

**SETTLEMENT MONITORING
NKU FOUNDATION PROPERTY
DIXIE HIGHWAY & MT. ALLEN ROAD
COVINGTON, KENTUCKY**

Prepared for:

**NKU FOUNDATION, INC.
HIGHLAND HEIGHTS, KENTUCKY**

Prepared by:

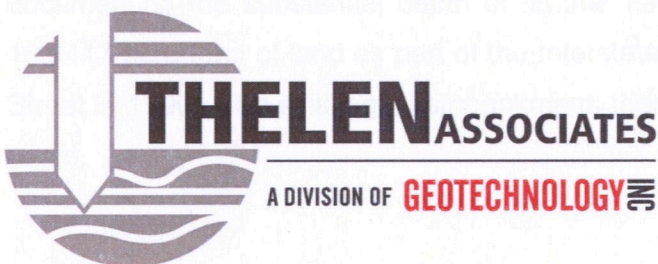
**THELEN ASSOCIATES,
A DIVISION OF GEOTECHNOLOGY, INC.
ERLANGER, KENTUCKY**

Date:

JULY 11, 2016

Thelen Project No.:

J027698.01



**SAFETY
QUALITY
INTEGRITY
PARTNERSHIP
OPPORTUNITY
RESPONSIVENESS**



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A Division of Geotechnology, Inc.
July 11, 2016

Ms. Mary Paula Schuh
NKU Foundation, Inc.
Seventh Floor
Lucas Administration Center
Highland Heights, Kentucky 41099

Re: Settlement Monitoring
NKU Foundation Property
Dixie Highway & Mt. Allen Road
Covington, Kentucky
Thelen Project No. J027698.01

Ladies and Gentlemen:

Pursuant to our Proposal-Agreement P027698.01, dated June 10, 2016, Thelen Associates, A Division of Geotechnology, Inc. (Thelen) was retained by the NKU Foundation, Inc. (NKUF) to make another reading on the settlement points established on top of the existing fill embankment constructed on the NKUF property south of the Dixie Highway and east of Mt. Allen Road, Covington, Kentucky. This work was authorized on June 21, 2016 by Mrs. Karen Zerhusen Kruer on behalf of NKUF.

The scope of our recommended monitoring program was to resurvey the elevations of the eight settlement monuments on the surface of the existing fill embankment and then to compare those readings to the results of the historical monitoring performed by Thelen since the settlement points were established in 2007.

Thelen had previously explored this property and had prepared a report dated February 28, 1995 documenting the substantial depth of fill that had been placed in the western portion of the 16.9417-acre tract of land as part of the Interstate 75 reconstruction from Kyles Lane to Twelfth Street in 1990. The existing fill embankment, therefore, has been in place for approximately 26 years.

Classical soil mechanics suggest that clayey soils undergo consolidation as a time dependent phenomena based upon induced stress. In the case of a compacted fill embankment, an initial state of stress in the soil is developed through the compaction process. The magnitude of that initial state of stress is a function of the degree of compactive effort applied in building the fill embankment. Based upon our research as discussed in our report of 1995, it appeared to Thelen that the bulk of the fill embankment was well compacted. For nominal thicknesses of fill on the order of 30 feet and less, normal compactive effort will consolidate the fill to a reasonable degree such that the stress induced by the overlying weight of fill on the underlying deeper zones of fill is comparable to the compactive effort and as such, the amount of post-construction consolidation is minor, likely $\frac{1}{4}$ inch or less. Under deeper fills, on the other hand, such as the 100-foot-thickness of fill estimated at the crest of the existing fill slope over the central portion of the original drainage valley that drained from west to east across the property, where the maximum thickness of fill is anticipated, the weight of the upper portion of the fill produces very high stresses on the deeper portion of the fill such that settlements can be extensive, on the order of feet. The high state of stress induced on the lower portion of the fill by the upper portion of the fill causes the soil particles to be compressed. This compression process squeezes the free water that is contained in the soil out of the soil. In clayey soils, this time dependent process is a function of the permeability of the soil, which dictates the rate at which the free water can be squeezed out of the soil. Another variable is the distance through which the free water must flow to get out of the soil. This could be from the central portion of the embankment vertically downward to a drainage blanket at the base of the fill, or vertically upward to the existing ground surface. If those are the only two paths for dissipation of the water, the consolidation process can take decades. If the amount of free water in the soil is very low, or if there are intermediate flow paths for the water, the time of settlement can be significantly less. Not knowing all of the potential variables, it was recommended that the settlement monitoring program be established to quantify the degree and rate of the settlement.

A settlement monitoring program was initiated with the establishment of eight (8) monitoring points on the surface of the existing fill in June 2007. Benchmarks were established off of the fill on the north side of the Dixie Highway at three (3) locations. Readings on the eight (8) monitoring points relative to the benchmarks were accomplished in July and September of 2007, in February and August of 2008, in February and December of 2009, and in July of 2016. Settlement Pin A was

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unable to be surveyed as it appears that since the pins were last read in December 2009, there has been some dumping on the property and Pin A was buried. We also note that one of the benchmarks (TBM-3) was damaged after the February 2008 reading. The locations of all of the benchmarks (numbered TBM-1, 2 and 3) and the settlement monuments (lettered PT-A through PT-H) are shown on the attached Monitoring Plan, Drawing 94821E-1.

The data from the settlement monitoring program is tabulated on the attached two settlement tabulation sheets included herewith, and are graphically illustrated on the two attached settlement graphs. There is some minor variability in the data as a result of the equipment and human limitations. Looking at the data collectively, there is reasonable correlation and some clear trends. Settlement Pin B, which was estimated to be on a fill embankment of only approximately 14 feet in depth, showed no signs of settlement over the 9-year monitoring period as one would expect.

Settlement Pins C, D, E, F and H included estimated fill thicknesses of 37 to 49 feet and showed a settlement range of approximately $\frac{1}{4}$ to $1 \frac{1}{8}$ inches over the 9-year monitoring period. The trends of each of those monitoring pins is continued settlement at a recent rate of approximately $\frac{1}{32}$ to slightly less than $\frac{3}{16}$ inch per year. Settlement Pin G was located near the crest of the fill slope near the alignment of the original valley where there was an estimated 100 feet of fill. That settlement pin settled approximately 0.66 inches over the past 9 years and at a rate within the range defined above.

Theory of consolidation indicates that the rate of settlement decreases with the progression of time such that there is a point in time at which the amount of settlement is within tolerable amounts, and the embankment can be considered to have "settled out". The degree to which the settled-out process has occurred is, in part, a function of the tolerance for future settlements, depending upon whatever would possibly be constructed upon the fill. Most structures have a tolerance level estimated at approximately 1 inch of differential settlement.

If the NKUF is considering selling the subject property, we recommend that it be done with language that would indicate that it is an "as-is" sale of the property with no guarantees or warranty with regard to the amount of settlement that could occur with future development. There is a lot of interpretation that goes into the assessment of the last 9 years of settlement data and into

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extrapolating that data for the some 26 years the fill embankment has been in place. It appears that there is settlement on-going in portions of the embankment, which may continue for possibly decades to come. The key will be the relative amount of differential settlement that may occur over the footprints of whatever would be proposed to be constructed upon the fill.

We recommend that the existing settlement pins and benchmarks be left in place for future monitoring. The survey can be repeated with time and the data added to the existing data to further assess the time rate and location of consolidation ongoing. We suggest as a minimum that the existing settlement pins be surveyed on an annual basis as long as the NKUF owns the property. If you elect to build on the property, we recommend that we be retained to consult early during the planning and design phases.

We appreciate the opportunity of being of service to you on this project. Should you have any questions concerning the contents of this letter, or if we may be of any additional assistance, please do not hesitate to contact us.

Respectfully submitted,

THELEN ASSOCIATES,
A DIVISION OF GEOTECHNOLOGY, INC.



Donald B. Thelen, P.E.
Senior Consultant

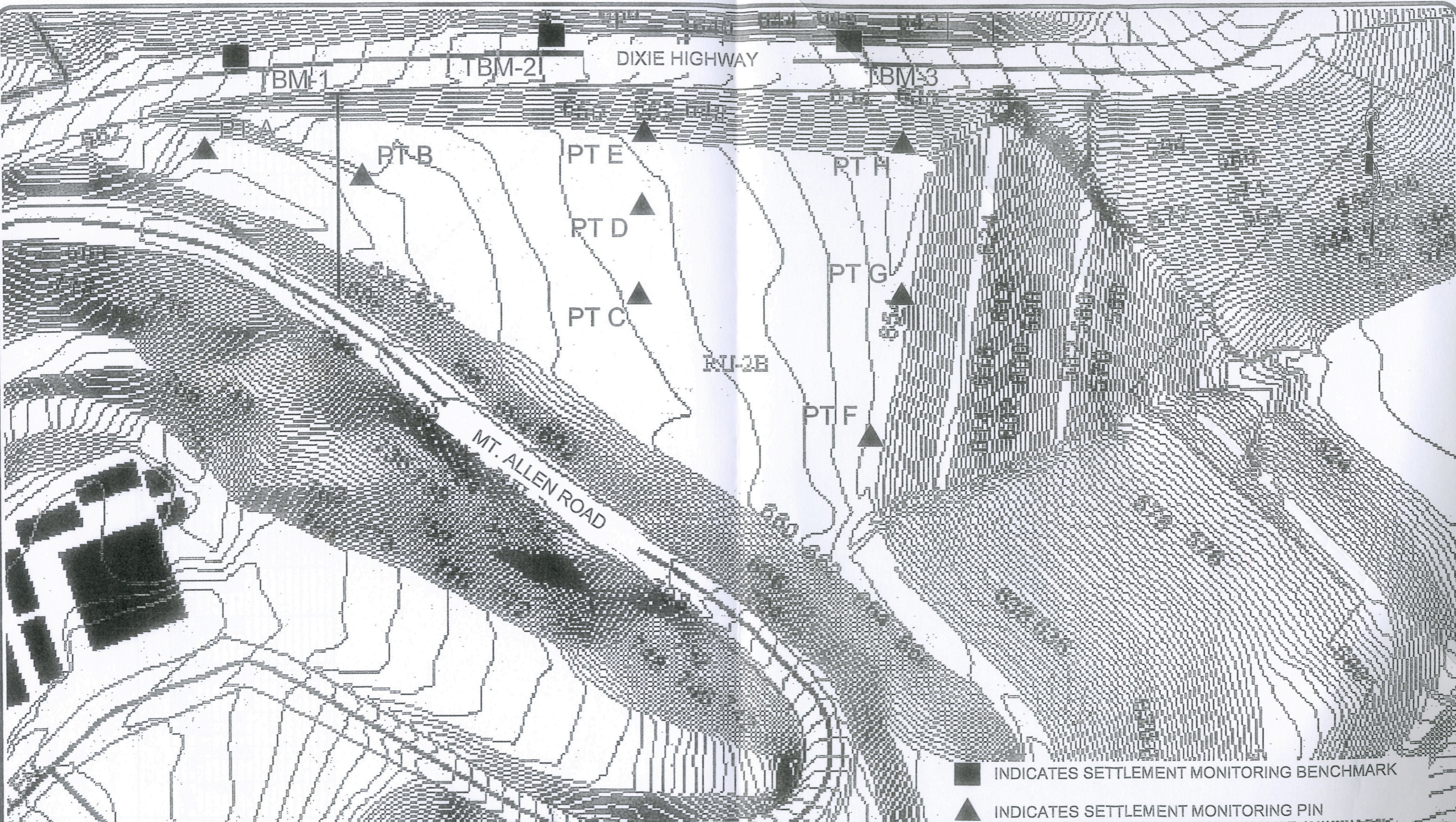


Andrew C. Casto, P.E.
Senior Geotechnical Engineer

DBT/ACC:dbt/tmk

Enclosures: Monitoring Plan, Drawing 94821E-1
Settlement Monitoring Tabulations
Settlement Vs. Time Graph
Settlement Vs. Log of Time Graph

Copies submitted: Client (3 mail)



Notes



THELEN ASSOCIATES, INC.
Geotechnical • Testing Engineers

1398 Cox Avenue / Erlanger, Kentucky 41018 / 859-746-9400
2140 Waycross Road / Cincinnati, Ohio 45240 / 513-825-4350

Title: MONITORING PLAN

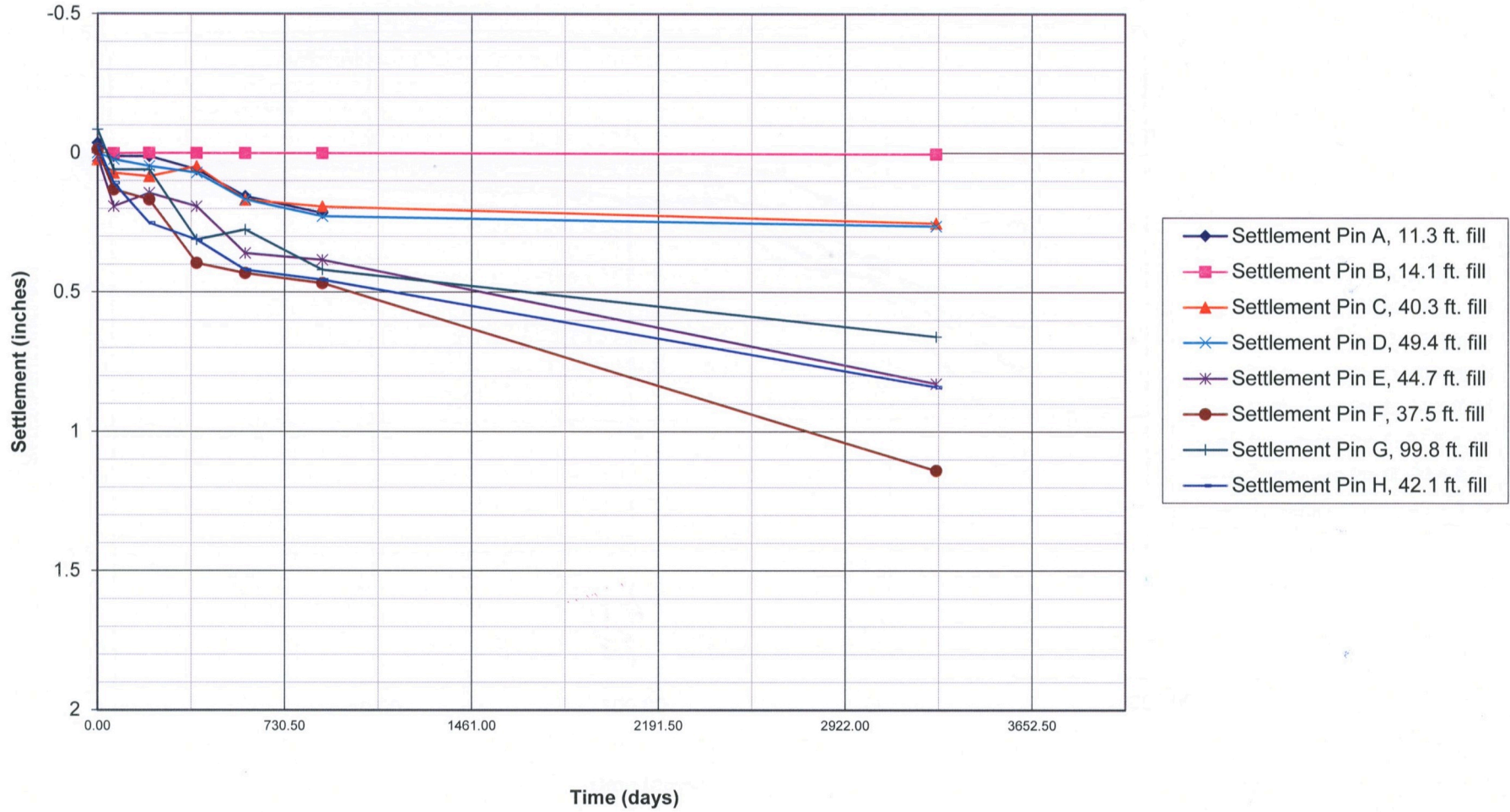
Client: NKU Foundation, Inc.

Project: Consulting Services
NKU Foundation Property

Location: Kenton County, Kentucky

Scale: 1" = 100'±
Date: 3/10/08
Drawing No.: 94821E-1

Settlement Vs. Time



Settlement Vs. Log of Time

