GEOTECHNICAL REPORT

ALLIED
LABORATORIES
A Department of Professional
Engineering Consultants, P.A.

CITY OF WICHITA

WASTEWATER TREATMENT PLANT 1 & 2 - EMERGENCY POWER DESIGN

WICHITA, KANSAS

Prepared For:

DESIGN DIVISION

CITY OF WICHITA

CITY HALL – 7TH FLOOR

WICHITA, KANSAS

January 2015

Allied Project No: 74-14229-001-0147

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INTRODUCTION

This report presents the results of a geotechnical study for the new City of Wichita Wastewater Treatment Plant 1 & 2 - Emergency Power Design. The study was conducted to develop geotechnical recommendations for project design and is intended for the exclusive use of the client for the referenced project.

The geotechnical study included a field exploration program to obtain information on the subsurface conditions and collect samples for laboratory testing. The samples obtained during the field exploration were visually observed and classified in the laboratory. Representative samples were selected for laboratory testing to determine physical and engineering characteristics of the in-situ soils. Field exploration and laboratory test results were analyzed to develop geotechnical recommendations for the proposed construction. All field testing, laboratory testing, analysis, and report preparation was performed under the direction of a registered Professional Engineer.

The following sections present the results of the field exploration, laboratory tests, and our conclusions and recommendations for project design. The conclusions and recommendations are based on the project information available at the time of this report and the subsurface conditions encountered in the borings at the locations and times indicated. If project details including structure, and parking/drive locations, elevations, cut and fill depths or other conditions change during design or if the subsurface conditions vary from those described in this report, the conclusions and recommendations may need to be re-evaluated and adjusted.

SITE LOCATION AND DESCRIPTION

The site for the subject project is located at the existing Wastewater Treatment Plant 1 & 2, located east of the intersection of 57th Street South and South Hydraulic Street in Wichita, Kansas.

Based on our visual observations at the time of our field exploration, the topography of the site is relatively level and is generally covered with grass and other low vegetation. The project site is bordered on the north and west by vacant fields, on the south by existing Wastewater Treatment Plant facilities, and on the east by the Arkansas River.

PROPOSED CONSTRUCTION

Although specific construction and design details for the project were not provided, we understand that the proposed improvements will consist of a 15,000 gallon below grade storage tank, standby generators and associated equipment, and an access drive. We understand that the asphalt and/or concrete pavement section is to be designed to accommodate a WB-65 tanker truck with an approximate weight of 80,000 lbs. The 15,000 gallon fuel tank (10 foot diameter) will be below grade with an approximate gross weight of the tank and diesel fuel of approximately 115,000 lbs. The generators will be placed on a slab-on-grade concrete foundation with an approximate weight of 52,000 lbs each. The equipment located at the south end of the site will have a concrete vault structure constructed below at an approximate elevation of 8.0 to 10.0 feet below final site grade.

Grading plans were not provided at the time of our evaluation; however, it is our understanding that the grading for the site will require fill on the order of 12.0 to 18.0 inches to promote site drainage.

If actual building loads, elevations, or fill/cut heights vary from these conditions, then the recommendations in this report may need to be re-evaluated. Any changes in these conditions should be provided to the undersigned Engineer so the need for re-evaluation of our recommendations can be assessed.

FIELD EXPLORATION

GENERAL

Boring locations were determined in the field by Allied Laboratories' drilling crew using the provided site plan and taped measurements from existing landmarks at the site and by using a handheld Global Positioning System (GPS). The boring locations should be considered accurate only to the degree implied by the method of measurement used. Approximate boring locations are shown on the attached Boring Location Plan (Figure 2).

STANDARD PENETRATION TEST BORINGS

The field exploration was conducted on December 12, 2014. Three (3) Standard Penetration Test (SPT) borings were performed to depths ranging from approximately 5.0 to 20.0 feet below existing site grade. The SPT borings were drilled with a Mobile Drill B-31 truck mounted drill rig, using 6-inch outside diameter (O.D.) continuous flight auger.

Subsurface conditions in the boreholes were visually logged in the field by Allied Laboratories' personnel referencing ASTM D-2488 visual-manual procedures. Water level measurements were taken in the boreholes shortly after completion of drilling.

Samples of the subsurface soils were primarily obtained using a 2-inch O.D. split-spoon sampler. The sampler was driven into the strata using a 140-pound safety hammer falling 30 inches. The number of blows required to advance the sampler three successive 6-inch increments is recorded. The total number of blows used to advance the sampler the second and third 6-inch increment is the penetration resistance "N" value. Standard Penetration Test borings were performed referencing ASTM D-1586.

LABORATORY TESTING

Soil samples obtained during the field exploration were observed and visually classified referencing the Unified Soil Classification System (USCS). Selected samples were tested to evaluate engineering and physical properties. Tests performed included natural moisture content, Atterberg Limits, Sieve Analysis, and percent passing the No. 200 sieve. Tests were performed referencing current ASTM procedures unless otherwise noted. Laboratory test results are summarized on the attached Summary of Exploratory Borings (Figure 3), the Exploratory Boring Log reports (Figures 4 through 6), and on the Summary of Laboratory Test Results report (Figure 8).

SITE CONDITIONS

This section presents brief descriptions of the subsurface conditions encountered at the SPT boring locations and general observations of the site. The attached Exploratory Boring Log reports (boring logs) should be reviewed for more information on the subsurface conditions at each boring location. Sharp transitions between soil types are presented on the boring logs. However, soil transitions may occur gradually and transition depths are approximate. The soil conditions noted on the boring logs are based on visual observations and periodic sampling. Additional sampling, testing and Petrographic analysis may provide a different classification of soil and bedrock types.

GENERAL

Borings B-1 and B-2 were drilled to depths ranging from approximately 15.0 feet to 20.0 feet below existing site grade, and Boring B-3 was drilled to a depth of approximately 5.0 feet below the existing pavement surface within the proposed construction and drive areas, respectively.

The SPT Borings B-1 and B-2 generally encountered sand soils with varying amounts of silt, clay, and gravel, and clay soils with varying amounts of sand, extending to boring termination depth. Boring B-3 encountered approximately 6 inches of asphalt pavement overlying approximately 6 inches of base material similar to KDOT Type AB-3 material.

The boring continued with layers of sandy lean clay overlying clayey sand extending to termination depth of the boring at 5.0 feet below existing pavement surface.

Near surface groundwater was not encountered at the boring locations at the time of sampling.

EXISTING FILL

Apparent fill materials encountered at the Boring B-3 location consisted of base material similar to KDOT Type AB-3 material extending to a depth of approximately 1.0 feet below existing pavement surface. Apparent fill materials were not encountered at the Boring B-1 and B-2 locations.

Due to previous construction at the site, it should be noted that it is possible that additional fill materials may be encountered, at varying depths, on unexplored portions of this site that were not explored during our fieldwork.

SOILS

The subsurface soils encountered at the SPT Boring B-1 and B-2 locations generally consisted of sand soils with varying amounts of silt, clay, and gravel, and clay soils with varying amounts of sand, extending to boring termination depths of 20.0 and 15.0 feet below existing site grade, respectively. Boring B-3 encountered approximately 6 inches of asphalt pavement overlying approximately 6 inches of base material similar to KDOT Type AB-3 material. The boring continued with layers of sandy lean clay overlying clayey sand extending to termination depth of the boring at 5.0 feet below existing pavement surface.

The clay soils were predominantly characterized as slightly moist, moderate to high plasticity, with a stiff to hard consistency. For the samples tested, Liquid Limit values ranging from 38 to 59 and Plasticity Index values ranging from 23 to 40 were obtained. SPT N values ranged from 8 to 33 blows per foot of penetration.

The sand soils were predominantly characterized as dry to saturated with a loose to medium dense relative density. For the samples tested, natural moisture contents ranging from 1.8 to 17.5 percent were obtained. SPT N values ranged from 5 to 23 blows per foot of penetration.

GROUNDWATER

Near surface groundwater was not encountered in the boreholes at the time of our fieldwork. Near surface groundwater levels may fluctuate several feet depending on climatic conditions, time of year, surface runoff, water levels in nearby streams or creeks, and other factors beyond the scope of this report. Groundwater may be present in these areas during wet periods and at various times of the year.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

Our geotechnical engineering evaluation of the surface and subsurface conditions at the site, with respect to the planned construction, are based on (1) our site observations, (2) the field and laboratory test data obtained, and (3) our understanding of the project information and structural conditions as presented in this report.

If the project information is incorrect, or should the location of the structure change, please contact the undersigned Engineer so that these recommendations can be reviewed. The discovery of any site or subsurface conditions during construction that deviate from the data obtained during this geotechnical exploration should also be reported to the undersigned Engineer for evaluation.

The recommendations presented in the subsequent sections of this report present design and construction techniques that are appropriate for the planned construction. We recommend that we be provided the opportunity to review the foundation plans and earthwork specifications to verify that our recommendations have been properly interpreted and implemented.

Based on the results of our exploration, we consider the subsurface conditions at the site adaptable for support of the proposed structures when constructed on a properly designed conventional shallow foundation system placed on the native soils or engineered fill. Provided the site preparation and earthwork construction recommendations outlined in this report are performed, the following parameters may be used for foundation design.

SITE GRADING

Ponded water can present significant problems during and after construction. Site grading plans should be designed to provide positive drainage away from all structures, slabs-on-grade, pavements, and sidewalks. A minimum slope of 5 percent for the first 10 feet next to the structure and 2 percent thereafter is recommended for landscaped areas. Positive drainage should also be provided in all paved and sidewalk areas to the extent practicable within ADA requirements. All downspouts should be designed to discharge a minimum of

5 feet away from structures. Temporary drainage to a sump should be used to remove ponded water in excavations.

SUBGRADE PREPARATION

Prior to construction operations, the location of existing underground utility lines within the construction area should be established. Provisions should then be made to relocate interfering utilities to appropriate locations.

Any unsuitable existing fill, soft soil, vegetation, and deleterious materials should be removed, prior to placing new fill materials. Based on our fieldwork, a minimum stripping depth of approximately 6 to 12 inches is anticipated to remove the organic portion of the encountered soils.

Over-excavation and replacement of existing fill and isolated softer soils may also be necessary at this site due to previous construction operations near the site. The extent of over-excavation will not be known until construction. The over-excavation should be closely monitored to verify all unsuitable material is removed and all over-excavations are replaced with properly compacted, new engineered fill.

After stripping and over-excavation (as necessary), the exposed subgrade should be proof-rolled by the contractor using a heavily loaded scraper, dump truck, or front-end loader to verify all soft areas have been excavated and that the subgrade is suitable for fill placement. The proof-roll should be observed by a qualified Engineering Technician under the direction of a Professional Engineer. The exposed subgrade should be scarified to a minimum depth of 8 inches, moisture conditioned (as necessary), and re-compacted to requirements outlined below.

ENGINEERED FILL

All new fill should consist of clean soils free of debris and deleterious materials. Imported general fill should consist of clean soils with a maximum plasticity index of 25, or select fill.

Select fill should consist of Low Volume Change (LVC) materials including limestone gravel, limestone screenings, crushed sandstone, or equivalent. Natural LVC materials consisting of sandy clay, clayey sand or similar soils with a minimum of 20 percent passing the No. 200 sieve and a plasticity index between 5 and 15 may also be used with prior approval from the designers. The minimum plasticity index may be waived if the fill is placed in confined conditions (i.e. inside stem walls).

Although the select fill options presented above provide for the necessary structural support, they may not necessarily provide a stable working surface for construction activities or inclement weather. The contractor should select the appropriate select fill materials for the anticipated construction traffic and to minimize weather delays if necessary.

All engineered fill should be placed under controlled conditions with observation and testing by a licensed Professional Engineer or designated representative. The following minimum compaction requirements and moisture requirements based on the *Standard Proctor (ASTM D-698)* are recommended.

• Footings, Pavement Stabilized Base - Subbase	98 % of Maximum Dry Density
• Structural Fill (Floor Slabs, Pavement)	95 % of Maximum Dry Density
• Non-Structural Fill and Backfill	90 % of Maximum Dry Density

The following moisture ranges are recommended for various soil types:

• Fat Clay	+2% to +5 % of Optimum Moisture Content
• Lean Clay	Optimum Moisture Content to +4%
• Silts, Clayey Sand, LVC, Etc.	± 3 % of Optimum Moisture Content
• Sands, Gravel	At Workable Moisture Content

New engineered fill should extend a minimum of 5 feet beyond any proposed building and structure footprints, and a minimum of 2 feet beyond the edges of all pavements. All fill should be placed in horizontal lifts with maximum compacted lift thickness of 6 inches (approximately 8 to 9 inches loose). Each lift should be evenly graded to provide a consistent lift thickness prior to placing additional lifts. Thinner lifts may aid compaction for energy sensitive soils (i.e. clay), or for light compaction equipment. Moisture sensitive soils (i.e. silt) may require stricter moisture control to achieve compaction. Potentially expansive clay soils should not be compacted more than 5 percent above the recommended minimum compaction requirements.

FOUNDATIONS

Based on our test results and analysis, we anticipate a conventional shallow foundation system placed on the soils encountered at a depth of approximately 3.0 feet below existing site grade is feasible for the lightly to moderately loaded structure. Conventional trench footings should be designed for a maximum allowable net soil bearing capacity of 1,500 pounds per square foot (psf) to limit settlement and provide a minimum theoretical factor of safety against shear failure of 3. Net bearing capacity is defined as the soil bearing capacity at the foundation bearing level in excess of the natural overburden pressure at that level. The foundations should be designed based on the maximum load that could be imposed by all loading conditions. Minimum footing widths of 18 inches for trench footings, and 36 inches for isolated column footings are recommended.

All exterior footings and interior footings under unheated areas should be placed a minimum of 36 inches below finished grade to reduce the potential for adverse effects due to moisture variations of the near surface soils and frost.

For structures to be constructed with a basement (vault) founded on soils encountered at a depth of approximately 8 to 10 feet below existing site grade, conventional trench footings or isolated column footings placed on the encountered sand soils should be designed for a maximum allowable net soil bearing capacity of 2,000 pounds per square foot (psf) to limit settlement and provide a minimum theoretical factor of safety against shear failure of 3. Net bearing capacity is defined as the soil bearing capacity at the foundation bearing level in excess of the natural overburden pressure at that level.

Minimum footing widths of 18 inches for trench footings, and 36 inches for isolated column footings are recommended. The foundations should be designed based on the maximum load that could be imposed by all loading conditions.

Provided that the previous recommendations are performed, long-term structural settlement for shallow spread footings designed and constructed as outlined above are estimated to be on the order of 1.0 inch. Differential settlements of up to 1/2 inch should be anticipated across the site. The estimated settlements are approximate and based on assumed footing details and depths. Additional settlement analysis may be warranted depending on final footing design. Depending on settlement tolerances, the structural engineer may need to include measures to accommodate that differential settlement between the new and existing structures. The estimated settlements are approximate based on assumed footing details and depths. Additional settlement analysis may be warranted depending on final footing design.

All footing excavations should be performed in a manner to avoid disturbing the soils below the bearing elevation. Hand excavation should be used to remove slough. Concrete should be placed for footings as soon as practicable after excavation to avoid drying or wetting of the exposed soils. If the bearing soils are disturbed, allowed to dry, or are wetted by rain or seepage water, remove the affected soil and extend the footings. Alternately, the over-excavated soil may be replaced with new engineered fill. All footing excavations should be observed by a qualified Professional Engineer or Engineering Technician. Over-excavation and replacement of some soft soils and/or existing fill may be required at this site.

CONCRETE SLABS

Based on the subsurface conditions encountered at the boring locations, we recommend a minimum of 18 inches of select fill be placed below all at-grade concrete slabs to reduce the potential for heave of the near surface soils and provide a homogenous base. Lower portions of the fill soils below the select fill zones may consist of on-site soils, imported general fill, or select fill. Prior to placing the select fill (LVC) or new engineered fill, the exposed subgrade should be scarified, moisture conditioned, and re-compacted to the requirements of the Subgrade Preparation and Engineered Fill sections of this report.

In addition to the select fill, a minimum of 6 inches of a sand or gravel leveling course/moisture barrier is recommended for at-grade slabs with moisture sensitive floor coverings. The leveling course/moisture barrier should consist of clean, medium to coarse grained sand, or clean gravel/rock. An appropriate synthetic moisture barrier should also be used for moisture sensitive floor coverings as recommended by the floor covering manufacturer.

For portions of the slab to be constructed below grade in the basement (vault) area, and based on the subsurface conditions encountered at the boring locations, we recommend a minimum of 6 inches of select fill be placed below all at grade concrete slabs to reduce the potential for heave of the near surface soils and provide a homogenous base. Lower portions of the fill soils below the select fill zones may consist of on-site soils, imported general fill, or select fill. Prior to placing the select fill (LVC) or new engineered fill, the exposed subgrade should be scarified, moisture conditioned, and re-compacted to the requirements of the Subgrade Preparation and Engineered Fill sections of this report.

In addition to the select fill, a minimum of 6 inches of a sand or gravel leveling course/moisture barrier is recommended for at grade slabs with moisture sensitive floor coverings. The leveling course/moisture barrier should consist of clean, medium to coarse grained sand, or clean gravel/rock. An appropriate synthetic moisture barrier should also be used for moisture sensitive floor coverings as recommended by the floor covering manufacturer if necessary.

All utility lines entering the building or slab area should be sealed to prevent migration of surface and subsurface water and subsequent wetting of the subgrade soils below the floor slabs. The utility lines should be sealed from the building foundation to a minimum of 3 feet outside the building foundation. The seal may consist of clay soils with a minimum plasticity index of 25 or lean concrete.

The above recommendations provide for approximately 24 inches of a stabilized/moisture conditioned zone below the concrete slab, and 12 inches of a stabilized/moisture conditioned zone below the basement (vault) concrete floor slab. These recommendations are intended to reduce the potential for floor slab movement due to shrink and swell of the clay soils without adding undue costs to the project. However, some differential movement may still occur between floor slabs and foundations due to shrink/swell of the clay soils and/or differential settlement between the foundations and floor slabs.

The above recommendations are anticipated to reduce the potential for the at-grade concrete slab movement to approximately 1/2 inch under typical conditions. The potential for heave of the at-grade concrete slabs could be further reduced by placing additional select fill below the floor slabs. The potential for damage due to relative differential movement between the footings and floor slab may be reduced by isolating the floor slab from all bearing walls and columns to allow unrestrained vertical movement and to restrict load transfer to and from the structure. Due to the conditions encountered within the basement (vault) area, for floor slabs constructed using the above parameters, movement of the slab is expected to be negligible.

The floor slab recommendations presented are meant to address relative movement between floor slabs and foundations due to typical moisture variations in the subsurface soils beneath the structure. These recommendations do not address the potential for significant differential movement due to extreme moisture changes caused by excessive drying or saturation of the subgrade soils.

Causes for excessive moisture changes can include under-floor vents or heating ducts, leaking utility lines, poor surface or subsurface drainage, inadequate sealing of joints, refrigeration, and others. The recommendations presented may need to be re-evaluated and adjusted if the project includes items which can contribute to excessive moisture changes in the subsurface soils. Additional subgrade preparation, select fill, and other preventative measures may be required.

UNDERGROUND STORAGE TANKS

We anticipate the underground storage tanks included with this project will be founded approximately 10 to 12 feet below grade. The subsurface conditions encountered at the proposed fuel tank location (Boring B-2) generally consisted of medium dense sand soils extending from the bottom of the fuel tank to boring termination depth. Groundwater was not present at the time of the field exploration, however a wet cave of the borehole was experienced at a depth of approximately 12.0 feet below existing site grade indicating a perched water table may be present. The soils encountered at the bearing depth were characterized as slightly moist.

The tanks may also need to be designed to resist the potential for hydrostatic uplift pressures due to groundwater fluctuations. A minimum of 12 inches of coarse grained sand/gravel per KDHE and the tank manufacturer's requirements is recommended for bedding below the tanks. The coarse grained, free draining sand should also be used for backfill of the tanks. If wet soil conditions are encountered at the time of construction, a layer of coarse rock or a lean concrete slab may be needed to provide a stable work surface for installation of the tanks.

LATERAL EARTH PRESSURES

Underground tanks will be subject to lateral earth pressures. Lateral earth pressures are typically estimated by equivalent fluid unit weights. The magnitude of the lateral earth pressure is controlled by many factors including tank wall design, properties of the in-situ native soils and backfill adjacent to the tank walls, drainage conditions, surcharge loads and other factors.

We recommend all below grade tanks be designed and constructed using granular backfill and an appropriate drainage system. Significantly larger pressures will develop if the soils adjacent to the below grade tank walls become saturated. These measures are recommended to reduce the potential pressures on the tank walls, the potential for saturation of the soils, and the possible detrimental effects due to shrink/swell of the native lean to fat clay soils.

For the below grade tanks, backfilled with imported non-cohesive granular soils (as recommended), an active equivalent fluid pressure of 35 pounds per cubic foot (pcf) and an at-rest pressure equivalent fluid pressure of 50 pcf should be used for design. Below grade walls should only be designed for the active case if walls are allowed to rotate sufficiently to fully mobilize active pressure. The at-rest case should be used if the walls are rigid and little or no rotation is anticipated.

Near surface groundwater was not encountered at the site during drilling operations. However, it is possible that seasonal near surface groundwater fluctuations and/or perched groundwater may intercept the below grade structure.

Significantly larger pressures will develop below the groundwater level. An active equivalent fluid pressure of 75 pcf and an at-rest pressure equivalent fluid pressure of 90 pcf should be used for design of structures with a non-cohesive granular backfill that extends below the water level. A passive equivalent fluid unit weight of 350 pcf and a coefficient of friction of 0.3 may be used for resistance to sliding.

The earth pressure parameters do not include safety factors or surcharge loads (i.e., structure loads, fill loads, forces from construction equipment). Appropriate safety factors and surcharge loads should be applied to these values. The parameters also do not account for hydrostatic uplift pressures. Since the potential for near surface perched groundwater conditions are possible at the site, the below grade structure walls should be designed for full hydrostatic pressure.

HYDROSTATIC UPLIFT PRESSURES

We anticipate that the buried structures may be subject to hydrostatic uplift pressure. Below grade structures should be designed to resist lateral earth pressures and hydrostatic uplift pressures appropriate for their depth below existing grade and the normal seasonal high groundwater table.

When the fluid level within below-grade structures is maintained at or above the surrounding groundwater level, no net buoyancy will occur to the structure. However, when this is not the case, a positive means of uplift protection will be required. Hydrostatic uplift forces can be resisted in several ways, including:

- Addition of dead weight to the structure.
- Mobilizing the dead weight of the soil surrounding the structure through extension of footings outside the perimeter of the structure.

At your request, we would be pleased to assist you in the evaluation of uplift protection requirements.

EXCAVATION SLOPES

All excavations should be constructed and/or shored according to local, state, federal and OSHA requirements. Each excavation must be evaluated during construction by the responsible person to verify appropriate sloping, shoring and excavation techniques. Maximum OSHA recommended slopes for temporary excavations less than 20 feet deep with simple slopes include the following:

Stable Rock - vertical, Type A (stiff soils) - 3/4 H to 1 V, Type B (medium stiff soils) - 1 H to 1 V, Type C (soft soils/sands) - 1.5 H to 1 V. These classifications are presented for general information only and preliminary design only. OSHA regulations should be reviewed for details regarding soil strengths, sloping/shoring requirements and other guidelines.

SEISMIC

The soil profiles encountered at the site consist primarily of stiff to hard clay soils and loose to medium dense sand soils. Standard penetration test (SPT) values ranging from 5 to 33 blows per foot of penetration were obtained. Based on these conditions, we recommend the site be characterized as Class D for seismic design according to the International Building Code (IBC) site classification definitions outlined in Table 1615.1.1. and in American Society of Civil Engineers (ASCE) 7.

EXCAVATIONS

All excavations should be constructed and/or shored according to local, state, federal and OSHA requirements. Each excavation must be evaluated during construction by the responsible person to determine appropriate sloping, shoring and excavation techniques. Maximum OSHA recommended slopes for temporary excavations less than 20 feet deep with simple slopes include the following:

Stable Rock - vertical, Type A (stiff soils) - 3/4 H to 1 V, Type B (medium stiff soils) - 1 H to 1 V, Type C (soft soils/sands) - 1.5 H to 1 V. These classifications are presented for general information only and preliminary design only. OSHA regulations should be reviewed for details regarding soil strengths, sloping/shoring requirements and other guidelines.

PAVEMENT

Pavement performance is directly related to the physical properties of the subgrade soils and traffic loading. Design traffic information was not provided for this report and was assumed to generally be light to moderate with occasional heavy fuel truck.

The subgrade soils in the exploratory boring within the existing roadway (Boring B-3) consisted of sandy lean clay, and sand soils overlying to high plasticity fat clay soils within the remainder of the site (Borings B-1 and B-2). California Bearing Ratio (CBR) values generally range from 3 to 10 for the encountered clay soils, and 5 to 40 for the encountered sand soils. Based on these conditions, we recommend a stabilized subbase be placed below all pavement sections. Prior to placing the stabilized subbase, the existing subgrade should be prepared according to the Subgrade Preparation and Engineered Fill sections of this report.

The stabilized subbase (base) beneath the pavement should consist of imported Type AB-1, AB-2, or AB-3 gravel (or equivalent), or chemically stabilized soil. Placing a subgrade separation geotextile beneath imported gravel will protect it from contamination by the underlying soils and add strength. For chemically stabilized subbase the addition of 4 percent hydrated or pebble quick lime is sufficient to chemically stabilize the clay soils. For chemical stabilization of sand soils, the addition of 15 percent class C fly-ash is typically sufficient. The exposed subgrade should be tested during construction in order to evaluate the appropriate stabilizing agent and application rate.

Based on assumed traffic loading, the following typical pavement sections are presented for light and moderately loaded pavements. These sections are typical sections based on assumed pavement loads. Additional analysis and thicker pavement sections may be needed for heavy traffic and vehicle loads.

FLEXIBLE PAVEMENT		
PAVEMENT SECTION	**LIGHT LOADS**	**MODERATE LOADS**
Wearing Course (BM-2)[1]	2 inches	2 inches
Base Course (BM-4)[1]	3 inches	7 inches
Stabilized Subbase[2]	8 inches	8 inches

RIGID PAVEMENT		
PAVEMENT SECTION	**LIGHT TO MODERATE LOADS**	**HEAVY LOADS**
Portland Cement Concrete	6 inches[3]	8 inches[3]
Stabilized Subbase[3]	8 inches	12 inches

[1] KDOT Asphaltic Concrete Designations
[2] Compacted Type AB-1, AB-2 or AB-3 gravel, chemically stabilized soil, or equivalent
[3] Minimum recommended thickness due to construction tolerances

Asphaltic concrete pavement should consist of a plant mixture composed of aggregate and bituminous material which meets the requirements of KDOT specifications established by a qualified engineer. Concrete should be based on a mix design prepared by a qualified engineer.

The pavement sections presented are based on an estimated service life of 20 years. However, periodic maintenance including crack sealing and overlays may be required to achieve the service life. The performance and service life of the pavement will be significantly affected by poor surface and subsurface drainage. Adequate surface drainage and crack sealing should be maintained throughout the life of the pavement.

QUALITY CONTROL TESTING

We recommend that Allied Laboratories be retained to perform the construction materials testing and observations required for this project, to verify that our recommendations have been satisfied. Due to our familiarity with the project and the intent of our engineering design, we are the most qualified to efficiently address any problems that may arise during construction.

A representative number of field in-place density tests should be made in the upper 2 feet of compacted natural soils, in each lift of compacted backfill and fill, and in the upper 12 inches below the bearing levels in the footing excavations. The density tests are considered necessary to verify that satisfactory compaction operations have been performed. We recommend density testing be performed (1) at a minimum of 3 locations within each of the structure areas, (2) at 25 percent of any isolated column footing locations, (3) at one location for every 50 linear feet of continuous wall footings, and (4) at one location for every 5,000 square feet of pavement area.

GENERAL NOTES AND LIMITATIONS

The recommendations presented are based on experience with similar soils in this area. Performance of the structure depends on following the design recommendations and maintenance after construction.

Clay soils with a moderate to high volume change potential are present at this site. These soils are stable at a constant moisture content, but can expand or consolidate with moisture variations. The volume change potential of soils can change erratically in both vertical and lateral extent. Moisture changes also occur erratically, resulting in conditions that cannot always be predicted. Fill soils were encountered at Boring B-3. Over-excavation and replacement of existing fill may be required. Project plans and specifications should provide some contingency for over-excavation and replacement of existing fill due to previous grading activities.

Geotechnical recommendations are based on periodic sampling in widely spaced, small diameter borings and subsurface conditions may vary from those encountered in the borings. Our scope of services was intended to evaluate the soil conditions within the zone of soil influenced by the foundation systems. Our scope of services does not address geologic conditions, such as sinkholes or soil conditions existing below the depth of the soil borings.

No other warrantees or guarantees are intended. The nature and extent of subsurface conditions may vary across the site. If subsurface conditions are encountered other than described in this report, the recommendations presented may need to be re-evaluated and adjusted.

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APPENDIX

FIELD EXPLORATION AND LABORATORY TEST RESULTS

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design
Wichita, Kansas
FILE NO: 74-14229-001-0147

ALLIED LABORATORIES
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350 SOUTH WASHINGTON
WICHITA, KANSAS

SITE LOCATION MAP

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design
Wichita, Kansas
FILE NO: 74-14229-001-0147

Figure 1

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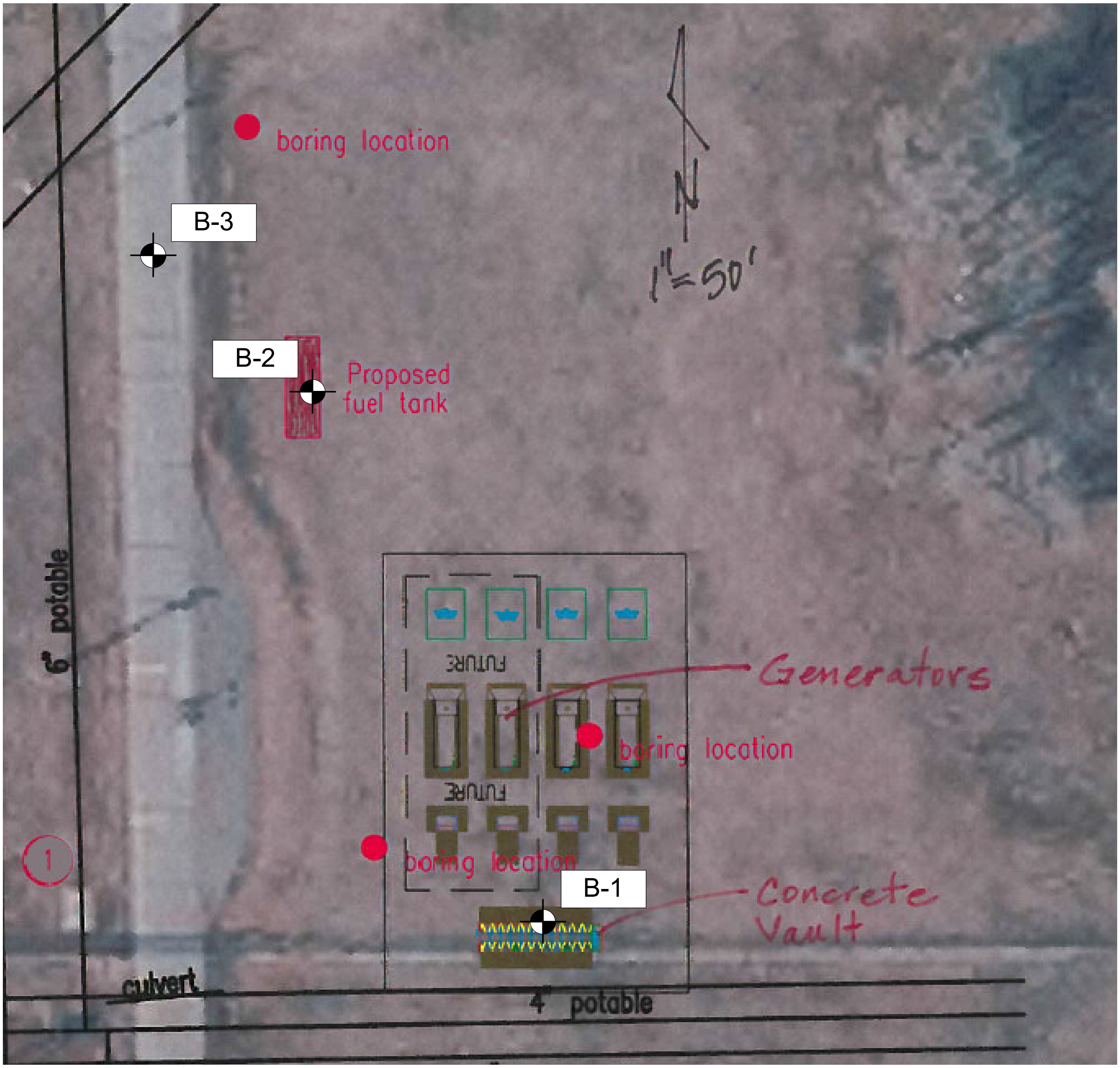
350 SOUTH WASHINGTON
WICHITA, KANSAS

BORING LOCATION PLAN

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design
Wichita, Kansas
FILE NO: 74-14229-001-0147



No Scale

⌖ Standard Penetration Test Boring Approximate Location

Plan provided by client for Boring location illustration only.
Not for Construction.

N

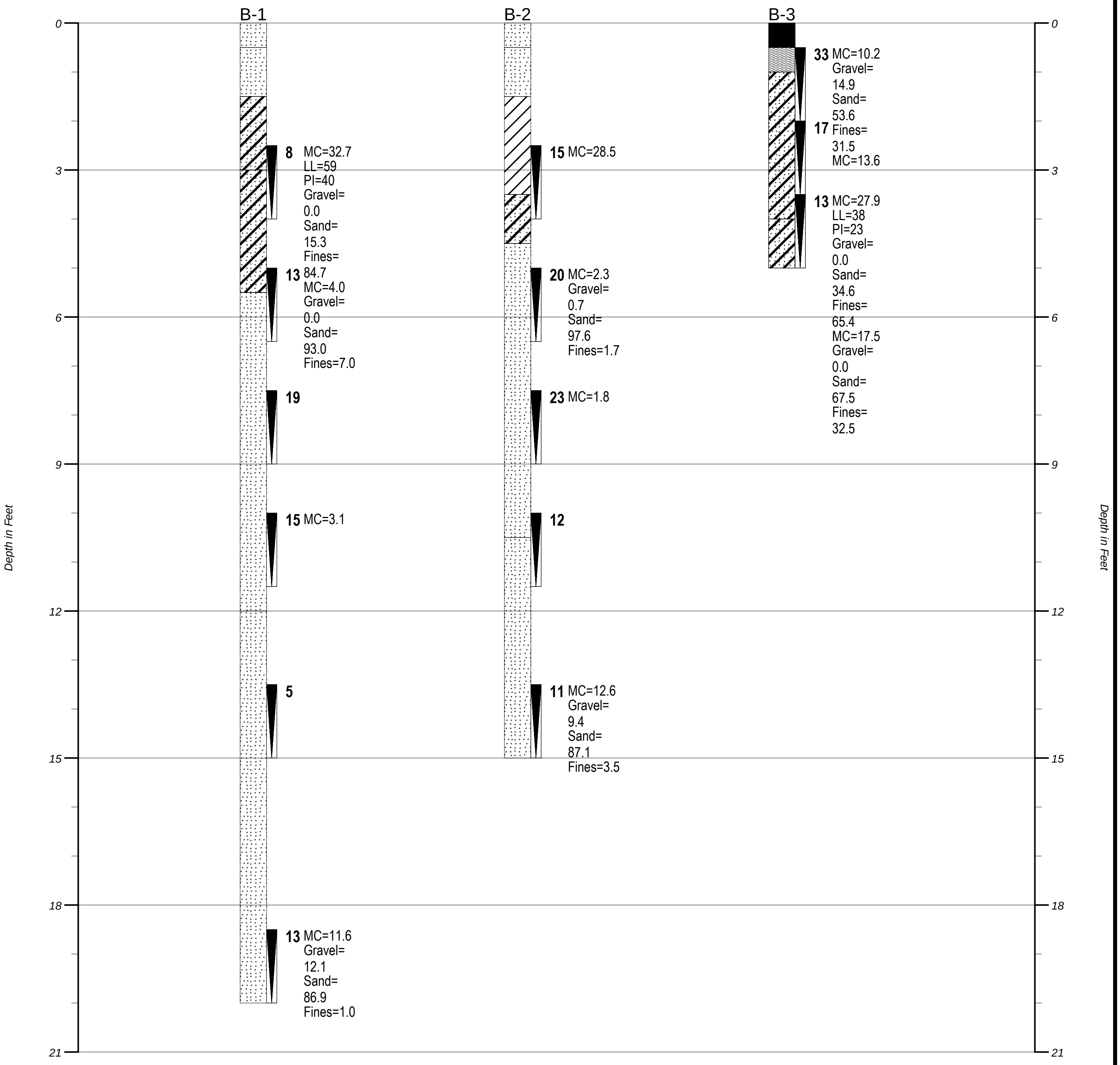
Figure 2

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202
316-262-6457

SUMMARY OF EXPLORATORY BORINGS

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power

74-14229-001-0147



⁘ Sand, Poorly Graded

▨ Sandy Clay, Low to Medium Plasticity

▧ Clay, Medium to High Plasticity

■ Asphalt Paving

▒ Pavement Base

▼ (P) 2" OD Splitspoon Sampler Standard Penetration Test

NOTE: Profiles present a summary of data.
They are not proportional and do not present a cross-section of the site.

Figure 3

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-1

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design

PROJECT NO: **74-14229-001-0147**

BORING LOCATION: **See boring location plan**

SCALE: 1 IN= 1.5 FT.

BORING DATE **12-12-2014**

DRILLER **BH**

LOGGED BY **BH**

CHECKED BY **BR**

WATER LEVEL @ DRILL:

WATER LEVEL AFTER DRILL

24 HOUR WATER LEVEL:

DRILL RIG: **B-31**

NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0	0	SAND, brown and dark brown mixed, fine to medium grained, slightly moist, loose														
	-0.5	SAND, light brown and pale brown mixed, fine to medium grained, slightly moist, loose														
1.5	-1.5	SANDY CLAY, brown and dark brown mottled, slightly moist, soft														
3	-3	FAT CLAY with SAND, brown and grayish brown mottled, slightly moist, stiff		B1-1	P	18	3 3 5	**8**	32.7			0.0	15.3	84.7	59	40
4.5																
	-5.5	SAND, light brown, light reddish brown and pale brown mixed, fine grained, trace clay, moist, medium dense		B1-2	P	18	5 6 7	**13**	4.0			0.0	93.0	7.0		
6																
7.5				B1-3	P	18	8 8 11	**19**								
9																
10.5				B1-4	P	18	6 8 7	**15**	3.1							

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 4

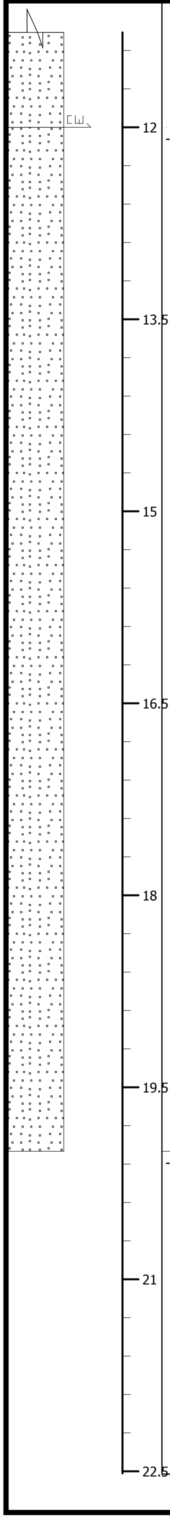
Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-1

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design

PROJECT NO: **74-14229-001-0147**
BORING LOCATION: **See boring location plan**
SCALE: 1 IN= 1.5 FT.
BORING DATE **12-12-2014**
DRILLER **BH**
LOGGED BY **BH**
CHECKED BY **BR**
WATER LEVEL @ DRILL:
WATER LEVEL AFTER DRILL
24 HOUR WATER LEVEL:
DRILL RIG: **B-31**
NOTES:



LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
	-12	SAND, light brown, light reddish brown and pale brown mixed, fine to coarse grained, some fine gravel, saturated, loose to medium dense														
				B1-5	P	18	2 2 3	**5**								
				B1-6	P	18	5 5 8	**13**	11.6			12.1	86.9	1.0		
	-20	End of boring at 20 feet.														

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 4

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-2

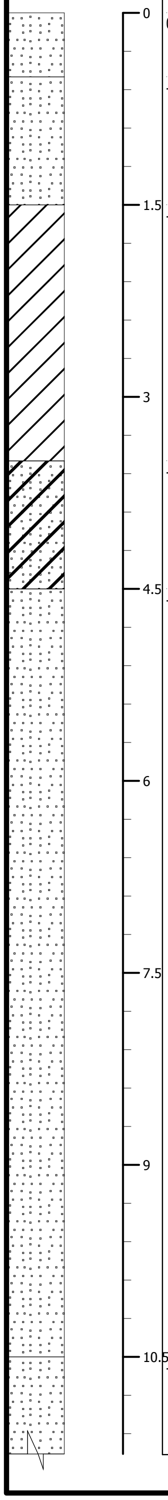
City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design

PROJECT NO: **74-14229-001-0147** BORING LOCATION: **See boring location plan**

SCALE: 1 IN= 1.5 FT. BORING DATE **12-12-2014** DRILLER **BH** LOGGED BY **BH** CHECKED BY **BR**

WATER LEVEL @ DRILL: WATER LEVEL AFTER DRILL 24 HOUR WATER LEVEL:

DRILL RIG: **B-31** NOTES:



LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
	0	SAND, brown and dark brown mixed, fine to medium grained, slightly moist, loose														
	-0.5	SAND, light brown and brown mixed, fine to medium grained, slightly moist, loose														
	-1.5	FAT CLAY, dark brown and black mottled, slightly moist, stiff														
				B2-1	P	18	4 6 9	**15**	28.5							
	-3.5	SANDY CLAY, light brown and grayish brown mottled, slightly moist, stiff														
	-4.5	SAND, light reddish brown and light brown mixed, fine grained, trace fine gravel, trace clay, dry, medium dense														
				B2-2	P	18	6 8 12	**20**	2.3			0.7	97.6	1.7		
				B2-3	P	18	7 11 12	**23**	1.8							
	-10.5	SAND, light brown and light reddish brown mixed, fine to coarse grained, trace fine gravel, trace clay, slightly moist, medium dense		B2-4	P	18	7 7 5	**12**								

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 5

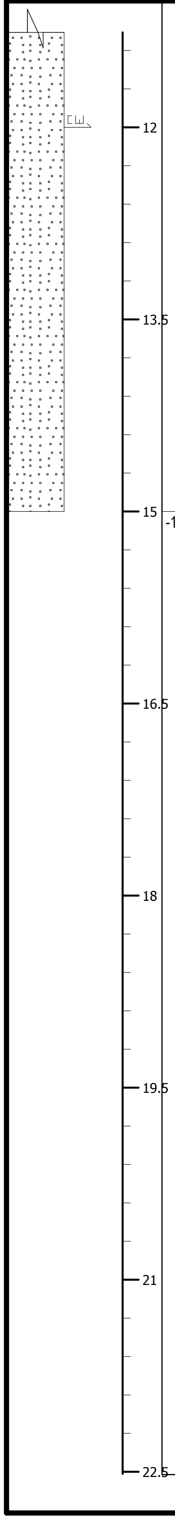
Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-2

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design

PROJECT NO: **74-14229-001-0147**
BORING LOCATION: **See boring location plan**
SCALE: 1 IN= 1.5 FT.
BORING DATE **12-12-2014**
DRILLER **BH**
LOGGED BY **BH**
CHECKED BY **BR**
WATER LEVEL @ DRILL:
WATER LEVEL AFTER DRILL
24 HOUR WATER LEVEL:
DRILL RIG: **B-31**
NOTES:



Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
		▼													
		▼	B2-5	P	18	4 4 7	**11**	12.6			9.4	87.1	3.5		
-15	End of boring at 15 feet.														

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 5

Allied Laboratories
Dept. of PEC, P.A.
350 South Washington
Wichita, Kansas 67202

EXPLORATORY BORING LOG

B-3

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design

PROJECT NO: **74-14229-001-0147**
BORING LOCATION: **See boring location plan**
SCALE: 1 IN= 1.5 FT.
BORING DATE **12-12-2014**
DRILLER **BH**
LOGGED BY **BH**
CHECKED BY **BR**
WATER LEVEL @ DRILL:
WATER LEVEL AFTER DRILL
24 HOUR WATER LEVEL:
DRILL RIG: **B-31**
NOTES:

LOG	Elev.	MATERIAL DESCRIPTION	Sym.	No.	Type	Len.	SPT	N Value	% Moist.	D. Den. (pcf)	Unconf. Qu(psf)	% Gravel	% Sand	% Fines	LL	PI
0 ■	0	ASPHALT														
▒	-0.5	BASE, KDOT Type AB-3, yellowish gray and yellowish brown mottled, some fine to coarse gravel, fine to coarse grained sand, some highly weathered Limestone clay, moist, hard	▼	B3-1	P	18	13 14 19	**33**	10.2			14.9	53.6	31.5		
1.5 ▨	-1	SANDY LEAN CLAY, dark brown and grayish brown mottled, dry, very stiff														
3 ▨			▼	B3-2	P	18	11 10 7	**17**	13.6							
4.5 ▨	-4	CLAYEY SAND, light reddish brown and yellowish brown, fine grained, slightly moist, medium dense	▼	B3-3	P	18	5 6 7	**13**	27.9 17.5			0.0 0.0	34.6 67.5	65.4 32.5	38	23
6 7.5 9 10.5	-5	End of boring at 5 feet.														

NOTE: This information only pertains to this boring at the time of drilling and may not be indicative of entire site.

Figure 6

KEY TO SYMBOLS

Symbol	Description
░	Sand, Poorly Graded
▨	Sandy Clay, Low to Medium Plasticity
▨	Clay, Medium to High Plasticity
■	Asphalt Paving
≋	Pavement Base

Misc. Symbols

⌁	Boring continues
CW	Depth to Wet Cave after drilling

Soil Samplers

▼	(P) 2" OD Splitspoon Sampler Standard Penetration Test

Notes:

Exploratory borings were drilled on the dates indicated on the Exploratory Boring Log reports. Borings were drilled with a Mobile Drill B-53 or B-31 rotary drill rig using 6 inch continuous flight auger and/or 3-1/4 inch ID hollow stem auger.

Groundwater encountered during drilling is presented on the Exploratory Boring Log reports. The water levels presented are for the times indicated. The water levels are approximate. Water levels can fluctuate several feet due to factors beyond the scope of this study.

Boring locations were determined by the drilling crew referencing existing site features unless denoted otherwise in the Geotechnical Report. Boring locations obtained by the drilling crew are approximate.

Ground surface elevations were determined by the drilling crew using a level survey referencing a temporary benchmark unless denoted otherwise in the Geotechnical Report. Elevations obtained by the drilling crew are approximate.

The subsurface soils presented on the Exploratory Boring Log reports are approximate. The Exploratory Boring Log reports represent general subsurface conditions based on visual observation of auger cuttings and periodic sampling. Additional drilling, sampling, Petrographic analysis and other testing may indicate other soil and bedrock types, and soil/bedrock layers may be present which could not be identified with this type of investigation.

The Exploratory Boring Log reports present sharp transitions between the various soil types. However, transitions usually occur more gradually in the field. The depths to the transitions are approximate.

The data presented on the Exploratory Boring Log reports is subject to the conclusions, recommendations and limitations discussed in the Geotechnical Report. Additional information on the subsurface soil, bedrock, groundwater and other conditions may be included in the report which are not presented on the Exploratory Boring Log reports.

Allied Laboratories
350 South Washington
Wichita, Kansas 67202

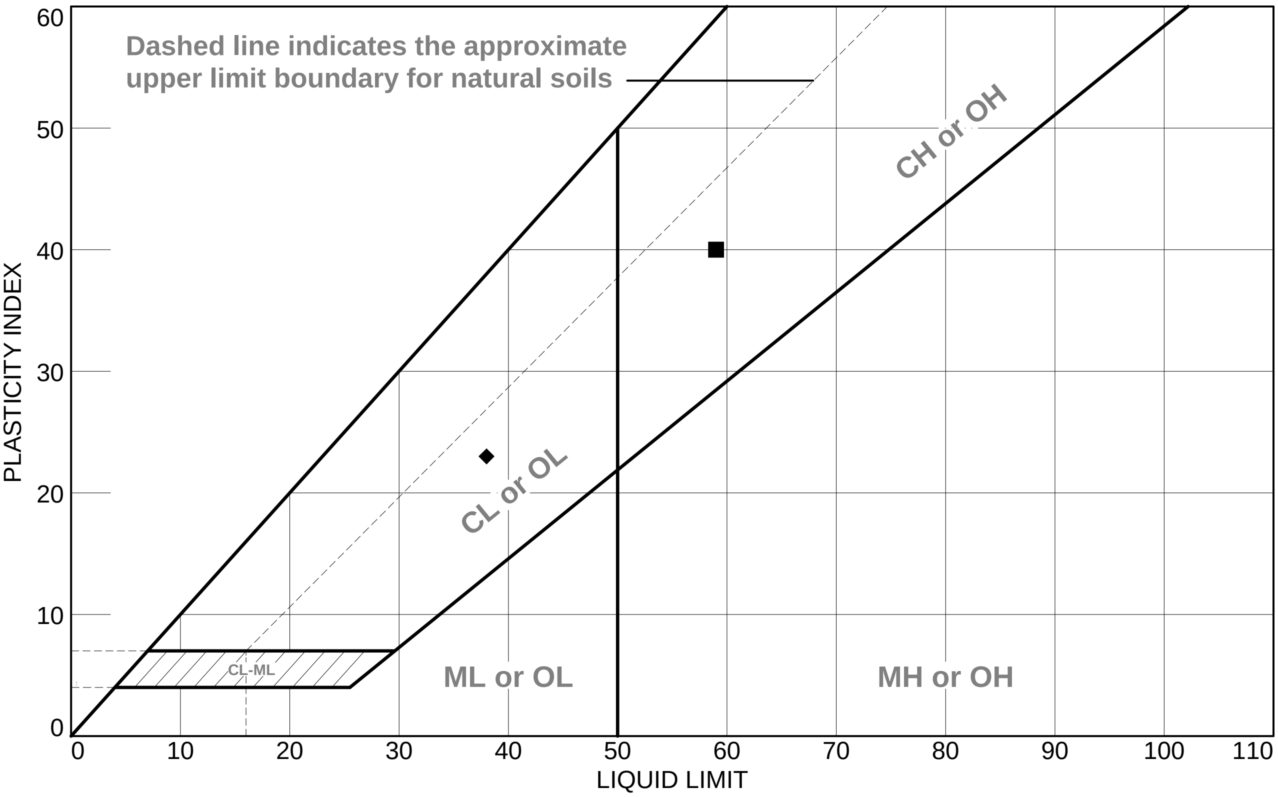
SUMMARY OF LABORATORY TEST RESULTS

City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design

74-14229-001-0147

BORING	SAMP. NO.	DEPTH (feet)	SPT (B/FT)	MOISTURE %	DRY DENSITY (pcf)	UCC (psf)	LL	PL	PI	% PASSING #10	% PASSING #40	% PASSING #200
B-1												
	B1-1	2.5	8	32.7			59	19	40	0.0	15.3	84.7
	B1-2	5	13	4.0						0.0	93.0	7.0
	B1-3	7.5	19									
	B1-4	10	15	3.1								
	B1-5	13.5	5									
	B1-6	18.5	13	11.6						12.1	86.9	1.0
B-2												
	B2-1	2.5	15	28.5								
	B2-2	5	20	2.3						0.7	97.6	1.7
	B2-3	7.5	23	1.8								
	B2-4	10	12									
	B2-5	13.5	11	12.6						9.4	87.1	3.5
B-3												
	B3-1	.5	33	10.2				NP		14.9	53.6	31.5
	B3-2	2	17	13.6								
	B3-3	3.5	13	27.9			38	15	23	0.0	34.6	65.4
				17.5						0.0	67.5	32.5

LIQUID AND PLASTIC LIMITS TEST REPORT



SOIL DATA

	SOURCE	SAMPLE NO.	DEPTH	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	USCS
●	B-1	B1-6	18.5	11.6				
■	B-1	B1-1	2.5	32.7	19	59	40	
▲	B-3	B3-1	.5	10.2	NP			
◆	B-3	B3-3	3.5	27.9	15	38	23	

ALLIED LABORATORIES

Department of

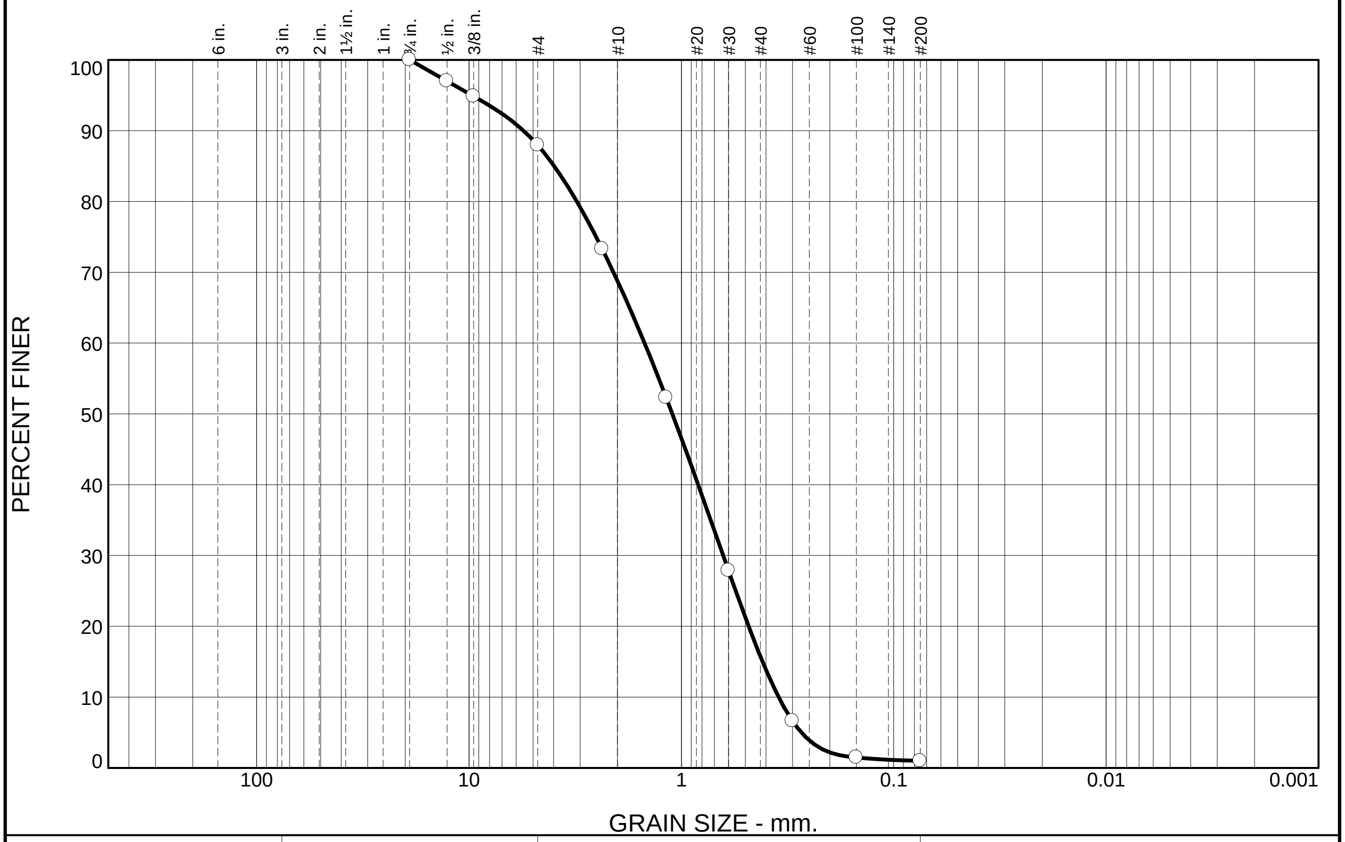
PROFESSIONAL ENGINEERING CONSULTANTS

Client: PEC

Project: City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design

Project No.: 74-14229-001-0147 **Figure** 9

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	12.1	19.1	53.0	14.8	1.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	97.0		
3/8"	94.9		
#4	87.9		
#8	73.3		
#16	52.3		
#30	27.9		
#50	6.6		
#100	1.5		
#200	1.0		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 5.5454 D_{85}= 3.9742 D_{60}= 1.4919
D_{50}= 1.1038 D_{30}= 0.6359 D_{15}= 0.4150
D_{10}= 0.3487 C_u= 4.28 C_c= 0.78

Classification

USCS= SP AASHTO=

Remarks

Source of Sample: B-1 **Depth:** 18.5
Sample Number: B1-6 **Date:**

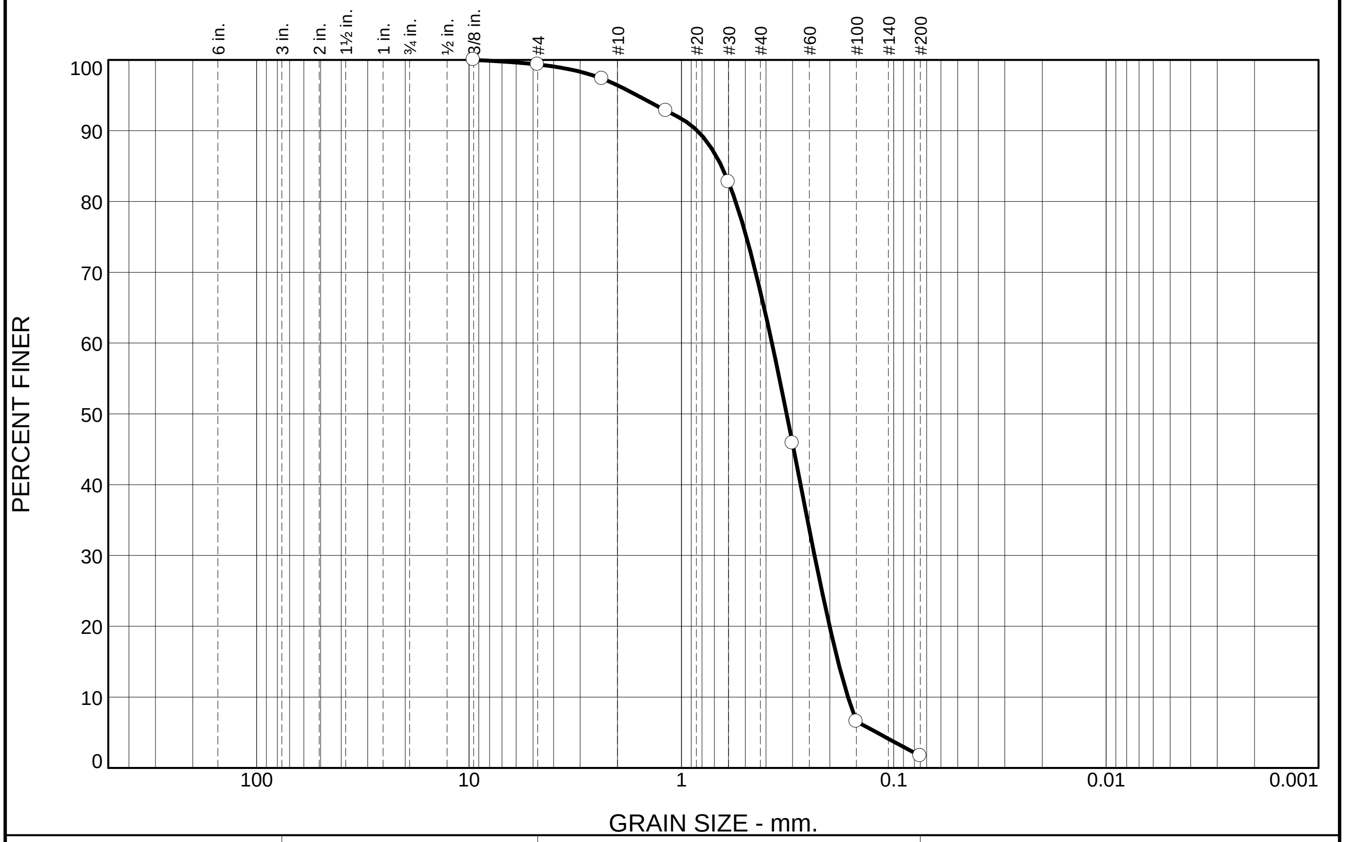
ALLIED LABORATORIES

Department of

PROFESSIONAL ENGINEERING CONSULTANTS

Client: PEC
Project: City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design
Project No: 74-14229-001-0147 **Figure** 10A

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.7	2.9	29.1	65.6	1.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	99.3		
#8	97.3		
#16	92.8		
#30	82.7		
#50	45.8		
#100	6.6		
#200	1.7		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.8423 D_{85}= 0.6473 D_{60}= 0.3748
D_{50}= 0.3196 D_{30}= 0.2361 D_{15}= 0.1829
D_{10}= 0.1644 C_u= 2.28 C_c= 0.90

Classification

USCS= SP AASHTO=

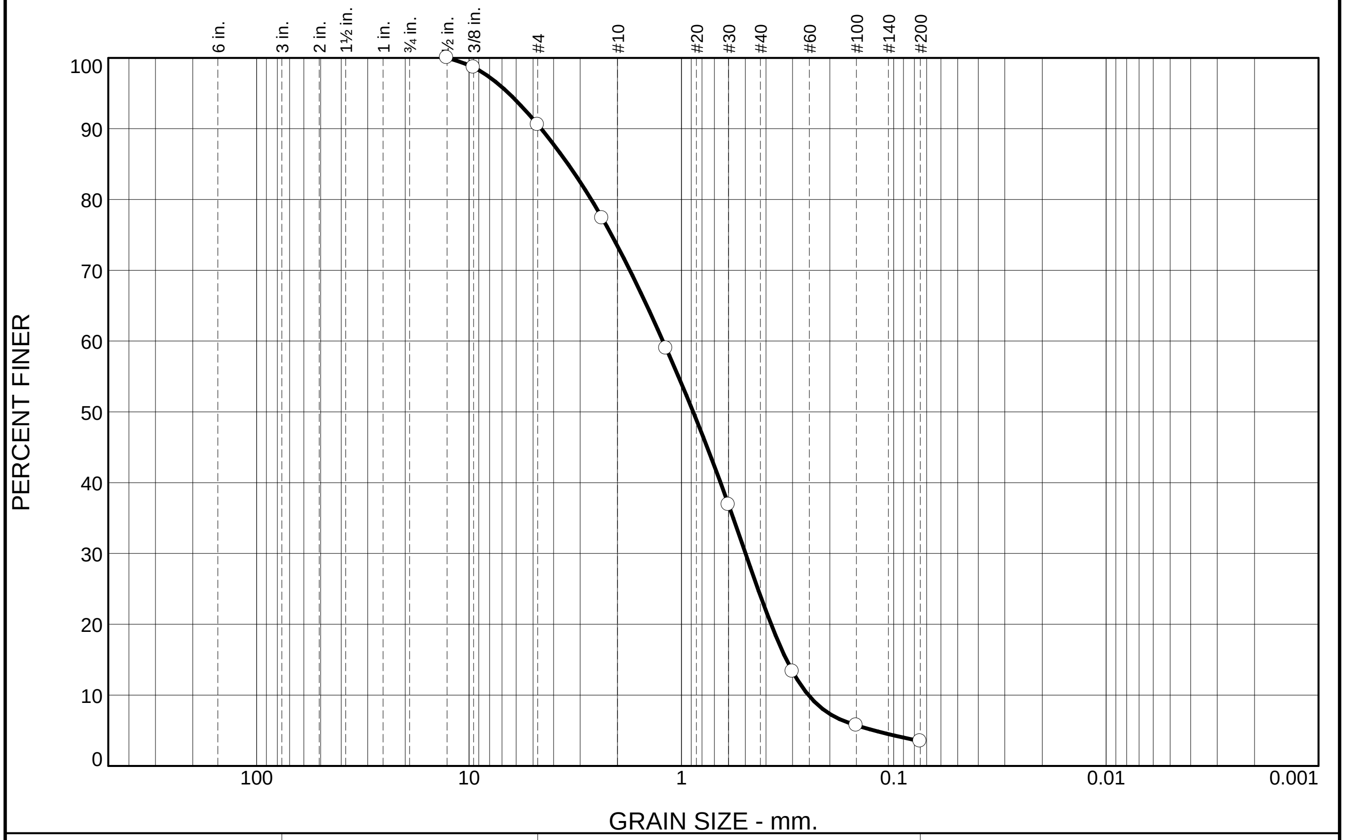
Remarks

Source of Sample: B-2 **Depth:** 5
Sample Number: B2-2 **Date:**

ALLIED LABORATORIES
Department of
PROFESSIONAL ENGINEERING CONSULTANTS

Client: PEC
Project: City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design
Project No: 74-14229-001-0147 **Figure** 10B

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.4	17.2	49.4	20.5	3.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100.0		
3/8"	98.7		
#4	90.6		
#8	77.4		
#16	59.0		
#30	36.9		
#50	13.3		
#100	5.7		
#200	3.5		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 4.5815 D_{85}= 3.4212 D_{60}= 1.2220
D_{50}= 0.8806 D_{30}= 0.4991 D_{15}= 0.3204
D_{10}= 0.2524 C_u= 4.84 C_c= 0.81

Classification

USCS= AASHTO=

Remarks

Source of Sample: B-2 **Depth:** 13.5
Sample Number: B2-5 **Date:**

ALLIED LABORATORIES
Department of
PROFESSIONAL ENGINEERING CONSULTANTS

Client: PEC
Project: City of Wichita Waste Water Treatment Plant 1 & 2 Emergency Power Design
Project No: 74-14229-001-0147 **Figure** 10C

ALLIED LABORATORIES
DEPT. OF PEC, P.A.
350 SOUTH WASHINGTON
WICHITA, KANSAS

SOIL CLASSIFICATION CHART

REFERENCE: ASTM D 2487
(Based on Unified Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse-Grained Soils More than 50 % retained on No. 200 sieve.	**Gravels** More than 50 % coarse faction retained on No. 4 sieve.	Clean Gravels Less than 5% fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]	**GW**	Well graded gravel [C, F]
			Cu < 4 and\or 1 > Cc > 3 [E]	**GP**	Poorly graded gravel [C, F]
		Gravels with fines More than 12% fines[C]	Fines Classify as ML or MH	**GM**	Silty gravel [F,G,H]
			Fines Classify as CL or CH	**GC**	Clayey gravel [F,G,H]
	Sands 50 % or more passes No. 4 sieve.	Clean Sands Less than 5% fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]	**SW**	Well graded sand [D, I]
			Cu < 6 and\or 1 > Cc > 3 [E]	**SP**	Poorly graded sand [D, I]
		Sands with Fines More than 12% fines[D]	Fines Classify as ML and MH	**SM**	Silty sand [G,H,I]
			Fines Classify as CL and CH	**SC**	Clayey sand [G,H,I]
Fine Grained Soils 50 % or more passes No. 200 sieve.	**Silts and Clays** Liquid Limit less than 50.	Inorganic	PI>7 and plots on or above "A" line [J]	**CL**	Lean clay [K,L,M]
			PI<4 and plots on or below "A" line [J]	**ML**	Silt [K,L,M]
		Organic	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}} \le 0.75$	**OL**	Organic clay [K,L,M,N]
					Organic silt [K,L,M]
	Silts and Clays Liquid Limit of 50 or more.	Inorganic	PI plots on or above "A" Line	**CH**	Fat clay [K,L,M]
			PI plots below "A" Line	**MH**	Elastic silt [K,L,M]
		Organic	$\frac{\text{Liquid Limit – oven dried}}{\text{Liquid Limit – not dried}} \le 0.75$	**OH**	Organic clay [K,L,M,P]
					Organic silt [K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			**Pt**	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
GW-GM Well graded gravel with silt.
GW-GC Well graded gravel with clay.
GP-GM Poorly graded gravel with silt.
GP-GC Poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols:
SW-SM Well graded sand with silt.
SW-SC Well graded sand with clay.
SP-SM Poorly graded sand with silt.
SP-SC Poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$; $Cc = (D_{30})^2 / (D_{10} \times D_{60})$.

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel" to group name.

[L] If soil contains ≥ 30% plus No. 200, predominately sand, add "sandy" to group name.

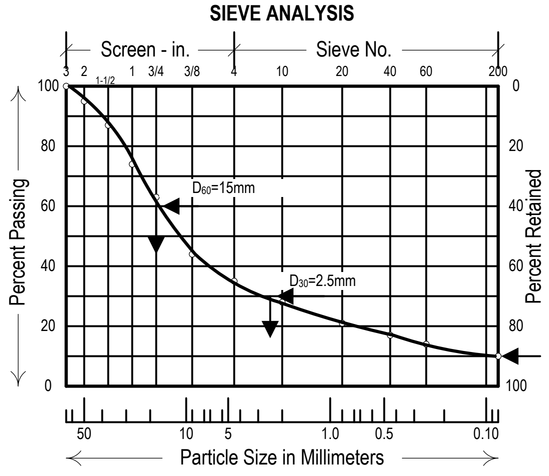
[M] If soil contains ≥ 30% plus No. 4, predominately gravel, add "gravely" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

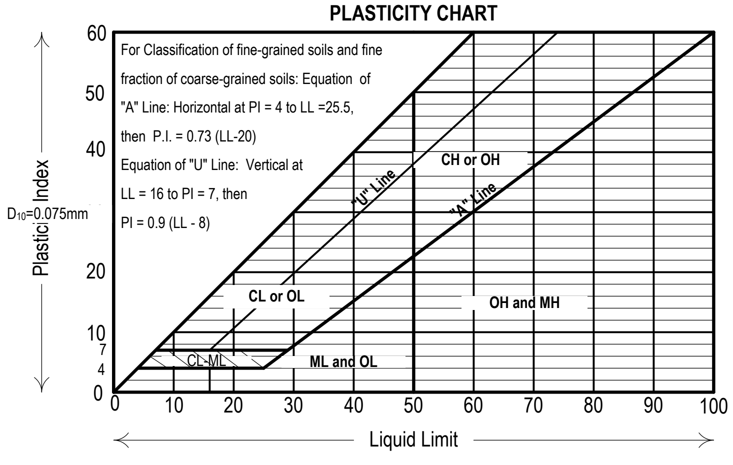
[Q] PI plots below "A" line.



SIEVE ANALYSIS

$C_u = D_{60}/D_{10} = 15/0.075 = 200$

$C_c = (D_{30})^2/(D_{10} \times D_{60}) = (2.5)^2/(0.075 \times 15) = 5.6$



PLASTICITY CHART

For Classification of fine-grained soils and fine fraction of coarse-grained soils: Equation of "A" Line: Horizontal at PI = 4 to LL =25.5, then P.I. = 0.73 (LL-20)
Equation of "U" Line: Vertical at LL = 16 to PI = 7, then PI = 0.9 (LL - 8)

Figure 11

ALLIED LABORATORIES
DEPT. OF PEC, P.A.
350 SOUTH WASHINGTON
WICHITA, KANSAS

GENERAL GEOTECHNICAL NOTES

SOIL CLASSIFICATION TERMINOLOGY

Soil classification is based on ASTM D-2487 "Soil Classification for Engineering Purposes" which is based on the Unified Soil Classification System. Fine grained soils have less than 50 percent of their particles retained on the No. 200 sieve. These soils are classified as silts if they are non-plastic to slightly plastic and as clays if they classify as plastic. Coarse grained soils have more than 50 percent of their particles retained on the No. 200 sieve and are classified as sands, gravels, cobbles and boulders depending on the grain size. Minor and major constituents may be added as modifiers depending on the proportions of the soil types. Additionally, fine grained soils are described based on their consistency and coarse grained soils are delineated by their relative density. Examples: Fat clay with sand (CH) and Silty sand (SM).

WATER LEVEL MEASUREMENTS

Water level measurements presented on the test boring logs are for the times indicated. These measurements may not necessarily represent the actual groundwater levels at the site. Fine grained soils of low permeability may require measurements for extended periods to accurately reflect free water levels. Coarse grained soils will generally reflect true groundwater levels after short periods. Groundwater levels and seepage water can vary depending on time of year, climatic conditions and other factors beyond the scope of normal geotechnical explorations. Typical water level abbreviations follows:

WD - Water level during drilling
W24 - Water level 24 hours after drilling
CW - Depth to wet cave of boring
WA - Water level after drilling
W48 - Water level 48 hours after drilling
CD - Depth to dry cave of boring

SAMPLING AND DRILLING ABBREVIATIONS

Drilling and sampling procedures are typically performed in accordance with ASTM standards unless otherwise noted. Typical sampling and drilling abbreviations follows:

P - Standard Penetration sampler
(1-3/8 in. ID split-spoon)
S - 3 in. diameter thin walled Shelby Tube
D - Denison Barrel Sampler
B - Bulk/grab sample
SB - Sawtooth bit barrel sampler
CF4 - 4 in. diameter continuous flight auger
CF6 - 6 in. diameter continuous flight auger
HS - 7-1/4 in. diameter hollow stem auger
NX - Diamond bit coring

DENSITY OF COARSE GRAINED SOILS

Relative Density (D_R)	**Percent D_R**	**Approximate N - Value (blows/foot)**
Very Loose	less than 15	0 to 4
Loose	15 to 35	4 to 10
Medium Dense	35 to 65	10 to 30
Dense	65 to 85	30 to 50
Very Dense	85 to 100	over 50

CONSISTENCY OF FINE GRAINED SOILS

Consistency	**Unconfined Compressive Strength (Q_U) psf**	**Approximate N - Value (blows/foot)**
Very Soft	Less than 500	0 to 2
Soft	500 to 1000	2 to 4
Medium Stiff	1000 to 2000	4 to 8
Stiff	2000 to 4000	8 to 16
Very Stiff	4000 to 8000	16 to 30
Hard	Over 8000	Over 30

BEDROCK HARDNESS DESCRIPTIONS

Hardness	**Approximate N - Value (blows/foot)**
Weathered (Soft)	Less than 20
Firm	20 to 30
Medium Hard	30 to 50
Hard	50 to 80
Very Hard	Over 80

PROPORTIONING OF CONSTITUENTS

Constituent Description	**Percent**
Trace	Less than 5
With	5 to 12
Modifier	More than 12

GRAIN SIZE DESCRIPTIONS

Constituent Description	**Particle Size**
Silt or Clay	Passing No. 200 Sieve (0.075 mm)
Sand	No. 200 to No. 4 Sieve (0.075 to 4.75 mm)
Gravel	No. 4 to 3 inch Sieve (4.75 to 75 mm)
Cobbles	3 to 12 inch Sieve (75 to 300 mm)
Boulders	Over 12 inch Sieve (300 mm)

Figure 12