KAW VALLEY ENGINEERING, INC.

DRAFT GEOTECHNICAL ENGINEERING REPORT
STRATFORD ROAD WATER TANK
STRATFORD ROAD AND SUNSET DRIVE
LAWRENCE, KANSAS

Prepared For:

BLACK & VEATCH CORPORATION
8400 Ward Parkway
Kansas City, Missouri 64114

Prepared By:

KAW VALLEY ENGINEERING, INC.
14700 West 114th Terrace
Lenexa, Kansas 66215

October 3, 2014

Project No. **C14G7737**

Consulting Engineers

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KAW VALLEY ENGINEERING, INC.

October 3, 2014 **C14G7737**

Mr. Andrew Hansen
Black & Veatch Corporation
8400 Ward Parkway
Kansas City, Missouri 64114

RE: DRAFT GEOTECHNICAL ENGINEERING REPORT
STRATFORD ROAD WATER TANK
STRATFORD ROAD AND SUNSET DRIVE
LAWRENCE, KANSAS

Dear Mr. Hansen:

This report presents the results of a subsurface exploration and geotechnical engineering analysis conducted for the referenced project. This exploration has been conducted in accordance with the proposal dated May 6, 2014. This exploration and analysis was conducted as authorized by Black and Veatch Corporation.

Completing this report is information including a plan of the site and boring locations, logs of borings, physical laboratory testing results, corrosivity test results, a general stratigraphic column, and a boring profile.

We appreciate the opportunity to be of service to you on this project. Please do not hesitate to contact us if you have any questions or comments.

Respectfully submitted,
Kaw Valley Engineering, Inc.

Jessica A. Nixon, P.E.
Staff Engineer

Michael R. Osbourn, P.E.
Principal

MICHAEL R. OSBOURN
LICENSED
11676
10.03.14
KANSAS
PROFESSIONAL ENGINEER

Copies submitted: (5)

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PROJECT AND SITE DESCRIPTION

This exploration program was conducted for the purpose of identifying subsurface conditions for a new water tank and associated service mains for the City of Lawrence, Kansas. The new water tank is proposed to be located on an existing city-owned parcel of land located northwest of the intersection of Stratford Road and Sunset Drive in Lawrence, Kansas. The condition of the site at the time of drilling was an open, grass covered field surrounded by mature trees and bounded by an existing water tower on the west, a wooded area and residences to the north, Sunset Drive on the east, and Stratford Road on the south. The purpose of this report is to make recommendations regarding the construction and design of the proposed water tank and associated water mains based upon the field exploration and laboratory testing results.

The proposed construction is to include the rehabilitation or replacement of the Stratford Elevated Tank. Possible replacement options provided were 130 foot tall self supporting 0.5, 0.75, and 1 million gallon water tanks. The proposed finish grade elevation was not provided at the time of the report, but was assumed to be near the existing grade.

FIELD EXPLORATION

The field drilling exploration was performed on September 4 and 5, 2014 and included a total of two borings, identified as B-1 and B-2. Plan boring locations were provided by Black & Veatch Corporation. Measurements from existing surface features were used to locate the borings in the field. Surface elevations at the boring locations are displayed on the logs of borings. Field resistivity testing was performed on September 5, 2014 at B-1 and B-2 using the Wenner Four-Pin Method at spacings requested by Black & Veatch Corporation. The boring locations and elevations are displayed on Plate 1 and the logs of borings, respectively.

The borings were drilled with a truck-mounted CME-55 drill rig using 4 inch continuous flight augers. Soil samples were obtained at 2-foot intervals throughout the borings. A hand-held penetrometer was used on the tube samples to determine an indication of the unconfined compressive strength of cohesive soils. Bedrock core samples were obtained in both borings using NQ2 wireline coring methods. Boring B-1 was drilled to a depth of 24.5 feet and Boring B-2 to a depth of 16.1 feet. Detailed logs of the borings are displayed on Plates 2 and 3. Photographs of the bedrock cores are presented on Plates 4A, 4B, and 4C. A cross section of the boring logs is presented on Plate 5.

Upon completion of drilling, the borings were backfilled using a mixture of bentonite chips and soil cuttings. The bedrock core was examined, classified, and recorded on the boring logs upon return to the laboratory by a KVE geologist. Rock quality designation (RQD), and percent recovery were also calculated and included on the boring log. RQD is the percentage of the total core run in competent sections greater than 4 inches in length.

The borings were logged in the field by the geologist working with the drill crew. The field logs were developed based upon visual classifications of materials encountered during drilling, as well as the logger's interpretation of the subsurface conditions between samples. Final boring logs included with this report represent the engineer's interpretation of the field logs and include revisions based upon results of the laboratory testing and a geologist’s review of the bedrock cores.

LABORATORY TESTING PROGRAM

The laboratory testing program was designed to determine the pertinent engineering and index properties of the soil and bedrock. Tests performed on selected soil samples included moisture content, dry density, Atterberg limits, and unconfined compressive strength. In addition, grain size analyses were performed on cohesive soil samples. Samples of the bedrock cores were tested for density and unconfined compressive strength. Results of the moisture content, density, Atterberg limits, and unconfined compressive strength tests are displayed upon the boring logs. Grain size analyses results are displayed in Appendix A. Testing was performed in accordance with applicable ASTM standards.

Laboratory tests of the limestone bedrock yielded unconfined compressive strengths ranging from 2,919 psi to 10,063 psi. Moisture contents for the clay soils ranged from 19.2 to 25.7 percent, with in-situ dry densities ranging from 95.6 to 111.3 pounds per cubic foot. Measured unconfined compression strengths for the soils ranged from 2,177 to 25,004 pounds per square foot (psf). Atterberg limits tests indicate the upper soils generally classify as CL-CH (lean to fat) and CH (fat) inorganic clays of moderate and high plasticity, respectively, in accordance with the Unified Soil Classification System. These soils tend to have moderate and high swell potentials, respectively.

Two soil samples were selected for laboratory chemical analyses to assist in evaluation of corrosivity characteristics. The samples were tested for parameters including resistivity, pH, redox potential, sulfides, water-soluble sulfate, and water-soluble chloride. The chemical analyses were conducted by Pace Analytical Services, Inc. of Lenexa, Kansas. The test results and chain of custody forms are displayed in Appendix B.

SUBSURFACE CONDITIONS

Subsurface conditions over the site include undisturbed glacio-fluvial soil mantle over bedrock limestone and shale. The depth of soil mantle was 9.0 feet at Boring B-1 and 6.7 feet at Boring B-2.

The Web Soil Survey indicates that the surficial soils over the majority of the site are identified as the Woodson silt loam. The parent material for this soil is listed as silty and clayey alluvium. Copies of the soil map and soil descriptions are attached in Appendix C.

Bedrock consists of weathered, thin, wavy-bedded limestone at a depth of 9.0 feet in Boring B-1. However, weathering appeared to be variable from 10.6 feet to a depth of 18.6 feet, with hard, cherty zones of less weathered limestone separating moderately weathered limestone. Shale partings were also apparent in the limestone. At a depth of 18.6 feet down to 20.8 feet, a light brown to olive gray, highly weathered to moderately weathered, argillaceous shale was encountered. As the boring progressed from 20.8 feet down to 24.2 feet, a slightly weathered to fresh black fissile shale was encountered. Below 24.2 feet, an unweathered, hard, cherty, bluish gray limestone was observed. The boring terminated at 24.5 feet in this rock unit.

At Boring B-2, the thin, wavy-bedded limestone was encountered from 6.7 feet to 16.1 feet. The boring terminated at 16.1 feet within the limestone.

The bedrock units underlying the site are thought to be part of the Pennsylvanian Age Shawnee Group, specifically, the Plattsmouth Limestone Member and the Heebner Shale Member of the Oread Formation.

Groundwater. Groundwater was not encountered in either boring prior to coring. At completion of coring operations, the water level at B-1 and B-2 was at 3.0 and 4.0 feet, respectively. These results would seem to indicate that the strata at the site are not very permeable. However, it should be understood that the level of the groundwater may fluctuate due to rainfall and other climatic factors, and that groundwater may or may not be present during construction or at other times during the life of the project.

DESIGN CONSIDERATIONS AND RECOMMENDATIONS

On the basis of the anticipated finish grade elevations near existing grade, minimal cuts and fills are anticipated for the proposed construction area. We recommend that the proposed water towers be founded on continuous ring footings founded upon the existing limestone bedrock. A net allowable bearing pressure of 40,000 psf may be used to design and proportion these footings.

Site Preparation. Site preparation should commence with stripping of all vegetation, topsoil, and other deleterious materials from the construction areas. Stripping should extend a minimum of 5 feet beyond the structure footprint. A minimum stripping depth of approximately 8 inches should be anticipated. However, stripping depths will likely vary and should be adjusted to remove all vegetation and root systems. Soils removed during site stripping operations could be used for final site grading outside the proposed tower area.

Following stripping and cutting to grade, the moisture content of the exposed soils should be evaluated. Depending on the in-situ moisture content of the exposed soils, moisture conditioning of the exposed grade may be required. The moisture content of the exposed grade should be adjusted to within the range recommended for structural fill to allow the exposed material to be compacted to a minimum density of 95% of maximum density as determined by the standard Proctor compaction procedure. Extremely wet or unstable areas that hamper compaction of the subgrade may require undercutting and replacement with structural fill or other stabilization techniques. Suitable structural fill should be placed to design grade as soon as practical after reworking the subgrade to avoid moisture changes in the underlying soils.

Following moisture conditioning of the exposed soils, it is recommended that the exposed grade be proofrolled to provide a more stable base for placement of structural fill and to assist in identifying soft or disturbed areas. Unsuitable areas identified by the proofrolling operation should be undercut and replaced with structural fill. Proofrolling can be accomplished through use of a fully-loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading.

Structural Fill. On-site soils are acceptable as general fill and backfill materials. All structural fill should consist of approved materials, free of organic matter and debris. Imported fill material should consist of low swell potential cohesive soils with a liquid limit less than 45 and a plasticity index between 10 and 25.

All structural fill should be placed in lifts having a maximum loose lift thickness of 8 inches, with cohesive soils compacted to a minimum of 95% of the material's maximum dry density as determined by ASTM D 698 (standard Proctor compaction) and granular soils compacted to a minimum of 70% of relative density. This includes all fill under and adjacent to pavements and any structures. Cohesive soil backfill under landscape areas should be compacted to a minimum of 90% of the materials maximum density; the recommendation for granular soil backfill is the same. The moisture content of cohesive soil fill at the time of compaction should be within a range of optimum moisture to 3% above optimum moisture content as defined by the standard Proctor compaction procedure. The recommended moisture content range for granular soil fill is 2% below to 2% above optimum moisture.

The geotechnical engineer should approve all fill material. Approval requires that a moisture-density relationship and Atterberg limits be performed for each proposed fill material prior to its placement.

Continuous observation by the geotechnical engineer or his representative should be maintained during site preparation and compaction of all fill and backfill materials.

Soil Excavation. The on-site soils are classified as Type B, as indicated by the OSHA Excavation Standard Handbook. Using sloping to protect against cave-ins, Type B soils can be cut at no steeper than a 1:1 vertical slope. If these slopes cannot be achieved, shoring or bracing will be required.

So as to avoid any unnecessary collapsing or sliding, no more trench should be excavated ahead of the current pipe placement than is necessary. All trenches should be backfilled before the end of the day.

Differential Settlement. If the water tank foundation elements are founded on the limestone that underlies the site, differential settlement between the pipeline and the water storage tank should be less than 1 inch.

Allowable Bearing Pressures. It is anticipated that the footing excavations for the proposed water tank will extend through the existing soil mantle and loose weathered limestone, and bear in the hard limestone. An allowable bearing pressure of 40,000 psf for foundation elements bearing within the limestone bedrock can be generally utilized. The bedrock zone for which this allowable pressure may be utilized is between elevations 1,030 and 1,023 feet.

Preparation of the bearing surface should include the remove of all loose, weathered and broken rock to expose the underlying intact, sound limestone. Excavations that extend into the limestone may require the use of pneumatic breakers or some other method of hard rock removal. If joints or cracks are encountered in the limestone bearing surface and these joints or

cracks are filled with clay, it is recommended that the joints or cracks be cleaned as deep as possible and poured as the foundation is poured. The base of all footing excavations should be clean and free of all water and loose materials, prior to placement of concrete. Concrete should be placed as soon as possible after excavating the footings. The contractor should include a contingency to cover the cost of removing highly weathered and/or unsuitable rock.

Granular Fill for Pipe Embedment. The granular fill for pipe embedment should be a crushed stone product similar to ASTM C-33. The geotextile separation layer or wrap properties should conform to AASHTO M288, Class 2 specifications for separation geotextiles.

Seismic Soil Classification. According to the 2012 International Building Code, the site soils are best characterized by the "Class C" site classification. This classification can be utilized by the structural engineer as a seismic design parameter.

Corrosion Protection. Laboratory measurements of pH, redox potential, and chemical tests for the presence of chloride, sulfate, and sulfide ions were conducted. The results of this testing can be found within this report in Appendix B. These particular chemical tests do not indicate an increased potential for corrosion problems. However, both laboratory and field resistivity tests (results attached in Appendix E) indicated resistivities in the range of 16,600 to 2,514 ohm-cm. These tests indicate there is a mild to moderate potential for future corrosion problems with the water main installation. Kaw Valley Engineering recommends any buried pipe be coated or lined with a chemically inert material to reduce the potential for ongoing corrosion.

Lateral Loads. A coefficient of base friction of 0.30 may be used for the contact between the foundations and supporting materials.

Lateral Pressures. Unrestrained walls below grade should be designed for an equivalent active fluid pressure of 45 psf/ft. Restrained walls below grade should be designed for an "at-rest" equivalent fluid pressure of 60 psf/ft. These values assume no additional loads due to the buildup of hydrostatic pressure.

OBSERVATION OF CONSTRUCTION

The conclusions and recommendations given in this report are based on interpretation of boring data and our experience. Variations may occur from conditions observed within test borings; therefore, it is imperative to involve the geotechnical engineer in the final design and construction process.

Field observation services are viewed as a continuation of the design process. Unless these services are provided, the geotechnical engineer will not be responsible for improper use of recommendations, or failure by others to recognize conditions which may be detrimental to the successful completion of project.

LIMITATIONS

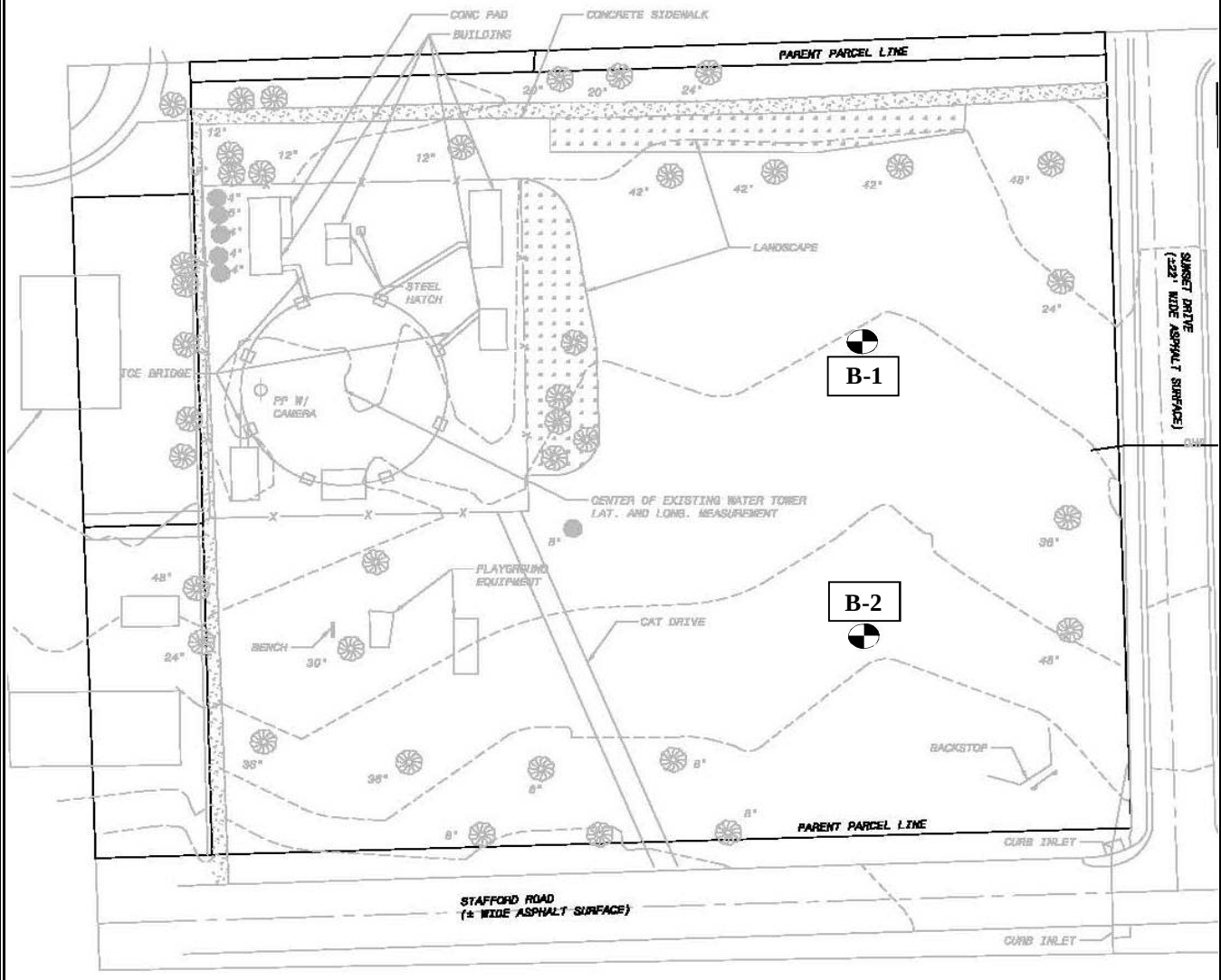
The analysis, conclusions, and recommendations contained in this report are based on the site conditions and project layout described herein and further assume that the conditions throughout the site, i.e., the subsurface conditions elsewhere on the site are the same as those disclosed by the borings. If, during construction, subsurface conditions different from those encountered in the exploratory borings are observed or appear to be present beneath excavations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary.

If there is a substantial lapse in time between the submittal of this report and the start of work at the site, or if conditions or the project layout have changed due to natural causes or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of conclusions and recommendations considering the changed conditions and time lapse.

We recommend that we be retained to review the project layout and those portions of plans and specifications, which pertain to foundations and earthwork to determine if they are consistent with our findings and recommendations. In addition, we are available to observe construction, particularly site grading, earthwork, and foundation construction. We would be available to make other field observations as may be necessary.

This report was prepared for the exclusive use of the owner, architect, and engineer for evaluating the design of the project as it relates to the geotechnical aspects discussed herein. It should be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions included in the report. Unanticipated soil conditions may require that additional expense be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

ILLUSTRATIONS



North

Site Plan and Boring Locations

Plate 1

STRATFORD ROAD WATER TOWER

Stratford Road and Sunset Drive
Lawrence, Kansas

Approved By: JAN	Not to Scale	C14G7737

Kaw Valley Engineering, Inc.

LOG OF BORING B-1

Kaw Valley Engineering
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: Black and Veatch Corporation
PROJECT: Stratford Water Tower
NUMBER: C14G7737
LOCATION: Stratford Road and Sunset Drive - Lawrence, Kansas
DATE(S) DRILLED: 9/9/14 - 9/9/14

DRILLING METHOD(S): 4" CFA AND NQ2
DRILL RIG: CME 55
DRILL RIG OPERATOR: Reece Nigh
LOGGED BY: Scott Bishop

GROUNDWATER INFORMATION:
Water level prior to coring - Dry
Water level after coring - 3.0'

SURFACE ELEVATION: 1040.9'

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LL	ATTERBERG LIMITS PL	ATTERBERG LIMITS PI	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
			P = 4.5	19	22.2	46	22	24	95.6	5,564			LEAN TO FAT CLAY: Brown; stiff; slightly moist; trace silt
													1038.9'
			P = 4.5	18	19.2				111.3	25,004			LEAN CLAY: Brown; very stiff; slightly moist
													1036.9'
	5		P = 4.5	13	20.6				102.1	13,228			FAT CLAY: Red brown; very stiff; moist
			P = 4.5	12	21.0								
													1031.9'
	10												LIMESTONE: Yellow brown; soft; highly weathered
													1030.3'
			REC = 88 RQD = 36						153.3	4,777psi			LIMESTONE: Light blue gray with light yellow brown (primarily around bedding planes); hard; thin and wavy bedded; fine crystalline; with vugs (some calcite lined or filled); fossiliferous; with black chert nodules from 10.6' to 10.8'; with shale partings; moderately weathered (PLATTSMOUTH LIMESTONE MEMBER)
	15		REC = 95 RQD = 70						154.0	2,919psi			
													1022.3'
	20												SHALE: Light brown to olive gray; soft; argillaceous; calcareous at top; highly to moderately weathered (HEEBNER SHALE MEMBER)
													1020.1'
			REC = 100 RQD = 30										SHALE: Black; fissile; with thin phosphate laminations; slightly weathered to fresh (HEEBNER SHALE MEMBER)
													1016.7'
	25		**BORING TERMINATED AT 24.5'**										1016.4' LIMESTONE: Blue gray; hard; siliceous; lower 1/2 inch is dark gray chert; fresh (LEAVENWORTH LIMESTONE MEMBER)

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial conditions - Grass

LOG OF BORING B-2

Kaw Valley Engineering
14700 W 114th Terrace
Lenexa, Kansas 66215
Telephone: (913)894-5150
Fax: (913)894-5977

CLIENT: Black and Veatch Corporation
PROJECT: Stratford Water Tower
NUMBER: C14G7737
LOCATION: Stratford Road and Sunset Drive - Lawrence, Kansas
DATE(S) DRILLED: 9/5/14 - 9/5/14

DRILLING METHOD(S): 4" CFA AND NQ2
DRILL RIG: CME 55
DRILL RIG OPERATOR: Reece Nigh
LOGGED BY: Scott Bishop

GROUNDWATER INFORMATION:
Water level prior to coring - Dry
Water level after coring - 4.0'

SURFACE ELEVATION: 1039.2'

SOIL SYMBOL	DEPTH (FT)	SAMPLES	N: BLOWS/FT P: TONS/SQ FT T: BLOWS/SIX INCHES REC: % RQD: %	RECOVERY (IN)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT LL	ATTERBERG LIMITS PLASTIC LIMIT PL	ATTERBERG LIMITS PLASTICITY INDEX PI	DRY DENSITY POUNDS/CUBIC FT	COMPRESSIVE STRENGTH (POUNDS/SQ FT)	CONFINING PRESSURE (POUNDS/SQ IN)	MINUS NO. 200 SIEVE (%)	DESCRIPTION OF STRATUM
													TOPSOIL 1038.7'
			P = 4.5	7	21.4				81.4	2,177			SILTY CLAY: Brown; stiff; slightly moist 1037.2'
			P = 4.5	12	25.7	57	21	36	99.5	10,260			FAT CLAY: Brown; very stiff; slightly moist 1034.2'
	5		P = 4.5	14	22.1	47	22	25	103.9	7,221			LEAN TO FAT CLAY: Red brown; very stiff; moist 1032.5'
													LIMESTONE: Yellow brown; soft; highly weathered 1030.8'
	10		REC = 55 RQD = 19						154.0	5,084psi			LIMESTONE: Light blue gray with light yellow brown (primarily around bedding planes); hard; thin and wavy bedded; fine crystalline; with vugs (some calcite lined or filled); fossiliferous; dark gray to black chert nodules fro 8.4' to 8.7'; with highly weathered shale partings; moderately weathered (lower 2" highly weathered) (PLATTSMOUTH LIMESTONE MEMBER)
									162.4	10,063psi			
			REC = 96 RQD = 46										
	15												1023.1'
			BORING TERMINATED AT 16.1'										
	20												
	25												

N - STANDARD PENETRATION TEST RESISTANCE
P - POCKET PENETROMETER RESISTANCE
T - BLOWS PER SIX INCHES
REC - ROCK CORE RECOVERY
RQD - ROCK QUALITY DESIGNATION

REMARKS:
Surficial conditions - Grass

Boring B-1 Surface Elevation: 1,040.9 feet

Run 1 of 3 from 10.6 – 15.5 feet Recovery: 88% RQD: 36%

Run 2 of 3 from 15.5 – 20.5 feet Recovery: 95% RQD: 70%

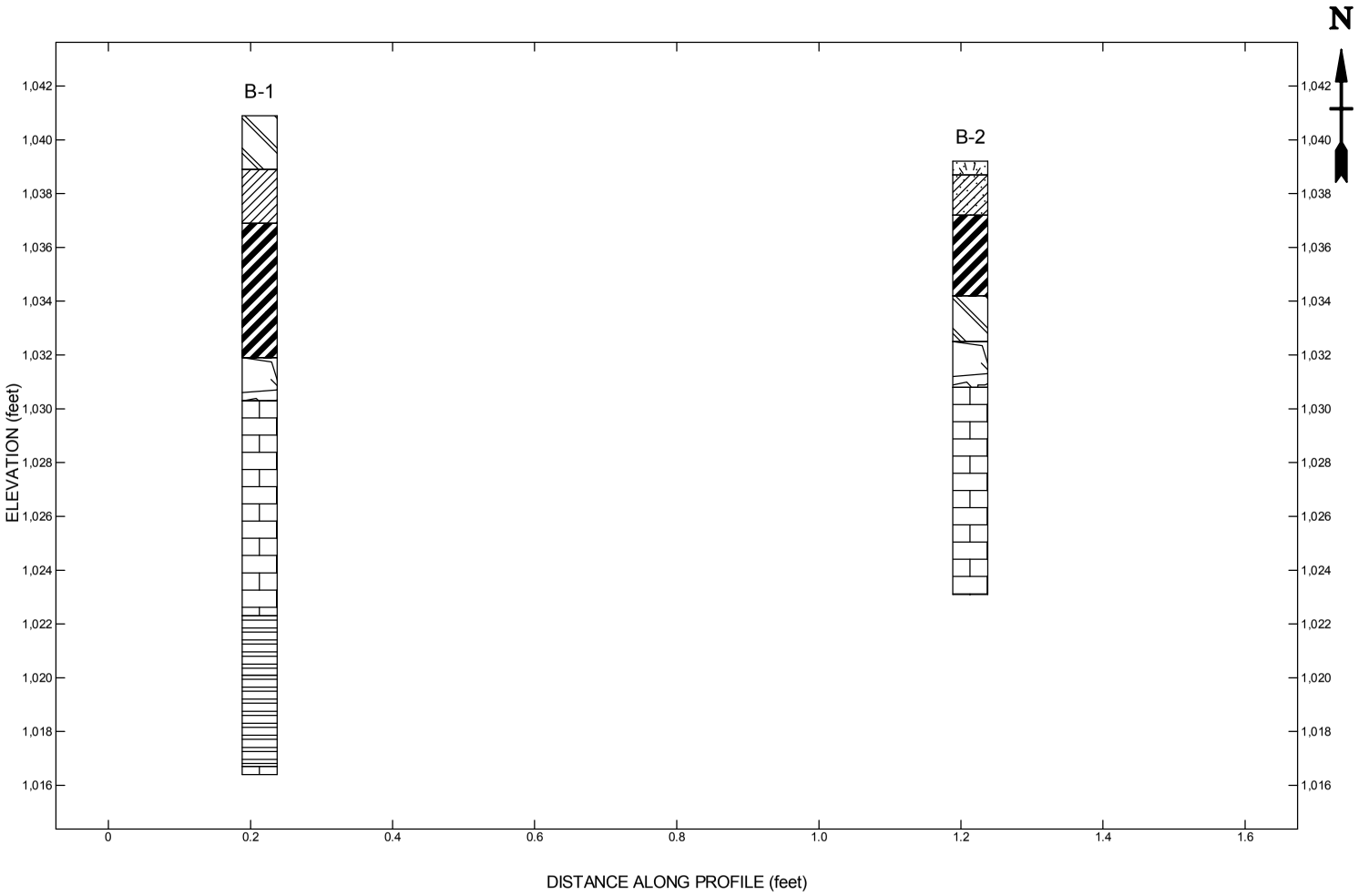
Boring B-1 Surface Elevation: 1,040.9 feet

Run 3 of 3 from 20.5 – 24.5 feet Recovery: 100% RQD: 30%

Boring B-2 Surface Elevation: 1,039.2 feet

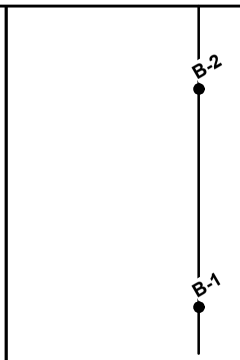
Run 1 of 2 from 8.4 – 11.1feet Recovery: 55% RQD: 19%

Run 2 of 2 from 11.1 – 16.1 feet Recovery: 96% RQD: 46%



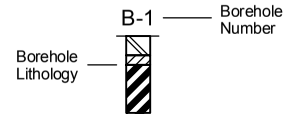
Lithology Graphics

- USCS Low to High Plasticity Clay
- USCS Low Plasticity Clay
- USCS High Plasticity Clay
- Highly weathered Limestone
- Limestone
- Shale
- Topsoil
- USCS Low Plasticity Sandy Clay



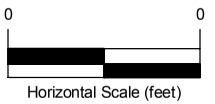
Site Map Scale 1 inch equals 0 feet

Explanation



Water Level Reading after drilling.

Delayed Water Level Reading



Vertical Exaggeration: 0x

Kaw Valley Engineering, Inc.
14700 W 114th Terrace
Lenexa, KS 66215

Stratford Water Tower

Boring Log Profile

JOB NUMBER	PLATE NUMBER
C14G7737	Plate 5

BORING LOG REFERENCE LEGEND

DESCRIPTIVE SOIL CLASSIFICATION

Soil description is based on the Unified Soil Classification System as outlined in ASTM Designation D-2487. The Unified Soil Classification group symbol for soil descriptions shown on the boring logs corresponds with the group names listed below. The description includes soil constituents, consistency, relative density, color and any other appropriate descriptive terms. Geologic description of bedrock, when encountered, is also shown in the description column. Refer to the appropriate notes for bedrock classification.

Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name
GW	Well graded gravel	SW	Well graded sand	CL	Lean clay	CH	Fat clay
GP	Poorly graded gravel	SP	Poorly graded sand	ML	Silt	MH	Elastic silt
GM	Silty gravel	SM	Silty sand	OL	Organic clay Organic silt	OH	Organic clay Organic silt
GC	Clayey gravel	SC	Clayey sand			PT	Peat

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf

< 500	Very Soft
500 – 1,000	Soft
1,001 – 2,000	Firm
2,001 – 4,000	Stiff
4,001 – 8,000	Very Stiff
8,001 – 16,000	Hard
> 16,000	Very Hard

RELATIVE PROPORTIONS

Descriptive Term(s) (Components also Percent in Sample)	Sand & Gravel Percent of Dry Wt.	Fines Percent of Dry Wt.
Trace	< 15	<5
Some	15 – 29	5 - 12
Modifier	> 30	> 12

RELATIVE DENSITY OF COARSE-GRAINED SOILS

N - (blows/ft)	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
50+	Very Dense

GRAIN SIZE TERMINOLOGY

Major Component	Size Range
Cobbles	12 in to 3 in
Gravel	3 in to #4 sieve
Sand	#4 to #200 sieve
Silt or Clay	Passing #200 sieve

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

DEFINITIONS OF ABBREVIATIONS

CR – Core recovery, length of core recovered in each run compared to the length drilled expressed as percent
LL – Liquid limit of specimen
N – Number of blows to penetrate last 12 inches with 140-pound hammer in standard penetration test
Blow count reported for each 6-inch interval on logs
PL – Plastic limit of specimen
RQD – Rock quality designation, aggregate length of core pieces greater than 4 inches long, expressed as percent of length drilled
TW – Thin walled tube
SS – Standard penetration test
NQ2 – 2 inches diameter core
CFA – Continuous flight augers
HSA – Hollow stem augers
EOB – End of boring

KAW VALLEY ENGINEERING

A P P E N D I X A

PHYSICAL LABORATORY TEST RESULTS

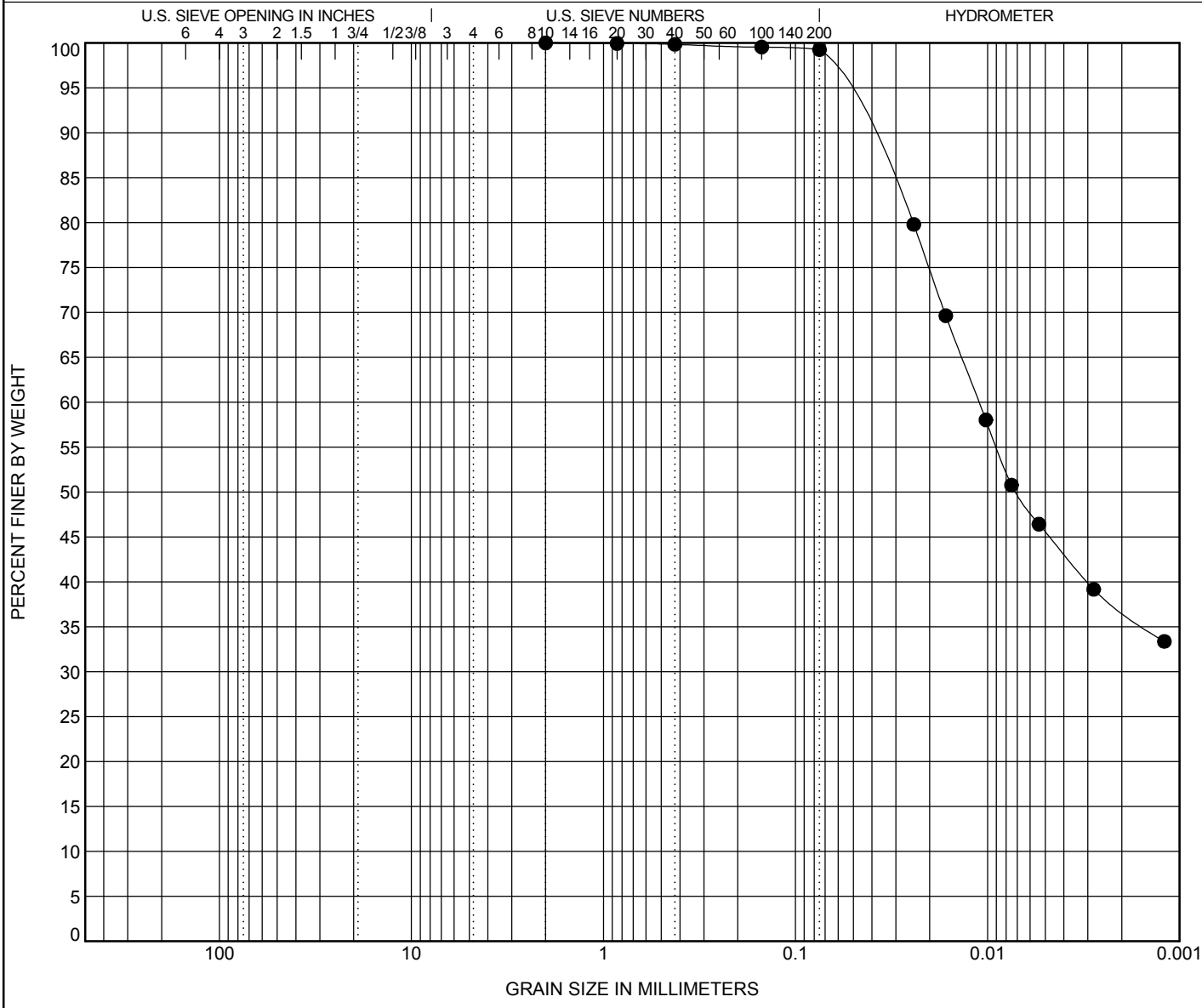
Grain Size Analyses Results

Kaw Valley Engineering
14700 W 114th Terrace
66215
Telephone: 913-894-5150
Fax: 913-894-5977

GRAIN SIZE DISTRIBUTION

CLIENT Black and Veatch Corporation **PROJECT NAME** Stratford Water Tower

PROJECT NUMBER C14G7737 **PROJECT LOCATION** Stratford Road and Sunset Drive - Lawrence, Kansas



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**0.0**	**LEAN CLAY(CL)**	**46**	**22**	**24**		

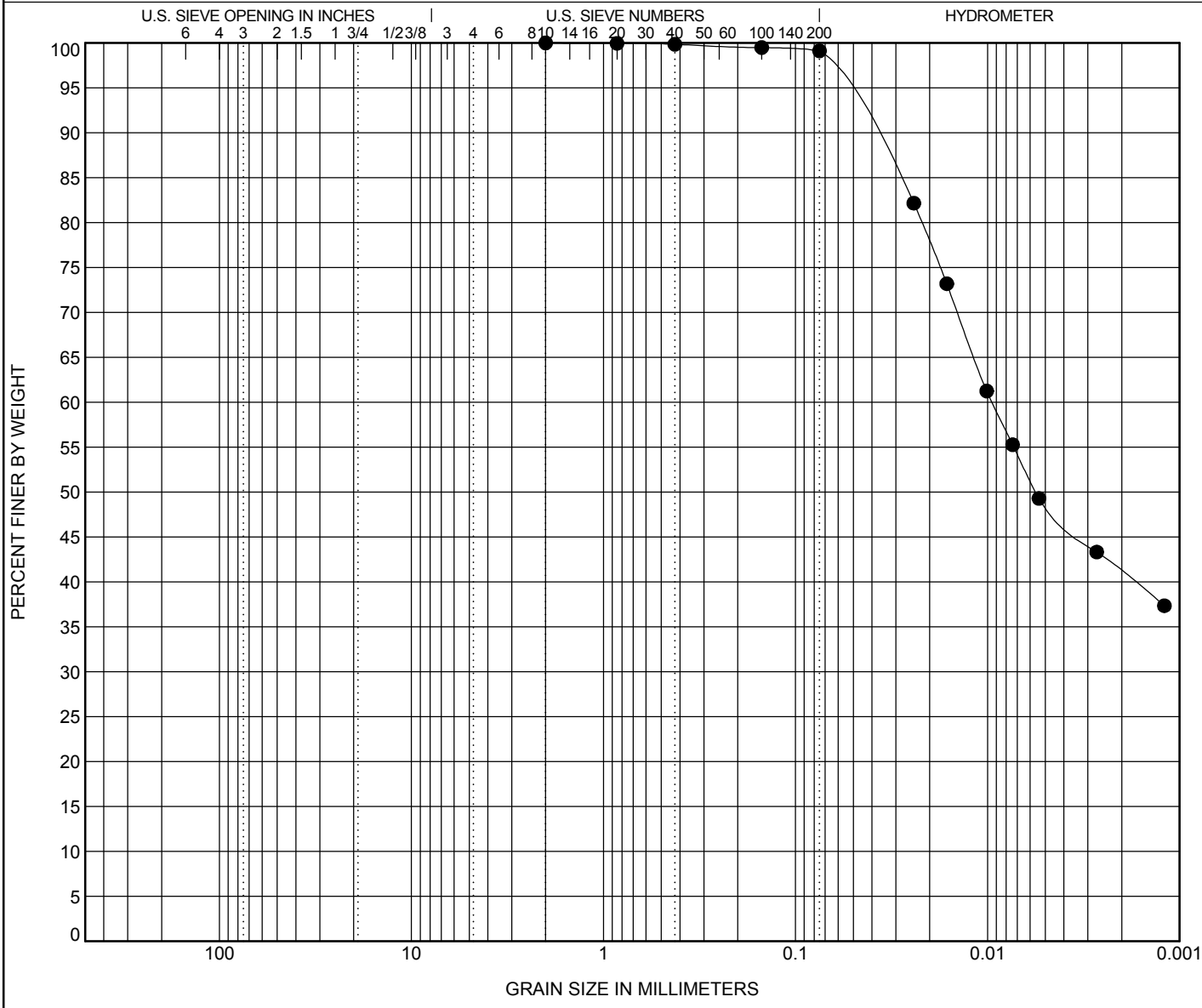
	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1**	**0.0**	**2**	**0.011**			**0.0**	**0.8**	**53.7**	**45.6**

Kaw Valley Engineering
14700 W 114th Terrace
66215
Telephone: 913-894-5150
Fax: 913-894-5977

GRAIN SIZE DISTRIBUTION

CLIENT Black and Veatch Corporation **PROJECT NAME** Stratford Water Tower

PROJECT NUMBER C14G7737 **PROJECT LOCATION** Stratford Road and Sunset Drive - Lawrence, Kansas



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-2**	**2.0**	**FAT CLAY(CH)**	**57**	**21**	**36**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-2**	**2.0**	**2**	**0.009**			**0.0**	**0.9**	**50.5**	**48.6**

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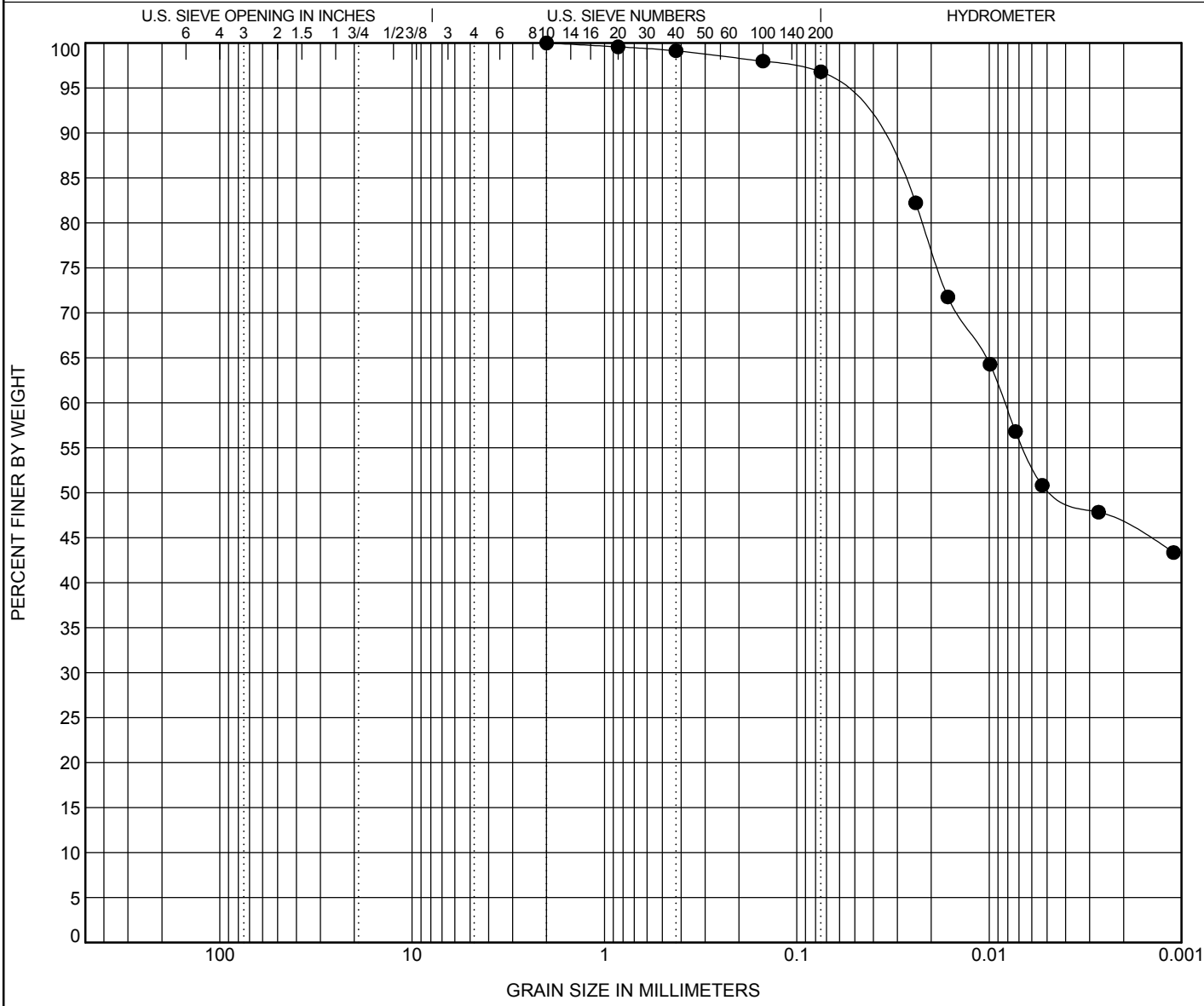
66215
Telephone: 913-894-5150
Fax: 913-894-5977

GRAIN SIZE DISTRIBUTION

CLIENT Black and Veatch Corporation **PROJECT NAME** Stratford Water Tower

PROJECT NUMBER C14G7737 **PROJECT LOCATION** Stratford Road and Sunset Drive - Lawrence, Kansas



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	**B-2**	**5.0**	**LEAN CLAY(CL)**	**47**	**22**	**25**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-2**	**5.0**	**2**	**0.008**			**0.0**	**3.2**	**46.2**	**50.6**

A P P E N D I X B

CORROSIVITY TEST RESULTS

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

September 24, 2014

Kris Moore
Kaw Valley Engineering, Inc.
14700 W. 114th Terrace
Lenexa, KS 66215

RE: Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

Dear Kris Moore:
Enclosed are the analytical results for sample(s) received by the laboratory on September 09, 2014. The results relate only to the samples included in this report. Results reported herein conform to the most current TNI standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Sherri Rosenstangle

Sherri Rosenstangle
sherri.rosenstangle@pacelabs.com
Project Manager

Enclosures

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

CERTIFICATIONS

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

New Orleans Certification IDs

California Env. Lab Accreditation Program Branch: 11277CA
Florida Department of Health (NELAC): E87595
Illinois Environmental Protection Agency: 0025721
Kansas Department of Health and Environment (NELAC): E-10266
Louisiana Dept. of Environmental Quality (NELAC/LELAP): 02006
Oklahoma Department of Environmental Quality: 2010-139
Oregon Environmental Laboratory Accreditation: LA200001
Pennsylvania Dept. of Env Protection (NELAC): 68-04202
Texas Commission on Env. Quality (NELAC): T104704405-09-TX
U.S. Dept. of Agriculture Foreign Soil Import: P330-10-00119
Washington Department of Ecology: C2078

Kansas Certification IDs

9608 Loiret Boulevard, Lenexa, KS 66219
WY STR Certification #: 2456.01
Arkansas Certification #: 13-012-0
Illinois Certification #: 003097
Iowa Certification #: 118
Kansas/NELAP Certification #: E-10116
Louisiana Certification #: 03055
Nevada Certification #: KS000212008A
Oklahoma Certification #: 9205/9935
Texas Certification #: T104704407
Utah Certification #: KS00021

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SAMPLE SUMMARY

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

Lab ID	Sample ID	Matrix	Date Collected	Date Received
60177647001	**B-1 4-5'**	Solid	09/09/14 08:00	09/09/14 17:10
60177647002	**B-2 4-5'**	Solid	09/09/14 08:00	09/09/14 17:10

REPORT OF LABORATORY ANALYSIS

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(913)599-5665

SAMPLE ANALYTE COUNT

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
60177647001	**B-1 4-5'**	ASTM D2974	DWC	1	PASI-K
		EPA 9034	LJL	1	PASI-N
		EPA 9045	JML	1	PASI-K
		SM 2580B	ESM	1	PASI-K
		EPA 120.1 Resistivity	ESM	1	PASI-K
		EPA 9056	OL	2	PASI-K
60177647002	**B-2 4-5'**	ASTM D2974	DWC	1	PASI-K
		EPA 9034	LJL	1	PASI-N
		EPA 9045	JML	1	PASI-K
		SM 2580B	ESM	1	PASI-K
		EPA 120.1 Resistivity	ESM	1	PASI-K
		EPA 9056	OL	2	PASI-K

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ANALYTICAL RESULTS

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

Sample: B-1 4-5' **Lab ID: 60177647001** Collected: 09/09/14 08:00 Received: 09/09/14 17:10 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**14.7**	%	0.50	1		09/15/14 00:00		
9034 Sulfide, Titration	Analytical Method: EPA 9034 Preparation Method: EPA 9030B							
Sulfide	ND	mg/kg	58.6	1	09/15/14 16:11	09/15/14 16:20		
9045 pH Soil	Analytical Method: EPA 9045							
pH at 25 Degrees C	**6.5**	Std. Units	0.10	1		09/22/14 14:00		H1
Oxidation/Reduction Potential	Analytical Method: SM 2580B							
Oxidation/Reduction Potential	**98.1**	mV	1.0	1		09/16/14 14:00		
Resistivity	Analytical Method: EPA 120.1 Resistivity							
Resistivity	**16600**	ohms-cm	100	1		09/22/14 16:00		
9056 IC Anions	Analytical Method: EPA 9056 Preparation Method: EPA 9056							
Chloride	ND	mg/kg	115	10	09/18/14 14:00	09/19/14 12:59	16887-00-6	
Sulfate	ND	mg/kg	115	10	09/18/14 14:00	09/19/14 12:59	14808-79-8	

REPORT OF LABORATORY ANALYSIS

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ANALYTICAL RESULTS

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

Sample: B-2 4-5' **Lab ID: 60177647002** Collected: 09/09/14 08:00 Received: 09/09/14 17:10 Matrix: Solid

Results reported on a "dry-weight" basis

Parameters	Results	Units	Report Limit	DF	Prepared	Analyzed	CAS No.	Qual
Percent Moisture	Analytical Method: ASTM D2974							
Percent Moisture	**17.6**	%	0.50	1		09/15/14 00:00		
9034 Sulfide, Titration	Analytical Method: EPA 9034 Preparation Method: EPA 9030B							
Sulfide	ND	mg/kg	60.7	1	09/15/14 16:11	09/15/14 16:20		
9045 pH Soil	Analytical Method: EPA 9045							
pH at 25 Degrees C	**6.5**	Std. Units	0.10	1		09/22/14 14:00		H1
Oxidation/Reduction Potential	Analytical Method: SM 2580B							
Oxidation/Reduction Potential	**77.7**	mV	1.0	1		09/16/14 14:00		
Resistivity	Analytical Method: EPA 120.1 Resistivity							
Resistivity	**15800**	ohms-cm	100	1		09/22/14 16:00		
9056 IC Anions	Analytical Method: EPA 9056 Preparation Method: EPA 9056							
Chloride	ND	mg/kg	122	10	09/18/14 14:00	09/19/14 13:44	16887-00-6	
Sulfate	ND	mg/kg	122	10	09/18/14 14:00	09/19/14 13:44	14808-79-8	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
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(913)599-5665

QUALITY CONTROL DATA

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

QC Batch: PMST/10016
QC Batch Method: ASTM D2974
Analysis Method: ASTM D2974
Analysis Description: Dry Weight/Percent Moisture
Associated Lab Samples: 60177647001, 60177647002

METHOD BLANK: 1442878 Matrix: Solid
Associated Lab Samples: 60177647001, 60177647002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Percent Moisture	%	ND	0.50	09/15/14 00:00	

SAMPLE DUPLICATE: 1442879

Parameter	Units	60177391001 Result	Dup Result	RPD	Max RPD	Qualifiers
Percent Moisture	%	15.8	15.9	0	20	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

REPORT OF LABORATORY ANALYSIS

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QUALITY CONTROL DATA

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

QC Batch: WET/3465 Analysis Method: EPA 9034
QC Batch Method: EPA 9030B Analysis Description: 9034 Sulfide Solid
Associated Lab Samples: 60177647001, 60177647002

METHOD BLANK: 50610 Matrix: Solid
Associated Lab Samples: 60177647001, 60177647002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Sulfide	mg/kg	ND	50.0	09/15/14 16:20	

LABORATORY CONTROL SAMPLE: 50611

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Sulfide	mg/kg	1000	922	92	80-120	

MATRIX SPIKE SAMPLE: 50613

Parameter	Units	60177647001 Result	Spike Conc.	MS Result	MS % Rec	% Rec Limits	Qualifiers
Sulfide	mg/kg	ND	1170	1080	88	75-125	

SAMPLE DUPLICATE: 50612

Parameter	Units	60177647001 Result	Dup Result	RPD	Max RPD	Qualifiers
Sulfide	mg/kg	ND	ND		20	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

REPORT OF LABORATORY ANALYSIS

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(913)599-5665

QUALITY CONTROL DATA

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

QC Batch: WET/50416 Analysis Method: EPA 9045
QC Batch Method: EPA 9045 Analysis Description: 9045 pH
Associated Lab Samples: 60177647001, 60177647002

SAMPLE DUPLICATE: 1447189

Parameter	Units	60177647001 Result	Dup Result	RPD	Max RPD	Qualifiers
pH at 25 Degrees C	Std. Units	6.5	6.5	0	3	H1

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

REPORT OF LABORATORY ANALYSIS

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(913)599-5665

QUALITY CONTROL DATA

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

QC Batch: WET/50307 Analysis Method: SM 2580B
QC Batch Method: SM 2580B Analysis Description: Oxidation/Reduction Potential
Associated Lab Samples: 60177647001, 60177647002

SAMPLE DUPLICATE: 1443720

Parameter	Units	60177647001 Result	Dup Result	RPD	Max RPD	Qualifiers
Oxidation/Reduction Potential	mV	98.1	100	2	10	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, Inc.
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(913)599-5665

QUALITY CONTROL DATA

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

QC Batch: WETA/31058 Analysis Method: EPA 9056
QC Batch Method: EPA 9056 Analysis Description: 9056 IC Anions
Associated Lab Samples: 60177647001, 60177647002

METHOD BLANK: 1445098 Matrix: Solid
Associated Lab Samples: 60177647001, 60177647002

Parameter	Units	Blank Result	Reporting Limit	Analyzed	Qualifiers
Chloride	mg/kg	ND	99.4	09/19/14 12:30	
Sulfate	mg/kg	ND	99.4	09/19/14 12:30	

LABORATORY CONTROL SAMPLE: 1445099

Parameter	Units	Spike Conc.	LCS Result	LCS % Rec	% Rec Limits	Qualifiers
Chloride	mg/kg	499	487	98	80-120	
Sulfate	mg/kg	499	482	97	80-120	

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 1445100 1445101

Parameter	Units	60177647001 Result	MS Spike Conc.	MSD Spike Conc.	MS Result	MSD Result	MS % Rec	MSD % Rec	% Rec Limits	RPD	Max RPD	Qual
Chloride	mg/kg	ND	577	575	546	560	95	97	80-120	3	15	
Sulfate	mg/kg	ND	577	575	551	560	96	97	80-120	2	15	

SAMPLE DUPLICATE: 1445102

Parameter	Units	60177647002 Result	Dup Result	RPD	Max RPD	Qualifiers
Chloride	mg/kg	ND	ND		15	
Sulfate	mg/kg	ND	45.2J		15	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

REPORT OF LABORATORY ANALYSIS

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Lenexa, KS 66219
(913)599-5665

QUALIFIERS

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to changes in sample preparation, dilution of the sample aliquot, or moisture content.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine (8270 listed analyte) decomposes to Azobenzene.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

LABORATORIES

PASI-K	Pace Analytical Services - Kansas City
PASI-N	Pace Analytical Services - New Orleans

ANALYTE QUALIFIERS

H1	Analysis conducted outside the EPA method holding time.

Pace Analytical Services, Inc.
9608 Loiret Blvd.
Lenexa, KS 66219
(913)599-5665

QUALITY CONTROL DATA CROSS REFERENCE TABLE

Project: STRATFORD WATER TOWER
Pace Project No.: 60177647

Lab ID	Sample ID	QC Batch Method	QC Batch	Analytical Method	Analytical Batch
60177647001	**B-1 4-5'**	ASTM D2974	PMST/10016		
60177647002	**B-2 4-5'**	ASTM D2974	PMST/10016		
60177647001	**B-1 4-5'**	EPA 9030B	WET/3465	EPA 9034	WET/3475
60177647002	**B-2 4-5'**	EPA 9030B	WET/3465	EPA 9034	WET/3475
60177647001	**B-1 4-5'**	EPA 9045	WET/50416		
60177647002	**B-2 4-5'**	EPA 9045	WET/50416		
60177647001	**B-1 4-5'**	SM 2580B	WET/50307		
60177647002	**B-2 4-5'**	SM 2580B	WET/50307		
60177647001	**B-1 4-5'**	EPA 120.1 Resistivity	WET/50428		
60177647002	**B-2 4-5'**	EPA 120.1 Resistivity	WET/50428		
60177647001	**B-1 4-5'**	EPA 9056	WETA/31058	EPA 9056	WETA/31059
60177647002	**B-2 4-5'**	EPA 9056	WETA/31058	EPA 9056	WETA/31059

Pace Analytical
www.pacelabs.com

Sample Condition Upon Receipt

WO# : 60177647

60177647

Client Name: Kaw Valley

Optional
Proj Due Date:
Proj Name:

Courier: Fed Ex ☐ UPS ☐ USPS ☐ Client ☒ Commercial ☐ Pace ☐ Other ☐

Tracking #: _____ Pace Shipping Label Used? Yes ☐ No ☒

Custody Seal on Cooler/Box Present: Yes ☐ No ☒ Seals intact: Yes ☐ No ☐

Packing Material: Bubble Wrap ☐ Bubble Bags ☐ Foam ☐ None ☐ Other ☐ Ziplc

Thermometer Used: ~~T-239~~ / T-194 **Type of Ice:** (Wet) Blue None ☐ Samples received on ice, cooling process has begun.
(circle one)

Cooler Temperature: 2.2

Temperature should be above freezing to 6°C

Date and initials of person examining contents: 5 9/9/14

Chain of Custody present:	☒Yes ☐No ☐N/A	1.
Chain of Custody filled out:	☒Yes ☐No ☐N/A	2.
Chain of Custody relinquished:	☒Yes ☐No ☐N/A	3.
Sampler name & signature on COC:	☒Yes ☐No ☐N/A	4.
Samples arrived within holding time:	☒Yes ☐No ☐N/A	5.
Short Hold Time analyses (<72hr):	☐Yes ☒No ☐N/A	6.
Rush Turn Around Time requested:	☐Yes ☒No ☐N/A	7.
Sufficient volume:	☒Yes ☐No ☐N/A	8.
Correct containers used:	☒Yes ☐No ☐N/A	
Pace containers used:	☒Yes ☐No ☐N/A	9.
Containers intact:	☒Yes ☐No ☐N/A	10.
Unpreserved 5035A soils frozen w/in 48hrs?	☐Yes ☐No ☒N/A	11.
Filtered volume received for dissolved tests?	☐Yes ☐No ☒N/A	12.
Sample labels match COC:	☒Yes ☐No ☐N/A	
Includes date/time/ID/analyses Matrix: SL		13.
All containers needing preservation have been checked.	☐Yes ☒No ☐N/A	
All containers needing preservation are found to be in compliance with EPA recommendation.	☐Yes ☒No ☐N/A	14.
Exceptions: VOA, coliform, TOC, O&G, WI-DRO (water), Phenolics	☐Yes ☒No	Initial when completed / Lot # of added preservative
Trip Blank present:	☐Yes ☒No ☐N/A	
Pace Trip Blank lot # (if purchased): _____		15.
Headspace in VOA vials (>6mm):	☐Yes ☐No ☒N/A	16.
Project sampled in USDA Regulated Area:	☐Yes ☐No ☒N/A	17. List State:

Client Notification/ Resolution: Copy COC to Client? (Y) / N Field Data Required? Y (/) N

Person Contacted: Kris Moure Date/Time: 9.11.14

Comments/ Resolution:

Analyze batch samples

Project Manager Review: [signature] Date: 9.11.14

CHAIN-OF-CUSTODY / Analytical Request Document

Pace Analytical® www.pacelabs.com

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: of 1634748

Section A Required Client Information:

Company: KAW VALLEY ENG.
Address: 14700 W 114 TERR
LENEXA KS 66215
Email To: moore@kveng.com
Phone: (913) 894-5150 Fax: 913 894 5977
Requested Due Date/TAT: STANDARD

Section B Required Project Information:

Report To: KAW VALLEY ENG.
Copy To:
Purchase Order No.: C14G7737
Project Name: STRATFORD WATERTOWER
Project Number: C14G7737

Section C Invoice Information:

Attention: LISA MARTIN
Company Name: KAW VALLEY
Address:
Pace Quote Reference:
Pace Project Manager:
Pace Profile #: 7622-3

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☑ OTHER _____

Site Location STATE: _____

Section D Required Client Information

SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE

Matrix Codes (MATRIX / CODE): Drinking Water DW; Water WT; Waste Water WW; Product P; Soil/Solid SL; Oil OL; Wipe WP; Air AR; Tissue TS; Other OT

Requested Analysis Filtered (Y/N)

ITEM #	SAMPLE ID	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED: COMPOSITE START DATE	COMPOSITE START TIME	COMPOSITE END/GRAB DATE	COMPOSITE END/GRAB TIME	SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives: Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Analysis Test Y/N: pH	Redox Potential	Resistivity	Sulfates	Chlorides	Sulfides	Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
1	B-1 4-5'	SL	G	9-9					2									Y	Y	Y	Y	Y	Y		2(2PL) 001
2	B-2 4-5'	SL	G	9-9					2									Y	Y	Y	Y	Y	Y		002
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
11																									
12																									

60177647

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
CONTACT KRIS MOORE BEFORE RUNNING TESTS. 894-5150 (913)	L. Kristopher Moore	9-9-2014			9/4	1710	2.2	Y	N	Y

SAMPLER NAME AND SIGNATURE: L. Kristopher Moore
PRINT Name of SAMPLER: L. KRISTOPHER MOORE
SIGNATURE of SAMPLER: L. Kristopher Moore
DATE Signed (MM/DD/YY): 09 SEPT 2014

Temp in °C | Received on Ice (Y/N) | Custody Sealed Cooler (Y/N) | Samples Intact (Y/N)

ORIGINAL

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

A P P E N D I X C

SOIL SURVEY MAP AND SOIL DESCRIPTIONS

Soil Map—Douglas County, Kansas
(Stratford Water Tower)

Map Scale: 1:1,140 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 15 30 60 90

Feet
0 50 100 200 300

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 15N WGS84

Map Unit Legend

Douglas County, Kansas (KS045)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
7460	Oska silty clay loam, 3 to 6 percent slopes	1.2	26.1%
8962	Woodson silt loam, 1 to 3 percent slopes	3.5	73.9%
Totals for Area of Interest		**4.7**	**100.0%**

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Report—Map Unit Description

Douglas County, Kansas

7460—Oska silty clay loam, 3 to 6 percent slopes

Map Unit Setting

National map unit symbol: 1l9fz
Elevation: 700 to 1,200 feet
Mean annual precipitation: 31 to 47 inches
Mean annual air temperature: 52 to 59 degrees F
Frost-free period: 175 to 215 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Oska and similar soils: 88 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Oska

Setting

Landform: Hillslopes

Landform position (three-dimensional): Crest, side slope

Down-slope shape: Convex

Across-slope shape: Convex

Parent material: Silty and clayey residuum weathered from limestone and shale

Typical profile

Ap - 0 to 9 inches: silty clay loam

Bt - 9 to 31 inches: silty clay

C - 31 to 38 inches: silty clay loam

R - 38 to 42 inches: bedrock

Properties and qualities

Slope: 3 to 6 percent

Depth to restrictive feature: 20 to 39 inches to lithic bedrock

Natural drainage class: Well drained

Runoff class: High

Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Available water storage in profile: Moderate (about 6.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 3e

Hydrologic Soil Group: C

Ecological site: Loamy upland (draft) (pe 35-42) (R112XY015KS)

8962—Woodson silt loam, 1 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2thdw

Elevation: 810 to 1,200 feet

Mean annual precipitation: 37 to 43 inches

Mean annual air temperature: 55 to 59 degrees F

Frost-free period: 175 to 225 days

Farmland classification: All areas are prime farmland

Map Unit Composition

Woodson and similar soils: 90 percent

Minor components: 0 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodson

Setting

Landform: Divides
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Silty loess and/or silty and clayey alluvium

Typical profile

Ap - 0 to 8 inches: silt loam
Bt1 - 8 to 18 inches: silty clay
Bt2 - 18 to 31 inches: silty clay
BC - 31 to 43 inches: silty clay
C - 43 to 79 inches: silty clay

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 6 to 24 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum in profile: 7.0
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: D
Ecological site: Clay upland (pe 35-42) (R112XY007KS)

Minor Components

Aquolls

Percent of map unit: 0 percent
Landform: Divides
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave

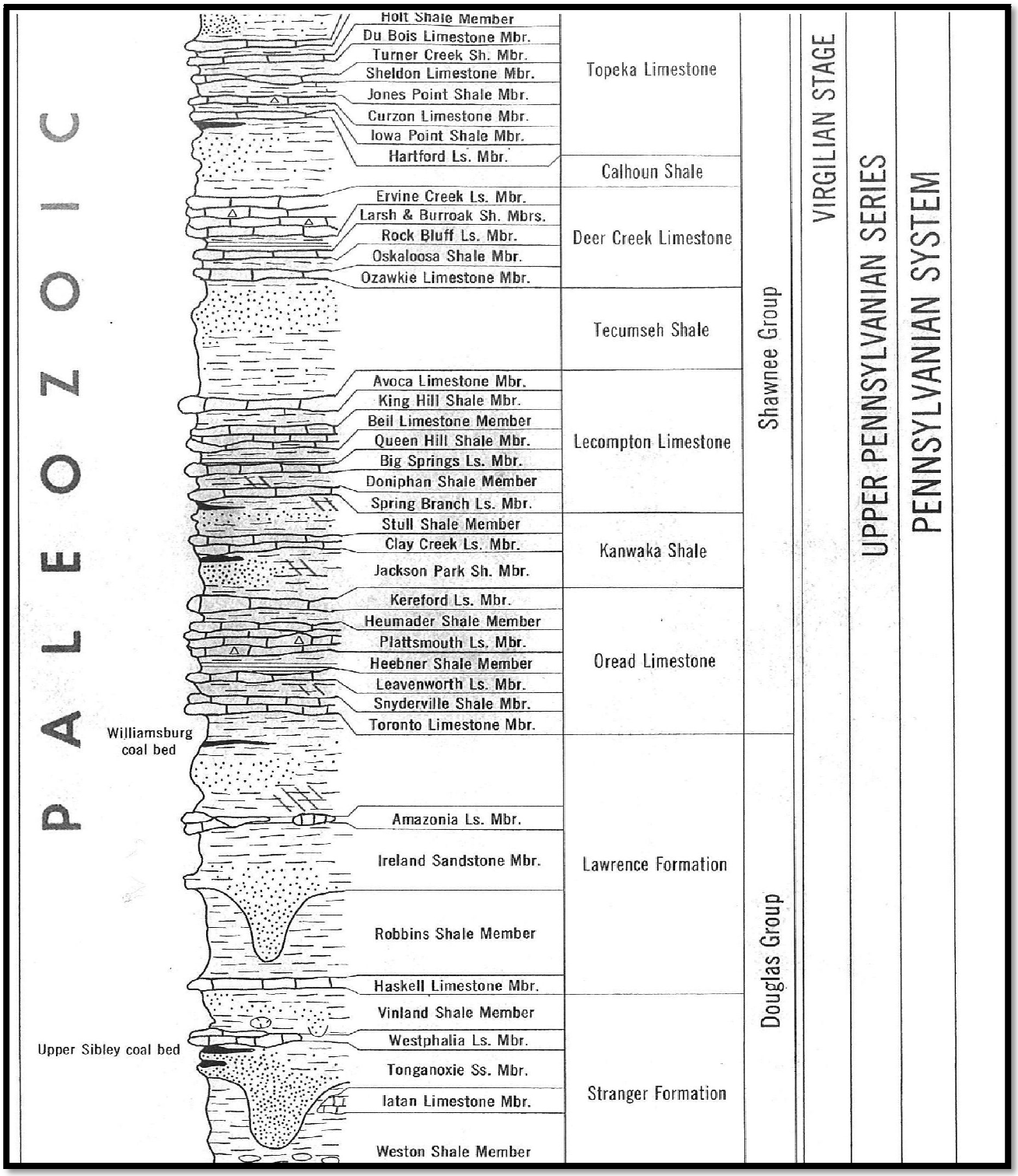
Ecological site: Clay upland (pe 35-42) (R112XY007KS)

Data Source Information

Soil Survey Area: Douglas County, Kansas
Survey Area Data: Version 10, Dec 5, 2013

A P P E N D I X D

BEDROCK INFORMATION


PALEOZOIC
Holt Shale Member
Du Bois Limestone Mbr.
Turner Creek Sh. Mbr.
Sheldon Limestone Mbr.
Jones Point Shale Mbr.
Curzon Limestone Mbr.
Iowa Point Shale Mbr.
Hartford Ls. Mbr.
Topeka Limestone
Calhoun Shale
Ervine Creek Ls. Mbr.
Larsh & Burroak Sh. Mbrs.
Rock Bluff Ls. Mbr.
Oskaloosa Shale Mbr.
Ozawkie Limestone Mbr.
Deer Creek Limestone
Tecumseh Shale
Avoca Limestone Mbr.
King Hill Shale Mbr.
Beil Limestone Member
Queen Hill Shale Mbr.
Big Springs Ls. Mbr.
Doniphan Shale Member
Spring Branch Ls. Mbr.
Lecompton Limestone
Stull Shale Member
Clay Creek Ls. Mbr.
Jackson Park Sh. Mbr.
Kanwaka Shale
Kereford Ls. Mbr.
Heumader Shale Member
Plattsmouth Ls. Mbr.
Heebner Shale Member
Leavenworth Ls. Mbr.
Snyderville Shale Mbr.
Toronto Limestone Mbr.
Oread Limestone
Shawnee Group
Williamsburg coal bed
Amazonia Ls. Mbr.
Ireland Sandstone Mbr.
Robbins Shale Member
Haskell Limestone Mbr.
Lawrence Formation
Vinland Shale Member
Westphalia Ls. Mbr.
Tonganoxie Ss. Mbr.
Iatan Limestone Mbr.
Weston Shale Member
Stranger Formation
Douglas Group
Upper Sibley coal bed
VIRGILIAN STAGE
UPPER PENNSYLVANIAN SERIES
PENNSYLVANIAN SYSTEM

A P P E N D I X E

FIELD RESISTIVITY TEST RESULTS

RESISTIVITY DATA

SITE:	Stratford Water Tower
PROJECT NO:	C14G7737
TEST DATE:	9/5/2014
LOCATION:	BORING B-1

A= (ft)	**2.5**	**5**	**10**	**15**	**20**	**25**	**30**
FORMULA= (OHM-CM)	*478.8*R*	*957.5*R*	*1915*R*	*2873*R*	*3830*R*	*4788*R*	*5745*R*
AREA 1 MEASURED	11.05	3.62	2.56	2.12	1.95	1.87	1.79
AREA 1 CALCULATED	5291	3466	4902	6091	7469	8954	10284
AREA 2 MEASURED	8.23	3.53	2.25	2.09	1.85	1.74	1.69
AREA 2 CALCULATED	3941	3380	4309	6005	7086	8331	9709
AREA 3 MEASURED	9.40	3.71	2.22	1.98	1.93	1.82	1.69
AREA 3 CALCULATED	4501	3552	4251	5689	7392	8714	9709
AREA 4 MEASURED	6.93	3.34	2.71	2.45	2.24	2.14	1.97
AREA 4 CALCULATED	3318	3198	5190	7039	8579	10246	11318

AREA 1 - NORTH OF BORING B-1, EAST TO WEST
AREA 2 - SOUTH OF BORING B-1, EAST TO WEST
AREA 3 - WEST OF BORING B-1, NORTH TO SOUTH
AREA 4 - EAST OF BORING B-1, NORTH TO SOUTH

RESISTIVITY DATA

SITE:	Stratford Water Tower
PROJECT NO:	C14G7737
TEST DATE:	9/5/2014
LOCATION:	BORING B-2

A= (ft)	**2.5**	**5**	**10**	**15**	**20**	**25**	**30**
FORMULA= (OHM-CM)	*478.8*R*	*957.5*R*	*1915*R*	*2873*R*	*3830*R*	*4788*R*	*5745*R*
AREA 1 MEASURED	6.88	3.18	2.32	1.99	1.89	1.74	1.38
AREA 1 CALCULATED	3294	3045	4443	5717	7239	8331	7928
AREA 2 MEASURED	6.21	2.42	2.05	1.79	1.62	1.43	1.29
AREA 2 CALCULATED	2973	2317	3926	5143	6205	6847	7411
AREA 3 MEASURED	4.27	2.30	1.94	1.76	1.65	1.48	1.29
AREA 3 CALCULATED	2044	2202	3715	5056	6320	7086	7411
AREA 4 MEASURED	5.25	2.58	2.07	2.12	1.86	1.60	1.37
AREA 4 CALCULATED	2514	2470	3964	6091	7124	7661	7871

AREA 1 - NORTH OF BORING B-2, EAST TO WEST
AREA 2 - SOUTH OF BORING B-2, EAST TO WEST
AREA 3 - WEST OF BORING B-2, NORTH TO SOUTH
AREA 4 - EAST OF BORING B-2, NORTH TO SOUTH