SUBSURFACE INVESTIGATION

FOR

MEMORIAL PARKWAY TREATMENT PLANT IMPROVEMENTS

RECEIVED

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PUBLIC SERVICE COMMISSION

NORTHERN KENTUCKY WATER DISTRICT

JULY 2006

GEOTECHNICAL EXPLORATION

PROPOSED CHEMICAL STORAGE AND FEED SYSTEMS IMPROVEMENTS

NORTHERN KENTUCKY WATER DISTRICT MEMORIAL PARKWAY PLANT

FT. THOMAS, KENTUCKY

Prepared for: **Jordan, Jones & Goulding, Inc.**

Thelen Project No.: **050916E**

THELEN ASSOCIATES, INC.
Geotechnical • Testing Engineers

☑ 1398 Cox Avenue / Erlanger, Kentucky 41018-1002 / 859-746-9400 / Fax 859-746-9408
○ 2140 Waycross Road / Cincinnati, Ohio 45240-2719 / 513-825-4350 / Fax 513-825-4756
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November 14, 2005

Jordan, Jones & Goulding, Inc.
4219 Harrison Avenue
Cincinnati, Ohio 45211

Attn: Mr. Warner Moore

Re: Geotechnical Exploration
NKWD Chemical Storage and
Feed Systems Improvements
Memorial Parkway Plant
Ft. Thomas, Kentucky

Ladies and Gentlemen:

This letter is the report of our geotechnical exploration for the proposed Chemical Storage and Feed Systems Improvements at the Northern Kentucky Water District's (NKWD) Memorial Parkway Treatment Plant on Memorial Parkway in Ft. Thomas, Kentucky. Our services were authorized by the written signature of Mr. Warner Moore of Jordan, Jones & Goulding, Inc. (JJG) on JJG's "Agreement For Subconsultant Services" on September 22, 2005. A progress letter for the project was submitted on October 21, 2005.

SCOPE

The scope of our services included two test borings within the existing sedimentation basins; one test boring outside of the sedimentation basins; laboratory testing; engineering evaluation of the accumulated data, including recommendations for foundation design; and preparation of this geotechnical report.

PROJECT DESCRIPTION

As discussed in NKWD's "Request For Proposals For Professional Services", NKWD has conducted an engineering evaluation of the Memorial Parkway Treatment Plant in order to evaluate options for upgrading the chemical storage and feed systems. The plant has six concrete sedimentation basins that were built in 1961 and are no longer used. Based on Sheet M-4 of the May 31, 1961 plans prepared by J. Stephen Watkins Consulting Engineers, the sedimentation basin floors are at El. 746.25 feet (mean sea level [MSL] datum). Based on Sheets G-2 and G-3 of the plans, mass grading for the basins required up to about 15 feet of cut that exposed the interbedded shale and limestone bedrock over most of the project area.

Sedimentation Basins 5 and 6 are to be reused as the foundation and containment area for the new chemical feed facilities. The basins are to be subdivided to provide for the bulk storage and associated feed equipment for ferric sulfate, sodium hypochlorite, caustic soda, polyaluminum chloride, copper sulfate, corrosion inhibitor, hydrofluosilicic acid, coagulant aid polymer, and filter aid polymer. These chemical storage areas will be covered by a new concrete roof slab, insulation, and a wearing slab. A small structure housing the boiler room, electrical room, sand storage, janitor's room, washroom, and exit stairs will be located on the upper area and supported by concrete beams and a concrete slab.

A September 29, 2005 e-mail by Mr. Ed Neely indicates that the new infill "will weigh over twice the basin's previous liquid design weight", and will cause "a noticeable increase in unit stress on the foundation soils." The e-mail requests that potential for both differential and total settlement of the subbase below the existing basins be evaluated. Based on Sheet M-4 of the plans, the basins were designed to hold a maximum 12.0 feet of water, which would have exerted a distributed pressure of 750 pounds per square foot (psf) on the basin slabs. We are assuming that the new infill will generate a new distributed pressure of up to 2,000 psf on the basin slabs and wall foundations. We understand there is a possibility that new footings may need to be installed through the existing basin slabs.

EFFECTS OF KENTUCKY BUILDING CODE, 2002 REVISIONS

The Kentucky Building Code (KBC) was revised effective August 15, 2001. Effective January 1, 2002, all commercial building project plans and specifications are required to meet the requirements of KBC 2002.

A significant change in KBC 2002 is that it adopted the earthquake event having a 2 percent probability of exceedance in any 50-year period as the basis for seismic design. Previous codes had used the earthquake event having a 10 percent probability of exceedance in any 50-year period as the basis for seismic design. Another significant change is a KBC 2002 requirement that local site geology, including overburden soils above the bedrock, be factored into the determination of seismic parameters to be used in structural design.

In our opinion and based on our experience with the new code revision, the higher seismic standard will have an impact on structural design in the Northern Kentucky Area. The effects of regional seismicity (as mandated by KBC 2002, as amended) have been considered in this study and will be addressed later in this report.

Based on our interpretation of KBC 2002, the facility will either fall within Seismic Use Group II or III. Seismic Use Group II includes water treatment facilities for potable water, and Seismic Use Group III includes water treatment facilities required to maintain water pressure for fire suppression.

SUBSURFACE EXPLORATION

Three (3) test borings were drilled on the property on September 27 and October 12, 2005 at the locations shown on the Boring Plan, Drawing 050916E-1, in the Appendix of this report. This plan is based on Sheet G-2 of the May 31, 1961 plans. Thelen marked the test boring locations in the field. The boring elevations were based on the basin floor elevation of 746.25 feet shown on Sheet M-4 of the plans, and on interpolation between the proposed final surface contours shown on Sheet G-2 of the plans.

The project was originally to include four borings, but only three were drilled. (Boring 1 was deleted at NKWD's request.) Boring 2A was drilled through the slab and along the east wall of Sedimentation Basin 2, about 30 feet north of the inlet port structure. Boring 3 was drilled through the slab and along the west wall of Sedimentation Basin 5, about 18 feet north of the inlet port structure. Boring 4 was drilled outside and along the east wall of Sedimentation Basin 6, roughly in line with Borings 2A and 3.

Borings 2A and 3 were made using hand equipment following coring of the existing slab using a concrete coring machine. Samples were obtained using a 2-inch OD split spoon driven with a 35-pound weight falling 30 inches. Boring 4 was made with a truck-mounted drill rig using continuous flight augers, and by sampling ahead of the augers with a 2-inch OD split spoon driven with a 140-pound weight falling 30 inches. This procedure is described as the standard drive sample method and results in the standard penetration test (SPT).

As each test boring was advanced, the Drilling Technician kept a log of the subsurface profile encountered, noting soil and bedrock types and stratifications, SPT results, groundwater, and other pertinent data. In addition, a representative portion of each split spoon sample was placed in a glass jar. The jars were sealed and marked for proper identification.

Borings 2A and 3 were backfilled with bentonite chips and concrete surface patches. Boring 4 was backfilled with the drill cuttings. None of the borings encountered free subsurface water.

LABORATORY TESTING

The samples from the test borings were returned to our Soil Mechanics Laboratory where they were reviewed and classified by the Project Geotechnical Engineer. Representative soil samples were selected for natural moisture content testing. A tabulation of the test results is included in the Appendix to this report.

On the basis of the visual examination of the samples, the laboratory test results, and the field logs kept by our Drilling Technician, final test boring logs were prepared. Copies of the final logs are included in the Appendix together with a Soil Classification Sheet that describes the terms and symbols used on the logs.

SITE AND SUBSURFACE CONDITIONS

As discussed previously, the new construction is to take place within and over existing Sedimentation Basins 5 and 6. Boring 4 was drilled outside of Sedimentation Basin 6 to complete our evaluation of the general subsurface profile.

Boring 2A encountered 5¾ inches of concrete; 4 inches of a multicolored, very moist, coarse sand and fine gravel (i.e., pea gravel) subbase; 4 inches of interbedded, brown to olive brown, very soft, weathered shale and gray hard limestone; and two inches of interbedded, gray, soft, unweathered shale and gray hard limestone. The bedrock surface was encountered at El. 745.5 feet. The boring was terminated at a depth of about 16 inches below the top of the slab, and was backfilled with hydrated bentonite and a concrete patch.

Boring 3 encountered 7 inches of concrete; 11 inches of a multicolored, very moist, medium to coarse sand and fine gravel (i.e., pea gravel) subbase; about 9 inches of gray, moist, stiff, silty clay fill; and 4 inches of interbedded, gray, soft, unweathered shale and gray hard limestone. The bedrock surface was encountered at El. 744.1 feet. The boring was terminated at a depth of about 31 inches below the top of the slab, and was backfilled with hydrated bentonite and a concrete patch.

Boring 4 encountered 4 inches of topsoil; 7.3 feet of brown, moist, medium stiff to very stiff, silty clay wall backfill; 4.4 feet of interbedded, brown to olive brown, very soft, weathered shale and gray hard limestone; and 0.6 feet of interbedded, gray, soft, unweathered shale and gray hard limestone. The bedrock surface was encountered at El. 745.9 feet. The boring was terminated at a depth of 12.6 feet, and was backfilled with the soil cuttings.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations of this report have been derived by relating the general principles of the discipline of Geotechnical Engineering to the proposed construction outlined by the Project Description section of this report. Because changes in surface, subsurface, climatic, and economic conditions can occur with time and location, we recommend for our mutual interest that the use of this report be restricted to this specific project.

Our understanding of the proposed construction is based on our conversations with Mr. Warner Moore of JJG and on our review of NKWD's "Request For Proposals For Professional Services". We recommend that our office be retained to review the final design documents, plans, and specifications to assess any impact that changes, additions, or revisions in these documents may have on the conclusions and recommendations of this report. Any changes or modifications that are made in the field during the construction phase that alter site grading, structure location, infrastructure, or other related site work should be reviewed by our office prior to their implementation.

If conditions are encountered in the field during construction that vary from the facts of this report, we recommend that our office be contacted immediately to review the changed conditions in the field and to make appropriate recommendations.

The scope of our services did not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic materials in the soil, bedrock, surface water, groundwater or air, on or below or around this site.

We performed our test borings and laboratory tests for our evaluation of site conditions and for the formulation of the conclusions and recommendations of this report. We assume no responsibility for the interpretation or extrapolation of the data by others.

Based on our engineering reconnaissance of the site, the test borings, the laboratory test results, our understanding of the proposed construction, and our experience as Consulting Soil and Foundation Engineers in the Northern Kentucky Area, we have reached the following conclusions and make the following recommendations.

Subsurface Conditions

1. Boring 2A encountered the shale and limestone bedrock surface immediately below the 4-inch-thick, pea gravel subbase. Boring 4 encountered the shale and limestone bedrock surface about 1 to 2 inches above the slab bearing elevations determined by Borings 2A and 3. Boring 3 encountered the shale and limestone bedrock surface below an 11-inch-thick, pea gravel subbase and 9 inches of stiff, silty clay fill. No free subsurface water was noted.

2. Because Boring 3 indicates that some stiff, silty clay fill is present above the bedrock surface, we have assumed that the engineering properties of the stiff fill will control the

amount of new load that can be placed on the existing basin slabs and wall foundations. We note that based on the available test boring data, the areal extent of the occurrence of silty clay site fill beneath the pea gravel subbase cannot be estimated, nor can the presence and extent of any soft to medium stiff clayey fill be determined.

Seismicity

3. Based on KBC 2002 (as amended), it is our opinion that the following seismic parameters are applicable to the proposed building site.

Site Class	C
S_S	0.180 g (USGS Earthquake Hazards Website)
S_1	0.090 g (KBC 2002 minimum)
S_{MS}	0.216 g
S_{M1}	0.153 g
S_{DS}	0.144 g
S_{D1}	0.102 g
Seismic Design Category	A, B, or C

4. We recommend that the Project Architect and Structural Engineer assist the Owner in making the final determination of the site Seismic Design Category. The site can be assigned to Seismic Design Category 'A' if the approximate fundamental period of the structure, T_a, in each of the two orthogonal directions, determined in accordance with KBC 2002 Section 1617.4.2.1, is less than 0.8 T_s, determined in accordance with KBC 2002 Section 1615.1.4, where Equation 16-35 is used to determine the seismic response coefficient, C_s. Otherwise, the site would be assigned to Seismic Design Category 'B' if its Seismic Use Group is II, and to Seismic Design Category 'C' if its Seismic Use Group is III.

Foundations

5. In our opinion and based on the available test boring data, the existing basins can support allowable distributed loads of 2,000 psf, full dead plus full live load. The existing wall foundations can support allowable footing bearing pressures of 2,000 psf. Based on an assumption that the pea gravel subbase is 11 inches thick and in a loose condition, and that the silty clay fill is 9 inches thick and in a stiff condition, it is our

opinion that these pressures will generate less than ½ inch of total and differential settlement. Up to ½ inch of differential settlement is possible if a relatively large contiguous area of storage basins is emptied adjacent to a relatively large contiguous area of basins that remain full, e.g., if the area of Sedimentation Basin 5 is emptied while the area of Sedimentation Basin 6 remains full.

6. We understand that new footings may need to be constructed within the area of Sedimentation Basins 5 and 6. If the basin floors must be penetrated to construct new footings as part of the facility improvements, we recommend that the subgrades be lowered as necessary to bear below any site fill and on the highly weathered bedrock. Footings bearing on the highly weathered bedrock may be proportioned for a maximum allowable bearing pressure of 6,000 psf, full dead plus full live load.

7. Any new continuous footings should be a minimum of 16 inches wide. Individual column footings should be at least 24 inches square.

8. All loose, soft, wetted, or dried materials should be skimmed from footing excavations before reinforcing steel and concrete are placed. The concrete should be placed on bedrock that is moist, not wet or dry. If bearing surfaces become excessively wet or dry before the concrete is placed, they should be skimmed to expose moist, stiff shale.

9. We recommend that shale subgrades supporting new footings not be allowed to become wetted and saturated or excessively dried during or after construction of the footings. We recommend that footing trenches be filled with concrete the same day that they are excavated to prevent ponding of water on the subgrades. Foundation construction should be scheduled during favorable weather, and good drainage should be maintained during construction to prevent water from ponding in or around any new footing excavations.

10. Any new footing excavations and subgrades should be examined by the Project Geotechnical Engineer or his representative before reinforcing steel and concrete are

placed to confirm that the design recommendations have been properly interpreted and followed.

11. In our opinion, it would be prudent to verify the integrity of the concrete patches placed by Thelen's drilling crew in Borings 2A and 3, if these patches are to be relied upon to prevent future leakage from the basins.

CLOSURE

We have included with this letter a reprint of "Important Information About Your Geotechnical Engineering Report" published by ASFE, Professional Firms Practicing in the Geosciences, which our firm would like to introduce to you at this time.

We have appreciated the opportunity to provide these geotechnical recommendations to you for this project. If there are any questions concerning the information contained in this report, or if we may be of further service to you, please do not hesitate to contact us.

Respectfully submitted,
THELEN ASSOCIATES, INC.

John S. Nealon, P.E.
Senior Geotechnical Engineer

JSN/tmk
050916E

Copies submitted: 3 – Client

APPENDIX

ASFE Report Information

Tabulation Of Laboratory Tests

Boring Plan, Drawing No. 050916E-1

Test Boring Logs

Soil Classification Sheet

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you —* should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

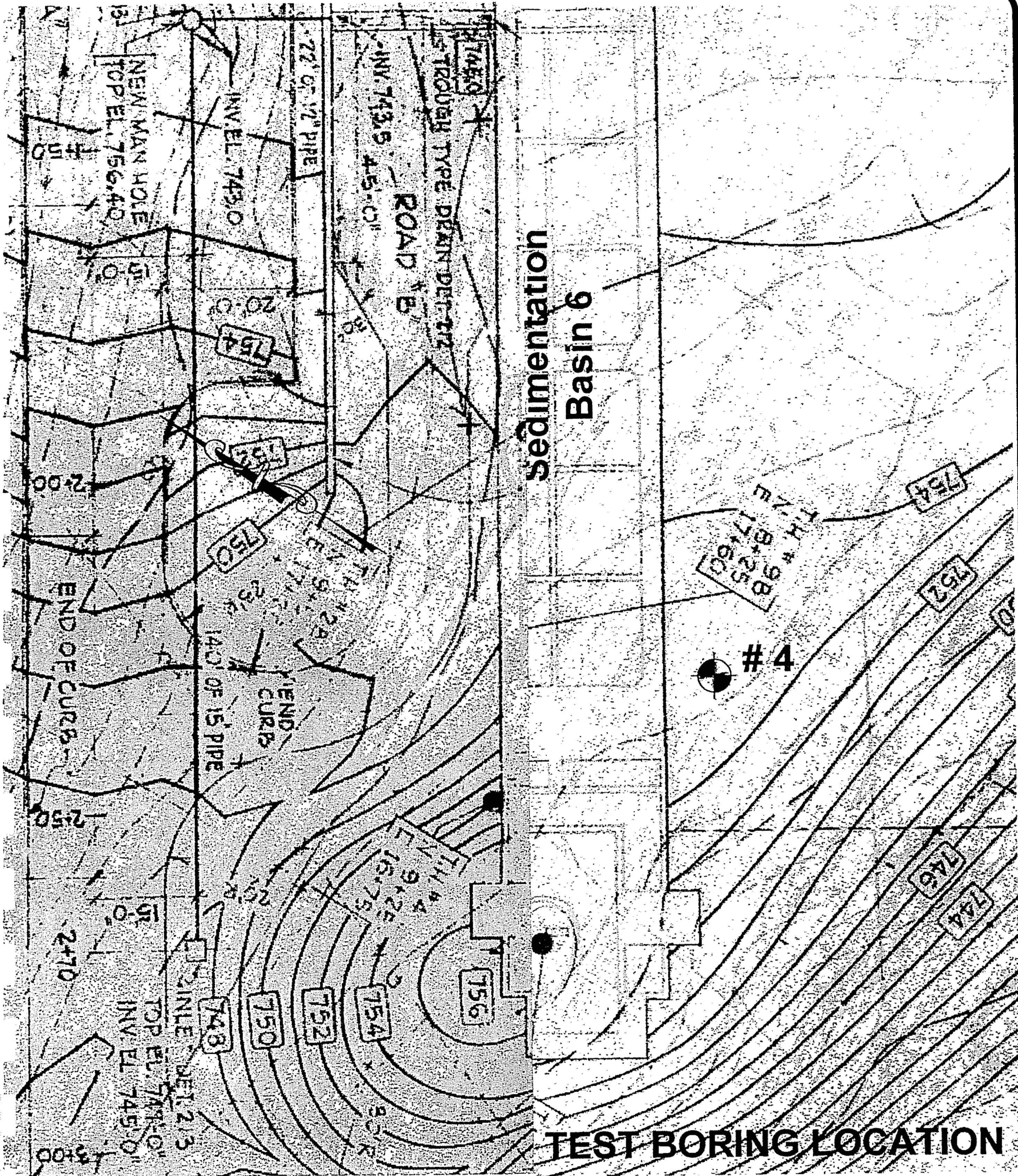
8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

THELEN ASSOCIATES, INC.
1398 COX AVENUE
ERLANGER, KENTUCKY 41018-1002

GEOTECHNICAL EXPLORATION
CHEMICAL FEED IMPROVEMENTS
NKWD MEMORIAL PARKWAY PLANT
FT. THOMAS, KENTUCKY
050916E

TABULATION OF LABORATORY TESTS

Boring Number	Sample Number	Depth, ft.		Moisture Content, %
		From	To	
2A	2A	0.8	1.1	9.7
	2B	1.1	1.3	12.6
3	2A	1.5	2.2	16.0
	2B	2.2	2.6	8.4
4	5	10.0	11.5	13.6
	6	12.5	14.0	5.2



Notes	Geotechnical Exploration Chemical Storage and Feed Systems Improvements Northern Kentucky Water District Memorial Parkway Plant Ft. Thomas, Kentucky	Scale: 1" = 20' Date: 11/14/05 Drawing No.: 050916E-1

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LOG OF TEST BORING

CLIENT: Jordan, Jones & Goulding, Inc. BORING # 2A
PROJECT: Geotechnical Exploration, NKWD Chemical Storage and Feed Systems Improvements JOB # 050916E
LOCATION OF BORING: As shown on Boring Plan, Drawing 050916E-1 Ft. Thomas, Kentucky

ELEV.	SOIL DESCRIPTION COLOR, MOISTURE, DENSITY, PLASTICITY, SIZE, PROPORTIONS	STRATA DEPTH feet	DEPTH SCALE feet	SAMPLE Cond	Blows/6"	No.	Type	Rec. Inches
746.3	SURFACE	0.0						
745.8	CONCRETE – 5 3/4"	0.5						
745.5	Multicolored wet FILL, coarse sand and fine gravel (pea gravel base).	0.8		D		1	CA	4
745.2	Interbedded brown to olive brown moist soft weathered SHALE and gray hard LIMESTONE (bedrock).	1.1	1	I	50/6"	2A 2B	DS	5
745.0	Interbedded gray moist soft SHALE and gray hard LIMESTONE (bedrock).	1.3	2					
	Bottom of test boring at 1.3 feet.							
	Note: Bentonite backfill and concrete patch.		3					
			4					
	NOTE:		5					

Datum MSL Hammer Wt. 35 lbs. Hole Diameter 4 in. Foreman BR/GB
Surf. Elev. 746.3 ft. Hammer Drop 30 in. Rock Core Dia. ____ in. Engineer JSN
Date Started 9/27/05 Pipe Size O.D. 2 in. Boring Method HAND Date Completed 9/27/05

SAMPLE CONDITIONS
D – DISINTEGRATED
I – INTACT
U – UNDISTURBED
L – LOST

SAMPLE TYPE
DS – DRIVEN SPLIT SPOON
PT – PRESSED SHELBY TUBE
CA – CONTINUOUS FLIGHT AUGER
RC – ROCK CORE

GROUND WATER DEPTH
FIRST NOTED None ft.
AT COMPLETION Dry ft.
AFTER -- hrs. -- ft.
BACKFILLED Immed. hrs.

BORING METHOD
HSA – HOLLOW STEM AUGERS
CFA – CONTINUOUS FLIGHT AUGERS
DC – DRIVING CASING
MD – MUD DRILLING

STANDARD PENETRATION TEST – DRIVING 2" O.D. SAMPLER 1' WITH 140# HAMMER FALLING 30"; COUNT MADE AT 6" INTERVALS

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LOG OF TEST BORING

CLIENT: Jordan, Jones & Goulding, Inc. BORING # 3
PROJECT: Geotechnical Exploration, NKWD Chemical Storage and Feed Systems Improvements JOB # 050916E
LOCATION OF BORING: As shown on Boring Plan, Drawing 050916E-1 Ft. Thomas, Kentucky

ELEV.	SOIL DESCRIPTION COLOR, MOISTURE, DENSITY, PLASTICITY, SIZE, PROPORTIONS	STRATA DEPTH feet	DEPTH SCALE feet	SAMPLE Cond	Blows/6"	No.	Type	Rec. Inches
746.3	SURFACE	0.0						
745.7	CONCRETE – 7"	0.6		X				
744.8	Multicolored wet FILL, medium to coarse sand and fine gravel (pea gravel base).	1.5	1	D		1	CA	11
744.1	Mixed gray moist stiff FILL, silty clay and shale with limestone fragments.	2.2	2	I	18/50/ 100/1"	2A 2B	DS	13
743.7	Interbedded gray moist soft SHALE and gray hard LIMESTONE (bedrock).	2.6						
	Bottom of test boring at 2.6 feet. Note: Bentonite backfill and concrete patch. NOTE: 7		3 4 5					

Datum MSL Hammer Wt. 35 lbs. Hole Diameter 4 in. Foreman BR/GB
Surf. Elev. 746.3 ft. Hammer Drop 30 in. Rock Core Dia. ____ in. Engineer JSN
Date Started 9/27/05 Pipe Size O.D. 2 in. Boring Method HAND Date Completed 9/27/05

SAMPLE CONDITIONS	SAMPLE TYPE	GROUND WATER DEPTH	BORING METHOD
D – DISINTEGRATED	DS – DRIVEN SPLIT SPOON	FIRST NOTED None ft.	HSA– HOLLOW STEM AUGERS
I – INTACT	PT – PRESSED SHELBY TUBE	AT COMPLETION Dry ft.	CFA– CONTINUOUS FLIGHT AUGERS
U – UNDISTURBED	CA – CONTINUOUS FLIGHT AUGER	AFTER -- hrs. -- ft.	DC – DRIVING CASING
L – LOST	RC – ROCK CORE	BACKFILLED Immed. hrs.	MD – MUD DRILLING

STANDARD PENETRATION TEST – DRIVING 2" O.D. SAMPLER 1' WITH 140# HAMMER FALLING 30"; COUNT MADE AT 6" INTERVALS

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☑ 1398 Cox Avenue / Erlanger, Kentucky 41018-1002 / 859-746-9400 / Fax 859-746-9408
○ 2140 Waycross Road / Cincinnati, Ohio 45240-2719 / 513-825-4350 / Fax 513-825-4756
www.thelenassoc.com

LOG OF TEST BORING

CLIENT: Jordan, Jones & Goulding, Inc. BORING # 4
PROJECT: Geotechnical Exploration, NKWD Chemical Storage and Feed Systems Improvements JOB # 050916E
LOCATION OF BORING: As shown on Boring Plan, Drawing 050916E-1 Ft. Thomas, Kentucky

ELEV.	SOIL DESCRIPTION COLOR, MOISTURE, DENSITY, PLASTICITY, SIZE, PROPORTIONS	STRATA DEPTH feet	SAMPLE Cond	Blows/6"	No.	Type	Rec. Inches
753.5	SURFACE						
753.2	TOPSOIL	0.3	I	4/7/21	1A 1B	DS	12
749.0	Mixed brown to olive brown moist stiff to very stiff FILL, silty clay with hairlike roots and traces of limestone and concrete.	4.5	I	5/15/10	2	DS	6
746.5	Mixed brown and gray very moist low-end medium stiff FILL, silty clay.	7.0	I	3/4/5	3	DS	18
745.9	Mixed brown moist medium stiff FILL, silty clay with small roots.	7.6	I	50/2"	4	DS	2
741.5	Interbedded brown to olive brown moist very soft weathered SHALE and gray hard LIMESTONE (bedrock).	12.0	I	16/50/2"	5	DS	7
740.9	Interbedded gray moist soft SHALE and gray hard LIMESTONE (bedrock).	12.6	I	50/2"	6	DS	2
	Split spoon refusal and bottom of test boring at 12.6 feet.						

Depth scale (feet): 5, 10, 15, 20, 25

Datum MSL Hammer Wt. 140 lbs. Hole Diameter 5 in. Foreman BR
Surf. Elev. 753.5 ft. Hammer Drop 30 in. Rock Core Dia. ____ in. Engineer JSN
Date Started 10/12/05 Pipe Size O.D. 2 in. Boring Method CFA Date Completed 10/12/05

SAMPLE CONDITIONS
D – DISINTEGRATED
I – INTACT
U – UNDISTURBED
L – LOST

SAMPLE TYPE
DS – DRIVEN SPLIT SPOON
PT – PRESSED SHELBY TUBE
CA – CONTINUOUS FLIGHT AUGER
RC – ROCK CORE

GROUND WATER DEPTH
FIRST NOTED None ft.
AT COMPLETION Dry ft.
AFTER -- hrs. -- ft.
BACKFILLED Immed. hrs.

BORING METHOD
HSA – HOLLOW STEM AUGERS
CFA – CONTINUOUS FLIGHT AUGERS
DC – DRIVING CASING
MD – MUD DRILLING

STANDARD PENETRATION TEST – DRIVING 2" O.D. SAMPLER 1' WITH 140# HAMMER FALLING 30"; COUNT MADE AT 6" INTERVALS

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SOIL CLASSIFICATION SHEET

NON COHESIVE SOILS
(Silt, Sand, Gravel and Combinations)

Density

Very Loose	- 5 blows/ft. or less
Loose	- 6 to 10 blows/ft.
Medium Dense	- 11 to 30 blows/ft.
Dense	- 31 to 50 blows/ft.
Very Dense	- 51 blows/ft. or more

Relative Properties

Descriptive Term	Percent
Trace	1 – 10
Little	11 – 20
Some	21 – 35
And	36 – 50

Particle Size Identification

Boulders	- 8 inch diameter or more	
Cobbles	- 3 to 8 inch diameter	
Gravel	- Coarse	- 3/4 to 3 inches
	- Fine	- 3/16 to 3/4 inches
Sand	- Coarse	- 2mm to 5mm (dia. of pencil lead)
	- Medium	- 0.45mm to 2mm (dia. of broom straw)
	- Fine	- 0.075mm to 0.45mm (dia. of human hair)
Silt		- 0.005mm to 0.075mm (Cannot see particles)

COHESIVE SOILS
(Clay, Silt and Combinations)

Consistency	Field Identification	Unconfined Compressive Strength (tons/sq. ft.)
Very Soft	Easily penetrated several inches by fist	Less than 0.25
Soft	Easily penetrated several inches by thumb	0.25 – 0.5
Medium Stiff	Can be penetrated several inches by thumb with moderate effort	0.5 – 1.0
Stiff	Readily indented by thumb but penetrated only with great effort	1.0 – 2.0
Very Stiff	Readily indented by thumbnail	2.0 – 4.0
Hard	Indented with difficulty by thumbnail	Over 4.0

Classification on logs are made by visual inspection.

Standard Penetration Test – Driving a 2.0" O.D., 1 3/8" I.D., sampler a distance of 1.0 foot into undisturbed soil with a 140 pound hammer free falling a distance of 30 inches. It is customary to drive the spoon 6 inches to seat into undisturbed soil, then perform the test. The number of hammer blows for seating the spoon and making the tests are recorded for each 6 inches of penetration on the drill log (Example – 6/8/9). The standard penetration test results can be obtained by adding the last two figures (i.e. 8+9=17 blows/ft.). Refusal is defined as greater than 50 blows for 6 inches or less penetration.

Strata Changes – In the column "Soil Descriptions" on the drill log, the horizontal lines represent strata changes. A solid line (————) represents an actually observed change; a dashed line (— — — —) represents an estimated change.

Groundwater observations were made at the times indicated. Porosity of soil strata, weather conditions, site topography, etc., may cause changes in the water levels indicated on the logs.