IL ROUTE 22 CULVERT IMPROVEMENTS

IL ROUTE 22 OVER CHUNGS CREEK

LAKE COUNTY, ILLINOIS

RUBINO PROJECT NO. G18.009 REV1

Structure Geotechnical Report

{ SGR }

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120 CENTER COURT

SCHAUMBURG, ILLINOIS

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PROJECT INFORMATION

Rubino Engineering, Inc. (Rubino) understands that Chastain and Associates, LLC (Chastain) is planning to provide design services to IDOT for culvert improvements where IL Route 22 crosses Chungs creek in North Barrington, IL just east of Route 59. The existing culvert headwall has failed due to the overgrowth of trees upslope of the headwall. The initial repair plan was to demolish the headwall and the first 2 to 3 feet of the culvert and replace.

After constructability review, it was identified the embankment slopes are too steep for excavation and re-construction of the headwall without removing a large portion of the embankment including the roadway Route IL 22. Chastain is proposing to install sheet piling behind the headwall and remove the headwall and first few feet of culvert allowing the sheet piling to act as the new headwall. The sheet piling is proposed to extend a length of 60 feet on both sides of the road for embankment stabilization. A soldier beam and lagging system is proposed to provide embankment support immediately above the culvert.

Documents received:

- "Contract 62D35 IDOT PTB-006 WO6 – IL 22 Over Chungs Creek Constructability Analysis" prepared by Chastain dated October 23, 2017.
- "Sheet Piling Walls" prepared by Chastain dated December 19th, 2017.
- Soil Map WO 6 by Illinois Natural History Survey
- Photo image of failed headwall from Chastain

Project Correspondence:

- RFP Email from Scott Kasper of Chastain on December 20, 2018.
- Authorization to proceed from Steve Frerichs of Chastain and Associates, LLC via email on January 16th, 2018

The geotechnical recommendations presented in this report are based on the available project information and the subsurface materials described in this report. If any of the information on which this report is based is incorrect, please inform Rubino in writing so that we may amend the recommendations presented in this report (if appropriate, and if desired by the client). Rubino will not be responsible for the implementation of our recommendations if we are not notified of changes in the project.

Purpose / Scope of Services

The purpose of this study was to explore the subsurface conditions at the site in order to prepare geotechnical recommendations for sheet piling system and general site development for the proposed construction.

Rubino's scope of services included the following drilling program:

Table 1: Drilling Scope

NUMBER OF BORINGS	DEPTH (FEET BEG*)	LOCATION
2	40 feet	Proposed IL Route 22 Culvert Improvements over Chungs Creek (See Boring Location Plan in Appendix for more details)

*BEG = below existing grade

Representative soil samples obtained during the field exploration program were transported to the laboratory for additional classification and laboratory testing.

This report briefly outlines the following:

- *Summary of client-provided project information and report basis*
- *Overview of encountered subsurface conditions*
- *Overview of field and laboratory tests performed including results*
- *Geotechnical recommendations pertaining to:*
  - *Design of Sheet Pile Walls and Soldier Beam and Lagging Systems*
- *Construction considerations, including temporary excavation and construction control of water*

DRILLING, FIELD, AND LABORATORY TEST PROCEDURES

Chastain selected the number of borings and the boring depths. Rubino located the borings in the field using a Garmin GPSMap 64s. The borings were advanced utilizing 3 ¼ inch inside-diameter, hollow stem auger drilling methods and soil samples were routinely obtained during the drilling process.

Selected soil samples were tested in the laboratory to determine material properties for this report. Drilling, sampling, and laboratory tests were accomplished in general accordance with ASTM procedures. The following items are further described in the Appendix of this report.

- *Field Penetration Tests and Split-Barrel Sampling of Soils (ASTM D1586)*
- *Field Water Level Measurements*
- *Laboratory Determination of Unconfined Compressive Strength (ASTM D2166)*
- *Laboratory Determination of Water (Moisture) Content of Soil by Mass (ASTM D2216)*
- *Laboratory Determination of Atterberg Limits (ASTM D4318)*
- *Laboratory Determination of Particle Size (Hydrometer) Analysis of Soils (ASTM D422)*
- *Laboratory Organic Content by Loss on Ignition (ASTM D2974)*

The laboratory testing program was conducted in general accordance with applicable ASTM specifications. The results of these tests are to be found on the accompanying boring logs located in the Appendix.

EXECUTIVE SUMMARY OF GEOTECHNICAL CONSIDERATIONS

The main geotechnical design and construction considerations at this site are:

- **Subgrade soils** generally consisted of black, brown, and gray clay, silty clay, clay loam, silty clay loam loam, and loam. See *Subsurface Conditions* section for more detailed information.
    - **Soft, high moisture content soils** were observed within the borings within the proposed sheet pile depth.
    - **Loam materials (FILL) with gravel and rocks** were encountered within the upper 5 feet of ground surface.
    - **Surface stream flows** may need to be managed during culvert construction based on the design and construction methods. See *Dewatering Discussion* for more information.

The geotechnical-related recommendations in this report are presented based on the subsurface conditions encountered and Rubino's understanding of the project. Should changes in the project criteria occur, a review must be made by Rubino to determine if modifications to our recommendations will be necessary.

SITE AND SUBSURFACE CONDITIONS

Site Location and Description

The general site location of exploration included IL Route 22 over Chungs Creek in North Barrington, Lake County, Illinois. The center of site has an approximate latitude and longitude of 42.190453° N and -88.128648° W, respectively.

The map below shows the general site location of where the soil borings were taken:

Subsurface Conditions

Beneath the existing undocumented fill soils, subsurface conditions generally consisted of brown, black, and/or gray silty clay, clay loam, clay, silty clay loam, and loam.

- The **undocumented fill** soils were generally classified as loam.
- The native **cohesive** soils were generally soft to very stiff in consistency

Table 2: Subsurface Conditions Summary

Elevation Range (ft)	Soil Description	SPT N-Values (Blows per Foot)	Moisture Content (%)	Estimated Shear Strength
843 – 839	UNDOCUMENTED FILL: Black and brown loam with gravel and rocks	11 – 12	16 – 17	N/A
839.5 – 831.5	Soft to medium stiff, brown and gray CLAY / SILTY CLAY / CLAY LOAM / SILTY CLAY LOAM (Possible fill)	4 – 8	17 – 28	c = 600 – 1,200 psf
834 – 827	Soft to stiff, gray to black, SILTY CLAY (Up to 10% organic content)	4 – 10	29 – 37	c = 600 – 1,500 psf
828.5 – 821	Stiff, brown and gray CLAY /SILTY CLAY / SILTY CLAY LOAM	9 – 14	17 – 22	c = 1,350 – 2,100 psf
821 – 819.5 (B-01)	Medium dense, gray, wet, LOAM	~10 - 12	12	$\phi' = 30°$
822 – 803	Stiff to very stiff, gray, CLAY	14 – 24	13 – 19	c = 2,100 – 3,600 psf

The above table is a general summary of subsurface conditions. Please refer to the boring logs for more detailed information.

Estimated shear strength of clay soils is based on empirical correlations using N-values, moisture content, and unconfined compressive strength.

Groundwater Conditions

Groundwater was encountered in the borings during drilling operations. Based on the groundwater levels encountered and the streambed conditions, Rubino anticipates that **groundwater may need to be controlled during construction.** A water level meter was used after drilling to measure the depth of free groundwater. The following table summarizes groundwater observations from the field:

Table 3: Groundwater Observation Summary

Boring Number	Groundwater Elevation During Drilling (Feet*)	Groundwater Elevation Upon Auger Removal (Feet*)	Estimated Seasonal High Groundwater Elevation
B-01	809.5 (33 ½*)	825 ½ (17 ½*)	828 feet
B-02	815.5 (27 ½*)	819 (24*)	822 feet

*Depth below existing grade

Due to the nature of the saturated cohesive soils, it is possible that the groundwater readings performed upon auger removal may represent saturated soils that triggered the water level meter instead of free groundwater. It should be noted that fluctuations in the groundwater level should be anticipated throughout the year depending on variations in climatological conditions and other factors not apparent at the time the borings were performed. Additionally, discontinuous zones of perched water may exist within the soils. The possibility of groundwater level fluctuation should be considered when developing the design and construction plans for the project.

EVALUATION AND RECOMMENDATIONS

The geotechnical-related recommendations in this report are presented based on the subsurface conditions encountered and Rubino's understanding of the project. Should changes in the project criteria occur, a review must be made by Rubino to determine if modifications to our recommendations will be necessary.

Dewatering Recommendations

The free groundwater encountered during drilling is understood to be below the culvert bottom, however should be accounted for during driving of sheet piles and soldier piles.

Due to the presence of water at within the culvert and flowing stream, dewatering measures may be required to maintain dry foundation conditions during culvert construction activity based on the design and construction methods. It is the responsibility of the design engineer and/contractor to determine the appropriate method of site dewatering and associated details. Temporary diversion methods may include diversion channels, pumping system(s), piped diversions, coffer dams, or similar practices.

Undocumented Fill Discussion

Undocumented fill materials were observed in the borings to an elevation of approximately 839 feet during the drilling operations, with possible fill materials observed to an elevation of approximately 834 feet; however, there is a possibility that undocumented fill soils could be encountered at other locations on the site.

Deleterious materials were not observed within the undocumented fill materials during the drilling operations. Although deleterious materials were not encountered in all the undocumented fill materials, this does not eliminate the possibility that deleterious materials could be present within the undocumented fill materials at other locations along the project.

> **Undocumented fill** is defined as fill that has been placed without being documented as to its placed density and moisture content.
>
> **Deleterious materials** could include, but are not limited to, bricks, asphalt, concrete, metal, wood, or other building debris.

Lateral Earth Pressures

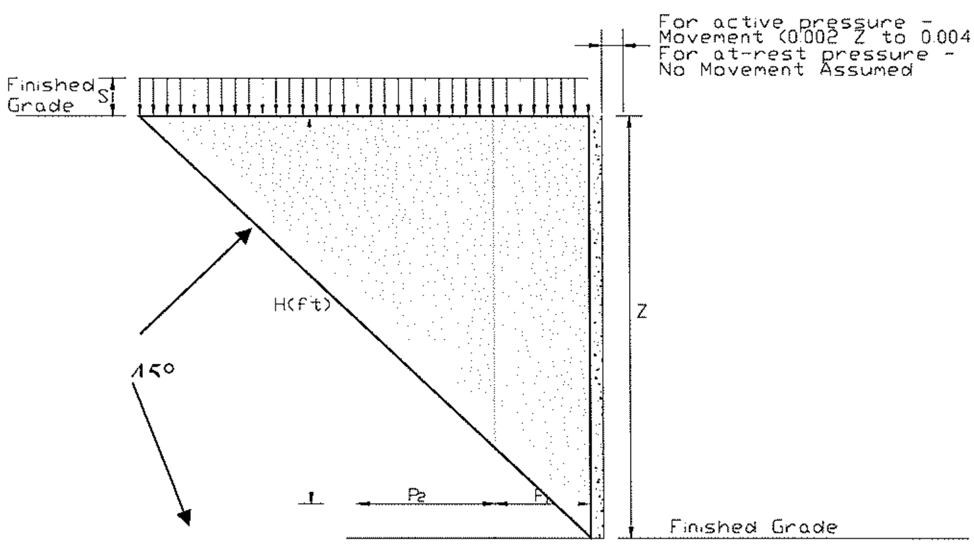
Walls with unbalanced backfill levels on opposite sides, such as below-grade walls, should be designed for earth pressures at least equal to those indicated in the following table in cases of new fill placement. Earth pressures will be influenced by the structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Recommended parameters for use in below grade walls are as follows:

Table 4: "K-Factor" Lateral Earth Pressure Parameters

SOIL TYPE	ESTIMATED TOTAL UNIT WEIGHT (LB/FT^3)	ANGLE OF INTERNAL FRICTION (DEG)	AT-REST EARTH PRESSURE COEFFICIENT; K_O	ACTIVE EARTH PRESSURE COEFFICIENT; K_A	PASSIVE EARTH PRESSURE COEFFICIENT; K_P
Granular Backfill	120	30°	0.50	0.33	3.00
Cohesive Backfill	125	28°	0.53	0.36	2.77

Lateral earth pressure is developed from the soils present within a wedge formed by the vertical below-grade wall and an imaginary line extending up and away from the bottom of the wall at an approximate 45° angle.

EARTH PRESSURE COEFFICIENTS



The following equations were used to calculate the earth pressure coefficients "k":

At-Rest:	$k_o = 1 - \sin\phi$	If the walls are rigidly attached to the structure and not free to rotate or deflect at the top such as shallow tunnels
Active:	$k_a = \tan^2(45 - \frac{\phi}{2})$	Walls that are permitted to rotate and deflect at the top
Passive:	$k_p = \tan^2(45 + \frac{\phi}{2})$	Passive pressure should be determined using a factor of safety of 2.0

Conditions applicable to the above conditions include:

- For active earth pressure, wall must rotate about base, with top lateral movements 0.002Z to 0.004Z, where Z is the wall height
- For passive earth pressure, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- In-situ soil backfill weight a maximum of 130 pcf for lean clay and 125 pcf for granular soils
- Horizontal backfill, compacted to at least 95% of standard Proctor maximum dry density
- Loading from heavy compaction equipment not included
- No groundwater acting on wall
- No safety factor included
- Ignore passive pressure frost depth zone
- The minimum factor of safety for overturning and sliding analysis is 1.5

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For granular values to be valid, the granular backfill must extend out from base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

To calculate the resistance to sliding, a value of 0.33 should be used as the allowable coefficient of friction between the footing and the underlying silty clay soils.

Equivalent Fluid Pressure

The values presented above were calculated based on positive foundation drainage is provided to prevent the buildup of hydrostatic pressure. Please refer to the following bullet points as they pertain to equivalent fluid pressure.

- An "equivalent fluid" pressure can be obtained from the above chart by multiplying the appropriate K-factor times the total unit weight of the stone fill. This applies to unsaturated conditions only.
- If a saturated "equivalent fluid" pressure is needed, the effective unit weight (total unit weight minus unit weight of water) should be multiplied times the appropriate K-factor and the unit weight of water added to that resultant.
- Rubino does not recommend that earth retaining walls be designed with a hydrostatic load. Instead, drainage should be provided to relieve the pressure.

In specific design cases where water is allowed to build up on the below-grade wall structure, the hydrostatic load correlating to the maximum height of the water build up should be added to the lateral loads acting on the wall.

CONSTRUCTION CONSIDERATIONS

Dewatering Recommendations

Due to the nature of construction within a flowing creek, water diversion measures are anticipated to be required to maintain dry foundation conditions during placement of culvert and construction of headwall on clay soils. It is the responsibility of the design engineer and/contractor to determine the appropriate method of site dewatering and associated details. Temporary diversion methods may include diversion channels, pumping system(s), piped diversions, coffer dams, or similar practices.

Federal Excavation Regulations

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better insure the safety of workmen entering trenches or excavations. This federal regulation mandates that all excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person," as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures.

In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. PSI is providing this information solely as a service to our client. PSI is not assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

Site Preparation and Testing Recommendations

The following comments are considered site-specific. To reference general subgrade preparation recommendations for proofrolling and compaction, please refer to the Appendix of this report.

- During construction, the site should be stripped of existing concrete, abandoned utilities, and pavement sections including asphalt, subbase, and curbs.

Areas of low support or soft spots should be tested with either a Static Cone Penetrometer (SCP) or Dynamic Cone Penetrometer (DCP). The results of the DCP or SCP tests should be evaluated according to IDOT's Subgrade Stability Manual, to determine the necessary depth of corrective action.

Rubino should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. Rubino cannot accept responsibility for conditions that deviate from those described in this report, nor for the performance of the foundation system if not engaged to also provide construction observation and testing for this project.

Temporary Soil Retention System Recommendations

A temporary soil retention system may be required at various stages to excavate for the construction of the proposed U.S. Route 45 Culvert in Will County, Illinois. If staged construction will be utilized for the construction of the proposed culvert to allow traffic to be maintained during construction, there will be a need for near vertical excavation along the centerline of the roadway to facilitate the construction of the culvert. The temporary soil retention system should include surcharge loads from the excavated materials, construction equipment, and trucks. The temporary soil retention system should extend to a sufficient depth below excavation bottom to provide the required lateral passive resistance if the active case is used for the design. Embedment depths should be determined based on the principles of force and moment equilibrium. The temporary soil retention system should be designed for at-rest condition if the adjacent roadway section cannot withstand the anticipated horizontal and vertical movements of the construction excavation. The temporary soil retention system shall be designed by an Illinois licensed structural engineer in accordance with the IDOT Bridge Manual dated January 2012.

Based on the anticipated conditions needed for staged construction, Rubino anticipates sheet pile walls as a viable option for a temporary soil retention system. The recommended parameters for the design of the temporary soil retention system are as follows:

Table 5: Temporary Soil Retention System Parameters

Elevation Range (ft)	Soil Type	Estimated In-Situ Unit Weight (lb/ft³)	Modulus of Subgrade Reaction, k (lb/in³)	Soil Strain, E_{50}	Undrained		Drained		Lateral Earth Pressures Coefficients		
					Cohesion c (psf)	Angle of Internal Friction ϕ (deg)	Cohesion c (psf)	Angle of Internal Friction ϕ (deg)	At Rest K_o	Active K_a	Passive K_p
843 – 839	UNDOCUMENTED FILL: Black and brown loam with gravel and rocks	$\Phi = 115$	20	0.024	300	0°	0	28°	0.53	0.36	2.77
839 – 828	Soft to medium stiff, brown and gray with black CLAY / SILTY CLAY / CLAY LOAM / SILTY CLAY LOAM (Possible fill)	$\Phi = 115$	40	0.016	600	0°	0	27°	0.55	0.38	2.66
828 – 803	Stiff, brown to gray CLAY /SILTY CLAY / SILTY CLAY LOAM, Groundwater Encountered	$\Phi_t = 115$ $\Phi' = 62.6$	300	0.008	1,300	0°	0	28°	0.53	0.36	2.77

The recommended soil parameters listed in the above table should be used to determine earth pressures acting on the temporary soil retention system. The selected earth retention system should be also designed for surcharge loading due to surface loads within the zone of the proposed backfill. Traffic loads are applicable only if the traffic lane is located horizontally from the face of the wall within a distance equal or less than one-half of the wall height.

CLOSING

The recommendations submitted are based on the available subsurface information obtained by Rubino Engineering, Inc. and design details furnished by Chastain & Associates, LLC. for the proposed project. If there are any revisions to the plans for this project or if deviations from the subsurface conditions noted in this report are encountered during construction, Rubino should be notified immediately to determine if changes in the foundation recommendations are required. If Rubino is not retained to perform these functions, we will not be responsible for the impact of those conditions on the project.

The scope of services did not include an environmental assessment to determine the presence or absence of wetlands, or hazardous or toxic materials in the soil, bedrock, surface water, groundwater or air, on, or below or around this site. Any statements in this report and/or on the boring logs regarding odors, colors, and/or unusual or suspicious items or conditions are strictly for informational purposes.

After the plans and specifications are more complete, the geotechnical engineer should be retained and provided the opportunity to review the final design plans and specifications to check that our engineering recommendations have been properly incorporated into the design documents. At this time, it may be necessary to submit supplementary recommendations. This report has been prepared for the exclusive use of Chastain & Associates, LLC. and their consultants for the specific application to the Culvert Sheet Piles at IL Route 22 at Chung's Creek in Lake County, Illinois.

Appendix A - Drilling, Field, and Laboratory Test Procedures

ASTM D1586 Penetration Tests and Split-Barrel Sampling of Soils

During the sampling procedure, Standard Penetration Tests (SPT's) were performed at regular intervals to obtain the standard penetration (N-value) of the soil. The results of the standard penetration test are used to estimate the relative strength and compressibility of the soil profile components through empirical correlations to the soils' relative density and consistency. The split-barrel sampler obtains a soil sample for classification purposes and laboratory testing, as appropriate for the type of soil obtained.

Water Level Measurements

Water level observations were attempted during and upon completion of the drilling operation using a 100-foot tape measure. The depths of observed water levels in the boreholes are noted on the boring logs presented in the appendix of this report. In the borings where water is unable to be observed during the field activities, in relatively impervious soils, the accurate determination of the groundwater elevation may not be possible even after several days of observation. Seasonal variations, temperature and recent rainfall conditions may influence the levels of the groundwater table and volumes of water will depend on the permeability of the soils.

ASTM D2166 Unconfined Compressive Strength

Unconfined compression tests are used to obtain approximate compressive strength of cohesive soils by recording the maximum load attained per unit area of a soil sample at failure or at 15% axial strain, whichever occurs first. A compression device may be a platform weighing scale equipped with a device with sufficient capacity and control to provide a specific rate of loading.

ASTM D2216 Water (Moisture) Content of Soil by Mass (Laboratory)

The water content is an important index property used in expressing the phase relationship of solids, water, and air in a given volume of material and can be used to correlate soil behavior with its index properties. In fine grained cohesive soils, the behavior of a given soil type often depends on its natural water content. The water content of a cohesive soil along with its liquid and plastic limits as determined by Atterberg Limit testing are used to express the soil's relative consistency or liquidity index.

ASTM D2974 Standard Test Method for Organic Soils using Loss on Ignition (Laboratory)

These test methods cover the measurement of moisture content, ash content, and organic matter in peats and other organic soils, such as organic clays, silts, and mucks. Ash content of a peat or organic soil sample is determined by igniting the oven-dried sample from the moisture content determination in a muffle furnace at 440°C (Method C) or 750°C (Method D). The substance remaining after ignition is the ash. The ash content is expressed as a percentage of the mass of the oven-dried sample. 2.4 Organic matter is determined by subtracting percent ash content from 100.

ASTM D4318 Atterberg Limits (Laboratory)

Atterberg limit testing defines the liquid limit (LL) and plastic limit (PL) states of a given soil. These limits are used to determine the moisture content limits where the soil characteristics changes from behaving more like a fluid on the liquid limit end to where the soil behaves more like individual soil particles on the plastic limit end. The liquid limit is often used to determine if a soil is a low or high plasticity soil. The plasticity index (PI) is difference between the liquid limit and the plastic limit. The plasticity index is used in conjunction with the liquid limit to determine if the material will behave like a silt or clay.

ASTM D422 Particle Size Analysis (Laboratory)

The Particle Size Analysis of Soils determines the distribution of particle sizes in order to further classify the soil. The distribution of particle sizes larger than 75µm (retained on the No. 200 sieve) is determined by sieving, while the distribution of particle sizes smaller than 75µm is determined by a sedimentation process, using a hydrometer to secure the necessary data. These soils are then classified more accurately based on the distribution information.

APPENDIX B - REPORT LIMITATIONS

Subsurface Conditions:

The subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The boring logs included in the appendix should be reviewed for specific information at individual boring locations. These records include soil descriptions, stratifications, penetration resistances, locations of the samples and laboratory test data as well as water level information. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition between layers may be gradual. The samples, which were not altered by laboratory testing, will be retained for up to 60 days from the date of this report and then will be discarded.

Geotechnical Risk:

The concept of risk is an important aspect of the geotechnical evaluation. The primary reason for this is that the analytical methods used to develop geotechnical recommendations do not comprise an exact science. The analytical tools that geotechnical engineers use are generally empirical and must be used in conjunction with engineering judgment and experience. Therefore, the solutions and recommendations presented in the geotechnical evaluation should not be considered risk-free, and more importantly, are not a guarantee that the interaction between the soils and the proposed structure will perform as planned. The engineering recommendations, presented in the preceding section, constitute Rubino's professional estimate of the necessary measures for the proposed structure to perform according to the proposed design based on the information generated and reference during this evaluation, and Rubino's experience in working with these conditions.

Warranty:

The geotechnical engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

Federal Excavation Regulations:

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document was issued to better insure the safety of workmen entering trenches or excavations. This federal regulation mandates that all excavations, whether they be utility trenches, basement excavation or footing excavations, be constructed in accordance with the new OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person," as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. Rubino is providing this information solely as a service to our client. Rubino is not assuming responsibility for construction site safety or the contractor's activities; such responsibility is not being implied and should not be inferred.

Appendix C - Soil Classification General Notes

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1 3/8" I.D., 2" O.D., unless otherwise noted	PS:	Piston Sample
ST:	Thin-Walled Tube - 3" O.D., Unless otherwise noted	WS:	Wash Sample
PM:	Pressuremeter	HA:	Hand Auger
RB:	Rock Bit	HS:	Hollow Stem Auger
DB:	Diamond Bit - 4", N, B	BS:	Bulk Sample

Standard "N" Penetration: Blows per foot of a 140-pound hammer falling 30 inches on a 2-inch O.D. split spoon sampler (SS), except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of ground water levels is not possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION:

Soil Classification is based on the Unified Soil Classification System as defined in ASTM D-2487 and D-2488. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are described as: clays, if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse grained soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their consistency. Example: Lean clay with sand, trace gravel, stiff (CL); silty sand, trace gravel, medium dense (SM).

CONSISTENCY OF FINE-GRAINED SOILS:

Unconfined Compressive Strength, Qu (tsf)	N-Blows/ft.	Consistency
< 0.25	< 2	Very Soft
0.25 - 0.5	2 - 4	Soft
0.5 - 1	4 - 8	Medium Stiff
1 - 2	8 - 15	Stiff
2 - 4	15 - 30	Very Stiff
4 - 8	30 +	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

N-Blows/ft.	Relative Density
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
50 +	Very Dense

RELATIVE PROPORTIONS OF SAND & GRAVEL

Descriptive Term	% of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

RELATIVE PROPORTIONS OF FINES

Descriptive Term	% of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

*Descriptive Terms apply to components also present in sample

GRAIN SIZE TERMINOLOGY

Major Component	Size Range
Boulders	Over 12 in. (300mm)
Cobbles	12 in. To 3 in. (300mm to 75mm)
Gravel	3 in. To #4 sieve (75mm to 4.75mm)
Sand	#4 to #200 sieve (4.75mm to 0.75mm)

SOIL CLASSIFICATION CHART

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SANDS		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		(LITTLE OR NO FINES)		SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES		SM	SILTY SANDS, SAND - SILT MIXTURES
		(APPRECIABLE AMOUNT OF FINES)		SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

APPENDIX E – SITE VICINITY MAP & BORING LOCATION PLAN

rubino ENGINEERING INC. 665 Tollgate Rd. Unit H Elgin, Illinois 60123	**Project Name:** IL Route 22 Culvert Improvements **Project Location:** IL Route 22 over Chungs Creek, North Barrington, Lake County, Illinois **Client:** Chastain & Associates, LLC **Rubino Project # :** G18.009	**Site Vicinity Map**

rubino
ENGINEERING INC.

665 Tollgate Rd. Unit H
Elgin, Illinois 60123

Project Name:	IL Route 22 Culvert Improvements
Project Location:	IL Route 22 over Chungs Creek North Barrington, Lake County, Illinois
Client:	Chastain & Associates, LLC
Rubino Project # :	G18.009

Boring Location Plan

Appendix F – Boring Logs

rubino ENGINEERING INC.

SOIL BORING LOG

Date 2/14/18

ROUTE IL Route 22 **DESCRIPTION** IL 22 & Chungs Creek Culvert **LOGGED BY** D.C.

SECTION PTB 181-006, WO #6 **LOCATION** North Barrington, IL

COUNTY Lake **DRILLING METHOD** 3 ¼" Hollow Stem Auger **HAMMER TYPE** Automatic

STRUCT. NO. ______
Station ______

BORING NO. B-01
Station ______
Offset 14' N of CL
Ground Surface Elev. 843.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 33.5 ft ▼
Upon Completion 17.5 ft ▽
After ____ **Hrs.** N/A ft

Description	Elev. (ft)	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
UNDOCUMENTED FILL: Black and brown loam with gravel and rocks					
			8 6 6	1.7 B	16
	839.00				
Medium stiff; Brown SILTY CLAY to SILTY CLAY LOAM Possible fill		-5	3 5 3	1.8 B	18
				1.6 B	18
	834.00				
Soft to stiff; Gray to black SILTY CLAY to CLAY		-10	2 1 3	0.4 B	30
10% Organic content from 11 - 11 ½'			3 4 6	1.3 B	37
	828.50	-15	2 3 3	1.7 B	32
Stiff; Brown and gray CLAY to SILTY CLAY					
▽				2.4 B	18
		-20	4 6 8	3.3 B	18

Description	Elev. (ft)	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Stiff; Brown and gray CLAY to SILTY CLAY *(continued)*					
	821.00		4 5	4.1 B	18
Medium dense; Gray, wet, LOAM			6	0.5 B	12
	819.50				
Stiff to very stiff; Gray CLAY		-25	4 5 10	4.5 B	13
			4 7 10	5.2 B	18
Pushed rock at 28 ½'		-30	4 7 10	4.1 B	19
▼ Wet at 33 ½'		-35	5 7 9	3.5 B	18
End of boring at approximately 40 feet below existing grade.	803.00	-40	5 7 12	3.1 B	15

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

rubino ENGINEERING INC.

SOIL BORING LOG

Date 2/14/18

ROUTE IL Route 22 **DESCRIPTION** IL 22 & Chungs Creek Culvert **LOGGED BY** D.C.

SECTION PTB 181-006, WO #6 **LOCATION** North Barrington, IL

COUNTY Lake **DRILLING METHOD** 3 ¼" Hollow Stem Auger **HAMMER TYPE** Automatic

STRUCT. NO. ______
Station ______

BORING NO. B-02
Station ______
Offset 15' S of CL
Ground Surface Elev. 843.00 ft

Surface Water Elev. N/A ft
Stream Bed Elev. N/A ft

Groundwater Elev.:
First Encounter 27.5 ft ▼
Upon Completion 24 ft ∇
After ____ **Hrs.** N/A ft

Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
UNDOCUMENTED FILL: Black and brown loam with gravel and rocks				
Blow count influenced by pushed rock		38 7 4		17
839.50				
Medium stiff; Brown SILTY CLAY to SILTY CLAY LOAM Possible fill	-5	3 2 4	2.9 B	17
837.00				
Medium stiff; Brown and gray CLAY to CLAY LOAM Possible fill		2 1 3	0.7 B	17
2" SILT seam observed @ 9¼'	-10	2 2 4	0.9 B	28
831.50 Medium stiff; Black SILTY CLAY to CLAY		1 3 5	1.8 B	29
	-15		0.5 P	
827.00 Stiff; Brown and gray CLAY to SILTY CLAY		3 4 5	2.9 B	22
		2 4	3.5 P	22
823.50	-20	6	1.0	17

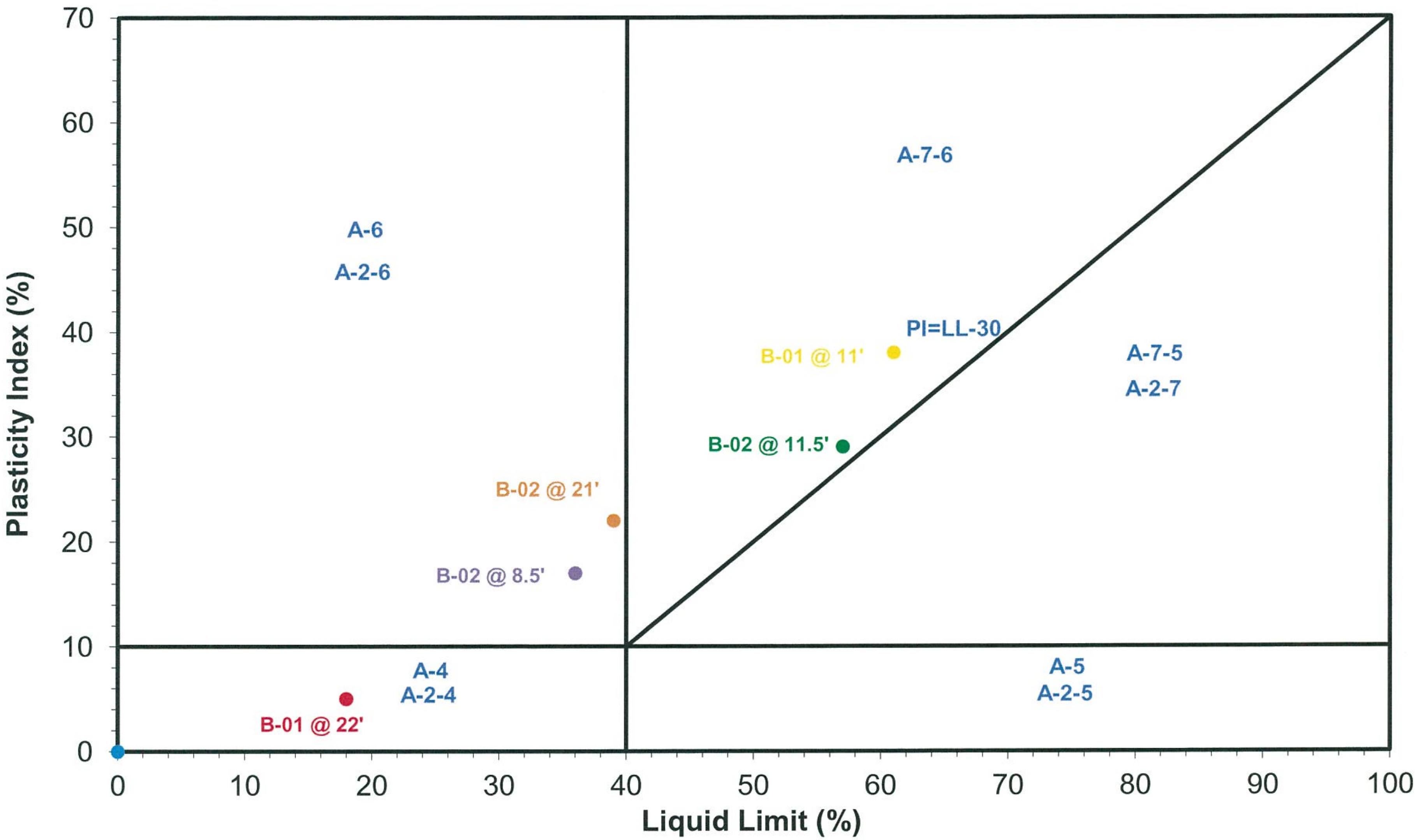
Description	DEPTH (ft)	BLOWS (/6")	UCS Qu (tsf)	MOIST (%)
Medium stiff, brown SILTY CLAY LOAM *(continued)* 822.00			P	
Stiff to very stiff; Gray CLAY		4 6 8	4.1 B	18
	∇ -25	5 8 11	6.6 B	16
	▼	4 7 9	3.5 B	15
Increased percentage of SAND observed from 27 ½' to 30' Saturated at 27 ½	-30	5 8 15	3.7 B	16
	-35	3 8 13	3.9 B	16
End of boring at approximately 40 feet below existing grade. 803.00	-40	6 9 15	4.1 B	17

The Unconfined Compressive Strength (UCS) Failure Mode is indicated by (B-Bulge, S-Shear, P-Penetrometer)
The SPT (N value) is the sum of the last two blow values in each sampling zone (AASHTO T206)

APPENDIX G – LABORATORY RESULTS

rubino ENGINEERING INC.

Report of Atterberg Limits Test (ASTM D4318 / AASHTO T89 / AASHTO T90)



Boring #	B-01 @ 11'	B-01 @ 22'	B-02 @ 8.5'	B-02 @ 11.5'	B-02 @ 21'	
LL	61	18	36	57	39	
PL	23	13	19	28	17	
PI	38	5	17	29	22	

Project: Sheet Pile Walls at IL-22, IDOT PTB 161, WO 6
Location: IL 22 & Chungs Creek, N. Barrington , IL
Client: Chastain & Associates, LLC
Project #: G18.009

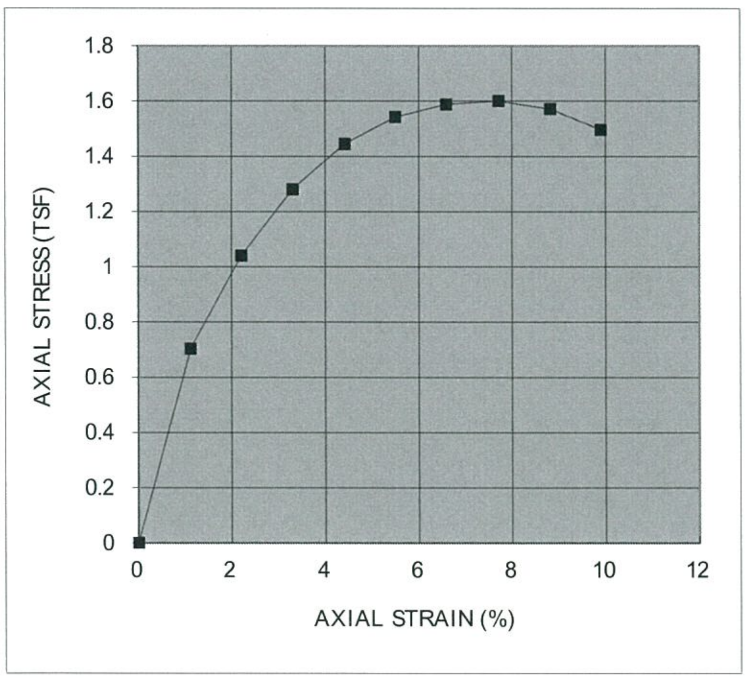
UNCONFINED COMPRESSION TEST

RUBINO ENGINEERING INC.

Project: IL Route 22 Culvert Improvements
Client: Chastain and Associates, LLC
Date Tested: March 9th, 2018
Soil Description: Brown silty CLAY to clay LOAM
Boring No.: B-01 **Rubino Project No.:** G18.009
Depth (ft): 6 feet

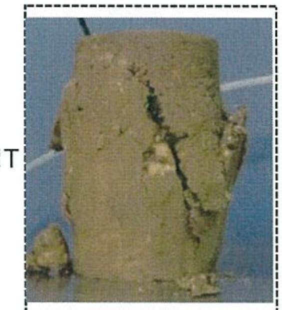
Height:	5.75 inches	Weight (lb):	2.978
Diameter:	2.86 inches	Volume (ft^3):	0.02131
Moisture Content:	17.8%	Saturation (%):	119.8
Ht.-Diameter Ratio:	2.01	Specific Gravity:	2.65
Unit Weight (pcf):	139.7	Dry Unit Weight (pcf):	118.6

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000			0.00	6.407	0.00
1	0.064	63.3	63.3	1.12	6.479	0.70
2	0.127	94.6	94.6	2.21	6.551	1.04
3	0.190	117.8	117.8	3.30	6.625	1.28
4	0.254	134.5	134.5	4.42	6.702	1.44
5	0.316	145.2	145.2	5.50	6.779	1.54
6	0.379	151.3	151.3	6.59	6.858	1.59
7	0.443	154.3	154.3	7.71	6.941	1.60
8	0.507	153.3	153.3	8.82	7.026	1.57
9	0.569	147.8	147.8	9.90	7.111	1.50
Qu =	1.60	tsf		Strain	7.71%	

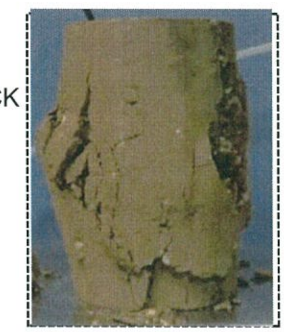


FAILURE SKETCH

FRONT



BACK



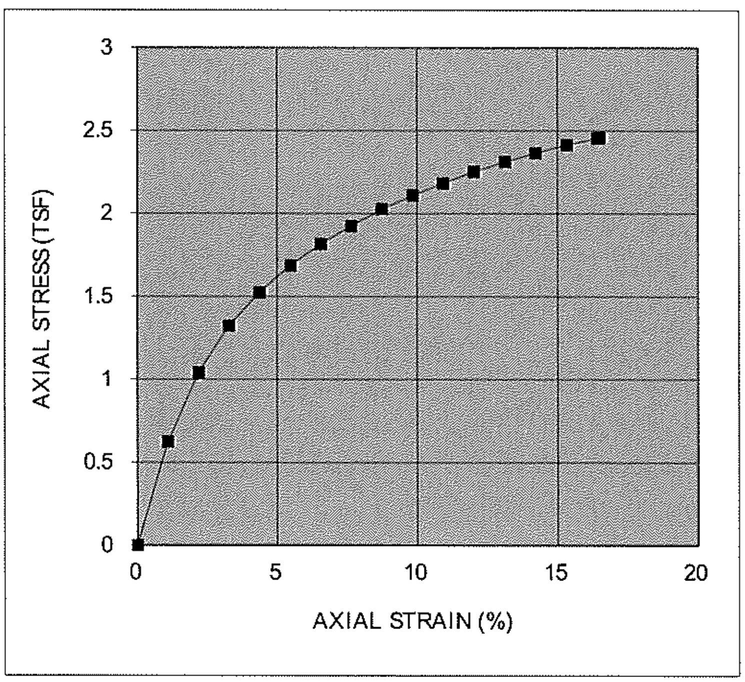
UNCONFINED COMPRESSION TEST

rubino ENGINEERING INC.

Project: IL Route 22 Culvert Improvements
Client: Chastain and Associates, LLC
Date Tested: March 9th, 2018
Soil Description: Brown and gray CLAY to silty CLAY
Boring No.: B-01 **Rubino Project No.:** G18.009
Depth (ft): 16 feet

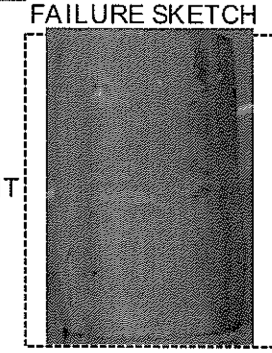
Height:	5.76 inches	Weight (lb):	2.800
Diameter:	2.90 inches	Volume (ft^3):	0.02197
Moisture Content:	18.2%	Saturation (%):	90.4
Ht.-Diameter Ratio:	1.99	Specific Gravity:	2.65
Unit Weight (pcf):	127.5	Dry Unit Weight (pcf):	107.8

READING NUMBER	DEFORM. (in.)	LOAD DIAL READING	LOAD (lbs)	STRAIN (%)	CORRECTED AREA (in^2)	AXIAL STRESS (tsf)
0	0.000			0.00	6.593	0.00
1	0.062	57.9	57.9	1.09	6.665	0.63
2	0.126	97.5	97.5	2.19	6.740	1.04
3	0.189	125.3	125.3	3.28	6.816	1.32
4	0.251	145.9	145.9	4.37	6.894	1.52
5	0.315	163.5	163.5	5.47	6.974	1.69
6	0.378	178.1	178.1	6.56	7.056	1.82
7	0.440	191.0	191.0	7.65	7.139	1.93
8	0.504	203.5	203.5	8.75	7.225	2.03
9	0.567	214.3	214.3	9.85	7.314	2.11
10	0.629	224.5	224.5	10.93	7.402	2.18
11	0.693	234.6	234.6	12.04	7.495	2.25
12	0.756	243.7	243.7	13.13	7.590	2.31
13	0.819	252.5	252.5	14.22	7.686	2.37
14	0.883	261.2	261.2	15.34	7.788	2.41
15	0.946	269.1	269.1	16.44	7.890	2.46
16	0.950	269.6	269.6	16.51	7.896	2.46
Qu =	2.37	tsf		Strain	15.00%	



FAILURE SKETCH

FRONT



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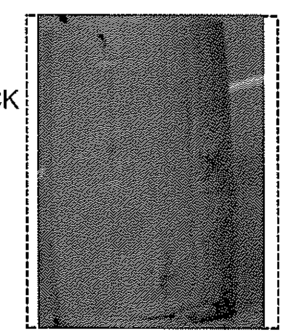
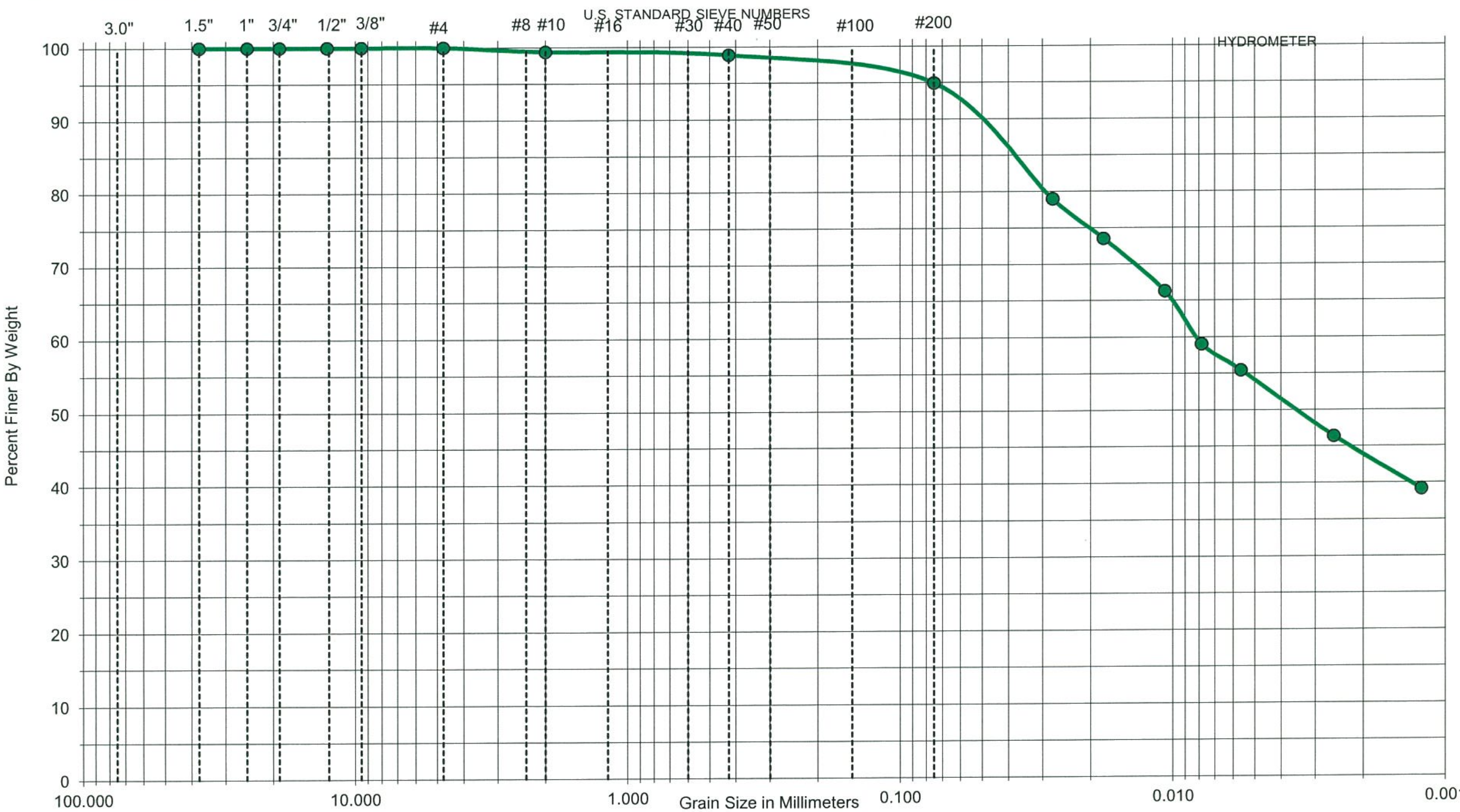


rubino ENGINEERING INC.

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL

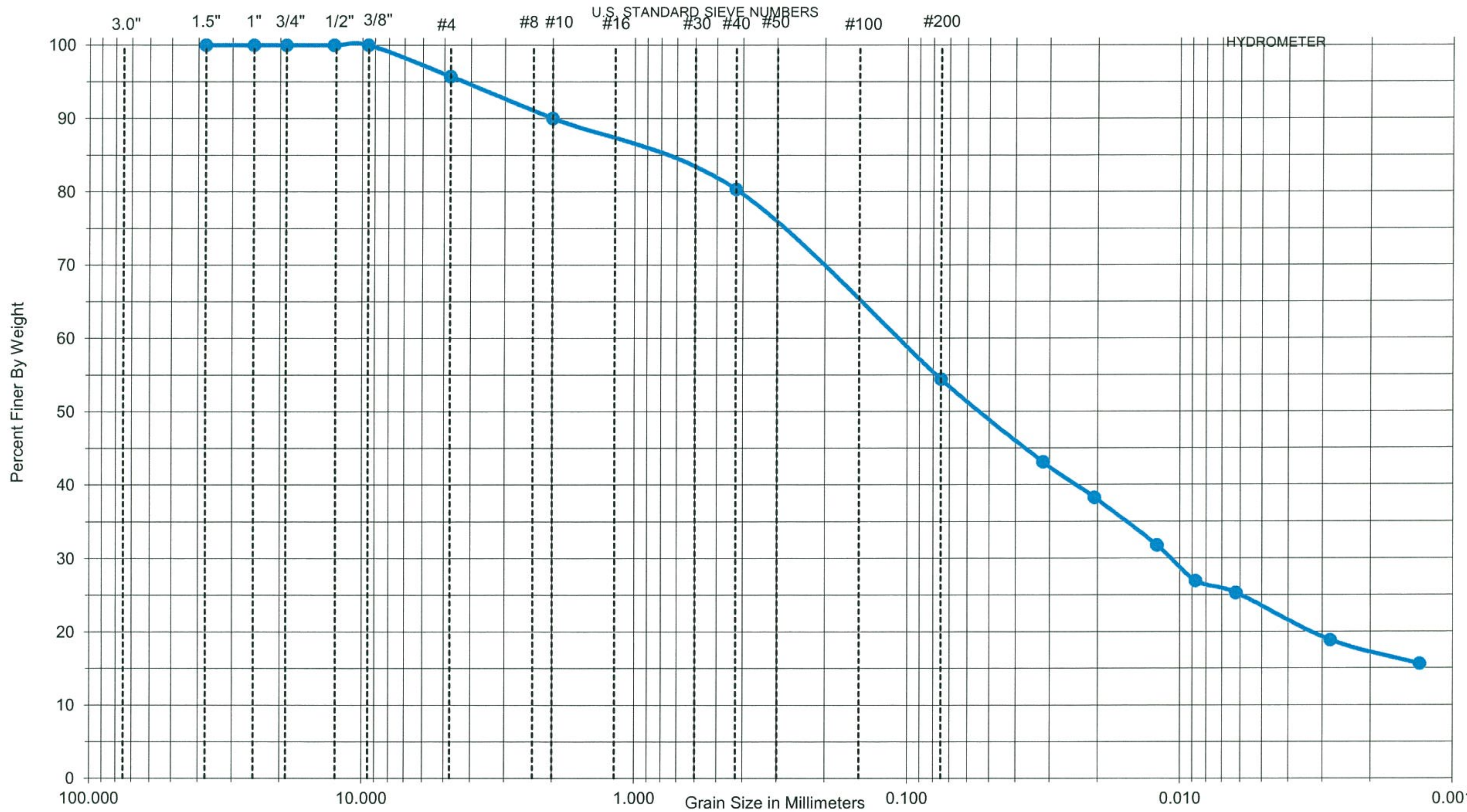


Key	Boring No.	Depth	IDH Textural Classification	WC%	ORG%			%Gravel	%Sand	%Silt	%Clay	D60		
●	B-01	11'	SILTY CLAY	37	10			0.0	5.1	51.6	43.4	0.008		

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL	Sheet Pile Walls at IL 22 & Chungs Creek, N. Barrington, IL	File No. G18.009

Rubino Engineering Inc • 665 Tollgate Rd. • Unit H • Elgin, IL 60123 • 847-931-1555 • 847-931-1560 (Fax)

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL



Key	Boring No.	Depth	IDH Textural Classification	WC%	ORG%			%Gravel	%Sand	%Silt	%Clay	D60	D30	
●	B-01	22'	LOAM	12	N/A			4.3	41.3	37.4	17.1	0.150	0.011	

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL	IL Route 22 Culvert Improvements - Lake County, IL	File No. G18.009

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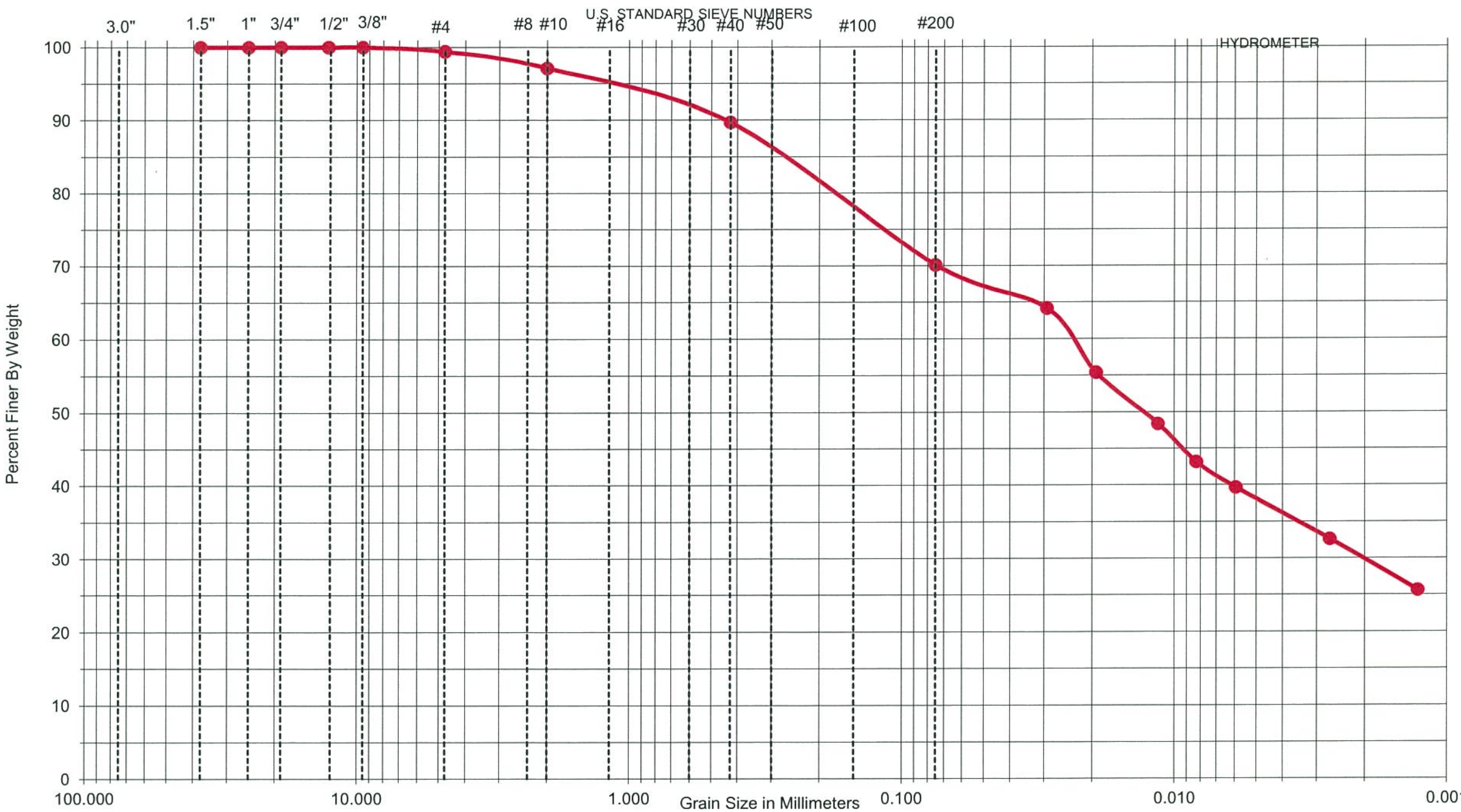
rubino ENGINEERING INC.

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL



Key	Boring No.	Depth	IDH Textural Classification	WC%	ORG%			%Gravel	%Sand	%Silt	%Clay	D60	D30	
●	B-02	8.5'	CLAY LOAM	28	8			0.6	29.3	40.9	29.2	0.025	0.002	

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL	IL Route 22 Culvert Improvements - Lake County, IL	File No. G18.009

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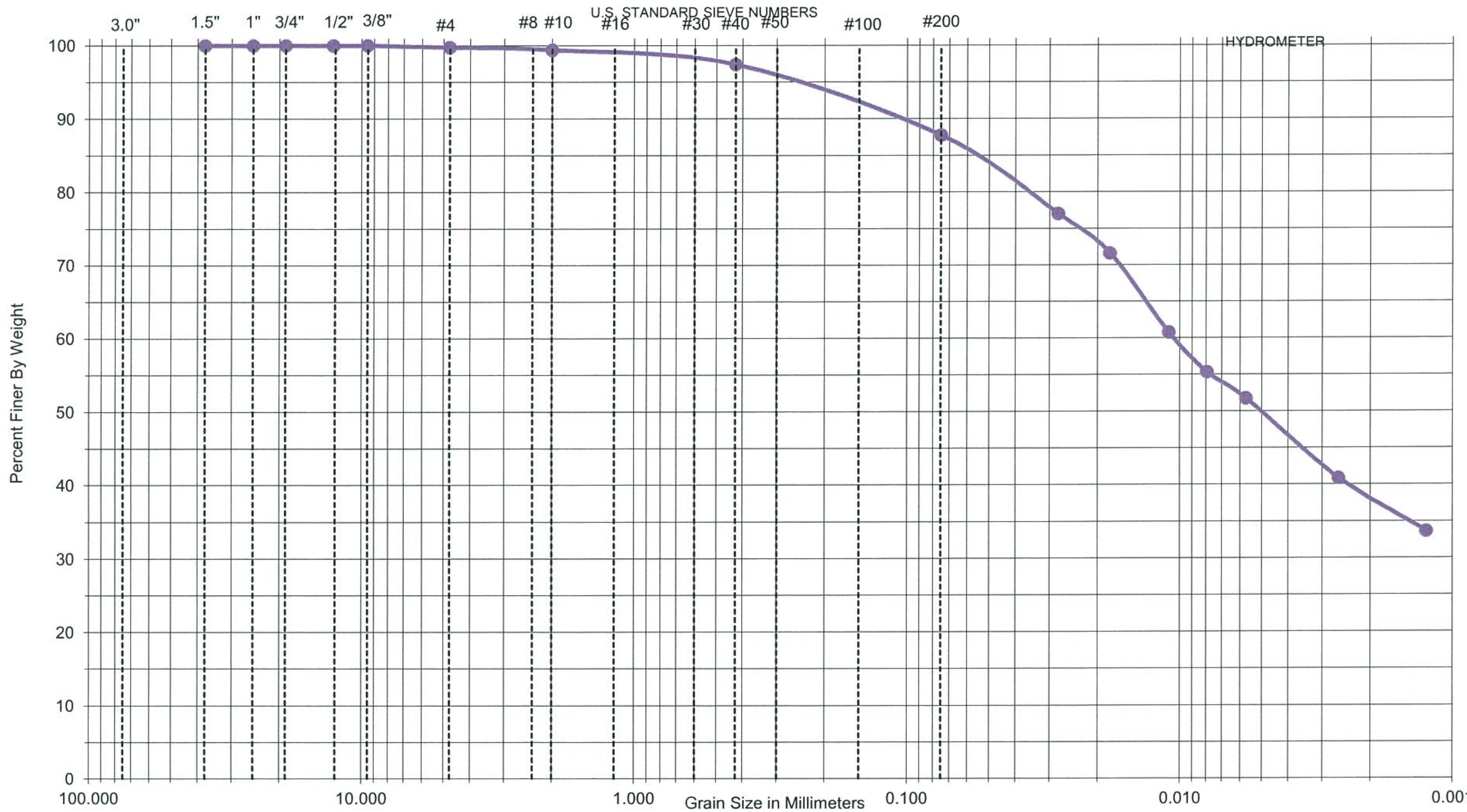
REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL



Key	Boring No.	Depth	IDH Textural Classification	WC%	ORG%			%Gravel	%Sand	%Silt	%Clay	D60		
●	B-02	11'	SILTY CLAY	29	7			0.2	12.0	50.1	37.6	0.011		

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL	IL Route 22 Culvert Improvements - Lake County, IL	File No. G18.009

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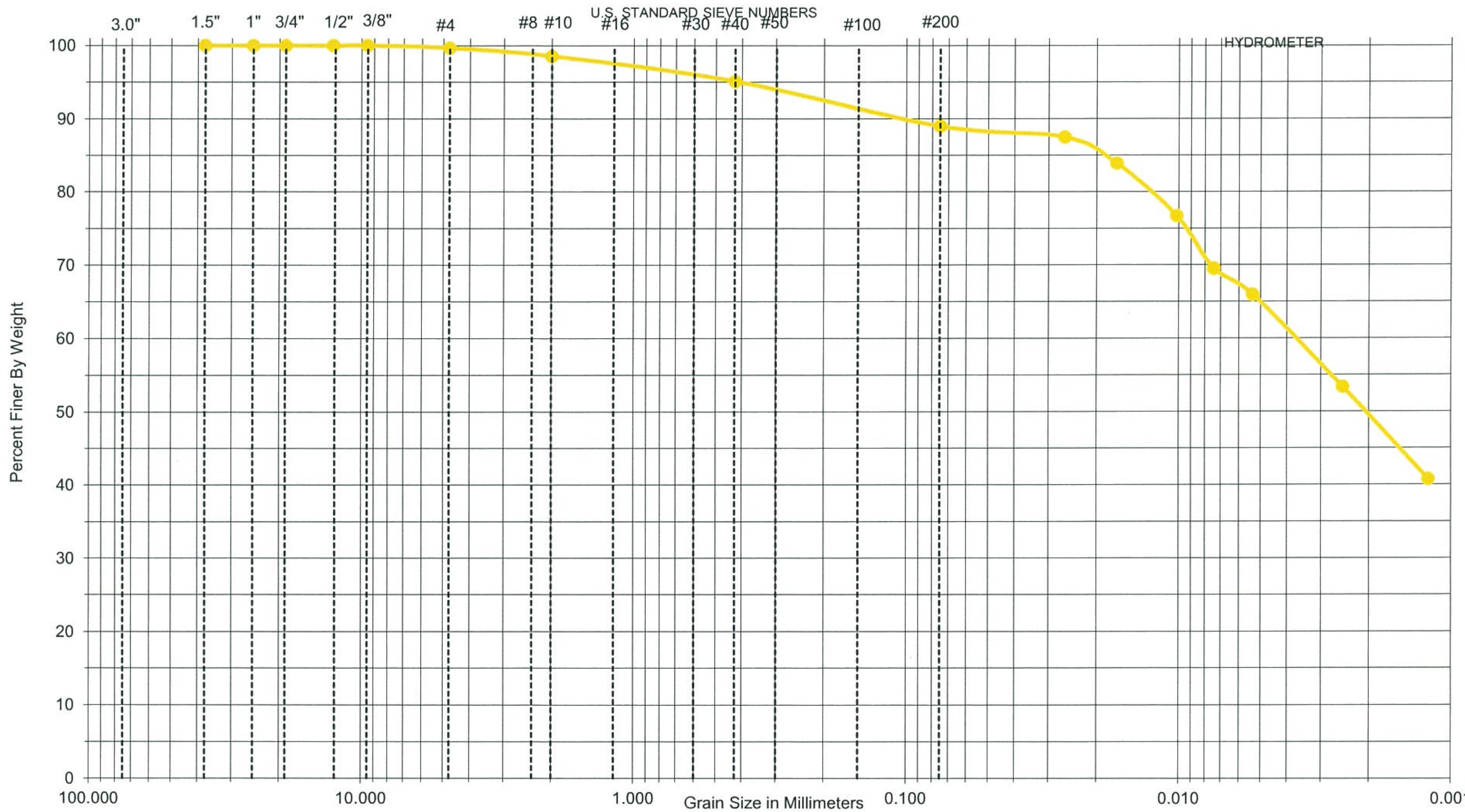
Rubino Engineering Inc.

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL



Key	Boring No.	Depth	IDH Textural Classification	WC%	ORG%			%Gravel	%Sand	%Silt	%Clay	D60		
●	B-02	21'	CLAY	18	N/A			0.3	10.7	40.5	48.5	0.004		

REPORT OF PARTICLE-SIZE ANALYSIS OF SOIL	IL Route 22 Culvert Improvements - Lake County, IL	File No. G18.009