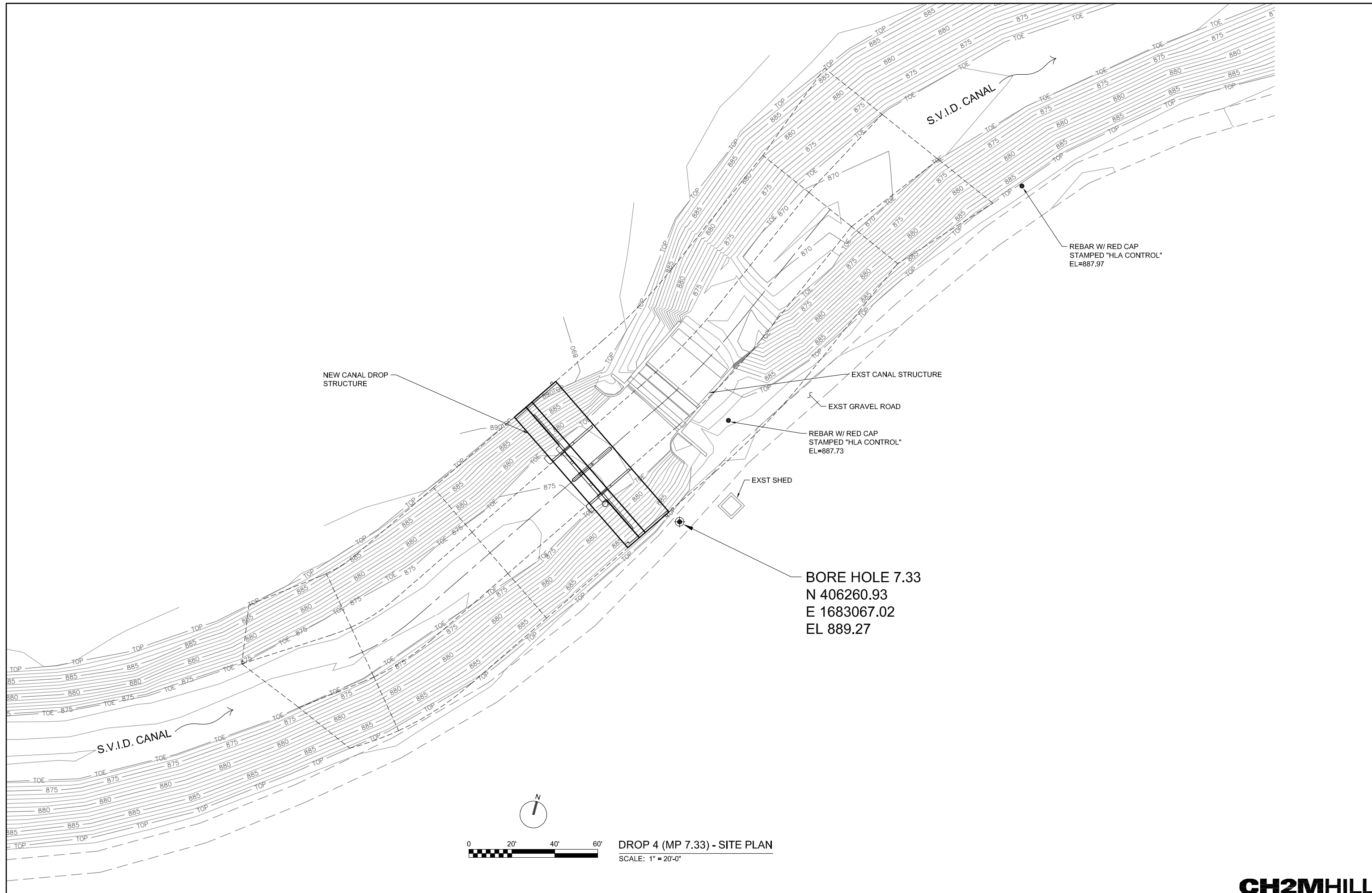
BORE HOLE 4.30
 N 415866.93
 E 1673631.79
 EL 891.20



DROP 2 (MP 4.30) - SITE PLAN
 SCALE: 1" = 20'-0"



DROP 3 (MP 5.98) - SITE PLAN
 SCALE: 1" = 20'-0"



NEW CANAL DROP
STRUCTURE

S.V.I.D. CANAL

EXST CANAL STRUCTURE

EXST GRAVEL ROAD

REBAR W/ RED CAP
STAMPED "HLA CONTROL"
EL=887.73

EXST SHED

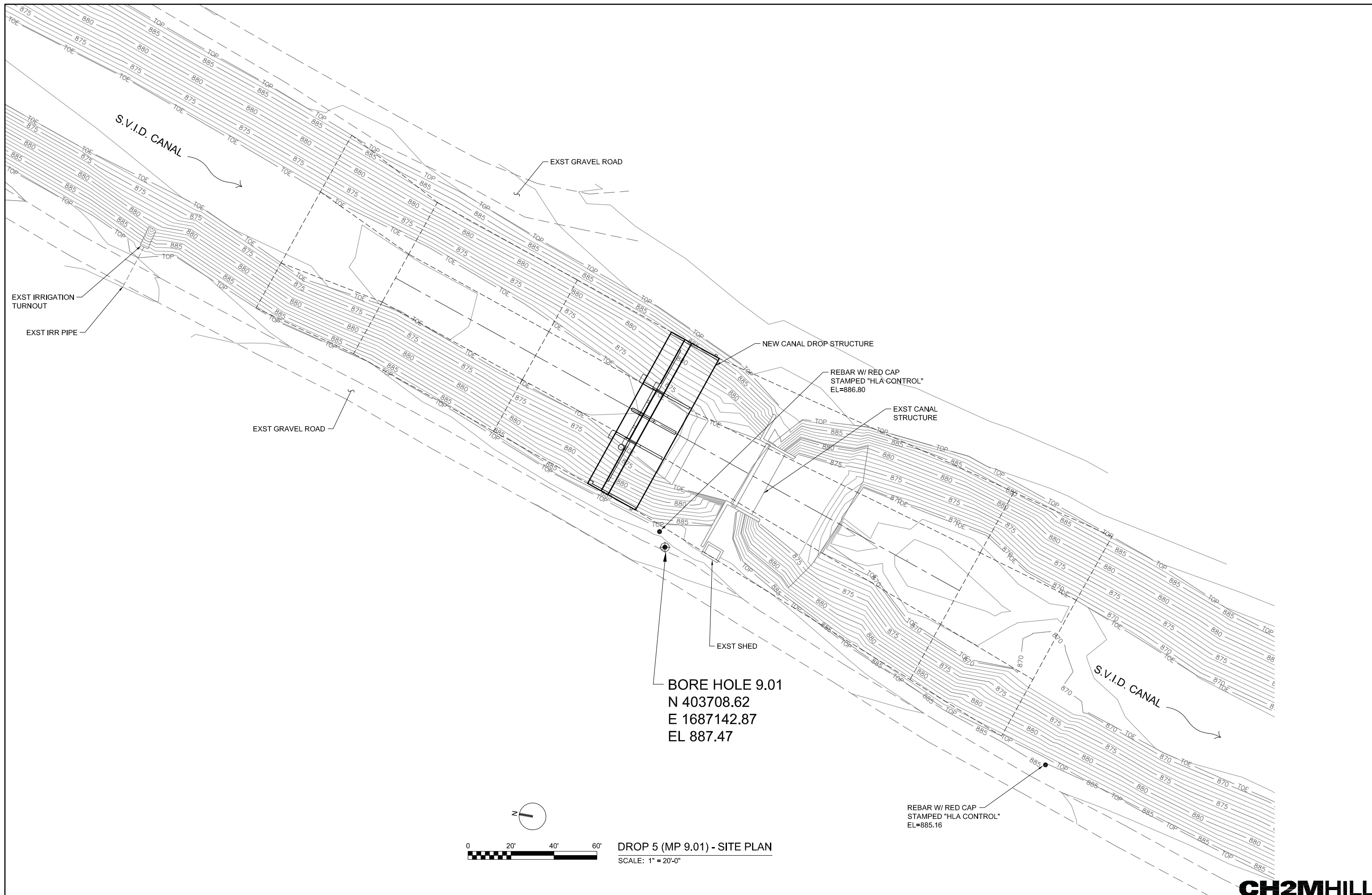
REBAR W/ RED CAP
STAMPED "HLA CONTROL"
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BORE HOLE 7.33
N 406260.93
E 1683067.02
EL 889.27

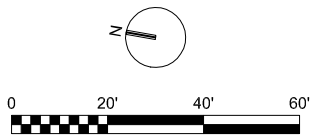
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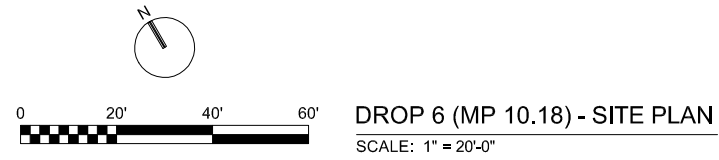
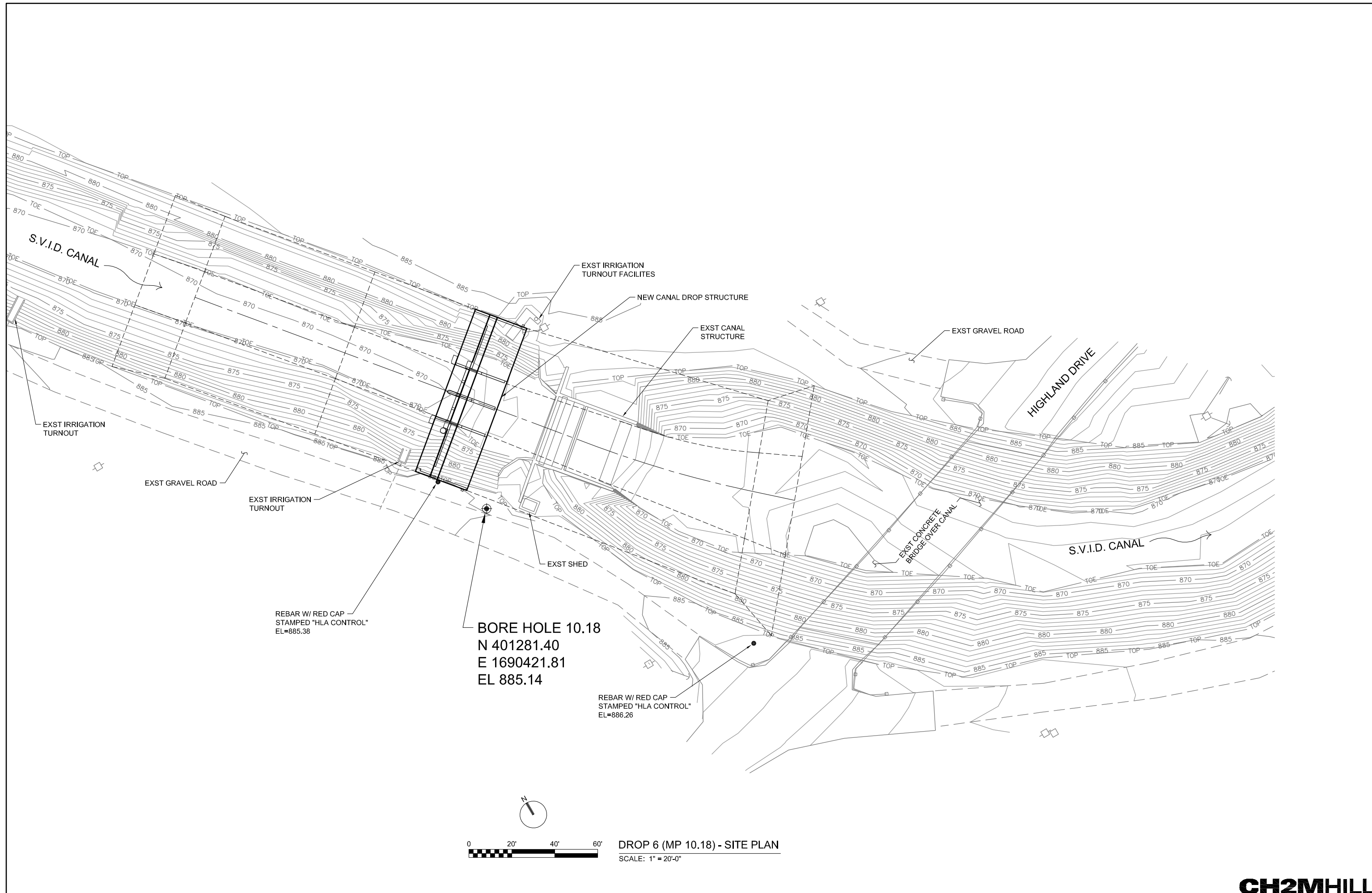
DROP 4 (MP 7.33) - SITE PLAN
SCALE: 1" = 20'-0"

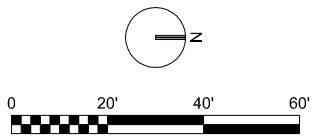
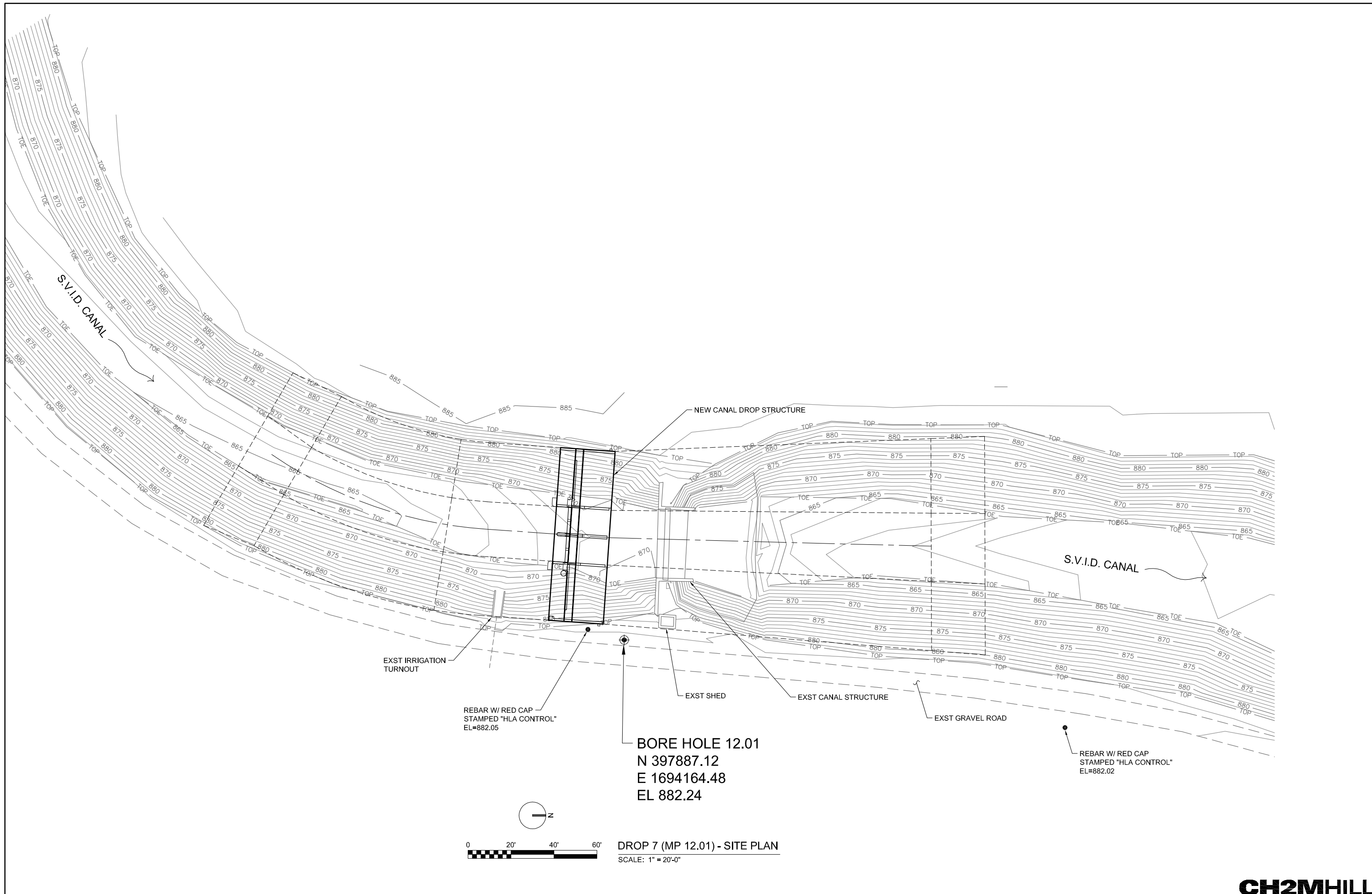


BORE HOLE 9.01
 N 403708.62
 E 1687142.87
 EL 887.47



DROP 5 (MP 9.01) - SITE PLAN
 SCALE: 1" = 20'-0"





DROP 7 (MP 12.01) - SITE PLAN
 SCALE: 1" = 20'-0"

Appendix B
Boring Logs



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-1-10	SHEET 1 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : South Side of Sunnyside Canal Access Road, Mile Post 2.93

ELEVATION : DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/10/2010 END: 12/10/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	RECOVERY (ft)	6"-6"-6" (N)				
5	5.0					PP = Pocket Penetrometer tsf = tons per square foot SPT with CME Autohammer water level not measured Note: SCB-1-10 coordinates (Elevation, Northing, Easting) not surveyed as the check structure at this location will not be constructed in 2011. Gravel = 0% Sand = 31% Fines = 69% PP = 1.25, 1.5 tsf Liquid Limit = 26 Plasticity Index = 21 PP = 1.25, 1.5, 1.5 tsf PP = 1.5, 1.25, 1.0 tsf Liquid Limit = 27 Plasticity Index = 1 Moisture = 33% PP = 1.5, 1.0, 1.25 tsf Driller notes gravelly material below 27 ft
	6.5	1.1	SS-1	2-2-2 (4)	SILT (ML), brown, moist to wet, soft, low plasticity, approximately 10-15% very fine sand	
10	10.0					
	11.5	1.2	SS-2	3-3-4 (7)	SILT (ML), similar to SS-1 except 30% sand	
15	15.0					
	16.5	1.5	SS-3	2-2-2 (4)	Clay-SILT (CL-ML), brown, moist, soft, low plasticity, homogenous	
20	20.0					
	21.5	1.5	SS-4	4-4-6 (10)	SILT (ML), dark gray-brown, moist, stiff, low plasticity	
25	25.0					
	26.5	1.5	SS-5	6-8-10 (18)	Interbedded SILT (ML) and LEAN CLAY (CL), brown, wet, very stiff, ML is non-plastic and rapidly dilatant; CL is low plasticity and slowly dilatant	



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-1-10	SHEET 2 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : South Side of Sunnyside Canal Access Road, Mile Post 2.93

ELEVATION : DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/10/2010 END: 12/10/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION	COMMENTS
	RECOVERY (ft)	60				
30.0 30.8	0.5	SS-6	15-50/4 (50/4")	POORLY GRADED GRAVEL with SILT and SAND (GP-GM), gray, wet, very dense, approximately 10% fines, gravel, fine to coarse, well-rounded	Slow rocky drilling below 30 ft Gravel = 58% Sand = 33% Fines = 9%	
35.0 35.4	0.4	SS-7	50/4 (50/4")	POORLY GRADED GRAVEL with SILT and SAND (GP-GM), gray, wet, very dense, gravel well rounded to subangular, mixed lithology		
40.0 40.3	0.0	SS-8	50/3 (50/3")	Only recovered coarse well rounded gravel piece, approximately 1" diameter	Very slow, rocky drilling	
45.0 45.3	0.1	SS-9	50/3 (50/3")	Recovered mixed lithology rounded to subangular gravel and basalt chips	Auger refusal at 45 ft Bottom of Borehole at 45.3 ft Backfill with Holeplug	
50						
55						



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-2-10	SHEET 1 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 4.30 (415866.9 N, 1673631.8 E)

ELEVATION : 891.2 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/10/2010 END: 12/10/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS	
	RECOVERY (ft)	#TYPE				6"-6"-6" (N)
5	5.0				PP = Pocket Penetrometer tsf = tons per square foot SPT with CME Autohammer water level not measured	
	6.5	1.2	SS-1	1-2-3 (5) LEAN CLAY (CL), brown, moist, firm, low plasticity		
10	10.0				Combined Sample (SS-2, SS-3) Moisture = 23% pH = 6.3 PP = 1.0, 0.75, 1.0 tsf	
	11.2	1.2	SS-2	3-2-3 (5) SILT with SAND (ML), brown, moist, firm, low to no plasticity with 15% sand		
15	15.0				PP = 0.5, 1.0, 0.5 tsf	
	16.5	1.5	SS-3	1-2-3 (5) Stratified SILT (ML) and LEAN CLAY (CL), brown, firm, low plasticity, rapidly dilatant in zones, with voidular soil structure		
20	20.0					
	21.5	1.4	SS-4	3-4-5 (9) SILTY SAND (SM), brown, moist, loose, approximately 20-40% fines. One 0.3 ft zone of SILT within sample		
25	25.0				Gravel = 38% Sand = 42% Fines = 20%	
	26.5	1.5	SS-5	9-14-11 (25) SILTY SANDY GRAVEL (GM), brown, moist, medium dense, gravel is fine- to coarse-grained and well rounded		



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-2-10	SHEET 2 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 4.30 (415866.9 N, 1673631.8 E)

ELEVATION : 891.2 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/10/2010 END: 12/10/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION	COMMENTS
	RECOVERY (ft)					
30.0	1.5		SS-6	2-6-11 (17)	SILT (ML), gray to brown-gray, moist, very stiff, low plasticity, platy horizontal breaks	PP = 2.25, 3.0 tsf
31.5						
35	1.2		SS-7	15-25-11 (36)	Interbedded SILT (ML), and CLAYEY SAND with GRAVEL (SC), brown and gray, moist, very stiff/dense, coarse sand, rounded gravel	
35.0						
36.5						
40	1.4		SS-8	5-15-15 (30)	Continued interbedded SILT (ML) and CLAYEY SAND with GRAVEL (SC), similar to SS-7, silt has few rounded gravel entrained in matrix	PP = 2.25, 2.5 tsf for ML Driller notes gravelly material from 43 to 44.5 ft
40.0						
41.5						
45	1.5		SS-9	10-14-34 (48)	POORLY GRADED SAND with SILT (SP-SM) to SILTY SAND (SM), brown-gray, wet, dense, with 15-20% fines, sand is medium- and coarse-grained	Driller notes gravelly material from 46 to 50 ft
45.0						
46.5						
50	0.5		SS-10	45-50/1 (50/1")	Sandy slough, overlying basalt in shoe; basalt is vesicular, slightly weathered, maroon-gray	Bottom of Borehole at 50.6 ft Backfill with Holeplug
50.0						
50.6						
55						



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-3-10	SHEET 1 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 5.98 (409890.3 N, 1678825.7 E)

ELEVATION : 892.1 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : 29.3 ft bgs START: 12/9/2010 END: 12/9/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION
	RECOVERY (ft)	#TYPE				
5	5.0				SILT (ML), brown, moist, firm, non-plastic	PP = Pocket Penetrometer tsf = tons per square foot SPT with CME Autohammer
	6.5	0.9	SS-1	3-4-4 (8)		
10	10.0				SILT (ML), brown, wet, firm, low to no plasticity, homogenous	
	11.5	1.1	SS-2	2-3-5 (8)		
15	15.0				SILT (ML), brown, wet, stiff, low plasticity, with approximately 5% coarse sand	Combined Sample (SS-3, SS-4) Moisture = 27.4% Chlorides = not detected Sulfates = 7.9 ppm PP = 1.0, 1.25, 1.5 tsf
	16.5	1.5	SS-3	3-7-8 (15)		
20	20.0				LEAN CLAY (CL), mottled white and brown, moist, hard, low to medium plasticity, blocky, angular structure with white calcified streaks	PP = > 4.5 tsf
	21.5	1.5	SS-4	5-15-25 (40)		
25	25.0				LEAN CLAY (CL), similar to SS-4 except harder, soil is nearly a residual soil, with rock-like structure, miniature vesicles (<1mm), cannot break some pieces with fingers	
	25.9	1.4	SS-5	28-50/5 (50/5")		



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-3-10	SHEET 2 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 5.98 (409890.3 N, 1678825.7 E)

ELEVATION : 892.1 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : 29.3 ft bgs START: 12/9/2010 END: 12/9/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION	COMMENTS
	RECOVERY (ft)	60				
30.0 30.9	1.0		SS-6	16-50/5 (50/5")	LEAN CLAY with SAND (CL), brown, moist, hard, low plasticity, approximately 15-20% medium-grained sand, lightly indurated with rock-like structure, similar to SS-5	
35 35.0 36.0	1.0		SS-7	19-50/5.5 (50/5.5")	LEAN CLAY with SAND (CL), similar to SS-6	SS-6 and SS-7 are more easily crumbled by hand than SS-5 Gravel = 3% Sand = 71% Fines = 26%
40 40.0 41.3	1.5		SS-8	6-29-50/4 (79/10")	LEAN CLAY with SAND (CL), similar to SS-7, brown, moist to wet, hard, structure slightly blocky, low-medium plasticity, with approximately 15-25% medium-grained sand	PP = 2.75, 3.5 tsf
45 45.0 46.5	1.5		SS-9	12-19-29 (48)	CLAYEY SAND (SC), brown, moist to wet, dense to very dense, approximately 25-30% fines, sand is fine- and medium-grained	Moisture = 24.1% Fines = 33.8%
50 50.0 51.3	1.5		SS-10	19-33-50/4 (83/10")	Top 6 inches: WELL GRADED SAND (SW), brown, moist, very dense Bottom 12 inches: CLAYEY SAND (SC), brown, moist, very dense, fine- to medium-grained with occasional coarse-grained sand, bottom 6 inches is weakly cemented, low-plasticity	Bottom of Borehole at 51.3 ft Backfill with Holeplug
55						



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-4-10	SHEET 1 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 7.33 (406260.9 N, 1683067.0 E)

ELEVATION : 889.3 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/9/2010 END: 12/9/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	STANDARD PENETRATION TEST RESULTS			SOIL DESCRIPTION	COMMENTS	
	INTERVAL (ft)	RECOVERY (ft)				6"-6"-6" (N)
		#TYPE				
5	5.0				SILT (ML), brown, moist, stiff, non-plastic, horizontally bedded	
	6.5	1.1	SS-1	3-4-5 (9)		
10	10.0				SILT (ML), brown, wet, stiff to very stiff, voids in soil structure (1-2 mm diameter), slow to rapid dilatancy	
	11.5	1.5	SS-2	8-7-9 (16)		
15	15.0				SILT (ML), similar to SS-2, dilatant in zones, approximately 0.2 to 0.3 ft apart	
	16.5	1.5	SS-3	4-9-11 (20)		
20	20.0				Stratified SILT (ML), similar to non-plastic SS-2, SS-3, and SILT (ML) to LEAN CLAY (CL), tan-brown, moist, very stiff, low plasticity with approximately 5% coarse-grained sand, also one 0.1 ft lens of SILTY SAND (SM)	
	21.5	1.5	SS-4	12-7-12 (19)		
25	25.0				Highly weathered CALICHE as SILTY SAND (SM), light white-tan, moist, very dense, layer contact at 25.4 ft	
	26.5	1.4	SS-5	12-20-35 (55)		

PP = Pocket Penetrometer
tsf = tons per square foot
SPT with CME Autohammer
water level not measured

PP = 2.25, 1.5, 1.75 tsf

PP = 1.0, 2.5, 2.0, 2.25 tsf

Liquid Limit = 38
Plasticity Index = 3



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-4-10	SHEET 2 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 7.33 (406260.9 N, 1683067.0 E)

ELEVATION : 889.3 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/9/2010 END: 12/9/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	STANDARD PENETRATION TEST RESULTS			SOIL DESCRIPTION	COMMENTS	
	INTERVAL (ft)	RECOVERY (ft)	#TYPE			6"-6"-6" (N)
30.0	1.5	SS-6	12-20-35 (55)	LEAN CLAY (CL), mottled white and tan, moist, hard, low to medium plasticity, few sand and fine gravel particles included, soil has weathered, blocky, residual structure		
31.5						
35	1.5	SS-7	9-17-17 (34)	SANDY LEAN CLAY (CL), brown, wet, hard, low plasticity, approximately 30-35% medium- and coarse-grained sand	PP = 2.75, 2.25 tsf	
35.0						
40	1.5	SS-8	13-15-20 (35)	SANDY LEAN CLAY (CL), similar to SS-7, sand content varies in layered zones, from approximately 20-35%		
40.0						
45	1.5	SS-9	7-12-19 (31)	Silt (ML), tan, moist, hard, low plasticity. 45.8-46.3 ft is layer of CLAYEY SAND (SC), orange and tan, wet, with approximately 25% fines	Liquid Limit = 31 Plasticity Index = 2 Moisture = 42.3% PP = 2.75 tsf	
45.0						
50	1.5	SS-10	13-15-18 (33)	LEAN CLAY (CL) to FAT CLAY (CH), tan-brown, moist, hard, medium to high plasticity		
50.0						
55					Bottom of Borehole at 51.5 ft Backfill with Holeplug	



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-5-10	SHEET 1 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 9.01 (403708.6 N, 1687142.9 E)

ELEVATION : 887.5 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/8/2010 END: 12/8/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS	
	RECOVERY (ft)	#TYPE				6"-6"-6" (N)
5	5.0				PP = Pocket Penetrometer tsf = tons per square foot SPT with CME Autohammer water level not measured	
	6.5	1.0	SS-1	2-4-2 (6)		SILT (ML), brown, moist, firm, low plasticity, horizontally bedded
10	10.0				Combined Sample (SS-2, SS-3) pH = 6.0 Chlorides = not detected Sulfates = 22.6 ppm Moisture = 20.6%	
	11.5	1.1	SS-2	2-3-6 (9)		SANDY SILT (ML), brown, moist, stiff, non-plastic, approximately 25-30% very fine-grained sand
15	15.0				very fast, consistent drilling	
	16.5	1.4	SS-3	2-6-5 (11)		SILT (ML), tan-brown, wet, stiff, low plasticity, with a blocky structure with few small voids in soil structure, rapidly dilatant
20	20.0				Combined Sample (SS-4, SS-5) Liquid Limit = 23 Plasticity Index = 1 Moisture = 27.2%	
	21.5	1.5	SS-4	2-4-7 (11)		SILT (ML) voids and rapidly dilatant, very similar to SS-3
25	25.0				PP=0.75, 1.0, 2.0 tsf	
	26.5	1.5	SS-5	2-4-7 (11)		SILT (ML), voidular and rapidly dilatant, similar to SS-3, SS-4
					Driller notes stiffer material at 27 ft	



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-5-10	SHEET 2 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 9.01 (403708.6 N, 1687142.9 E)

ELEVATION : 887.5 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/8/2010 END: 12/8/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION	COMMENTS
	RECOVERY (ft)	6"-6"-6" (N)				
30.0	1.4	SS-6	6-11-9 (20)	Highly weathered Caliche as SILTY SAND (SM) with less than 5% gravel pieces, white-tan, wet, medium dense, calcified		
31.5						
35	35.0					
	36.5	1.5	SS-7	3-11-10 (21)	LEAN CLAY (CL) to FAT CLAY (CH), tan-brown, moist to wet, very stiff, medium to high plasticity, less than 5% fine gravels	PP = 2.5, 3.5 tsf
40	40.0					
	41.5	1.5	SS-8	2-8-10 (18)	LEAN CLAY (CL) to FAT CLAY (CH), similar to SS-7	
45	45.0					
	46.5	1.5	SS-9	3-8-11 (19)	LEAN CLAY (CL) to FAT CLAY (CH), similar to SS-7, SS-8, very stiff to hard	PP = 4.25, 4.25, 4.5 tsf
50	50.0					
	51.5	1.5	SS-10	9-20-25 (45)	FAT CLAY (CH), light gray, moist, hard Contact at 50.5 ft with POORLY GRADED SAND (SP), dark gray, moist to wet, dense, clean, homogenous	SS-10 only bagged SP material
55						Bottom of Borehole at 51.5 ft Backfill with Holeplug



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-6-10	SHEET 1 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 10.18 (401281.4 N, 1690421.8 E)

ELEVATION : 885.1 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/8/2010 END: 12/8/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS	
	RECOVERY (ft)	#TYPE				6"-6"-6" (N)
5	5.0				PP = Pocket Penetrometer tsf = tons per square foot SPT with CME Autohammer water level not measured	
	6.5	0.9	SS-1	3-4-5 (9) SANDY SILT (ML), brown, moist, stiff, non-plastic, approximately 20-30% very fine-grained sand, homogenous		
10	10.0				SILT (ML), gray-brown, moist, stiff, little or no sand, non-plastic to very low plasticity, horizontally bedded	
	11.5	1.2	SS-2	3-6-7 (13)		
15	15.0				Moisture = 29% PP = 2.75, 2.75, 3.0 tsf in CL	
	16.5	1.4	SS-3	3-8-11 (19) LEAN CLAY (CL) becoming SILT (ML), brown, moist, stiff to very stiff, low plasticity at top of sample transitioning to non-plastic ML material, approximately 15% very fine-grained sand		
20	20.0				Liquid Limit = 24 Plasticity Index = 4 Clay = 14% Silt = 74%	
	21.5	1.5	SS-4	3-7-8 (15) SILT (ML), brown, moist to wet, stiff, stratified with some layers of lean clay and dilatant silt with very fine-grained sand		
25	25.0				PP = 2.0, 2.25, 2.25 tsf	
	26.5	1.5	SS-5	2-5-6 (11) LEAN CLAY (CL), tan-brown, moist to wet, stiff, low to medium plasticity, fairly homogenous except for one 0.3 ft zone at 25.8 ft that is rapidly dilatant		



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-6-10	SHEET 2 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 10.18 (401281.4 N, 1690421.8 E)

ELEVATION : 885.1 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/8/2010 END: 12/8/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	STANDARD PENETRATION TEST RESULTS			SOIL DESCRIPTION	COMMENTS	
	INTERVAL (ft)	RECOVERY (ft)	#TYPE			6"-6"-6" (N)
30.0	1.5	SS-6	2-7-7 (14)	30.0-30.6 ft and 31.0-31.5 ft is SILT (ML), brown, wet, stiff, rapidly dilatant, with few voids in soil structure 30.6-31.0 ft is LEAN CLAY (CL), similar to SS-5		
31.5						
35	1.5	SS-7	2-6-9 (15)	LEAN CLAY (CL), tan-brown, moist to wet, stiff, low to medium plasticity, homogenous, slow dilatancy		
35.0						
36.5						
40	0.8	SS-8	1-9-29 (38)	POORLY GRADED GRAVEL with SILT and SAND (GP-GM), dark gray, wet, dense, approximately 10% fines, gravel is fine to coarse, mixed lithology, rounded	Driller notes gravelly drilling 39 ft Gravel = 41% Sand = 49% Fines = 10%	
40.0						
41.5						
45	1.0	SS-9	29-50/3" (50/3")	CLAYEY GRAVEL with SAND (GC), tan to gray, wet, very dense, approximately 20% fines, rounded to subrounded	Driller notes boney, gravelly drilling between 45 and 50 ft	
45.0						
45.8						
50	1.5	SS-10	11-11-11 (22)	SILT (ML), brown, wet, very stiff, low to no plasticity, slow dilatancy		
50.0						
51.5					Bottom of Borehole at 51.5 ft Backfill with Holeplug	
55						



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-7-10	SHEET 1 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 12.01 (397887.1 N, 1694164.5 E)

ELEVATION : 882.2 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/8/2010 END: 12/8/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)			STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION	COMMENTS
	RECOVERY (ft)	#TYPE				
5	5.0					PP = Pocket Penetrometer tsf = tons per square foot SPT with CME Autohammer water level not measured Drilling on canal side of access road, near structure shed pH = 6.8 PP = 3.0 tsf Chlorides = not detected Sulfates = 21.7 ppm Moisture = 13.4% PP = 2.0, 2.25, 2.75 tsf
	6.5	1.1	SS-1	2-4-7 (11)	SILT (ML), brown, moist, stiff, non-plastic, approximately 5 to 10% very fine-grained sand, homogenous, some rootlets in shoe	
10	10.0				Continued SILT (ML), similar to SS-1 except very stiff	
	11.5	1.3	SS-2	5-10-11 (21)		
15	15.0				Stratified SILT (ML), POORLY GRADED SAND (SP), and SILTY SAND (SM), brown, moist to wet in layers, very stiff to medium dense, ML is slightly plastic, SP is very fine-grained and clean, SM is fine- to coarse-grained sand with approximately 25% fines, layers are less than 0.2 ft thick	
	16.5	1.5	SS-3	8-15-15 (30)		
20	20.0				SILT (ML), tan-brown, moist to wet, very stiff, increasing low to medium plasticity, slightly blocky and smoothed surfaces in structure, homogenous, thin layers with approximately 5% sand	
	21.5	1.5	SS-4	5-10-11 (21)		
25	25.0				SILT to SANDY SILT (ML), brown, moist to wet, stiff to very stiff, stratified, approximately 15-30% fine-grained sand, sandy silt zones are slow to rapidly dilatant, low to no plasticity	
	26.5	1.4	SS-5	5-9-9 (18)		



PROJECT NUMBER 371479.15.02	BORING NUMBER: SCB-7-10	SHEET 2 OF 2
SOIL BORING LOG		

PROJECT : Sunnyside Valley Irrigation District - Check Structures LOCATION : Sunnyside Canal, Mile Post 12.01 (397887.1 N, 1694164.5 E)

ELEVATION : 882.2 DRILLING CONTRACTOR : Haz-Tech (Jason Adams)

DRILLING METHOD AND EQUIPMENT : CME 75, Truck-Mounted, Hollow Stem Auger, 8 1/4-inch Outside Diameter

WATER LEVELS : --- START: 12/8/2010 END: 12/8/2010 LOGGER : J. Butler, P.E.

DEPTH BELOW GROUND SURFACE (ft)	INTERVAL (ft)		#TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION	COMMENTS
	RECOVERY (ft)	6"-6"-6" (N)				
30.0	1.5	SS-6	5-8-8 (16)	30.0-31.1 ft is SILT (ML), brown, wet, stiff, low plasticity, rapidly dilatant 31.1-31.5 ft is Highly weathered Caliche as SILTY SAND (SM), white-tan, moist, hard	Two separate samples SS-6A: top silt SS-6B: Caliche Driller notes slightly gravelly drilling between 31.5 and 32.1 ft	
31.5						
35	1.5	SS-7	14-27-25 (52)	POORLY GRADED SAND (SP) to SILTY SAND (SM), tan becoming brown, moist, very dense, fine-grained SP then fine- to medium-grained SM, approximately 15-20% fines, few angular fine gravel pieces in shoe	Gravel = 0% Sand = 72% Fines = 28%	
35.0						
36.5						
40	1.5	SS-8	12-23-21 (44)	SILTY SAND (SM), brown, wet, dense, similar to tip of SS-7, sand is fine- to coarse-grained and rounded, approximately 15-30% fines, approximately 5% fine angular gravel pieces, dilatant		
40.0						
41.5						
45	1.5	SS-9	4-8-12 (20)	Continued SILTY SAND (SM), brown, wet, medium dense, homogenous, rapidly dilatant, similar to SS-8		
45.0						
46.5						
50	1.5	SS-10	4-8-12 (20)	Continued SILTY SAND (SM), similar to SS-9		
50.0						
51.5						
55					Bottom of Borehole at 51.5 ft Backfill with Holeplug	

Appendix C

Laboratory Results



February 16, 2011
 File: CH2H07 S11014A

Mr. Josh Butler, P.E.
 Geotechnical Engineer
 CH2M Hill, Inc.
 322 East Front Street, Suite 200
 Boise, ID 83702

Project: Sunnyside Valley Irrigation District

LABORATORY TEST RESULT SUMMARY

Boring / Test Pit	Sample Type	Sample Depth	Moisture Content, %	Percent Fines	pH	Atterberg Limits
SCB-1-10	SS-2	10.0				
SCB-1-10	SS-3	15.0				Liquid Limit = 26 Plastic Index = 21 Fines Class: CL-ML
SCB-1-10	SS-5	25.0	33.0			Liquid Limit = 27 Plastic Index = 1 Fines Class: ML
SCB-1-10	SS-6	30.0				
SCB-2-10	SS-2,3	10.0-15.0	23.0		6.3	
SCB-2-10	SS-5	25.0				
SCB-3-10	SS-3,4	15.0-20.0	27.4			
SCB-3-10	SS-7	35.0				
SCB-3-10	SS-9	45.0	24.1	33.8		
SCB-4-10	SS-9	45.0-46.5	42.3			Liquid Limit = 31 Plastic Index = 2 Fines Class: ML

Boring / Test Pit	Sample Type	Sample Depth	Moisture Content, %	Percent Fines	pH	Atterberg Limits
SCB-5-10	SS-2,3	10.0-15.0			6.0	
SCB-6-10	SS-3	15.0	29.0			
SCB-6-10	SS-4	20.0				Liquid Limit = 24 Plastic Index = 4 Fines Class: CL-ML
SCB-6-10	SS-8	40.0				
SCB-7-10	SS-2	10.0			6.8	
SCB-7-10	SS-3	15.0				
SCB-7-10	SS-7	35.0				
SCB-4-10	SS-5	25.0-26.5				Liquid Limit = 38 Plastic Index = 3 Fines Class: ML
SCB-5-10	SS-4,5	20.0-25.0	27.3			Liquid Limit = 23 Plastic Index = 1 Fines Class: ML

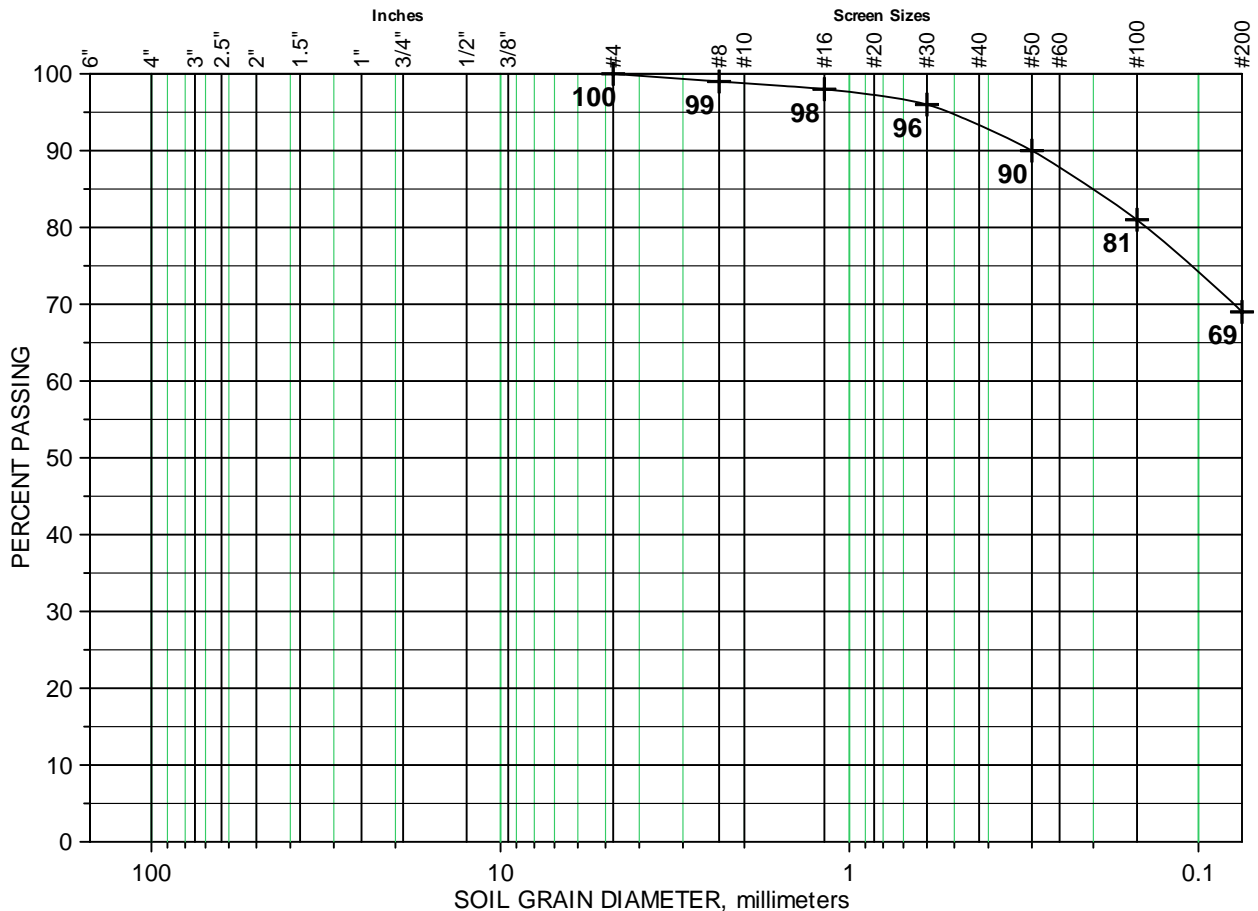


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-1-10, SS-2 @ 10.0 Feet
 Description: Sandy SILT
 Date Tested: February 8, 2011

Cobbles	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Reviewed by *Cole W. Wolf*



GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District

Client: CH2M Hill

File: CH2H07 S11014A

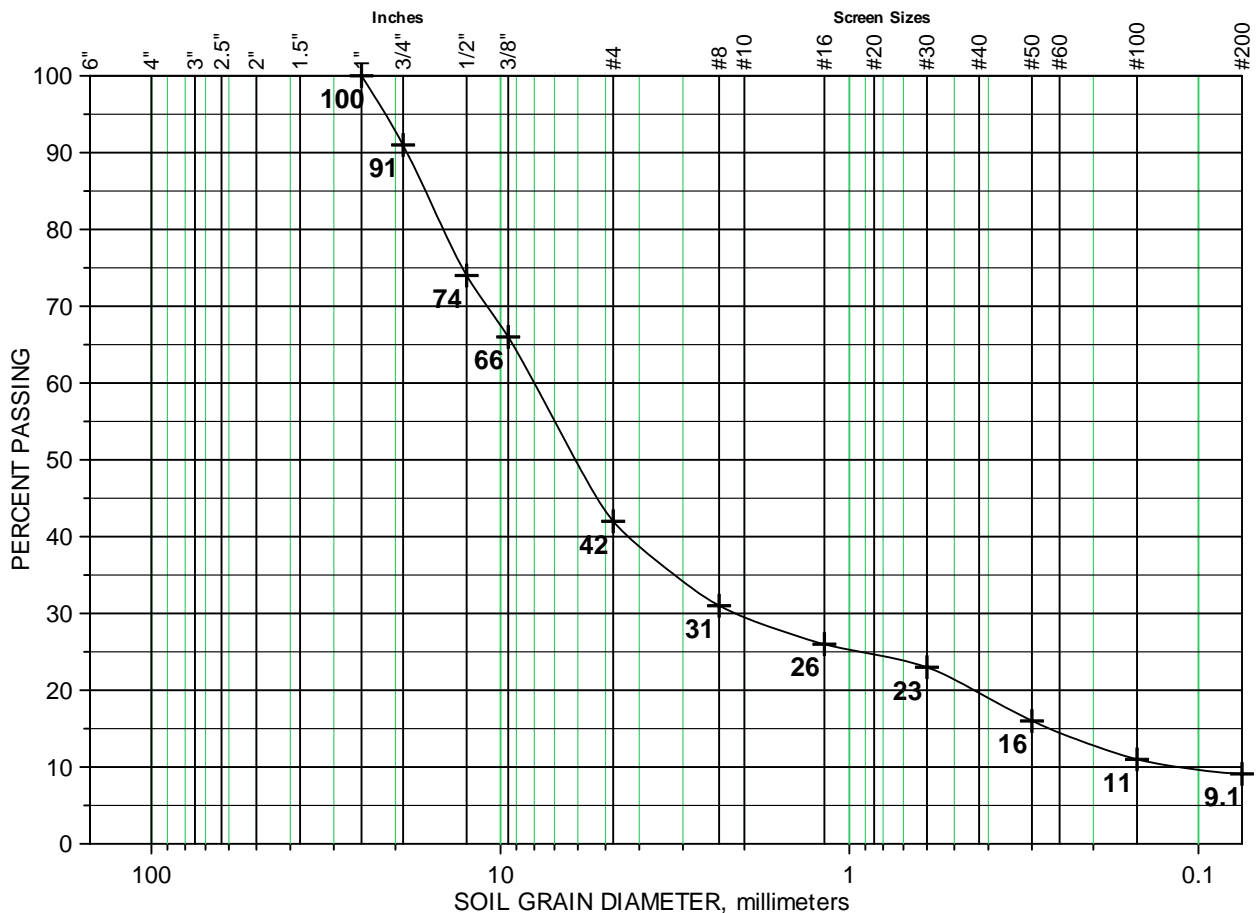
Sample No.: SL012611

Sample Location: SCB-1-10, SS-6 @ 30.0 Feet

Description: Poorly Graded GRAVEL with Sand and Silt

Date Tested: February 8, 2011

Cobbles	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Reviewed by: *Cole W. Wolf*

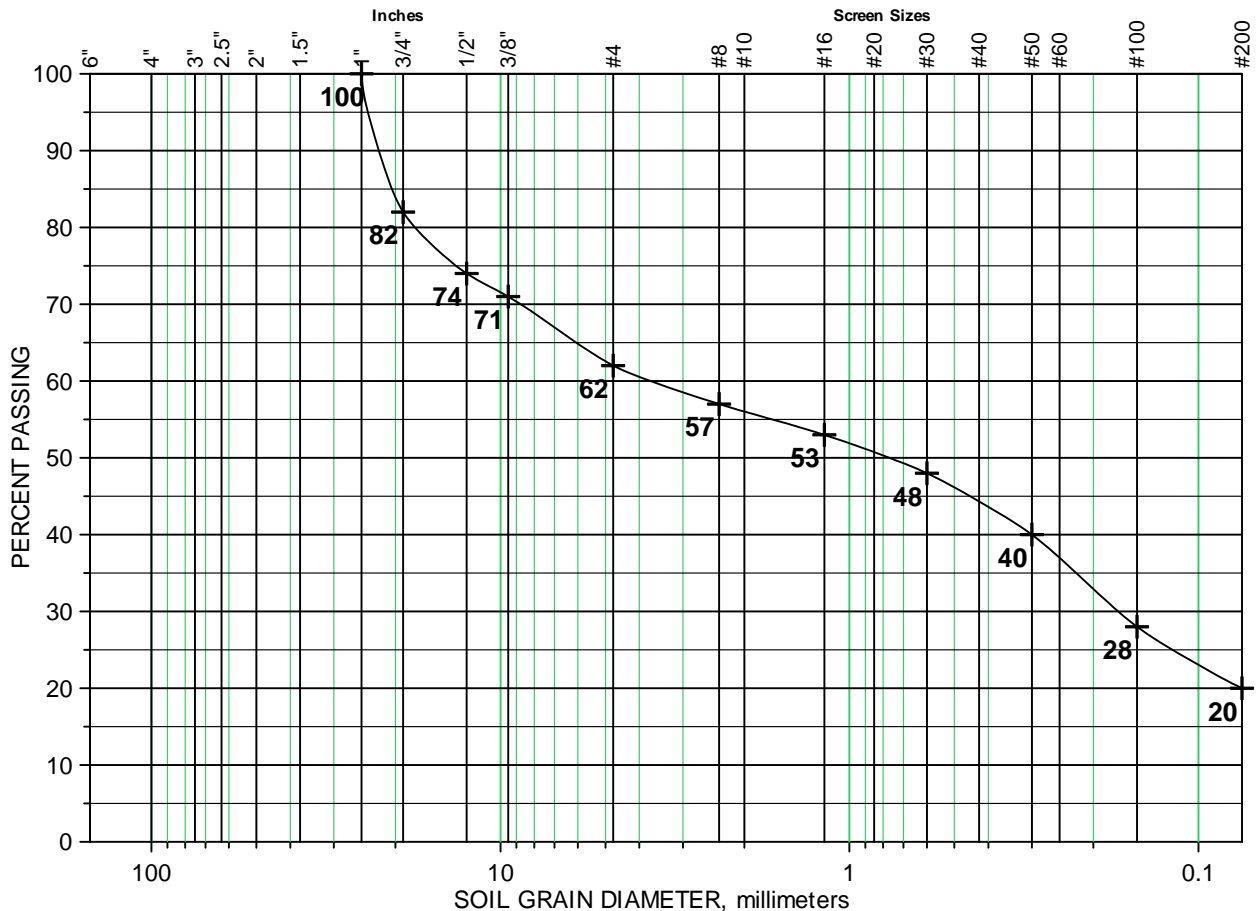


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-2-10, SS-5 @ 25.0 Feet
 Description: Silty SAND with Gravel
 Date Tested: February 8, 2011

Cobbles	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Reviewed by: *Cole W. Wolf*

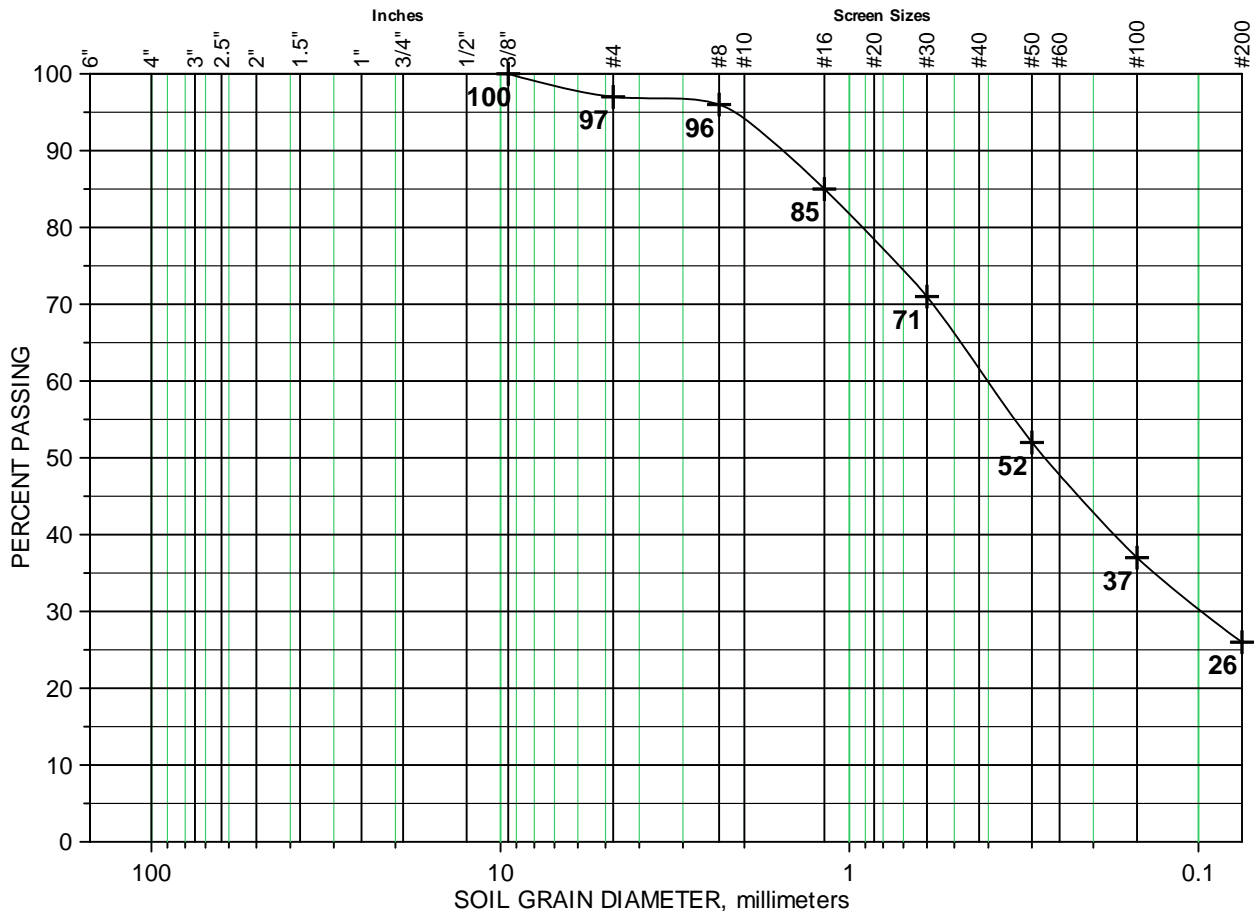


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-3-10, SS-7 @ 35.0 Feet
 Description: Clayey SAND
 Date Tested: February 8, 2011

Cobbles	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Reviewed by: *Cole W. Wolf*



GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District

Client: CH2M Hill

File: CH2H07 S11014A

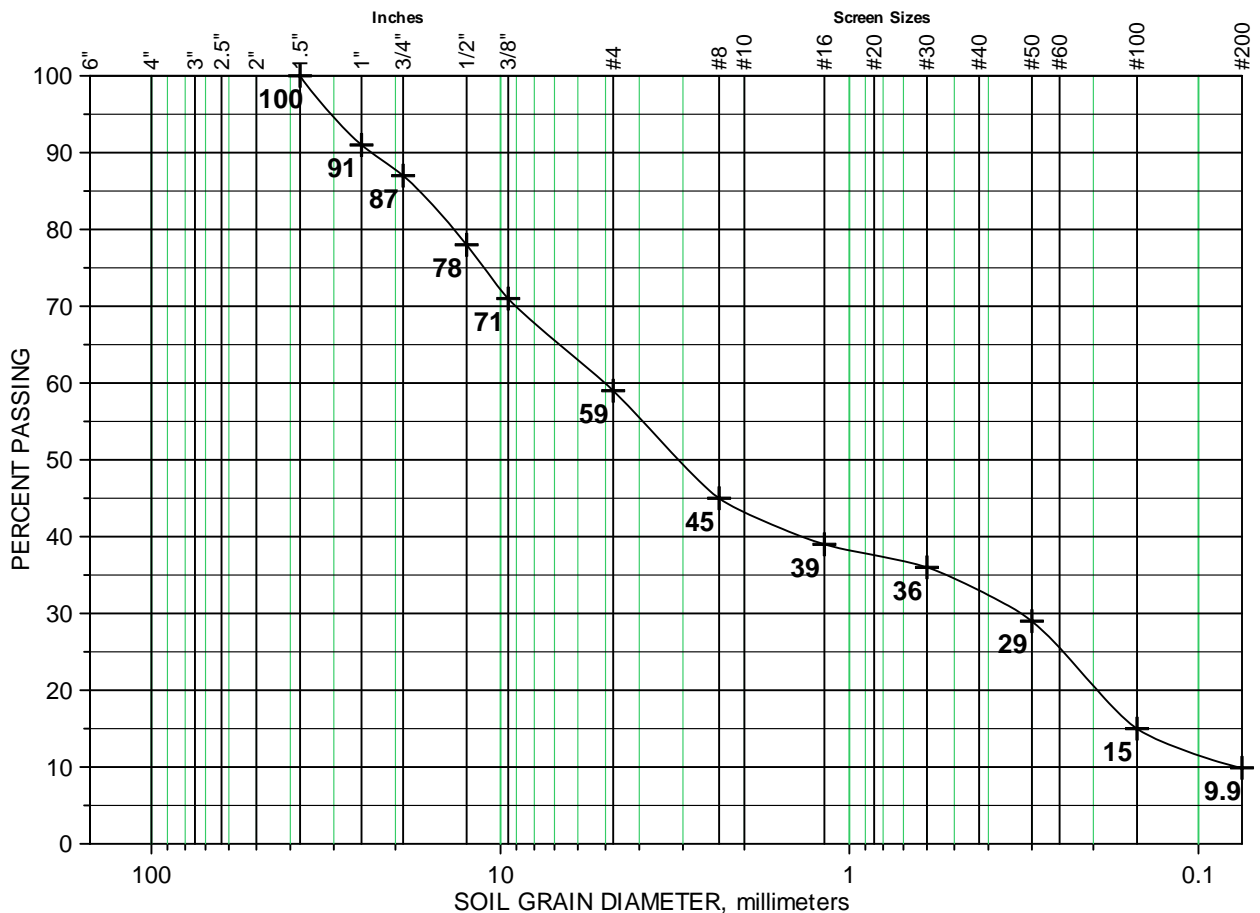
Sample No.: SL012611

Sample Location: SCB-6-10, SS-8 @ 40.0 Feet

Description: Poorly Graded SAND with Gravel and Silt

Date Tested: February 8, 2011

Cobbles	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Reviewed by: Cole W. Wolf

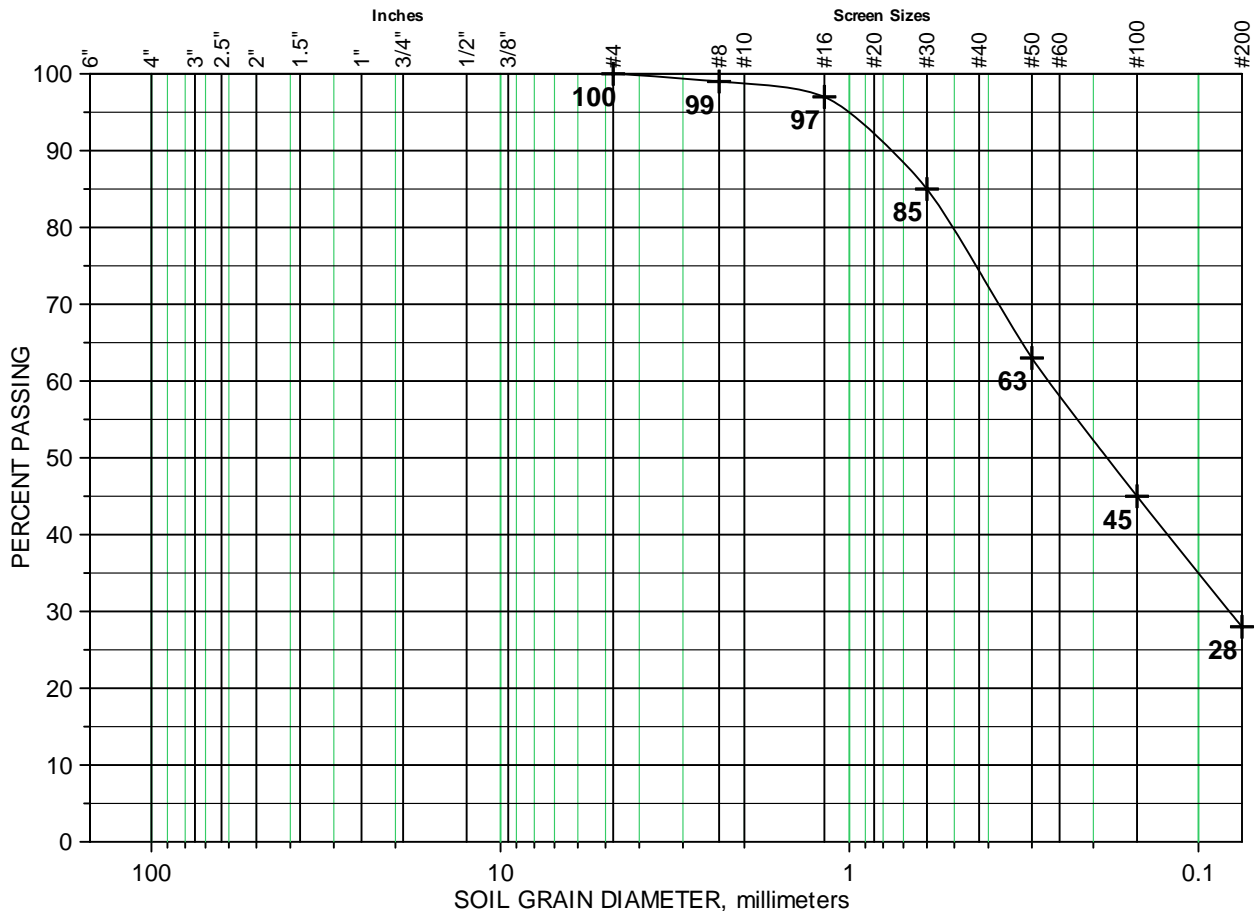


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-7-10, SS-7 @ 35.0 Feet
 Description: Silty SAND
 Date Tested: February 8, 2011

Cobbles	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Reviewed by: *Cole W. Wilf*

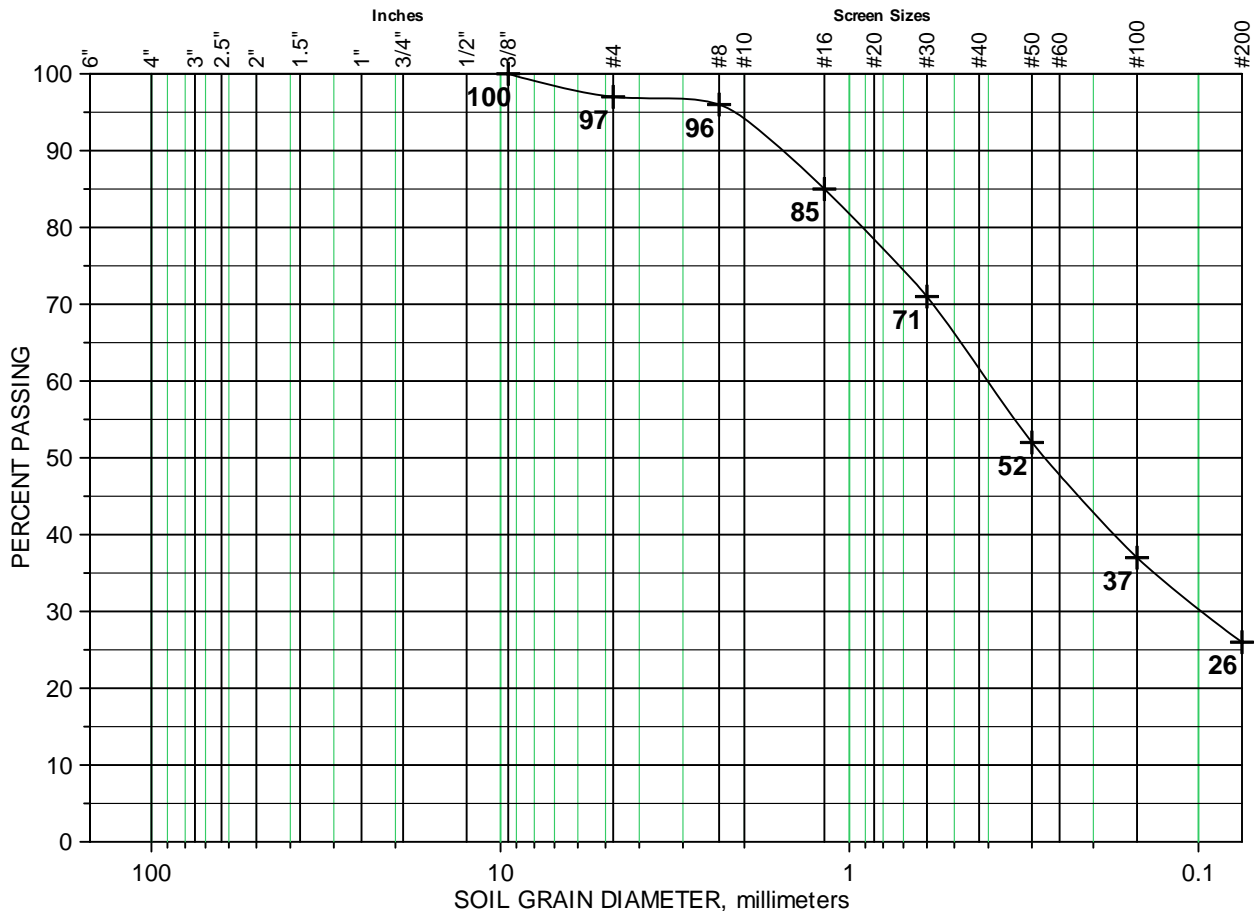


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-3-10, SS-7 @ 35.0 Feet
 Description: Clayey SAND
 Date Tested: February 8, 2011

Cobbles	Gravel			Sand		
	Coarse	Fine		Coarse	Medium	Fine



Reviewed by: *Cole W. Wilf*

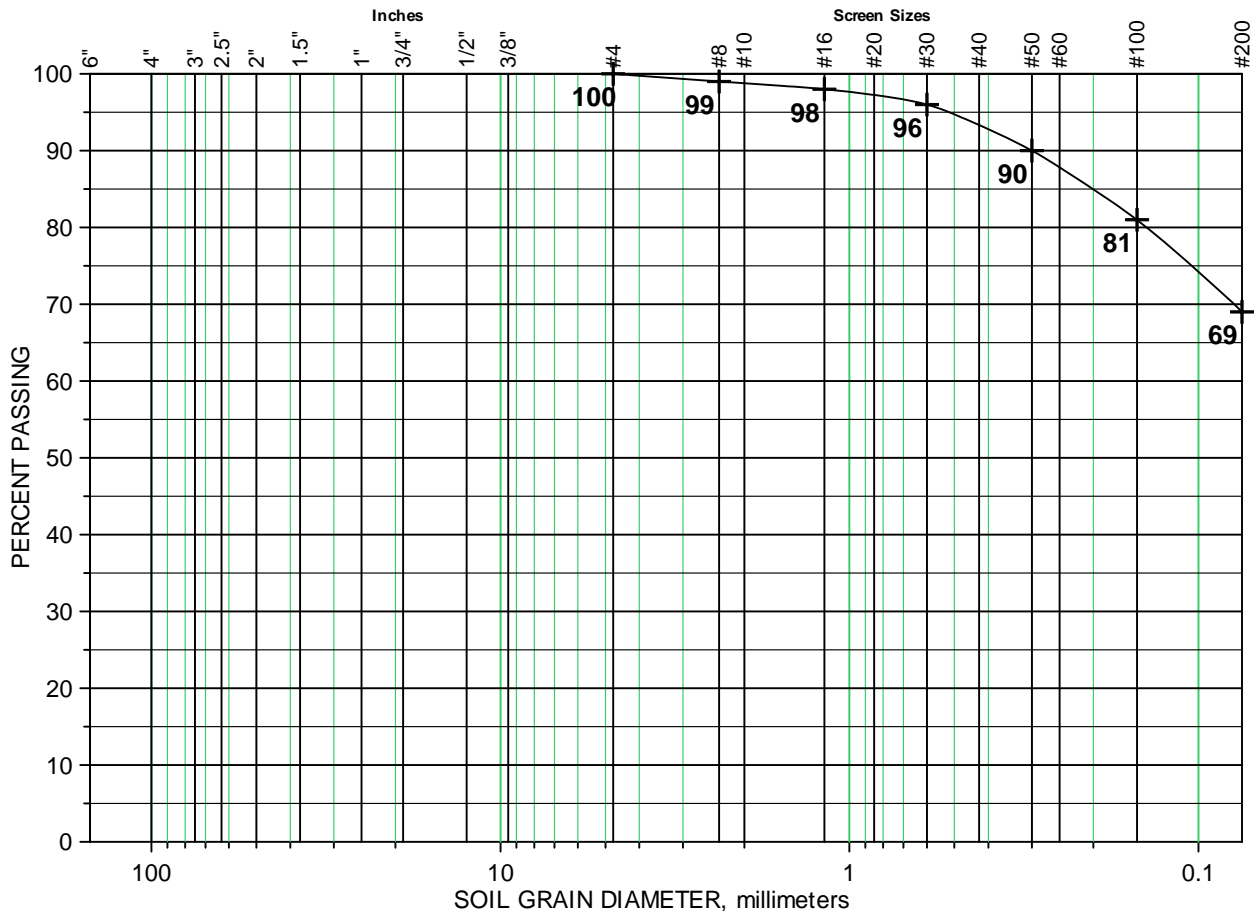


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-1-10, SS-2 @ 10.0 Feet
 Description: Sandy SILT
 Date Tested: February 8, 2011

Cobbles	Gravel			Sand		
	Coarse	Fine		Coarse	Medium	Fine



Reviewed by: *Cole W. Wild*



GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District

Client: CH2M Hill

File: CH2H07 S11014A

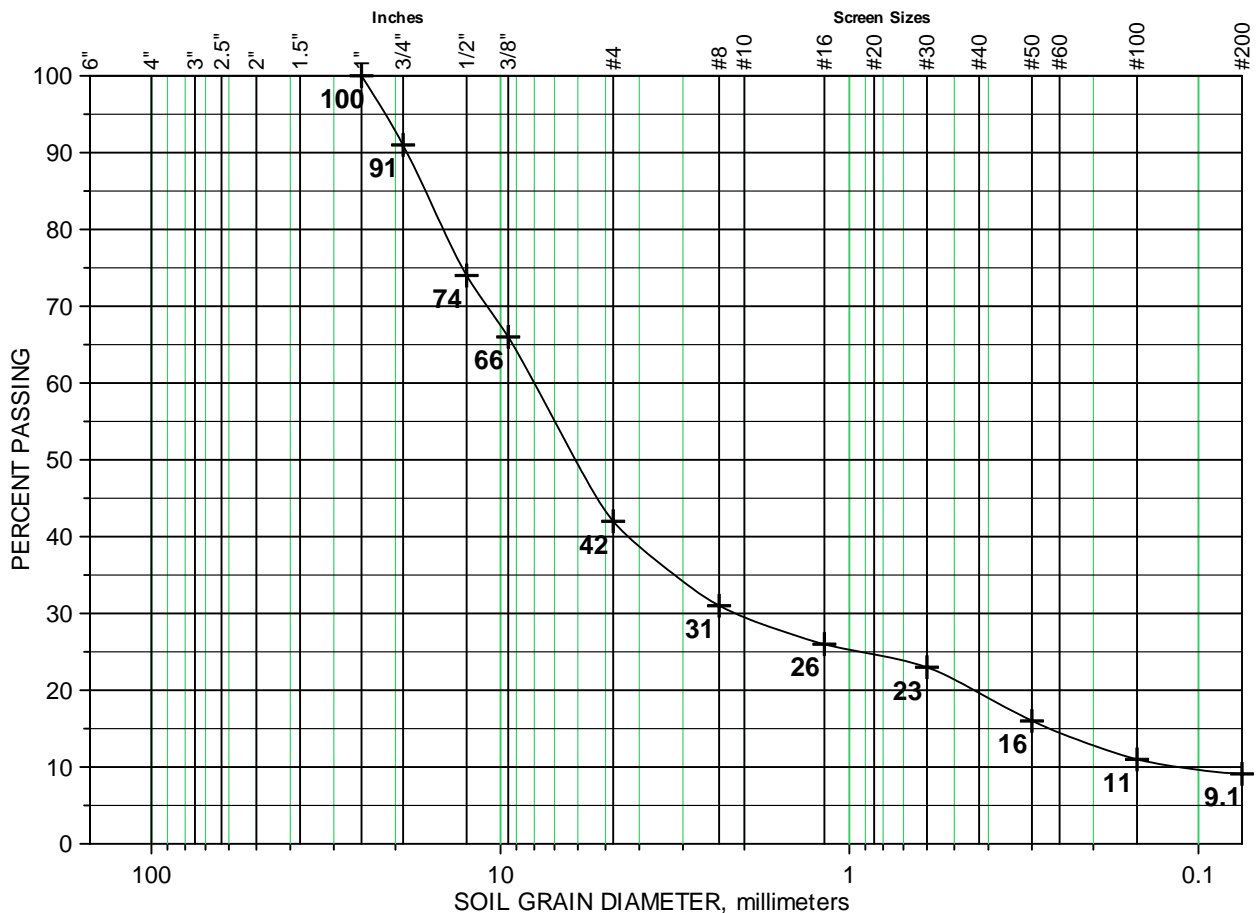
Sample No.: SL012611

Sample Location: SCB-1-10, SS-6 @ 30.0 Feet

Description: Poorly Graded GRAVEL with Sand and Silt

Date Tested: February 8, 2011

Cobbles	Gravel		Sand		
	Coarse	Fine	Coarse	Medium	Fine



Reviewed by: Cole W. Wolf

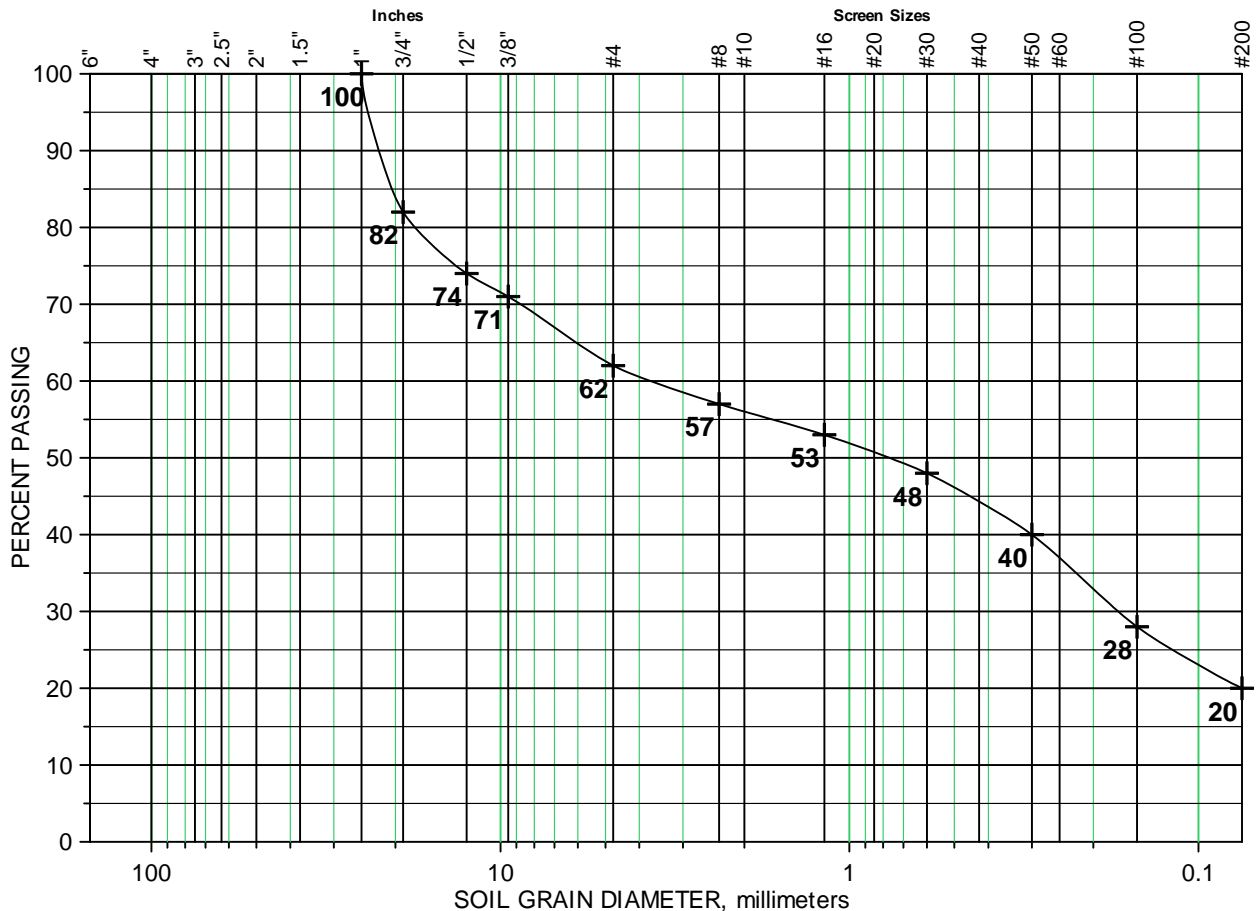


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-2-10, SS-5 @ 25.0 Feet
 Description: Silty SAND with Gravel
 Date Tested: February 8, 2011

Cobbles	Gravel			Sand		
	Coarse	Fine		Coarse	Medium	Fine



Reviewed by: *Cole W. Wilf*



GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District

Client: CH2M Hill

File: CH2H07 S11014A

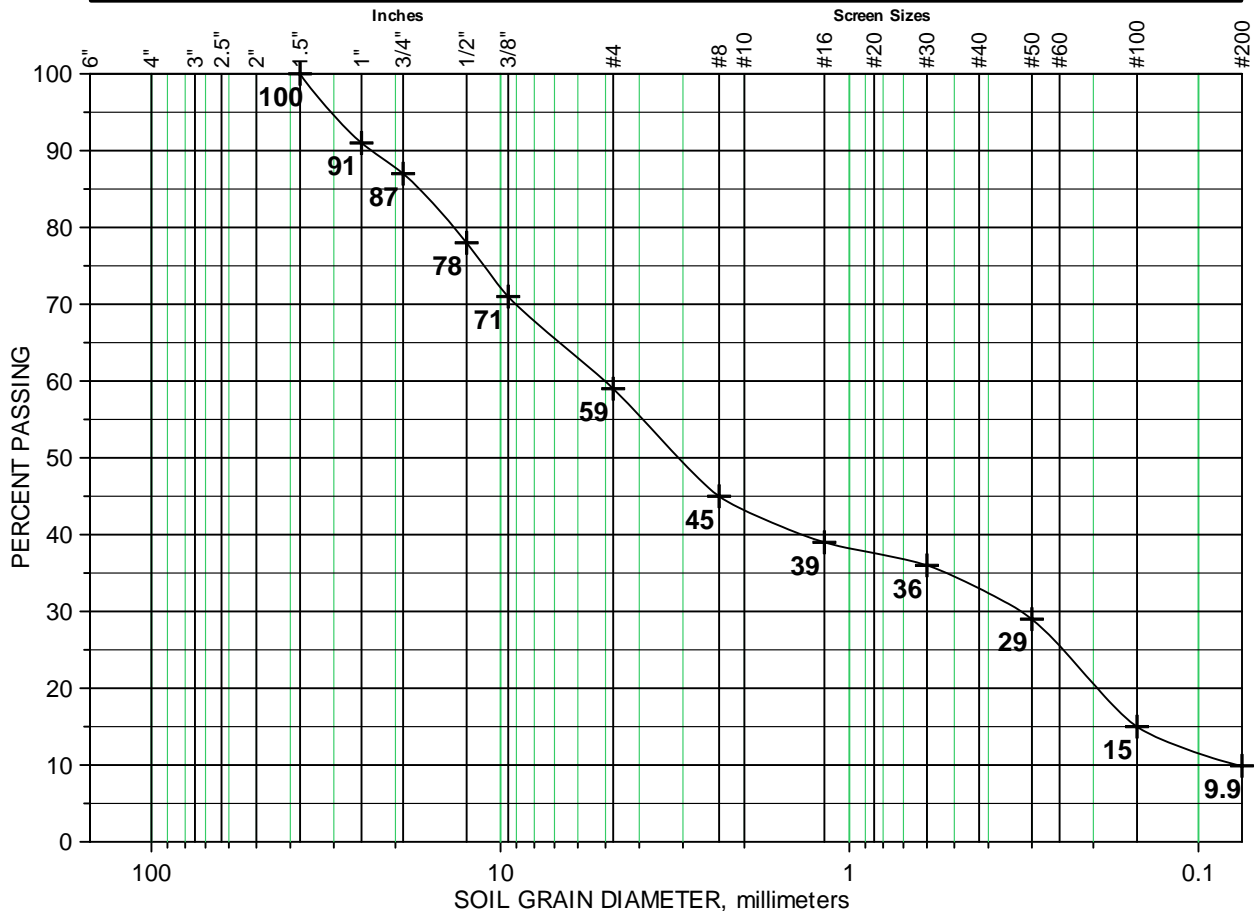
Sample No.: SL012611

Sample Location: SCB-6-10, SS-8 @ 40.0 Feet

Description: Poorly Graded SAND with Gravel and Silt

Date Tested: February 8, 2011

Cobbles	Gravel			Sand				
	Coarse	Fine		Coarse	Medium	Fine		



Reviewed by: *Col W. Wilf*

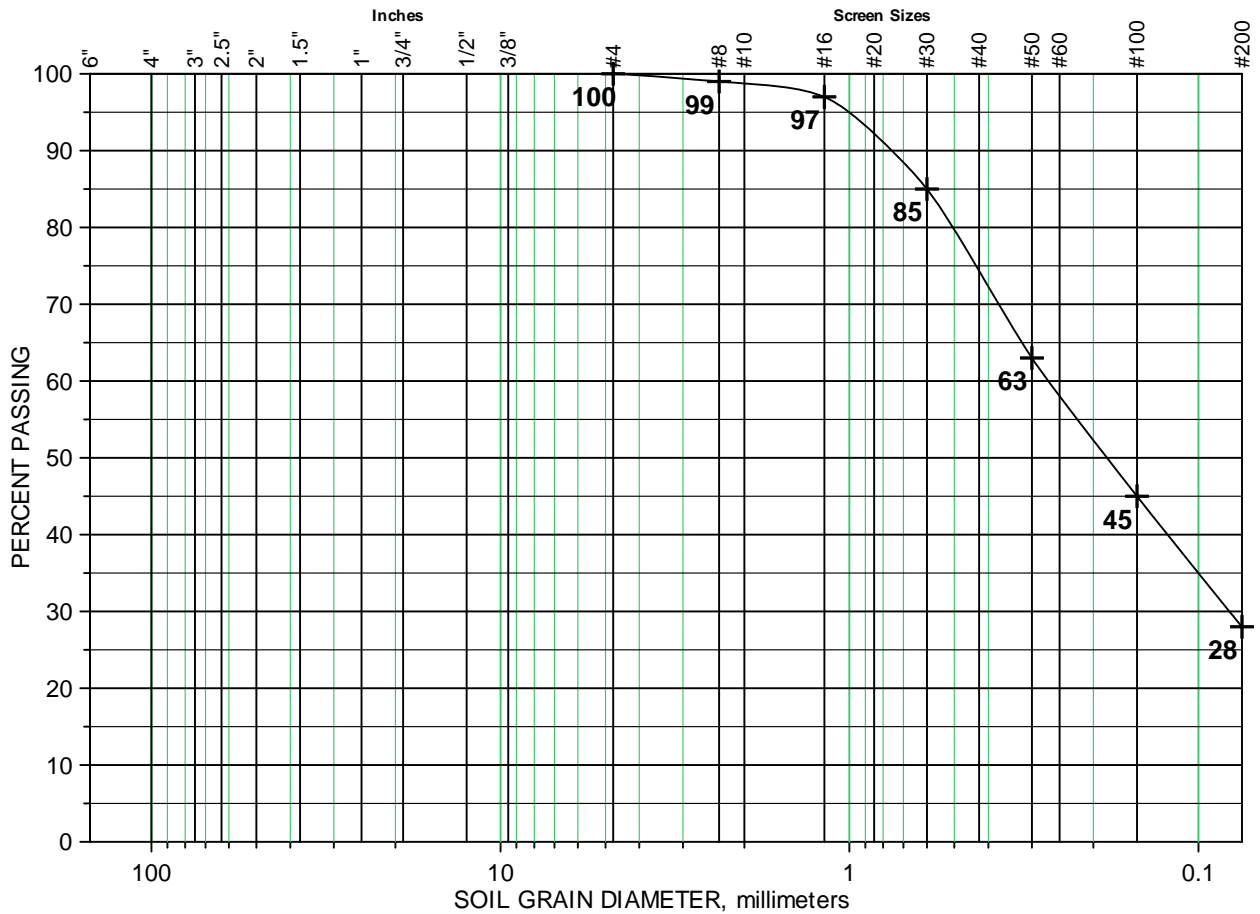


GRADATION ANALYSIS

ASTM D 6913

Project: Sunnyside Valley Irrigation District
 Client: CH2M Hill
 File: CH2H07 S11014A
 Sample No.: SL012611
 Sample Location: SCB-7-10, SS-7 @ 35.0 Feet
 Description: Silty SAND
 Date Tested: February 8, 2011

Cobbles	Gravel			Sand		
	Coarse	Fine		Coarse	Medium	Fine



Reviewed by:

Cole W. Wain



GRADATION ANALYSIS

ASTM D 422

Project: Sunnyside Valley Irrigation District

Client: CH2M Hill

File: CH2H07 S11014A

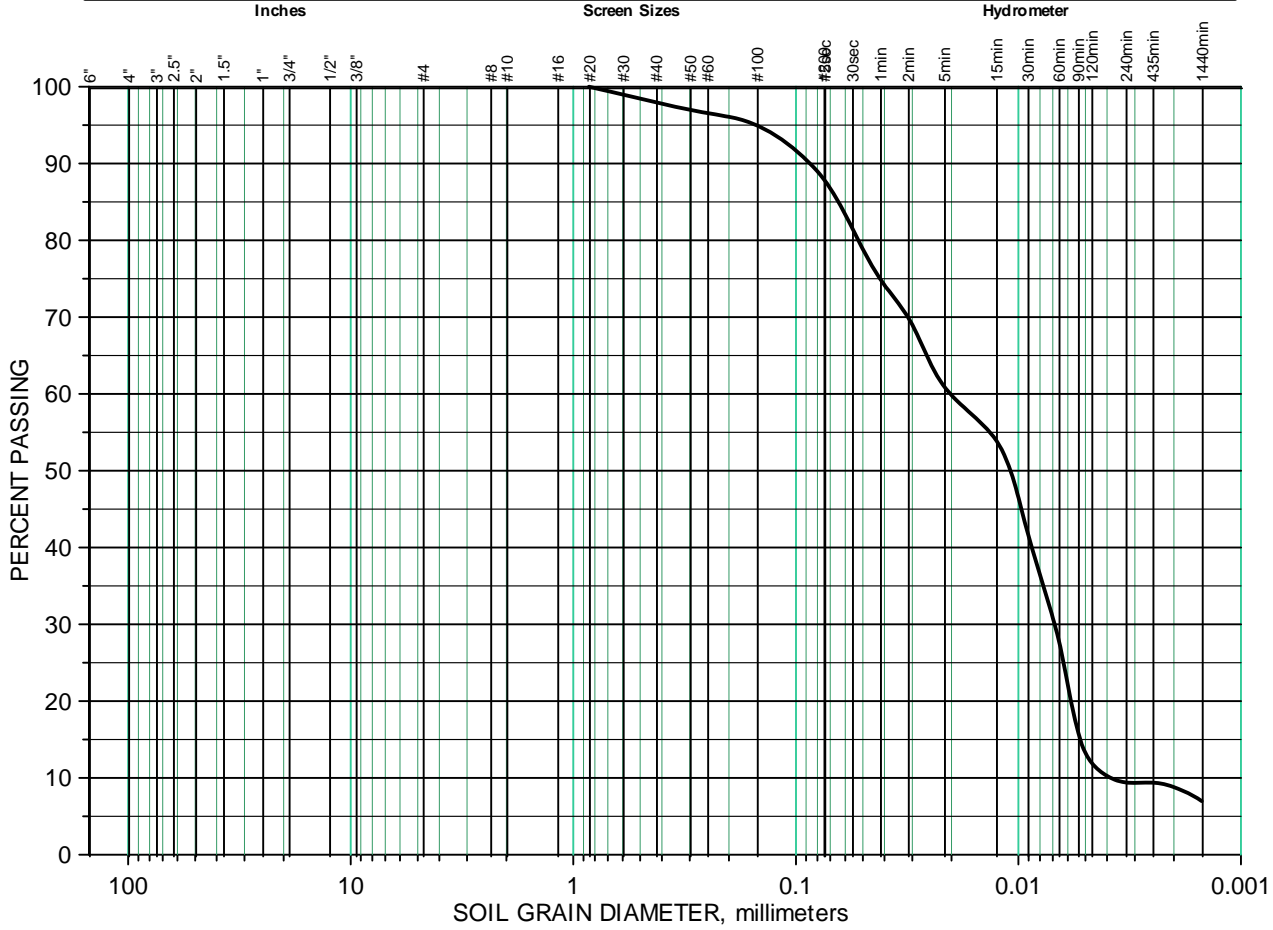
Sample No.: SL012611

Sample Location: SCB-6-10, SS-4 @ 20.0-21.5 Feet

Description: SILT

Date Tested: February 8, 2011

Cobbles	Gravel		Sand			Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay



Reviewed by: *Col W. Waif*



Anatek Labs, Inc.

1282 Alturas Drive • Moscow, ID 83843 • (208) 883-2839 • Fax (208) 882-9246 • email moscow@anateklabs.com
504 E Sprague Ste. D • Spokane WA 99202 • (509) 838-3999 • Fax (509) 838-4433 • email spokane@anateklabs.com

Client: STRATA SPOKANE
Address: 10020 E. KNOX AVE, SUITE 200
SPOKANE, WA 99206
Attn: COLE WARRICK

Batch #: 110209028
Project Name: SCB 12/08/10

Analytical Results Report

Sample Number	110209028-001	Sampling Date	12/8/2010	Date/Time Received	12/9/2011 3:00 PM		
Client Sample ID	SCB-3-10	Sampling Time		Extraction Date			
Matrix	Soil	Sample Location					
Comments							
Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Chloride	ND	mg/Kg	4.97	2/10/2011	JLU	EPA 300.0	
Sulfate	7.90	mg/Kg	4.97	2/10/2011	JLU	EPA 300.0	
%moisture	20.8	Percent		2/10/2011	JLU	%moisture	

Sample Number	110209028-002	Sampling Date	12/8/2010	Date/Time Received	12/9/2011 3:00 PM		
Client Sample ID	SCB-7-10	Sampling Time		Extraction Date			
Matrix	Soil	Sample Location					
Comments							
Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Chloride	ND	mg/Kg	4.56	2/10/2011	JLU	EPA 300.0	
Sulfate	21.7	mg/Kg	4.56	2/10/2011	JLU	EPA 300.0	
%moisture	13.4	Percent		2/10/2011	JLU	%moisture	

Anatek Labs, Inc.

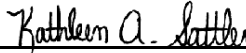
1282 Alturas Drive • Moscow, ID 83843 • (208) 883-2839 • Fax (208) 882-9246 • email moscow@anateklabs.com
504 E Sprague Ste. D • Spokane WA 99202 • (509) 838-3999 • Fax (509) 838-4433 • email spokane@anateklabs.com

Client: STRATA SPOKANE **Batch #:** 110209028
Address: 10020 E. KNOX AVE, SUITE 200 **Project Name:** SCB 12/08/10
SPOKANE, WA 99206
Attn: COLE WARRICK

Analytical Results Report

Sample Number	110209028-003	Sampling Date	12/8/2010	Date/Time Received	12/9/2011 3:00 PM		
Client Sample ID	SCB-5-10	Sampling Time		Extraction Date			
Matrix	Soil	Sample Location					
Comments							
Parameter	Result	Units	PQL	Analysis Date	Analyst	Method	Qualifier
Chloride	ND	mg/Kg	4.91	2/10/2011	JLU	EPA 300.0	
Sulfate	22.4	mg/Kg	4.91	2/10/2011	JLU	EPA 300.0	
%moisture	20.6	Percent		2/10/2011	JLU	%moisture	

Authorized Signature


Kathy Sattler, Lab Manager

MCL EPA's Maximum Contaminant Level
ND Not Detected
PQL Practical Quantitation Limit

This report shall not be reproduced except in full, without the written approval of the laboratory.
The results reported relate only to the samples indicated.
Soil/solid results are reported on a dry-weight basis unless otherwise noted.