GEOTECHNICAL ENGINEERING REPORT

OLD LONGVIEW LAKE
DAM AND SPILLWAY IMPROVEMENTS
LEE'S SUMMIT, MISSOURI

PREPARED FOR
M-III LONGVIEW, LLC

PREPARED BY
OLSSON ASSOCIATES
OLATHE, KANSAS

AUGUST 13, 2018

OA PROJECT NO. 017-0305

1700 East 123rd Street · Olathe, KS 66061 · (913) 829-0078 · FAX (913) 829-0258

OLSSON ®
ASSOCIATES

August 13, 2018

M-III Longview, LLC
Attn: Corey Walker
4220 Shawnee Mission Parkway, Ste. 200B
Fairway, KS 66205

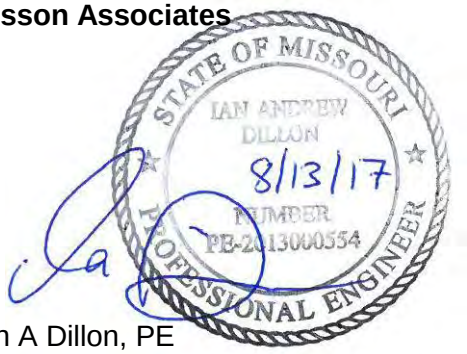
Re: Geotechnical Engineering Report
Old Longview Lake Dam and Spillway Improvements
Lee's Summit, MO
Olsson Project No. 017-0305

Dear Mr. Walker:

Olsson Associates has completed the Geotechnical Engineering Report for the Old Longview Lake Dam and Spillway improvements. This report provides the results of the geotechnical analysis performed on the planned geometry of the earthen dam and provides additional geotechnical engineering recommendations for the design of the dam and spillway improvements.

We appreciate the opportunity to provide our geotechnical engineering services for this project. If you have any questions or need further assistance, please contact us at your convenience.

Respectfully submitted,
Olsson Associates



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A. PROJECT UNDERSTANDING

A.1. GEOTECHNICAL SCOPE

This Geotechnical Engineering Report presents the results of the Geotechnical Engineering Analysis for the proposed improvements to the Old Longview Lake Dam and Spillway in Lee's Summit, Missouri. Four soil borings were drilled across the embankment as part of the report prepared by Kansas City Testing & Engineering. The appended Geotechnical Report provides the soil and bedrock conditions encountered at the boring locations. Our scope included reviewing information from the original Geotechnical Engineering Report and the Geotechnical Third-Party Review Report, visually observing the existing dam and performing a global stability analysis of the final planned dam cross-section. The reports we reviewed are listed below and included in the Appendices of this report.

> "Subsurface Exploration and Geotechnical Engineering Report, Longview Dam – North", prepared by Kansas City Testing & Engineering, LLC, dated February 17, 2017.
>
> "Geotechnical Third Part Review – Old Longview Lake Rehabilitation Project", prepared by Terracon Consultants, Inc., dated March 2, 2018.
>
> "Old Longview Lake – Dam and Spillway Observations and Preliminary Recommendations Letter", prepared by Olsson Associates, dated May 11, 2018.

A.2. PROJECT INFORMATION

As shown in Figure 1, Old Longview Lake is located south of the intersection of SW Mary Street and SW Arena Street in Lee's Summit, Missouri. The dam and spillway are located on the south side of the 18-acre lake.

Figure 1: Site Location

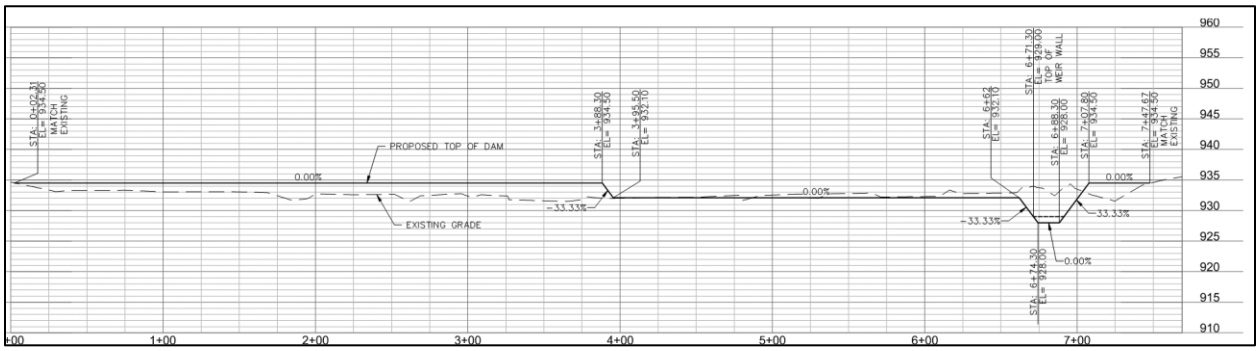
We understand the lake was constructed in 1914 and includes an approximately 20-foot high by 630-foot long earthen dam. A reinforced double box concrete spillway is located on the east side of the dam. The lake survey indicated a maximum water depth of around 9 feet, however several areas are significantly shallower as siltation has occurred across most of the lake. We understand the dam is classified as a "High Hazard Potential" Dam based on information obtained from the Missouri Department of Natural Resources (MDNR) website.

A.3. EXISTING AND PROPOSED DAM CONFIGURATION

The crest of the existing 20-foot tall dam embankment varies from around 6 to 10 feet wide and is at an elevation of approximately 933 feet. The upstream slope of the dam is at approximately 2H:1V with minimal rip-rap cover. The downstream slope of the dam is between 4H:1V and 5H:1V. The west portion of the slope is covered with grass and other shallow rooted vegetation. The east portion is wooded with many 2 to 3-inch diameter trees as well as four large 24 inch+ diameter trees located along the embankment. Near the base of the dam on the west side, we observed water seeping through the embankment.

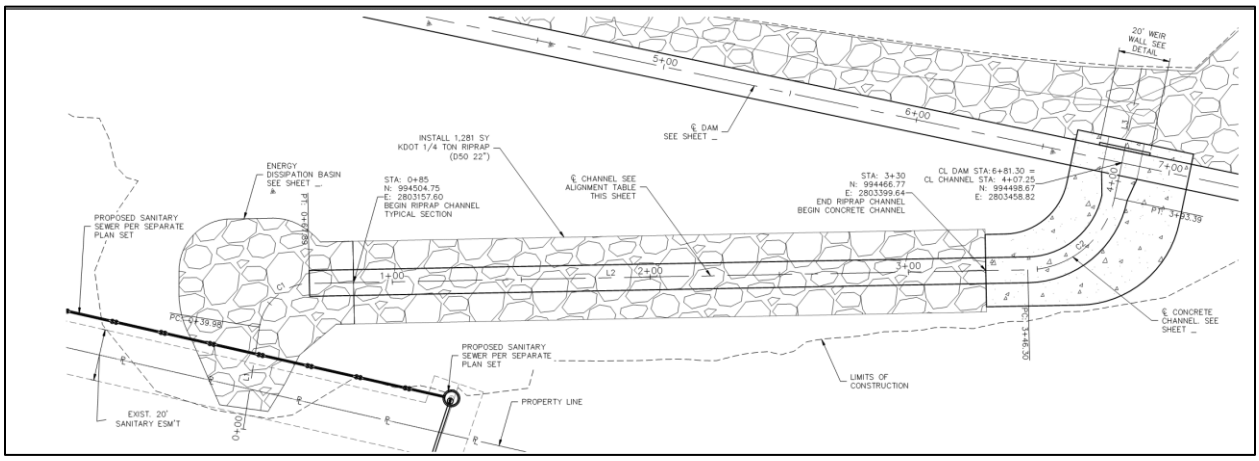
To meet required MDNR freeboard requirements, we understand the dam embankment is planned to be raised to elevation 934.5 feet and widened to a consistent width of 10 feet. In addition, a new primary concrete spillway and secondary earthen spillway are planned. The primary spillway will be located in the same place as the existing spillway and will consist of a trapezoidal concrete weir structure with a flow line elevation is 928 feet (similar flow line elevation as the existing structure). The. The secondary spillway will be 250 feet wide and have an overflow elevation of 923.1 feet. The proposed dam profile is shown in Figure 2.

Figure 2: Proposed Dam Profile



A new concrete channel that transitions to a rip-rap lined channel will be constructed downstream of the new spillway. The rip-rapped lined channel will transition into a settling basin before connecting to the existing stream. The outfall protection is shown in Figure 3.

Figure 3: Outfall Protection



B. SLOPE STABILITY ANALYSIS

We performed slope stability analyses of the planned configuration of the downstream and upstream slopes of the dam at the cross-section shown in the Figure 4. Our analysis was performed in accordance with the *Rules and Regulations of the Missouri Dam and Reservoir Safety Council* develop by MDNR.

We evaluated the cross-sections using Spencer's method. We used the computer program SLOPE/W 2007, developed by GEO-SLOPE International to perform the analyses. The analyses were performed on an idealized two-dimensional cross-section of the embankment as shown in Figure 5.

Figure 4: Slope Stability Cross-Section Location

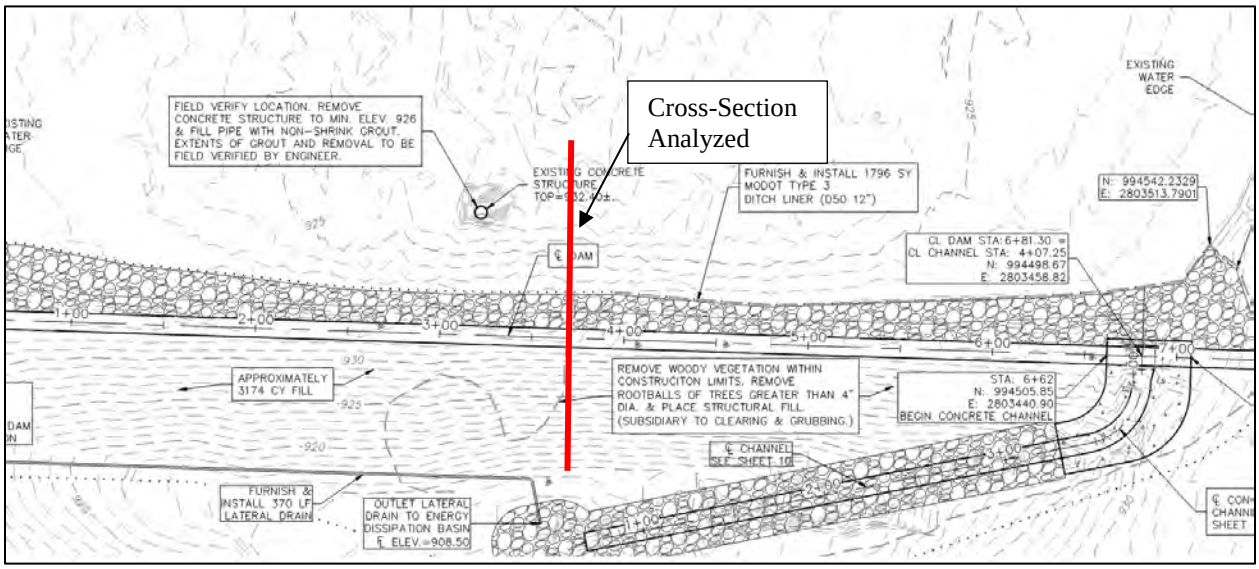
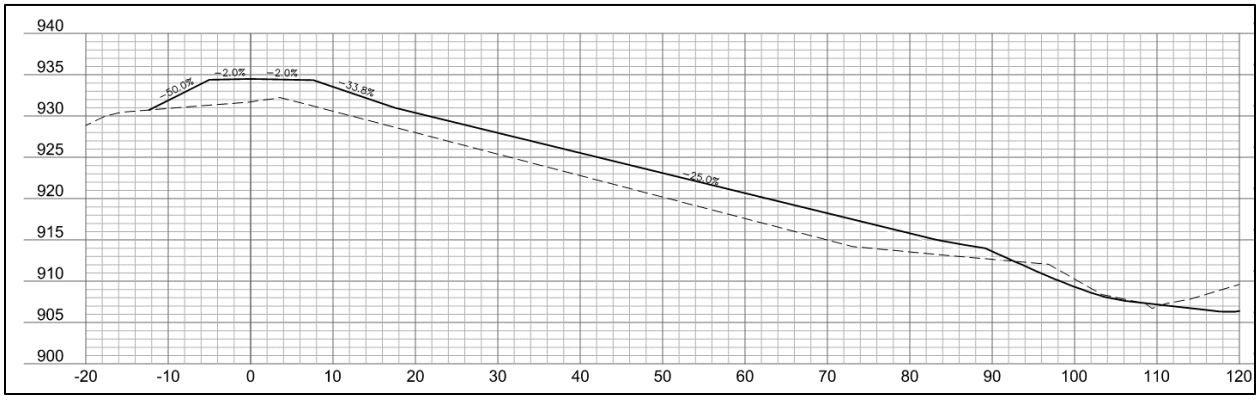


Figure 5: Slope Stability Cross-Section



We used effective stress shear strength parameters in our global stability analysis. These values are based on the borings and lab testing done by Kansas City Testing and Engineering and our experience with similar soils. These values are slightly more conservative than Kansas City Testing and Engineering's values.

Table 1: Effective Stress Shear Strength Parameters

Material	Unit Weight, pcf	Effective Stress Strength Parameters	
		c', psf[1]	ϕ, degrees
Existing Embankment Fill	120	50	24
New Structural Fill (Fat Clay Soils)	120	100	25
Shale Bedrock	125	300	22
Rip-Rap	135	0	40

The results of our analysis are shown in the Table below and attached to this report. Based on our calculated factors of safety, the proposed dam profile with the assumptions listed in this report meet the minimum guidelines proposed by MDNR.

Table 2: Resulting Factors of Safety

Condition Analyzed	Calculated Factor of Safety	MDNR Req. Minimum Factor of Safety
Steady State Seepage (Full Reservoir)	1.9	1.5
Steady State Seepage (Max Reservoir)	1.9	1.3
Rapid Drawdown	1.2	1.2
Earthquake, a = 0.20g	1.0	1.0

C. Dam Construction Considerations

C.1. General Site Preparation

Prior to placing fill on the dam crest and downstream embankment, all vegetation, major root systems, organic soils, and any loose, soft or otherwise unsuitable material should be removed from the proposed dam footprint. We understand the new dam footprint on the downstream side will extend out from the crest downward at a minimum 4H:1V slope. The large, mature trees on the embankment of the dam will need to be removed. The entire root structure of the tree should be removed prior to grading. Following site stripping and tree removal operations, the exposed ground surface should be visually observed by Olsson Associates (***Olsson***). Unstable and unsuitable soils revealed by visual observation, should be removed and replaced with structural fill.

Prior to placement of new fill, the upper 8 inches of exposed subgrade should be scarified, moisture conditioned and compacted to a minimum of 95 percent of the materials standard Proctor maximum dry density (ASTM Specification D-698) at a moisture content between 1 percent below optimum and 3 percent above optimum. Once the subgrade has been compacted, structural fill should be filled in accordance with the recommendations presented in section E.3 of this report.

C.2. Fill Placement and Compaction

All structural fill on the downstream side of the dam should consist of high plasticity, fat clay soils (LL>50), free of organic matter and debris (organic content less than 5 percent). Suitable fill materials should be placed in loose lifts of 8 inches or less. The soil should be compacted using equipment that is the appropriate type and properly sized for the job. Soils used as fill along the dam should be compacted to at least 95 percent of the maximum dry density as determined by the standard Proctor test at a moisture content between -1 and 3 percent above the optimum moisture content.

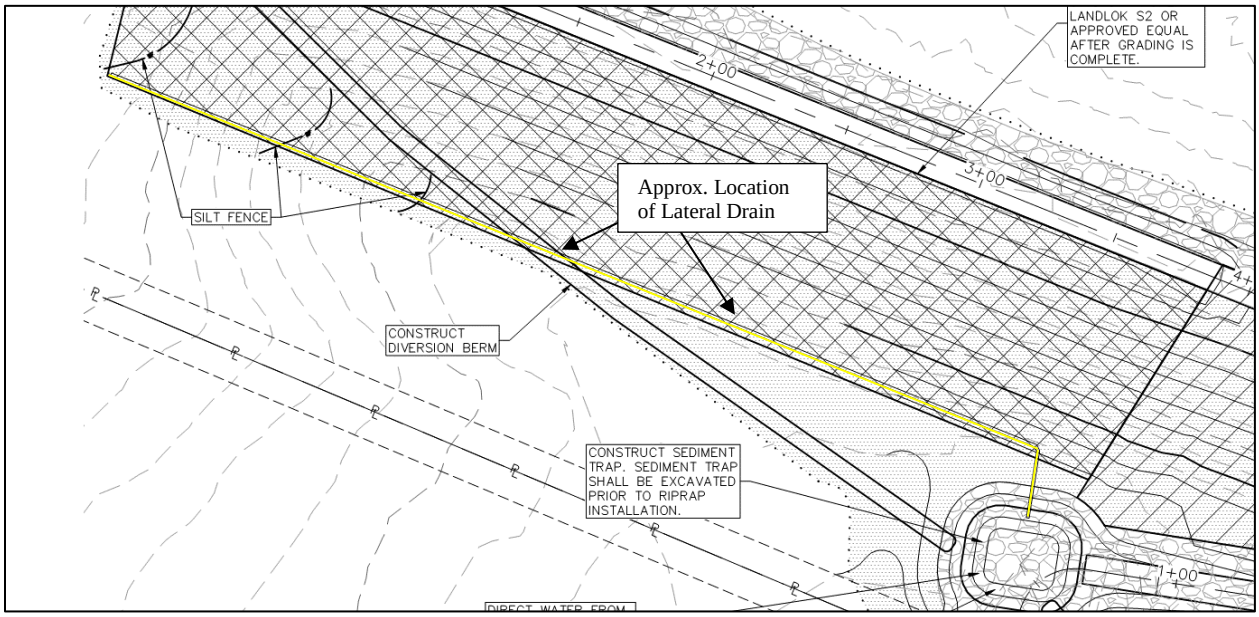
The downstream face of the dam should be flattened to at least 4H to 1V and suitably benched during placement of new fills. To properly bench the soils, cutbacks into the existing slope will be required. The benches should be cut parallel to the existing site contours and have maximum vertical face heights of three feet and minimum vertical faces of one foot.

The upstream side of the dam is currently sloped at approximately 2H:1V. Since only a limited amount of fill will be required on the upstream side, we recommend the fill placed consist of rip-rap stone appropriately sized to protect the dam embankment.

C.3. LATERAL DRAIN

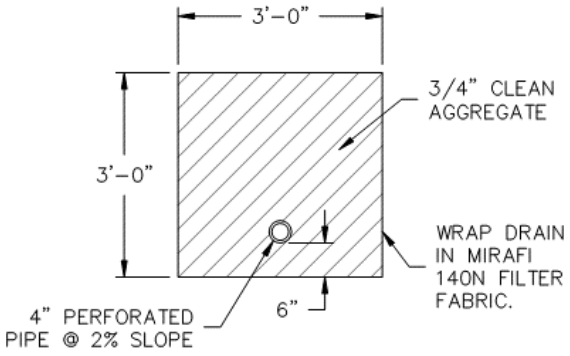
We recommend a lateral trench drain be installed near the toe of the slope on the west side of the embankment. As mentioned previously, water was observed seeping out of the ground in this area. The drain should be a minimum of three feet from the toe with at least 1 foot of clay cover. The location of the drain is shown in Figure 6 below.

Figure 6: Lateral Drain Location



The lateral drain should be three feet deep by three feet wide and consist of ¾ inch clean rock wrapped in Mirafi 140 N filter fabric. A four-inch diameter perforated pipe should be placed near the bottom of the drain and positioned to drain to the settling basin at a minimum slope of 2 percent. A typical detail of the drain is shown below.

Figure 7: Later Drain Cross-Section



C.4. INSTRUMENTATION

As recommended in the original report and third-party review letter, we recommend the earthen dam be instrumented for in order to evaluate the long-term stability of the dam. At a minimum, two inclinometers should be installed along the crest of the dam embankment. The inclinometers should be socketed into the shale and/or limestone bedrock below any fill or clay soils. A long-term monitoring schedule should be established.

In addition, a minimum of two vibrating wire piezometers should also be installed along the crest of the embankment to measure long-term pore water pressures.

C.5. MAINTENANCE

In addition to monitoring the dam for future instabilities, we also recommend the dam be maintained in accordance with MDNR standards. This would require routine inspections of the dam and spillway. MDNR's website provides further guidance on maintaining and inspecting an earthen dam.

D. CONCLUSIONS AND LIMITATIONS

D.1. CONSTRUCTION OBSERVATION AND TESTING

We recommend that all excavations during construction be monitored by a representative of ***Olsson***. The purpose of these services would be to provide ***Olsson*** the opportunity to observe the soil conditions encountered during construction, evaluate the applicability of the recommendations presented in this report to the soil conditions encountered, and recommend appropriate changes in design or construction procedures if conditions differ from those described herein.

D.2. LIMITATIONS

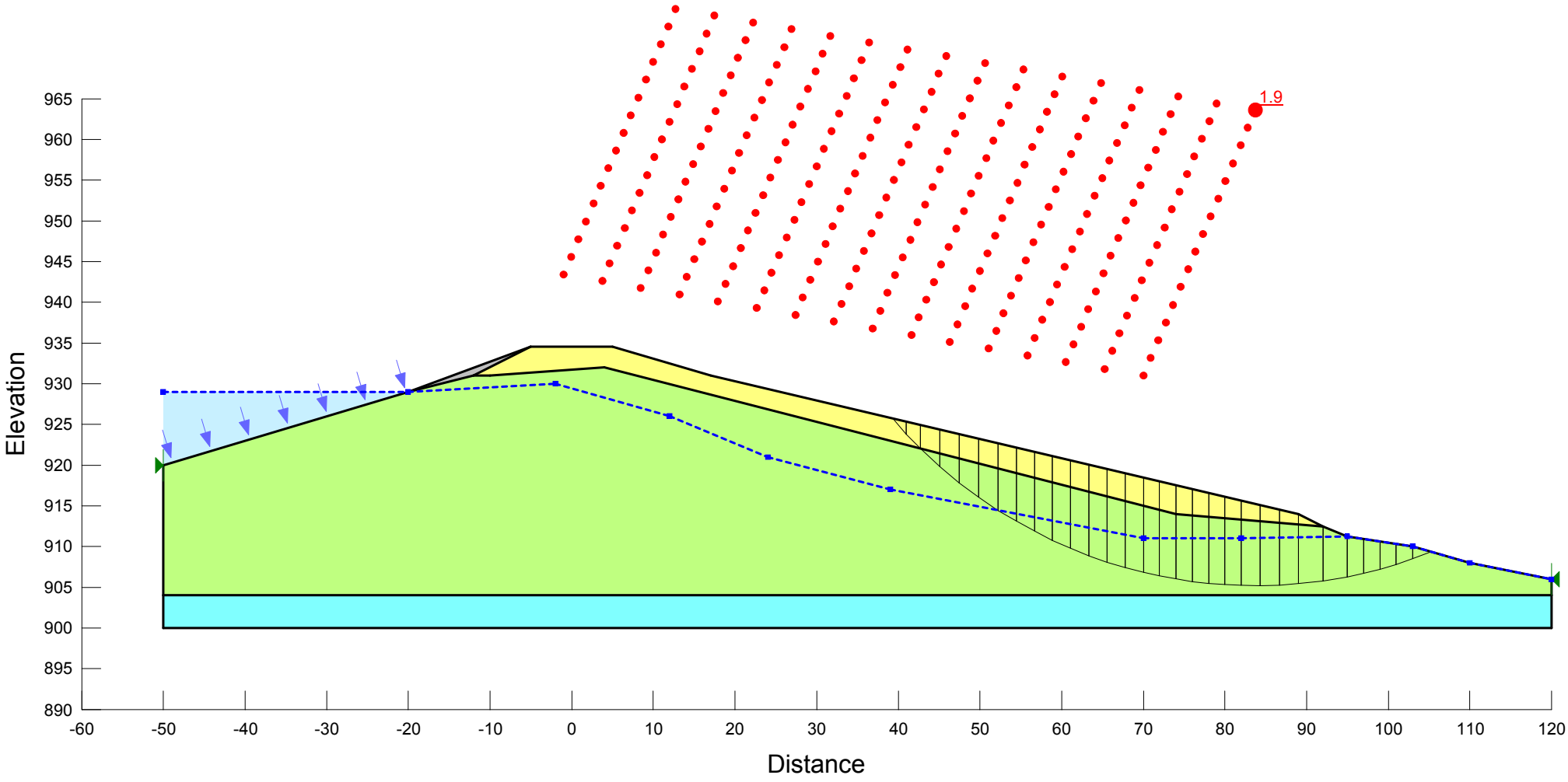
The conclusions and recommendations presented in this report are based on the information available regarding the proposed construction, the report we reviewed and our experience with similar projects. This geotechnical report is based on the site plan and our understanding of the project as noted in this report. Changes in the location or design of new structures could significantly affect the conclusions and recommendations presented in this geotechnical report. ***Olsson*** should be contacted in the event of such changes to determine if the recommendations of this report remain appropriate for the revised site design.

This report was prepared under the direction and supervision of a Professional Engineer registered in the State of Missouri with the firm of **Olsson Associates**. The conclusions and recommendations contained herein are based on generally accepted, professional, geotechnical engineering practices at the time of this report, within this geographic area. No warranty, express or implied, is intended or made. This report has been prepared for the exclusive use of **M-III Longview, LLC** and their authorized representatives for specific application to the proposed project described herein.

APPENDIX A
Global Stability Analysis

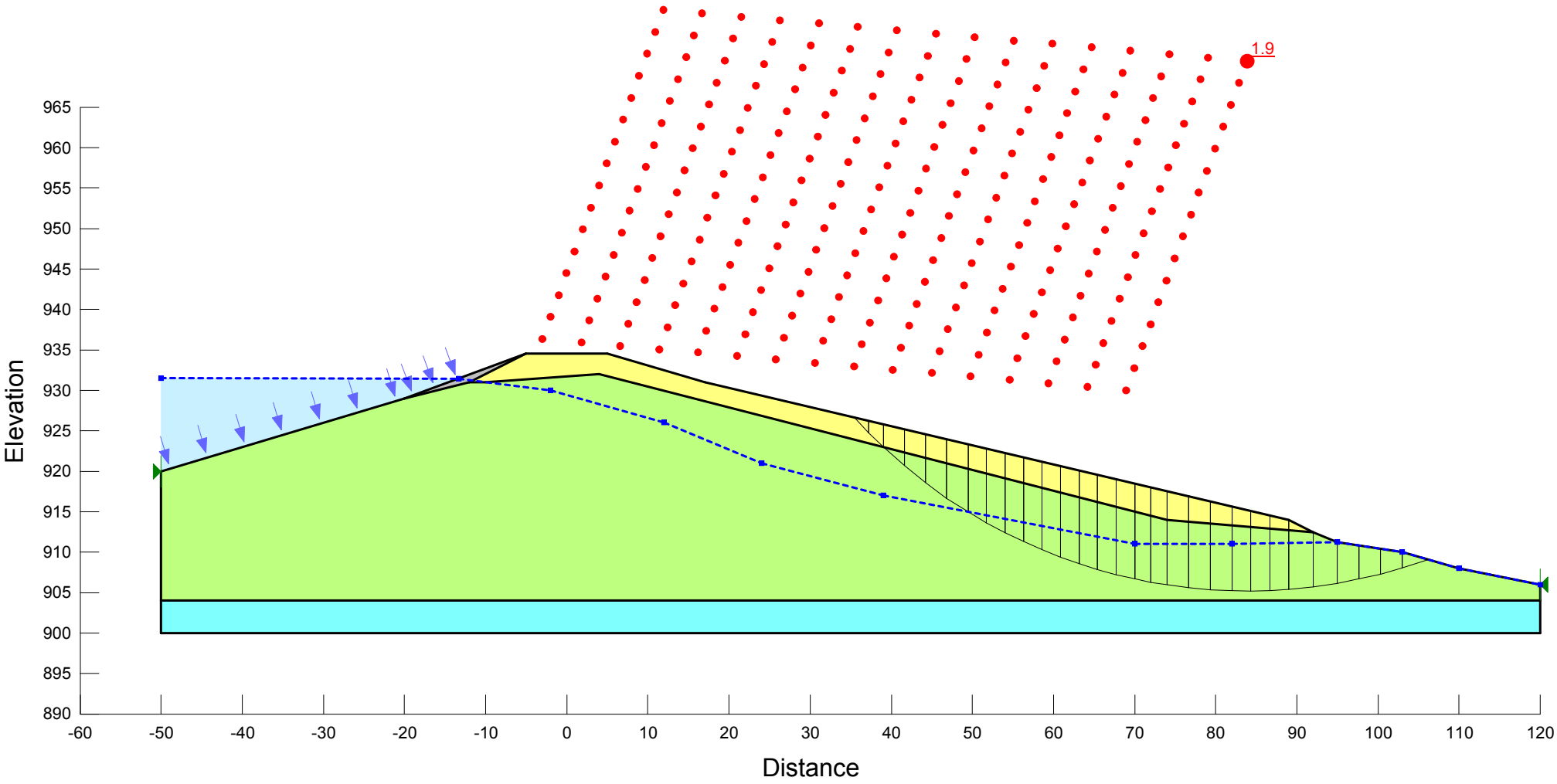
Old Longview Lake
Lee's Summit, MO
OA Project No. 017-0305

Steady State Seepage
Full Reservoir
Effective Stress Analysis



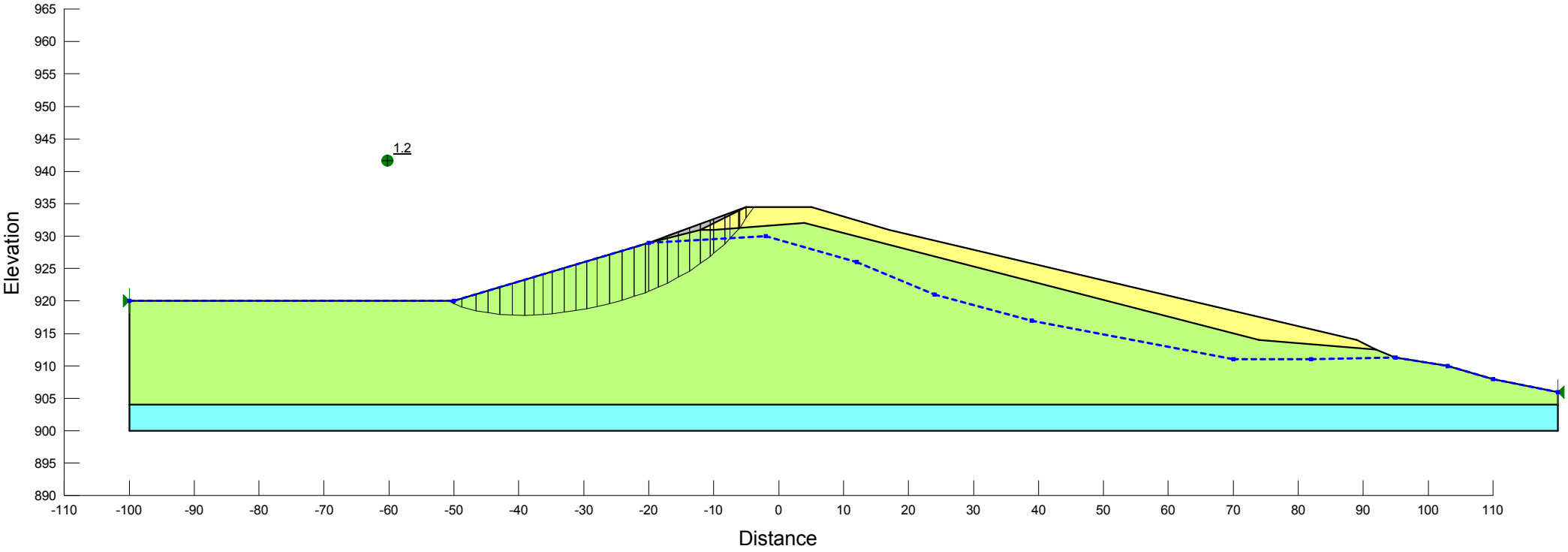
Old Longview Lake
Lee's Summit, MO
OA Project No. 017-0305

Steady State Seepage
Max Reservoir
Effective Stress Analysis



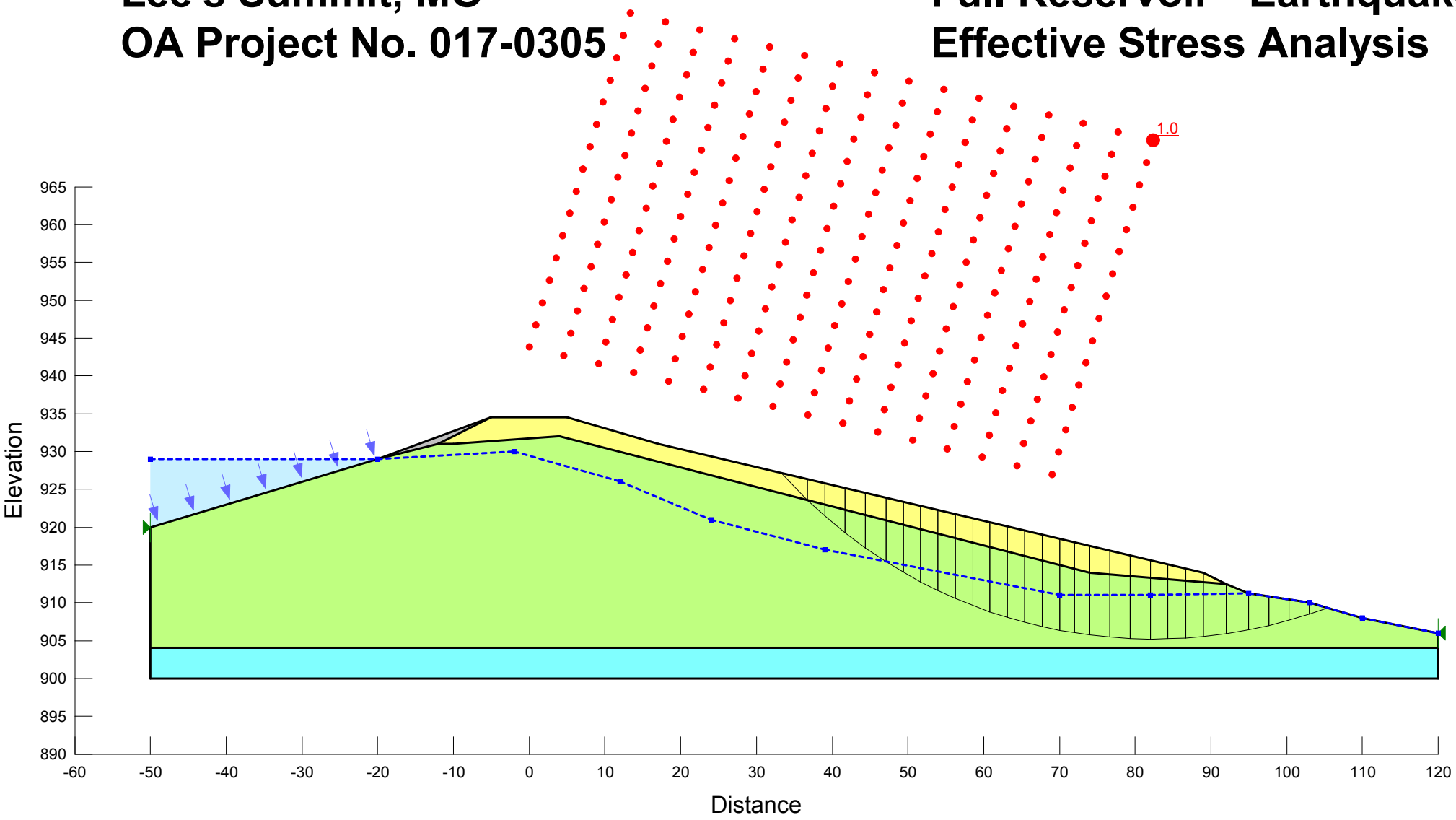
Old Longview Lake
Lee's Summit, MO
OA Project No. 017-0305

Rapid Drawdown
Effective Stress Analysis



Old Longview Lake
Lee's Summit, MO
OA Project No. 017-0305

Steady State Seepage
Full Reservoir - Earthquake
Effective Stress Analysis



APPENDIX B
Old Longview Lake Observation

May 11, 2018

Corey Walker
Platform Ventures
4220 Shawnee Mission Pkwy, Suite 200B
Fairway, KS 66205

Re: Old Longview Lake - Dam and Spillway Observations and Preliminary Recommendations Letter
Lee's Summit, MO
Olsson Project No. 017-0305

Dear Mr. Walker,

An Olsson Associates ***(Olsson)*** Geotechnical Engineer visited the site on April 30th, 2018 to observe the existing dam and spillway. This letter discusses our observations and includes recommendations for temporary remediation to the dam and spillway. This letter does not address the future design or construction plans for the lake. Recommendations and opinions on future design and construction plans will be presented under a separate cover.

Site Description

The existing 18-acre private lake with earthen dam and concrete spillway is located on the old Longview Estate, just south of the existing Longview Community College. The site location is shown in Figure 1.

Figure 1: Site Location

We understand the lake was constructed in 1914 and includes an approximately 20 feet high by 630 feet long earthen dam that has a downstream slope between 3H:1V to 5H:1V. Currently, a reinforced double box concrete spillway is located on the east side of the dam. The lake survey indicates a maximum water depth of around 9 feet, however several areas are significantly shallower as siltation has occurred across the majority of the lake. The survey depicting the dam, spillway and southern portion of the lake is shown in Figure 2.

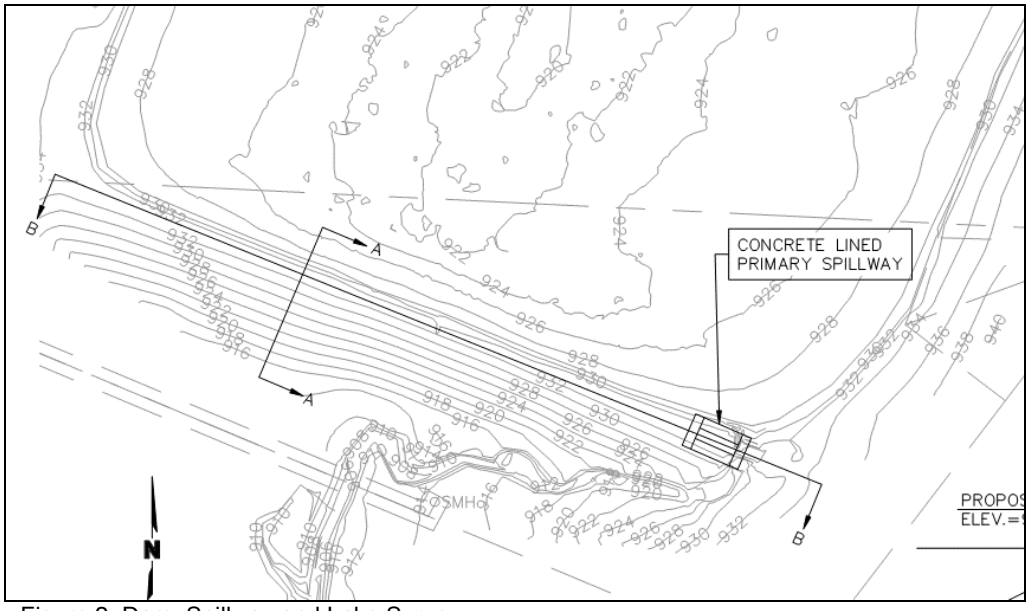


Figure 2: Dam, Spillway and Lake Survey

Several residential homes with maintained yards are located on the east side of the lake. The homes are bounded by the lake and the adjacent properties. On the west side of the lake, clearing has begun for a new development. A wood chip berm, from removal of the nearby vegetation, ran along the west bank of the lake. The berm is around 10 feet wide and 5 feet high. A historic pergola structure is located on the north bank of the lake. Several areas of the pergola have been undermined by the lake. An existing wetland is located to the north of the pergola.

Earthen Dam Observations

Portions of the upstream face of the dam are lightly armored with 4 to 8-inch diameter rip-rap. The rip-rap extends about 2 to 3 feet below the crest of the dam. Above the rip-rap, some minor erosion of the dam crest was observed, although it was difficult to see this area due to the vegetation that had recently established.

The west half of the downstream face of the dam slopes at an estimated 5H:1V and contains shallow rooted shrubs on the crest of the dam and shallow rooted grasses on the face of the slope. A photograph of the west portion of the dam is shown in Figure 3.

Figure 3: Photograph of West Portion of the Downstream Face of Dam

The center of the downstream face of the dam contains shallow rooted vegetation and two large mature trees on the crest of the dam (Figure 4). Smaller, less mature trees cover the remainder of the slope (Figure 5). The large trees appear to be around 24 inches in diameter and have canopies around 50 feet in diameter. The smaller trees are generally 6 inches in diameter or less. Additional vegetation, including shrubs and grasses, were observed in this area.

Figure 4: Photograph of Large Mature Tree on Crest of Dam

Figure 5: Smaller Trees on Slope of Downstream Side of Dam

Seepage was observed at the toe of the slope in the central portion of the dam. In our opinion, the amount of seepage observed was relatively minor as erosion from the seepage or flowing water out of the toe was not observed. In addition, seepage was only encountered at the toe and not found along the slope. The pooling of seepage water at the toe of the slope is shown in Figure 6.

Figure 6: Photograph of Seepage at Toe of Dam

The east portion of the dam contains two large trees near the crest of the dam, similar to the center of the dam. The vegetation downslope is slightly more mature and larger in diameter than the center portion.

Drawdown Structure Observations

What appears to be a drawdown structure with a set of valves is located within the lake approximately 50 feet north of the dam. We did not investigate the structure as access to the structure is only available by boat. However, it appears that this structure is no longer serviceable as we could not locate an outlet pipe downstream and the valves did not appear operable from our vantage point. In addition, the concrete foundation for the valve structure is in very poor condition. The structure is shown in Figure 7. We do not anticipate this structure will be reused.

Figure 7: Drawdown Structure

Concrete Spillway Observations

The primary spillway for the lake is located on the far east side of the dam. The spillway consists of a reinforced concrete double box with wingwalls downstream. The concrete is in very poor condition. Weathering has resulted in the exposure of the reinforcing elements. At the time of our site visit, the top portion of the box had punctured the concrete apron below (Figure 8).

Figure 8: Photograph of Spillway Puncture

The puncture appears to be due to loss of support from erosion below the bottom of the apron (Figure 9). In addition, the wingwalls appear to have been pushed into the channel from the growth of large vegetation (Figure 10).

Figure 9: Photograph of Erosion Below Concrete Apron

Figure 10: Photograph of Failed Concrete Wingwalls

In addition to erosion below the spillway, we also observed erosion around the west side of the spillway (Figure 11). Erosion around the west side was around 3 to 4 feet deep and around 3 feet wide. At the time of our observations, the majority of water loss from the lake is directed through this area of erosion, however, the water level of the lake during our site visit did not reach the height of the spillway apron. It appears that during high water events, water would be directed over the spillway as normal. The areas downstream of the spillway appear consistent with most streams in the area. Some erosion is present, but erosion is limited by the thick vegetation and shallow rock elevation.

Figure 11: Photograph of Erosion Around West Side of Spillway

Opinions and Recommendations

We have provided the following opinions and recommendations for the dam and spillway. All opinions and recommendations provided herein are for temporary protection of the dam and spillway and should be implemented within 30 days. These opinions and recommendations are not intended for future site improvements. Final recommendations can be provided once future construction plans are known.

- *Principal Recommendation*

In our opinion, despite the seepage observed, the earthen dam is in relatively good condition. This is likely because the slopes of the dam are flatter than what new construction usually dictates. As such, remediation should begin with the construction of a pathway to the spillway. This will include removal of small vegetation 6 inches in diameter or less and any brush or weeds in the pathway. For trees greater than 6 inches in diameter, the path should be rerouted around the larger trees as the excavation to remove the entire root ball could be large and leaving the root ball in place could result in additional seepage paths developing in the dam.

Removal of the large trees should be delayed until final construction plans are developed and the lake can be drawn down to a level that does not destabilize the dam during excavations. Repair of the toe seepage can also be delayed until final construction.

We recommend the top portion of the double box spillway that has punctured the apron be removed to provide improved drainage along the spillway. From our observations, this portion of the spillway appears to only have been constructed to level the dam crest. Once the upper portion is removed, we recommend the holes in the concrete apron of the spillway be filled with non-shrink cement grout, flowable fill or Portland cement concrete. Any other noticeable seepage paths should also be grouted, including the erosion around the west side of the spillway. Once all the seepage paths are grouted, a minimum of 3 feet of rip-rap should be placed in front of the spillway extending 10 feet to either side of the spillway to help protect the spillway from additional erosion. The rip-rap should appropriately sized. Rip-rap should also be placed on the downstream side of the spillway to prevent any movement that could occur during high water events.

- *Construction Observation for Principal Recommendations*

We recommend that all temporary remediation construction be monitored by a representative of ***Olsson***, including site clearing, placement of all grout or concrete and rip-rap. The purpose of these services would be to provide ***Olsson*** the opportunity to observe the conditions encountered after the removal of vegetation and the spillway after the top portion is removed, evaluate the applicability of the recommendations presented in this report to the conditions encountered, and recommend appropriate changes in construction procedures if conditions differ from those described herein.

- *Visual Inspections for Principal Recommendations*

We recommend the dam and spillway be monitored by an Olsson engineer on a weekly basis until the temporary recommendations presented in this report are accomplished. After the temporary recommendations have been completed, monitoring can be prolonged to once a month and after a 2-inch or greater rain event. Monthly monitoring should continue until final construction or rehabilitation of the dam is complete.

- *Secondary Recommendation*

We understand there may some delay in accessing the spillway due to environmental concerns and not being able to remove trees in the area. If tree removal cannot be completed at this time and access to the spillway is limited to individuals only, we recommend, at a very minimum, that the dam and spillway be monitored for movement, seepage and continued erosion on a weekly basis until the primary recommendation above can be implemented or final construction for the dam and spillway begin. The owner should be aware that if movement or excessive erosion is observed by ***Olsson*** personnel, emergency action will need to be taken. An Emergency Action Plan has been developed by ***Olsson*** and has been submitted to the city and developer.

Closing

We appreciate the opportunity to be of service to you on this project. This letter has been prepared for the exclusive use of Platform Ventures for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express or implied, are intended or made. If you have any questions regarding this letter, please contact us.

Sincerely,
Olsson Associates

Ian Dillon, PE
Geotechnical Engineer

James Landrum, PE
Senior Engineer

APPENDIX C
Old Longview Dam Review
Terracon

March 2, 2018

City of Lee's Summit
220 Southeast Green Street
Lee's Summit, Missouri 64063

Attn: Mr. Ryan Elam, PE
Development Services Director

RE: Geotechnical Third Party Review
Old Longview Dam Rehabilitation Project
Old Longview Dam
Lee's Summit, Missouri
Terracon Project No. 02185014

Dear Mr. Elam:

Terracon Consultants, Inc. (Terracon) has completed or review of the provided documents, referenced below, for the proposed rehabilitation of the Old Longview Dam in Lee's Summit, Missouri. This review was performed in general accordance with our Task Order dated January 25, 2018. This letter presents the findings of this review, and our recommendations for additional work and priorities on rehabilitating the dam.

PROJECT INFORMATION

The subject dam was a part of the historic Longview Estate Ranch, and was reportedly constructed circa 1914. It is a private earthen dam, with Missouri Department of Dam and Reservoir Safety ID# MO20012. It has an approximate surface area of 18 acres, and is approximately 20 feet high and approximately 630 feet long with a water surface elevation of approximately 929 feet above mean sea level (AMSL). It has been reported to have experienced significant siltation, and the approximate maximum depth is 9 feet. It appears that minimal maintenance of the dam and associated structures has occurred since its original construction.

Terracon was provided with a report prepared by Terra Technologies (Terra) entitled "Old Longview Lake Rehabilitation/Restoration Study, Lee's Summit," dated August 2017 (Reference 1 refers to the body of this report). Our scope of services was to provide a peer review of this report, with special attention to the geotechnical findings and recommendations in Appendix B. This appendix is the geotechnical report prepared by Kansas City Testing & Engineering, LLC (KCTE) entitled "Subsurface Exploration and Geotechnical Engineering Report, Longview Dam-North, Lee's Summit, Missouri," KCTE No. G20-16-310, dated February 17, 2017 (Reference 2 refers to this report).

SITE LOCATION

Item	Description
Location	South of intersection of Latitude: 38.899844° Longitude: - 94.448636°

SITE RECONNISANCE

Terracon visited the site twice, on February 9 and February 19, 2018 to observe the current condition of the dam, lake and the shorelines. The first trip was when the lake was frozen, and the second was following several days of warmer weather.

Existing improvements observed included a historic pergola structure location on the north shore of the lake. There are residential neighborhoods along the eastern and northern shores. We also observed an outlet works/spillway structure in the lake upstream from the dam and an emergency concrete spillway at the eastern abutment of the dam.

The dam is covered with grass along the downstream face, with heavy brush along the crest, and heavy brush and trees growing on the crest and downstream face of the eastern half of the dam. We did not observe any signs of seepage at the toe of the dam, which may be due to the ground still being frozen.

Photo 1- Looking at dam from western shore to the southeast

The upstream face appears to have rock fragments placed on it to control erosion (Photo 2). The freeboard area over the water surface does not appear to have any rock on its face and has experienced significant erosion (Photo 3).

Photo 2- Upstream face rock "erosion control"

Photo 3- Looking west at freeboard erosion of embankment

The primary spillway and outlets works appear to be in very poor condition, and is only accessible by boat, as there is no access walkway from the crest (Photo 4). The Terra Technologies report states that the outlet works valves and the spillway are inoperable. They could not find the outlet for this system, and Terracon could not locate the outlet during our site visits.

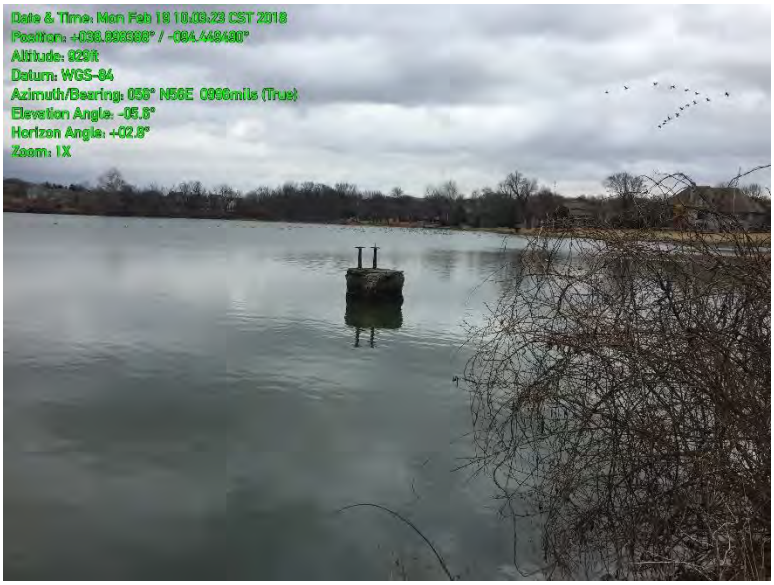


Photo 4- Primary spillway and outlet works

The emergency spillway was intact, but experiencing erosion that was undermining it when it was observed by KCTE (Photo 5). It has since collapsed (Photo 6) and we observed a steady flow of water (Photo 7) in the erosion channel coming from the lake.

Photo 5- Emergency spillway in late 2016/early 2017 (from Reference 2, Photo 5)

Photo 6- Emergency spillway February 19, 2018)

Photo 7- Seepage under emergency spillway

Downstream of the emergency spillway, significant erosion of the stream banks was observed during our visit (Photos 8 and 9).

Photo 8- Looking southwest from downstream side of emergency spillway

Photo 9- Looking south approximately 100 feet downstream from emergency spillway

REVIEW FINDINGS

Overall the reports (References 1 and 2) were complete and performed to the standard of practice for the Kansas City Metropolitan area for similar evaluations. The geotechnical report (Reference 2) should be considered as a preliminary report; a design level geotechnical study will need to be completed to provide design and construction related recommendations for the actual design of the dam rehabilitation concepts being considered. We will be discussing some alternate ideas to be considered for instrumenting and evaluating the dam itself in addition to

those discussed in the KCTE report (which discussed installation of inclinometers and piezometers).

Our comments on the Terra report (Reference 1) are as follows:

1. The stabilization berm costs analysis (Section 6(a)iii) and raising the dam elevation 1.2 feet (Section 6(c)i) did not consider the need for benching, keying and installation of a toe drain for the different buttress concepts. These grading methods should be considered in the final design if this concept is to be explored further.
2. In Section 7 on Page 14, there is a discussion on using a pump system to drain the lake if it is determined not to rehabilitate the existing outlet works. If the existing outlet works/primary spillway is not to be replaced, we strongly recommend that a pump system be stored onsite, and that city personnel are adequately trained to use and maintain this equipment in the event that the lake needs to be drained quickly.

RECOMMENDATIONS

Required Improvements

Based on conditions encountered during out site visits and our review of the subjects reports we have the following recommendations:

Vegetation on the dam crest and face- Clearing these trees and brush should be accomplished as soon as possible. It is important to have the geotechnical engineer provide recommendations for removal of root balls and replacement of the resulting excavations with proper engineered fill material.

Spillways- In Photos 6 through 9 the current condition of the emergency spillway structure (which has collapsed) and the downstream drainage course can be seen. Compare this to the Photo #5 (from Reference 2), when the structure was still intact (though heavy eroded adjacent and below it).

Note Photo 7 the seepage under the old emergency spillway and related/continuing erosion occurring at this location.

The condition of the emergency spillway is an immediate problem that should be addressed as soon as practical. We recommend that a civil engineer evaluate the spillway and provide recommendations for a temporary and/or permanent fix.

Riprap- Photos 2 and 3 indicate the that upstream crest of the dam is eroding. Also, the rock fragments that were used for erosion control on the upstream side of the dam, do not have the size or durability to be used as Rip Rap per current Standard of Practice. This rock lacks the durability and size to provide adequate protection against wave action of the water.

The final restoration design should include adequate rip rap erosion protection along the upstream dam face. The final geotechnical design for any buttress fill or raising the crest of the dam should include toe keys/drainage and benching recommendations/details.

Long-term Monitoring

KCTE recommended that inclinometers and vibrating wire piezometers be installed to monitor deformation and seepage through the dam long-term. Though these are suitable technologies for this purpose, they can be expensive. The following alternatives could be considered:

Embankment deformation- An alternative to inclinometers is the installation of Time Domain Reflectometry (TDR) inclinometers. This technology utilizes coaxial cable that is grouted into boreholes and can measure movements in the cable (between the center wire and the external shielding) as movement crimps the wire. This system is less expensive than traditional inclinometers, and can be automated to record and transmit readings. There has also been research showing that TDR can help identify areas of seepage. We can provide additional information if requested.

Seepage- We recommend that an Electrical Resistivity survey and/or Ground Penetrating Radar survey be performed along the crest to help identify areas of potential seepage within the dam embankment both as part of the design level geotechnical report. This testing should also be performed after rehabilitation of the dam has been completed. This type of testing can be done periodically (every couple of years) to monitor the seepage conditions. Piezometers can be expensive to install and maintain over a long period of time. Though an advantage of piezometers is that they can also be automated for data collection just like the TDR.

GENERAL COMMENTS

Our services and any correspondence are intended for the exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made.

CLOSURE

We appreciate the opportunity to be of service to you on this project. If you have any questions regarding this report, or if we may be of further assistance to you, please contact us.

Sincerely,
Terracon Consultants, Inc.

Michael W. Laney, P.E.
Senior Engineer/Senior Associate
Missouri: PE-2014011241

Kole C. Berg, P.E.
Senior Engineer/Senior Associate
Missouri: PE-2002016417

APPENDIX D
KCTE Geotechnical Report

KANSAS CITY
TESTING & ENGINEERING, LLC
1308 Adams I Kansas City, Kansas 66103
913.321.8100 I kctesting.com

SUBSURFACE EXPLORATION
AND
GEOTECHNICAL ENGINEERING REPORT

LONGVIEW DAM - NORTH
LEE'S SUMMIT, MISSOURI

PREPARED FOR

Mr. Corey Walker
M-III Longview, LLC
4220 Shawnee Mission Parkway, #200B
Fairway, Kansas 66205

KCTE Project No. G20-16-310

February 17, 2017

SUBSURFACE EXPLORATION
AND
GEOTECHNICAL ENGINEERING REPORT

LONGVIEW DAM - NORTH
LEE'S SUMMIT, MISSOURI

KCTE No. G20-16-310

February 17, 2017

Submitted to:

Mr. Corey Walker
M-III Longview, LLC
4220 Shawnee Mission Parkway, #200B
Fairway, Kansas 66205

Submitted by:

Kansas City Testing & Engineering, LLC
1308 Adams Street
Kansas City, Kansas 66103

Benjamin Wilmes, E.I.
Staff Engineer

Steven M. Bruer, P.E.
Senior Geotechnical Engineer
Geotechnical Services Manager
Missouri P.E. Registration No. E-29050

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FIGURES (attached)

APPENDIXES

1.0 INTRODUCTION

Kansas City Testing & Engineering, LLC (KCTE) has completed the authorized subsurface exploration and slope stability analysis for the existing earthen embankment dam in Lee's Summit, Missouri. The location of the dam is shown on the attached *Figure 1 – Site Location Plan*.

The purpose of this geotechnical exploration was to evaluate the subsurface conditions and physical properties of the soils comprising and underlying the existing dam, and based on that information, perform slope stability analysis on the existing dam.

The following information on the dam was obtained from Missouri Department of Natural Resources' (MDNR) *GeoSTRAT* website:

Dam Name:	Longview Dam – North
ID #:	MO20012
Ownership:	Private
Year Completed:	1914
State Regulated:	No (Agricultural Exemption)
Hazard Potential:	High
Hazard Class:	2
Dam Height:	20 feet
Length:	not known
Maximum Storage:	193 acre-feet
Surface Area:	18 acres (reservoir)
Drainage Area:	200 acres

No other information on the dam was available at the time of this report.

2.0 FIELD MEASUREMENT AND SUBSURFACE EXPLORATION

A two-person field crew from KCTE obtained measurements of the dam from the crest to the down-stream toe at _ locations in order to develop a typical cross section of the dam for stability analyses. Based on these field measurements, the downstream face of the dam has a slope of approximately 3 horizontal to 1 vertical (3H;1V). The measurements were not obtained by a professional survey, but are considered to be acceptable for the embankment stability analyses.

The site subsurface conditions were explored with four (4) borings at the approximate locations shown on the attached *Figure 2 – Boring Location Plan*. The boring locations were established in the field by a representative of KCTE based on existing site features. Elevations at the boring locations, shown on the boring logs, were estimated from Google Earth© and, therefore, should be considered as approximate. If more precise boring locations and elevations are desired, we recommend that the project surveyor locate the as-drilled locations of the borings.

The borings were drilled on December 22 and 27, 2016 and January 9, 2017 using a CME 55 truck-mounted drill rig and an ATV-mounted drill rig, both equipped with continuous flight augers. Soil samples were obtained during drilling using thin tube sampling techniques (ASTM D 1587) and standard penetration sampling (ASTM D 1586). Samples were generally obtained at 2-foot intervals until bedrock was encountered. A bulk sample of the auger cuttings was obtained from Boring B-2. The borings were backfilled with bentonite upon completion.

A field log was prepared for each boring. These logs contain visual classifications of the materials encountered during drilling as well as an interpolation of the subsurface conditions between samples. Final boring logs included in Appendix A represent our interpretation of the field logs and may include modifications based on laboratory observations and tests of the field samples. The final logs describe the materials encountered, their approximate thickness, and the depths at which the samples were obtained. This information includes soil descriptions, stratifications, penetration resistances, locations of the samples, and laboratory test data. The stratifications shown on the boring logs represent the conditions only at the actual boring locations. Variations may occur and should be expected between boring locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual.

Field samples obtained from the borings were returned to our laboratory where they were visually classified and logged. Laboratory tests were performed in general accordance with ASTM procedures. The results of these tests are presented on the boring logs in Appendix A and in Appendix B of this report. The field and laboratory test results were utilized in the development of the geotechnical parameters used in this evaluation.

3.0 LABORATORY TESTING PROGRAM

Laboratory testing was performed on the soil and bedrock samples to estimate pertinent engineering and index properties of the materials. Results of the laboratory tests are presented on the boring logs in Appendix C. The laboratory testing program consisted of the following:

- Visual classification (ASTM D 2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*)
- Moisture content tests (ASTM D 2216, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*)
- Atterberg limits tests (ASTM D 4318, *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*)
- Standard Proctor test (ASTM D 698, *Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort*)
- Unconfined compression tests on soils (ASTM D 2166, *Standard Test Method for Unconfined Compressive Strength of Cohesive Soil*)
- Triaxial Testing (ASTM D 4767, *Consolidated-Undrained Triaxial Compression Test on Cohesive Soil*)

4.0 SUBSURFACE CONDITIONS

In general, approximately 1 to 2 feet of topsoil material was encountered at the boring locations. In Borings B-1 and B-2, the topsoil material was underlain by clay embankment fill. In Borings B-3 and B-4, the topsoil material was underlain by approximately 1 foot to 1.5 feet crushed stone. The crushed stone was underlain by clay embankment fill.

The clay embankment fill encountered in the borings generally consisted of lean or fat clay. The clay was medium stiff to very stiff and moist to wet. The embankment fill continued to

depths of approximately 13 to 18 feet below existing grades. The embankment fill was underlain by native clay. The native clay was generally stiff to very stiff and continued to depths of approximately 18 feet to 27.7 feet. The native clay was underlain by shale or limestone bedrock.

Groundwater was observed in the borings during and upon completion of the borings. Groundwater levels were also obtained a minimum of 24 hours after completion of drilling. Water levels were not measured in Boring B-1. In Borings B-2 through B-4, measurements made after drilling indicated water levels at approximately 6.5 feet to 10.3 below existing grades. The observed water levels are included on the boring logs.

Groundwater levels may not have stabilized prior to backfilling the borings. Consequently, the indicated groundwater levels, or lack thereof, may not represent present or future levels. Groundwater levels generally vary significantly over time due to seasonal variation in precipitation, recharge or other factors not evident at the time of exploration.

5.0 DAM EMBANKMENT STABILITY ANALYSES

Engineering analyses were performed to evaluate the structural stability of the Longview Dam - North embankments. The analyses were performed in accordance with the Missouri Department of Natural Resources (MDNR) Division of Geology and Land Survey's Dam and Reservoir Safety Program document titled *Rule and Regulations of the Missouri Dam and Reservoir Safety Council, revised 1994.*

The cross-section through the dam used in our stability analyses is based on our field measurements, not a survey completed by a professional surveyor.

The engineering analyses for the embankment stability were performed using the Spencer Method in the *SLIDE 6.0* software developed by Rocscience. The embankment was analyzed for the following loading conditions:

- Steady seepage – full reservoir
- Steady seepage – maximum reservoir
- Sudden drawdown
- Earthquake

Fully softened shear strength parameters were used for the embankment fill. The fully softened shear strength was evaluated from equations developed by Stark and Hussain (2013) and Gamez and Stark (2014) and the results of the triaxial compression shear strength test. A liquid limit of 55% and clay-size fraction of 95% were used as input parameters in evaluating the fully softened shear strength. A summary of the soil and bedrock parameters used for the embankment stability analyses is presented in Table 1. A summary of the results is presented in Table 2. Copies of the embankment stability analyses are presented in Appendix C.

The results of the embankment stability analyses indicate that the required MDNR minimum Factor of Safeties (FSs) are satisfied for all conditions analyzed.

Table 1
Summary of Parameters for Embankment Stability Analyses

Material	Unit Weight (pcf)	Cohesion (psf)	Φ (degrees)
Embankment Fill	121	50	27*
Native Clay Soil	123	50	26
Shale Bedrock	125	200	24

*Fully softened friction angle

Table 2
Summary of Embankment Stability Analyses

Condition	Calculated Minimum Factor of Safety	MDNR Required Minimum Factor of Safety
Steady Seepage – Full reservoir	1.6	1.5
Steady Seepage – Max reservoir	1.4	1.3
Sudden Drawdown	1.2	1.2
Earthquake, a = 0.20g	1.1	1.0

6.0 LIMITED OBSERVATIONS OF EXISTING CONDITIONS

Limited observations of the existing conditions were made of the dam during the subsurface exploration by a professional engineer from KCTE. Not all appurtenances were accessible at the time of our observations. It appears that routine maintenance for the dam has not been performed for several years. Photographs of our observations are included in Appendix C. The following observations were noted:

1) Three (3) relatively large diameter trees were observed growing on the down-stream face of the dam near the crest.
2) The approximately eastern half of the down-stream face of the dam is covered with small diameter trees and other vegetation.
3) Trees of various diameters were also observed on the upstream face of the dam.
4) Some locations of the upstream face near the crest of the dam show indications of severe erosion.
5) The concrete overflow/spillway structure near the east abutment has severely deteriorated. The concrete, although generally intact, has degraded on the edges of the structure exposing the steel reinforcement (rebar). Observations of the exposed steel reinforcement indicate the rebar has a square cross section, suggesting that the structure may be a part of the original construction.

6) A relatively deeply incised erosion channel has formed on the west side of the overflow/spillway structure.

7) Thick vegetation and miscellaneous obstructions were observed in the spillway channel.

8) Water was observed seeping at the toe of the dam in the approximate center of the dam where it reaches its maximum height. The water flow was relatively light in terms of volume and was continuous. This water has made a channel that empties into the spillway.

9) A probable intake structure and gate house was observed in the reservoir approximately 50 feet from the upstream face of the dam near the maximum height of the dam. This structure could not be accessed for closer observation.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The construction of Longview Dam – North, according to the MDNR Dam Safety Program, was completed in 1914, approximately 103 years ago. The dam was constructed before rational design procedures were developed in the 1930s. The typical design life of an earthen dam is generally accepted to be 50 years; however, with proper maintenance earthen dams can safely function for much longer.

The hazard classification system categorizes dams according to the degree of adverse consequences of a failure or mis-operation of a dam. A dam's hazard potential is classified as either Low, Significant, or High. The MDNR Dam Safety program has classified this dam as a High Hazard dam. A High Hazard classification indicates that if a failure or mis-operation of the dam occurs, loss of human life is probable and there is a high potential for economic loss, environmental damage, and/or disruption to lifelines.

The embankment stability analyses performed for this evaluation indicate that appropriate factors of safety required by the MDNR Dam Safety Program are met for the conditions analyzed. However, the calculated factors of safeties were at or near the minimum required. Furthermore, any future modifications to the dam will impact its stability.

It is important to note, that the model developed for the embankment stability analyses is likely not entirely representative of the actual conditions with respect to the assumed water seepage through the dam due to the woody vegetation present on the dam which alters seepage paths. The seepage assumed for our analyses is based on the method recommended in the MDNR Dam Safety Program's document titled *Engineering Analysis of Dams* (1989), which cannot account for the affects that vegetation and possible animal burrows have on water seepage through the dam.

The following recommendations are provided based on our observations and analyses:

1) Given the age and current condition of the dam and its appurtances, KCTE recommends that a dam remediation design be implemented following the recommendations presented in *Technical Manual For Dam Owners – Impacts of Plants On Earthen Dams*, prepared by the Federal Emergency Management Agency, (FEMA 534) and dated September 2005. This document was developed in collaboration with the Association of State Dam Safety Officials (ASDSO).

2) A thorough structural and operational inspection of all appurtenances to include the spillway structure, spillway channel, an intake/gate house structure should be performed to evaluate their current conditions.

3) The dam should have a thorough topographic survey performed by a professional surveyor. If the topographic survey indicates the dam cross-section used in our stability analyses is significantly different than that developed by KCTE for this evaluation, then revised analyses should be performed using the results of the topographic survey prepared by the professional surveyor.

4) KCTE recommends that a permanent instrumentation and monitoring program be designed and implemented in order to evaluate the long-term stability of the dam. The program should include surveying and installation of inclinometers to monitor deformation and vibrating wire piezometers to monitor pore water pressures in the embankment.

5) A maintenance and inspection program should be developed specific to this dam. Although not required under the MDNR Dam Safety program, given the age and High Hazard classification given to this dam, KCTE recommends following their requirements for dam inspections.

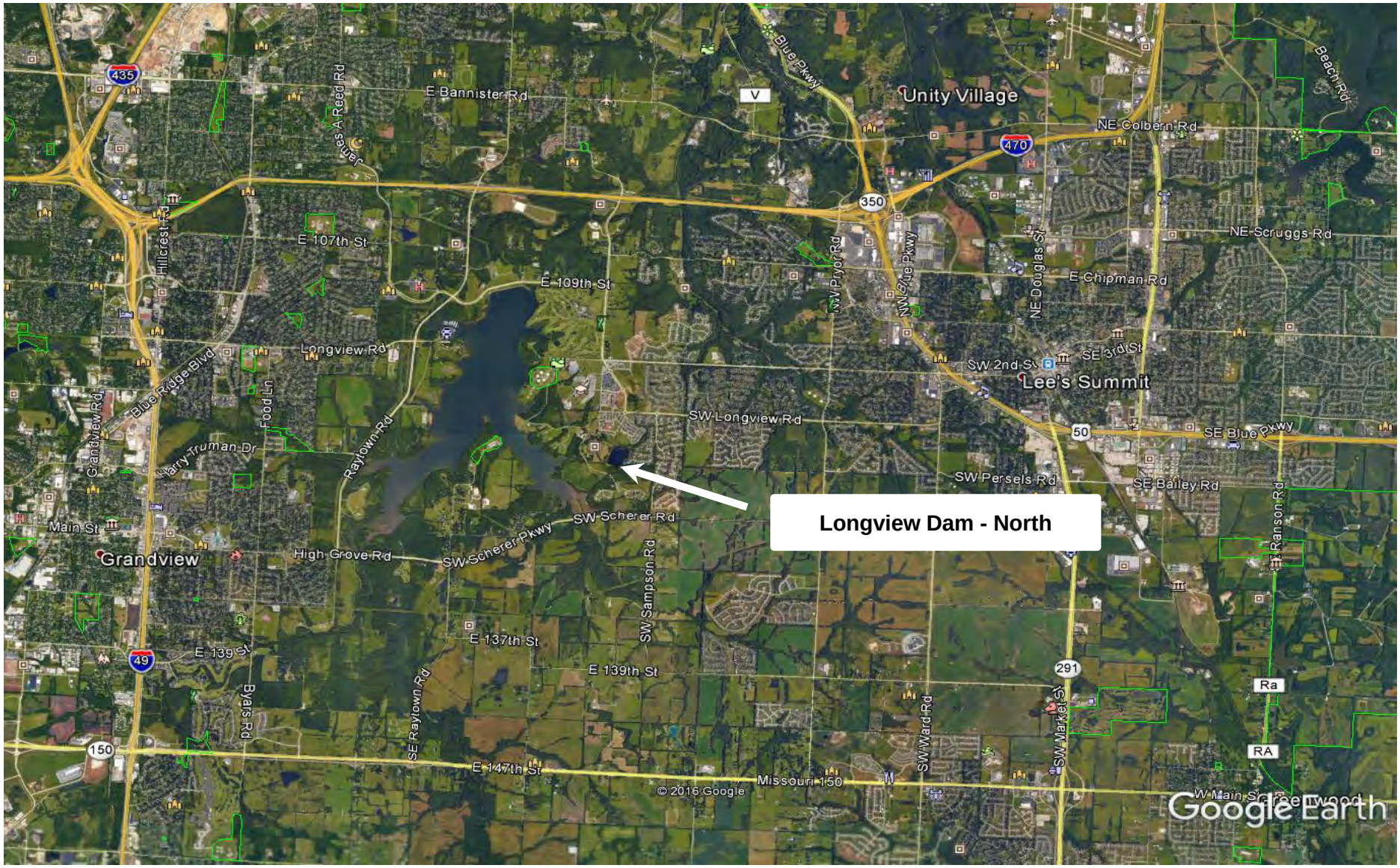
6) If modifications are planned for the dam, additional stability analyses must be performed to evaluate the impact of the modification(s).

8.0 LIMITATIONS

This report is presented in broad terms to provide an assessment of the subsurface conditions and their potential effect on the adequate design and economical construction of the proposed structure. Any changes in the design or location of the proposed structure should be assumed to invalidate the conclusions and recommendations given in this report until we have had the opportunity to review the changes and, if necessary, modify our conclusions and recommendations accordingly. It is recommended that the geotechnical engineer be afforded the opportunity of a general review of the final design plans and specifications prior to construction in order to determine if they are consistent with the conclusions and recommendations given in this report. For this project, these geotechnical document review services will be provided as part of the geotechnical report cost. Particular details of foundation design, construction specifications or quality control may develop, and we would be pleased to respond to any questions that you may have regarding these details.

This report has been prepared with generally accepted geotechnical engineering practices used in this area at the time the report was prepared. No other warranty, expressed or implied, is made. The conclusions and recommendations are based upon the data obtained from the borings drilled at the approximate locations shown in *Figure 2 – Boring Location Plan*. The nature and extent of the subsurface variations between borings may not become evident until excavation is performed. If during construction, soil, bedrock, fill, or groundwater conditions appear to be different than described in this report, we should be notified immediately so that re-evaluation of our recommendations may be made. On-site observation of foundation construction and sub-grade preparation by KCTE is

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



NORTH

Not to Scale

Note: Figure adapted from a Google Earth image.

Site Location Plan			Project No. G20-16-310
KANSAS CITY TESTING & ENGINEERING, LLC			1308 Adams Street Kansas City, Kansas 66103 www.kctesting.com
Drawn By: BW Checked By: SB	Date: 1/15/17	Longview Dam - North Lee's Summit, Missouri	Fig. No: 1

LEGEND: B-1 - Approximate Boring Location and ID

NORTH

Not To Scale

Note: Figure adapted from a Google Earth aerial photograph.

Boring Location Plan		Project No. G20-16-301	
KC TE KANSAS CITY TESTING & ENGINEERING, LLC		1308 Adams Street Kansas City, Kansas 66103 www.kctesting.com	
Drawn By: BW Checked By: SB	Date: 1-15-17	Longview Dam - North Lee's Summit, Missouri	Fig. No: 2

KANSAS CITY TESTING & ENGINEERING, LLC

APPENDIX A

BORING LOGS

GENERAL NOTES

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

Kansas City Testing and Engineering, LLC
1308 Adams Street
Kansas City, KS 66103
Tel: 913-321-8100
Fax: 913-321-8181

BORING NUMBER B-1

CLIENT M-III Longview, LLC
PROJECT NAME Longview Dam - North
PROJECT NUMBER G20-16-310
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 12/27/16 **COMPLETED** 12/27/16
GROUND ELEVATION 936 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR KCTE
GROUND WATER LEVELS:
DRILLING METHOD CME 55, 4.25 HSA, Mud Rotary
AT TIME OF DRILLING ---
LOGGED BY JW **CHECKED BY** SB
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF COMPR. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	Pocket Pen. (tsf)
0		TOPSOIL Material (embankment fill)	ST 1	71								
		FAT CLAY - medium stiff, dark bown (embankment fill)										
			SPT 2	100	4-4-5 (9)			28.4				
5												
			ST 3	75		1769	98	28.9				
			ST 4	79					55	22	33	
10												
		- very stiff below 13.5 feet (probable native clay)	ST 5	67		4352	105	24.6	51	23	28	
15												
			ST 6	90		6141	110	18.9				
20		SHALE BEDROCK - moderately hard, moderately weathered, olive, silty	SPT 7	100	24-25-24 (49)			22.6				

Bottom of borehole at 21.2 feet.

Kansas City Testing and Engineering, LLC
1308 Adams Street
Kansas City, KS 66103
Tel: 913-321-8100
Fax: 913-321-8181

BORING NUMBER B-2

CLIENT M-III Longview, LLC
PROJECT NAME Longview Dam - North
PROJECT NUMBER G20-16-310
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 12/22/16 **COMPLETED** 12/27/16
GROUND ELEVATION 936 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR KCTE
GROUND WATER LEVELS:
DRILLING METHOD CME 55, 4.25 HSA, Mud Rotary
AT TIME OF DRILLING 8.00 ft / Elev 928.00 ft
LOGGED BY JW **CHECKED BY** SB
AT END OF DRILLING ---
NOTES
AFTER DRILLING 7.50 ft / Elev 928.50 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF COMPR. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	Pocket Pen. (tsf)
0		TOPSOIL Material (embankment fill)										
		LEAN CLAY - very stiff, dark brown, trace gravel, moist (embankment fill)	SPT 1	100	17-17-7 (24)							
5		- medium stiff and very moist to wet below 5 feet	SPT 2	100	3-3-4 (7)			30.9				
			ST 3	33		1819	93	30.0				
10												
			ST 4	50		1564	92	30.5				
15												
		- very stiff, gray brown and very moist below 18 feet (probable native clay)	ST 5	100		3399	95	28.8	39	22	17	
20												
		FAT CLAY - very stiff, gray brown, moist	ST 6	79		4626	101	25.9	49	21	28	
25												

(Continued Next Page)

Kansas City Testing and Engineering, LLC
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Kansas City, KS 66103
Tel: 913-321-8100
Fax: 913-321-8181

BORING NUMBER B-2

CLIENT M-III Longview, LLC **PROJECT NAME** Longview Dam - North

PROJECT NUMBER G20-16-310 **PROJECT LOCATION** Lee's Summit, Missouri

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF COMPR. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	Pocket Pen. (tsf)
25		FAT CLAY - very stiff, gray brown, moist *(continued)*										
		SHALE BEDROCK - highly weathered, moderately hard, gray brown, moist	SPT 7	100	25-9-12 (21)			17.9	39	18	21	
30												

Bottom of borehole at 30.2 feet.

Kansas City Testing and Engineering, LLC
1308 Adams Street
Kansas City, KS 66103
Tel: 913-321-8100
Fax: 913-321-8181

BORING NUMBER B-3

CLIENT M-III Longview, LLC
PROJECT NAME Longview Dam - North
PROJECT NUMBER G20-16-310
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 1/9/17 **COMPLETED** 1/9/17
GROUND ELEVATION 936 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR KCTE
GROUND WATER LEVELS:
DRILLING METHOD ATV
AT TIME OF DRILLING 12.00 ft / Elev 924.00 ft
LOGGED BY KB **CHECKED BY** SB
AT END OF DRILLING 11.50 ft / Elev 924.50 ft
NOTES
24hrs AFTER DRILLING 10.30 ft / Elev 925.70 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF COMPR. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTIC LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	Pocket Pen. (tsf)
0		TOPSOIL Material (embankment fill)										
		CRUSHED STONE (embankment fill)	ST 1	42		2513	129	28.4				
		LEAN CLAY - very stiff, red brown, moist (embankment fill)	ST 2	96		6392	105	21.4				
5		- medium stiff and very moist to wet below 6 feet	ST 3	67		1163	90	30.5	46	23	23	
		- stiff below 8 feet	ST 4	54		3538	100	28.6				
10												
			ST 5	67			85	32.2	40	24	16	
15												
		- probable native clay below 18 feet	ST 6	79		2097	90	29.5				
20												
			ST 7	100			102	24.6				
25												

(Continued Next Page)

Kansas City Testing and Engineering, LLC
1308 Adams Street
Kansas City, KS 66103
Tel: 913-321-8100
Fax: 913-321-8181

BORING NUMBER B-3

CLIENT M-III Longview, LLC **PROJECT NAME** Longview Dam - North

PROJECT NUMBER G20-16-310 **PROJECT LOCATION** Lee's Summit, Missouri

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF COMPR. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	Pocket Pen. (tsf)
25		- stiff below 8 feet *(continued)*										
		LIMESTONE BEDROCK - hard										

Refusal at 27.4 feet.
Bottom of borehole at 27.4 feet.

Kansas City Testing and Engineering, LLC
1308 Adams Street
Kansas City, KS 66103
Tel: 913-321-8100
Fax: 913-321-8181

BORING NUMBER B-4

CLIENT M-III Longview, LLC
PROJECT NAME Longview Dam - North
PROJECT NUMBER G20-16-310
PROJECT LOCATION Lee's Summit, Missouri
DATE STARTED 1/9/17 **COMPLETED** 1/9/17
GROUND ELEVATION 936 ft **HOLE SIZE** 4 inches
DRILLING CONTRACTOR KCTE
GROUND WATER LEVELS:
DRILLING METHOD ATV
AT TIME OF DRILLING 7.90 ft / Elev 928.10 ft
LOGGED BY KB **CHECKED BY** SB
AT END OF DRILLING 7.50 ft / Elev 928.50 ft
NOTES
24hrs AFTER DRILLING 6.50 ft / Elev 929.50 ft

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF COMPR. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT	ATTERBERG LIMITS PLASTIC LIMIT	ATTERBERG LIMITS PLASTICITY INDEX	Pocket Pen. (tsf)
0		TOPSOIL Material (embankment fill)										
		CRUSHED STONE (embankment fill)	ST 1	0								
		FAT CLAY - stiff, brown and gray-brown, moist (embankment fill)	ST 2	54		2999	104	24.6	49	28	21	
5												
		- medium stiff, dark brown and very moist to wet below 6 feet	ST 3	100		1257	95	31.3				
			ST 4	54			95	29.0	47	22	25	
10												
		- stiff below 13 feet (probable native clay)	ST 5	75		2926	93	31.4				
15												
		SHALE BEDROCK - highly weathered, relatively hard, gray brown, moist	ST 6	96			103	22.3	47	28	19	

Bottom of borehole at 19.3 feet.

General Notes

KANSAS CITY TESTING & ENGINEERING, LLC

DRILLING NOTES

DRILLING AND SAMPLING SYMBOLS

AS	Auger Sample
CS	Continuous Sampler
HA	Hand Auger
HS	Hollow Stem Auger
PA	Power Auger
CF	Continuous Flight Auger
WB	Wash Bore
RB	Rock Bit
SS*	Split Spoon
ST	Shelby Tube

* The Standard Penetration Test (SPT) is conducted in conjunction with the split-spoon sampling procedure. The "N" value corresponds to the number of blows required to drive the the last 1 foot of an 18-inch-long, 2-inch O.D. split-spoon sampler with a 140-lb hammer falling a distance of 30 inches. The Standard Penetration Test is carried out according to ASTM D 1586.

WATER LEVEL MEASUREMENTS

ATD	At Time of Drilling
EOD	End of Drilling
AD	After Drilling

SOIL PROPERTIES & DESCRIPTIONS

TEXTURE

PARTICLE	*SIZE*
Clay	<0.002 mm
Silt	<#200 Sieve
Sand	#4 to #200 Sieve
Gravel	3 inch to #4 Sieve
Cobbles	12 inch to 3 inch
Boulders	> 12 inch

COMPOSITION

SAND & GRAVEL	
trace	< 15%
with	15% - 29%
some	> 30%
FINES (clay & silt)	
trace	< 5%
with	5% - 12%
some	> 12%

Soil descriptions are based on the Unified Soil Classification System (USCS) as outlined in ASTM D 2487 and D 2488. The USCS group symbol on the boring logs corresponds to the group names listed below. The descriptions include soil constituents, consistency or relative density, color and other appropriate descriptive terms. Geologic description of bedrock, when encountered, also is shown in the description column.

COHESIVE SOILS

CONSISTENCY	*UNCONFINED COMPRESSIVE STRENGTH* (psf)	(kPa)
Very Soft	< 500	< 24
Soft	500-1000	24-48
Medium Stiff	1001-2000	49-96
Stiff	2001-4000	97-192
Very Stiff	4001-8000	193-383
Hard	> 8001	> 384

PLASTICITY	Liquid Limit, %
Lean	< 45
Lean to Fat	45 - 49
Fat	> 50

COHESIONLESS SOILS

RELATIVE DENSITY	*N VALUE*
Very Loose	0 - 3
Loose	4 - 9
Medium Dense	10 - 29
Dense	30 - 49
Very Dense	> 49

BEDROCK PROPERTIES & DESCRIPTIONS

ROCK QUALITY DESIGNATION (RQD**)

QUALITY	*RQD, %*
Very Poor	0-25
Poor	25-50
Fair	50-75
Good	75-90
Excellent	90-100

**RQD is defined as the total length of sound core pieces, 4 inches (102 mm) or greater in length, expressed as a percentage of the total length cored. RQD provides an indication of the integrity of the rock mass and relative extent of seams and bedding planes.

DEGREE OF WEATHERING

Slightly Weathered	Slight decomposition of parent material.
Weathered	Well developed and decomposed.
Highly Weathered	Highly decomposed, may be extremely broken.

SOLUTION AND VOID CONDITIONS

Solid	Contains no voids.
Vuggy	Containing small cavities < 1/2 " (13mm)
Porous	Containing numerous voids, may be interconnected.
Cavernous	Containing cavities, sometime large.

When classification of bedrock materials has been estimated from disturbed samples, core samples and petrographic analysis may reveal other rock types.

HARDNESS & DEGREE OF CEMENTATION

LIMESTONE	
Hard	Difficult to scratch with knife.
Moderately Hard	Scratch with knife but not fingernail.
Soft	Can be scratched with fingernail.
SHALE	
Hard	Scratch with knife but not fingernail.
Moderately hard	Can be scratched with fingernail.
Soft	Can be molded easily with fingers.
SANDSTONE	
Well Cemented	Capable of scratching with a knife.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken easily with fingers.

BEDDING CHARACTERISTICS

TERM	*THICKNESS, INCHES (MM)*
Very Thick Bedded	> 36 (915)
Thick Bedded	12-36 (305-915)
Medium Bedded	4-12 (102-305)
Thin Bedded	1-4 (25-102)
Very Thin Bedded	0.4-1 (10-25)
Laminated	0.1-0.4 (2.5-10)
Thinly Laminated	< 0.1 (<2.5)

Bedding Planes - Planes dividing layers, beds or strata of rocks.
Joint - Fracture in rock, usually vertical or transverse to bedding.
Seam - Applies to bedding plane with unspecified weathering.

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CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 11

(Based on Unified Soil Classification System)

MAJOR DIVISIONS				GROUP SYMBOL	GROUP NAME
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines	$Cu \geq 4$ and $1 \leq Cc \leq 3^E$	GW	Well graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3^E$	GP	Poorly graded gravel [F]
		Gravels with Fines More than 12% fines	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 of coarse faction passes No. 4 sieve	Clean Sands Less than 5% fines	$Cu \geq 6$ and $1 \leq Cc \leq 3^E$	SW	Well-graded sand [I]
			$Cu < 6$ and/or $1 > Cc > 3^E$	SP	Poorly graded sand [I]
		Sands with Fines More than 12% fines	Fines classify as ML or MH	SM	Silty Sand [G H I]
			Fines classify as CL or CH	SC	Clayey sand [G H I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI > 7 and plots on or above "A" line	CL	Lean clay [K L M]
			PI < 4 or plots below "A" line	ML	Silt [K L M]
		Organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay [K L M N] Organic silt [K L M O]
	Silts and Clays Liquid limit 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	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay [K L M O] Organic silt [K L M O]
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% 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] $Cu = D_{60}/D_{10}$ $Cc=(D_{30})^2 / (D_{10} \times D_{90})$

[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.
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", whichever is predominant.

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

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" 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.

KANSAS CITY TESTING & ENGINEERING, LLC

APPENDIX B

LABORATORY TEST REPORTS

Kansas City Testing and Engineering, LLC
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Tel: 913-321-8100
Fax: 913-321-8181

SUMMARY OF LABORATORY RESULTS

CLIENT M-III Longview, LLC **PROJECT NAME** Longview Dam - North

PROJECT NUMBER G20-16-310 **PROJECT LOCATION** Lee's Summit, Missouri

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)	Satur-ation (%)	Void Ratio
B-1	3.5							28.4			
B-1	6.0							28.9	98.4		
B-1	8.5	55	22	33							
B-1	13.5	51	23	28				24.6	105.0		
B-1	18.5							18.9	110.3		
B-1	19.7							22.6			
B-2	5.5							30.9			
B-2	8.0							30.0	93.1		
B-2	13.5							30.5	91.5		
B-2	18.5	39	22	17				28.8	94.5		
B-2	23.5	49	21	28				25.9	101.1		
B-2	27.7	39	18	21				17.9			
B-3	0.0							28.4	129.1		
B-3	3.0							21.4	105.0		
B-3	6.0	46	23	23				30.5	90.4		
B-3	8.0							28.6	100.4		
B-3	13.0	40	24	16				32.2	85.2		
B-3	18.0							29.5	89.6		
B-3	23.0							24.6	101.6		
B-4	3.0							24.6	103.5		
B-4	3.5	49	28	21							
B-4	6.0							31.3	94.9		
B-4	8.0	47	22	25				29.0	94.6		
B-4	13.0							31.4	93.5		
B-4	18.0	47	28	19				22.3	103.3		

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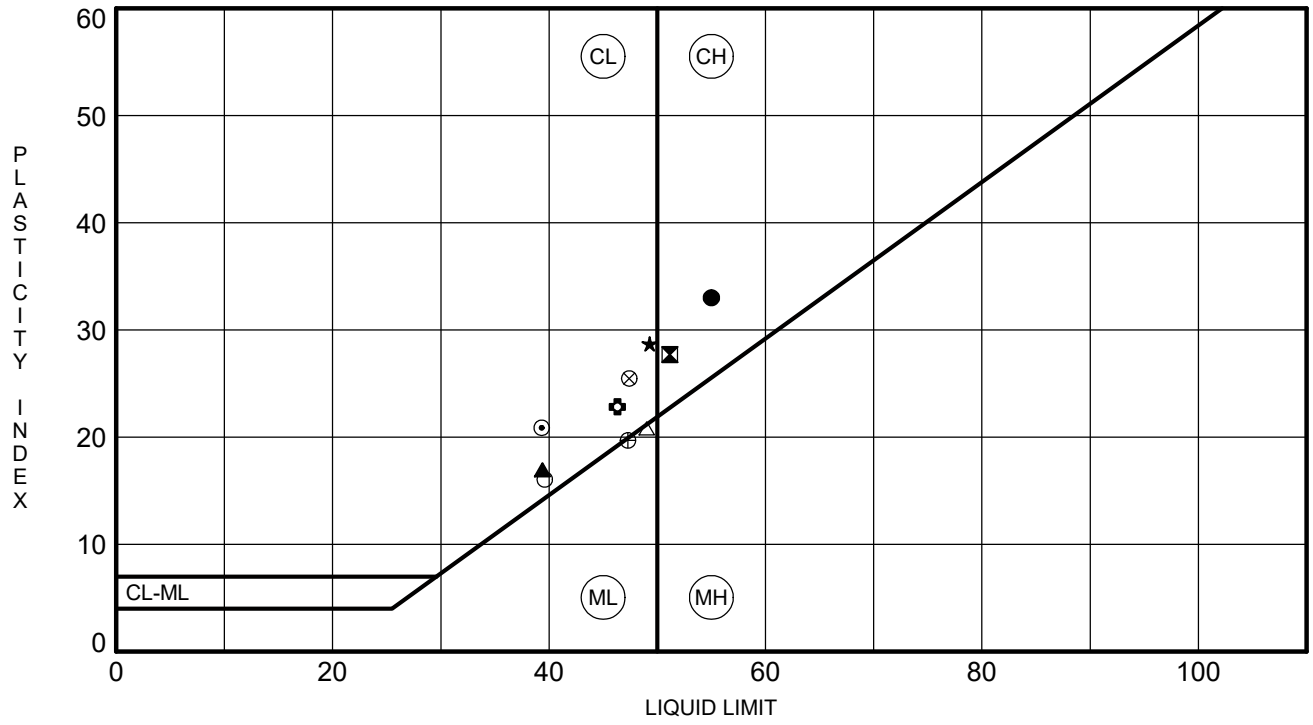
ATTERBERG LIMITS' RESULTS

CLIENT M-III Longview, LLC **PROJECT NAME** Longview Dam - North

PROJECT NUMBER G20-16-310 **PROJECT LOCATION** Lee's Summit, Missouri



	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**8.5**	**55**	**22**	**33**		
⊠	**B-1**	**13.5**	**51**	**23**	**28**		
▲	**B-2**	**18.5**	**39**	**22**	**17**		
★	**B-2**	**23.5**	**49**	**21**	**28**		
⊙	**B-2**	**27.7**	**39**	**18**	**21**		
✿	**B-3**	**6.0**	**46**	**23**	**23**		
○	**B-3**	**13.0**	**40**	**24**	**16**		
△	**B-4**	**3.5**	**49**	**28**	**21**		
⊗	**B-4**	**8.0**	**47**	**22**	**25**		
⊕	**B-4**	**18.0**	**47**	**28**	**19**		

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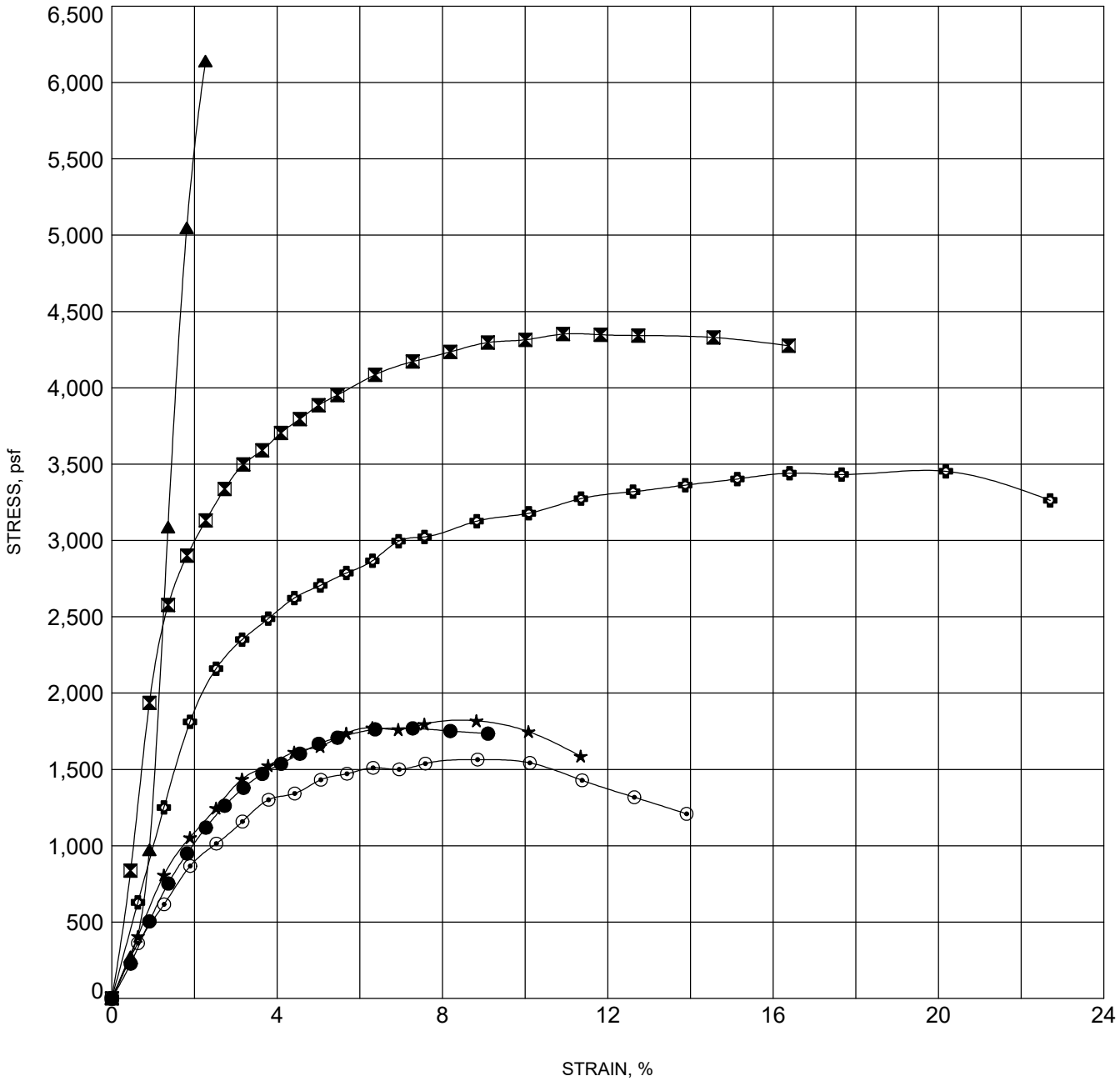
UNCONFINED COMPRESSION TEST

CLIENT M-III Longview, LLC **PROJECT NAME** Longview Dam - North

PROJECT NUMBER G20-16-310 **PROJECT LOCATION** Lee's Summit, Missouri



	BOREHOLE	DEPTH	Classification	γ_d	MC%
●	B-1	6.0		98	29
⊠	B-1	13.5		105	25
▲	B-1	18.5		110	19
★	B-2	8.0		93	30
⊙	B-2	13.5		92	31
✿	B-2	18.5		95	29

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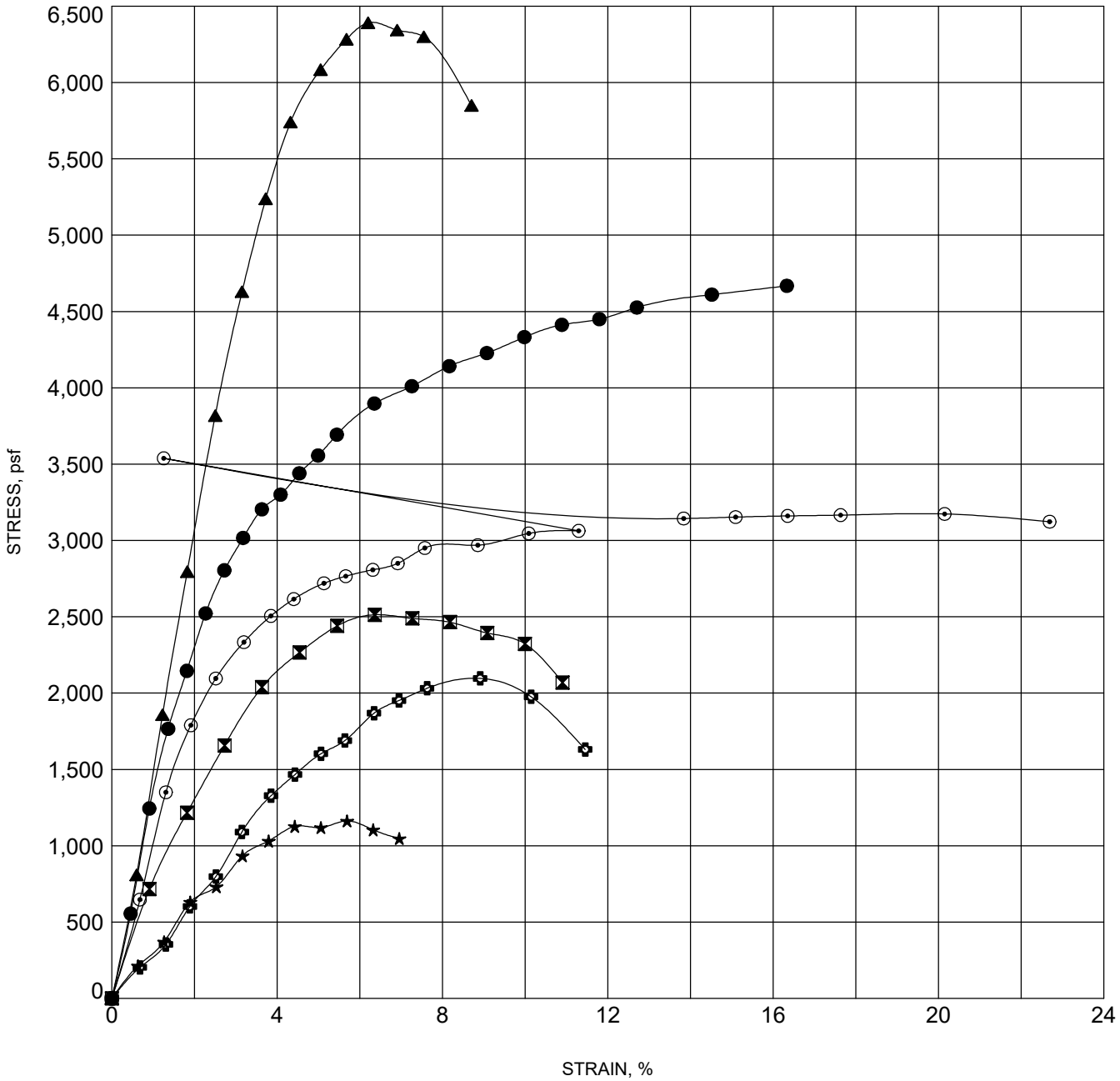
UNCONFINED COMPRESSION TEST

CLIENT M-III Longview, LLC **PROJECT NAME** Longview Dam - North

PROJECT NUMBER G20-16-310 **PROJECT LOCATION** Lee's Summit, Missouri



BOREHOLE		DEPTH	Classification	γ_d	MC%
●	B-2	23.5		101	26
⊠	B-3	0.0		129	28
▲	B-3	3.0		105	21
★	B-3	6.0		90	31
⊙	B-3	8.0		100	29
✿	B-3	18.0		90	30

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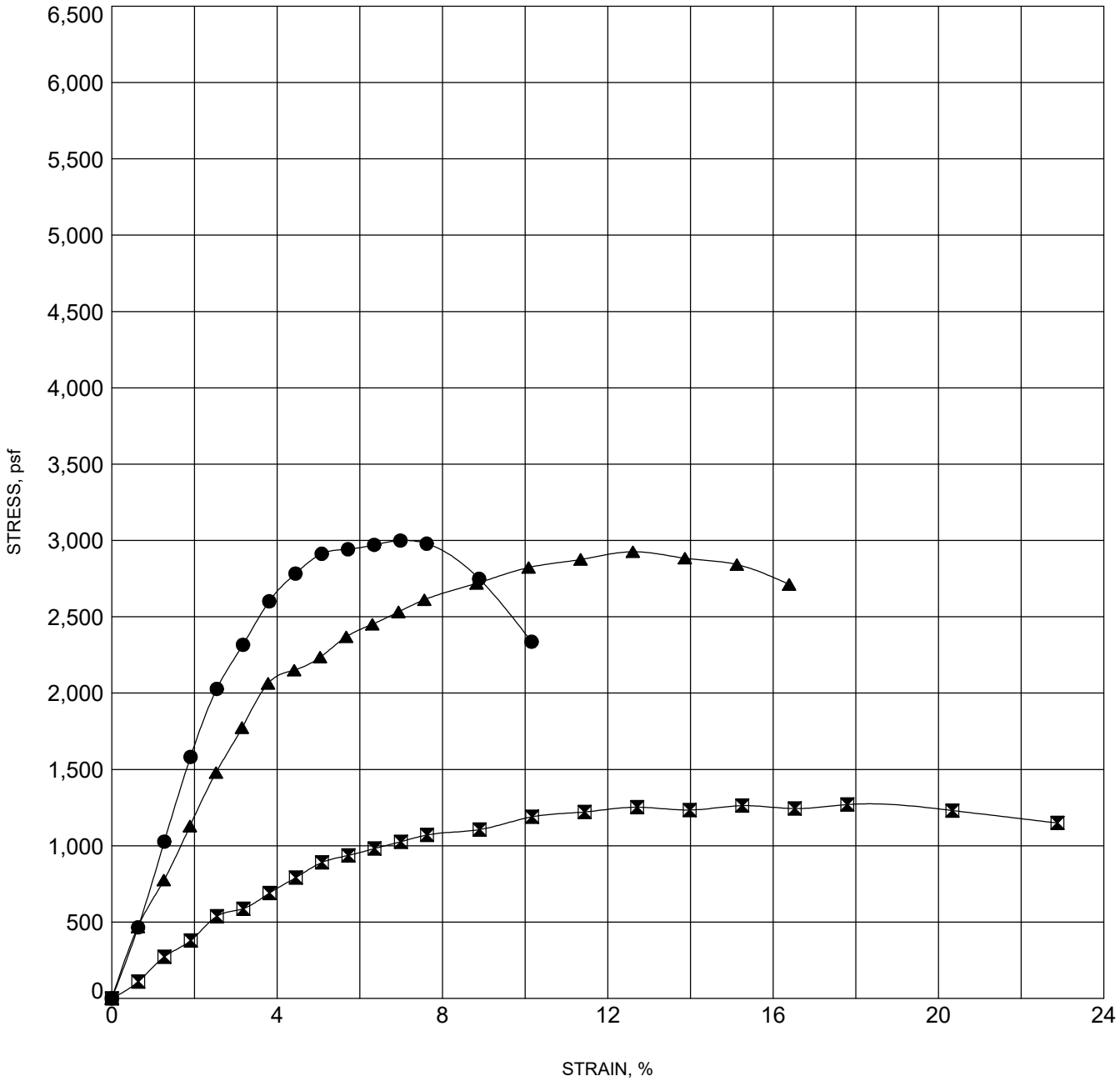
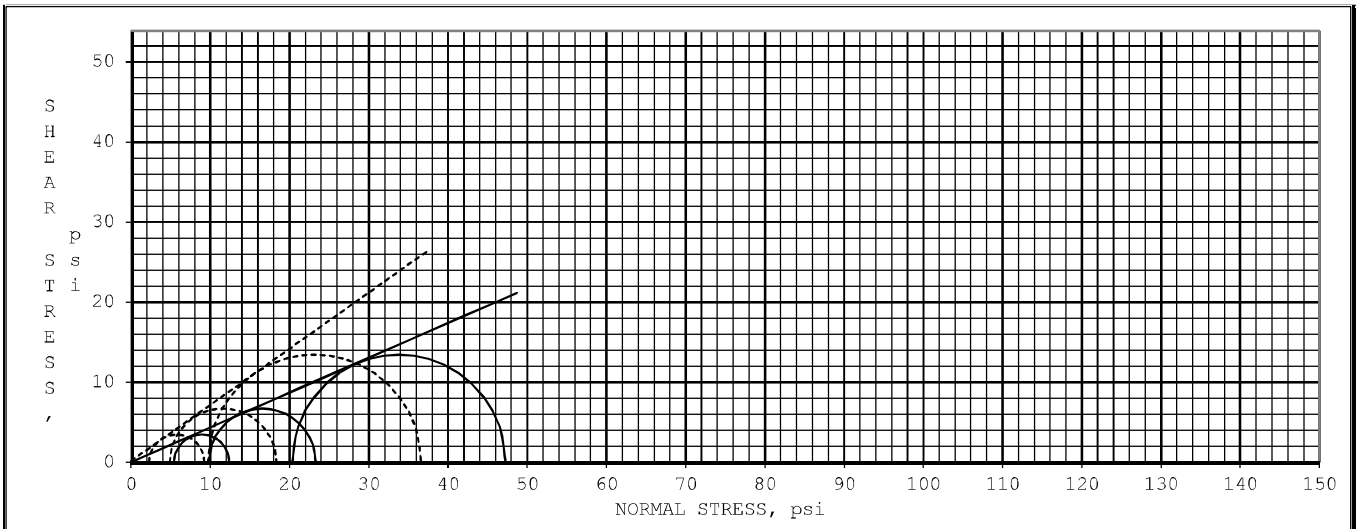
UNCONFINED COMPRESSION TEST

CLIENT M-III Longview, LLC **PROJECT NAME** Longview Dam - North

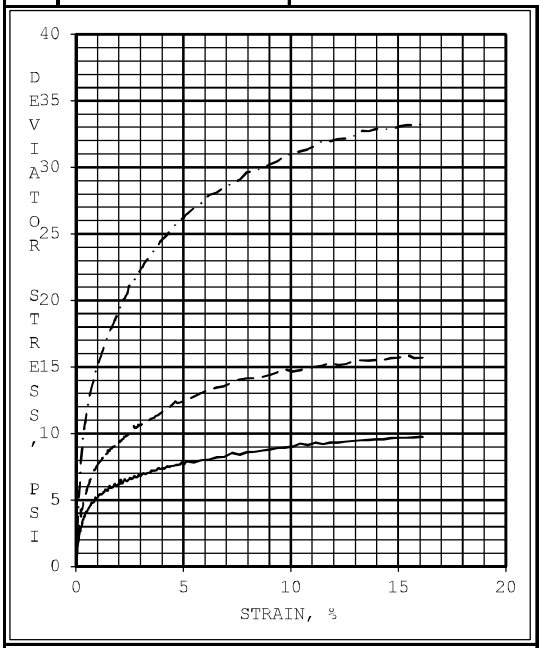
PROJECT NUMBER G20-16-310 **PROJECT LOCATION** Lee's Summit, Missouri



	BOREHOLE	DEPTH	Classification	γ_d	MC%
●	B-4	3.0		104	25
⊠	B-4	6.0		95	31
▲	B-4	13.0		93	31



	EFFECTIVE STRESS ---	ANGLE OF INTERNAL FRICTION, deg	**35.0**	COHESION, psi	**0.2**
	TOTAL STRESS ——	ANGLE OF INTERNAL FRICTION, deg	**23.5**	COHESION, psi	**0.0**



SPECIMEN ID:		A	B	C
INITIAL	WATER CONTENT, %	28.8	30.1	28.4
	DRY DENSITY, pcf	91.7	91.6	97.6
	SATURATION, %	93	97	105
	VOID RATIO	0.84	0.84	0.73
BEFORE SHEAR	WATER CONTENT, %	30.6	29.8	25.3
	DRY DENSITY, pcf	92.2	93.3	100.1
	SATURATION (B PARAMETER)	0.98	1.00	0.99
	VOID RATIO	0.83	0.81	0.68
	FINAL BACK PRESSURE, psi	98.8	99.2	98.7
MINOR PRINCIPAL STRESS, psi		5.4	9.8	20.3
EFFECTIVE STRESS PEAK AT % STRAIN		3.1	6.5	5.5
EFF. DEVIATOR STRESS AT PEAK STRAIN, psi		7.0	13.5	26.9
TOTAL STRESS PEAK AT % STRAIN		3.1	6.5	5.5
TOTAL DEVIATOR STRESS AT PEAK STRAIN, psi		7.0	13.5	26.9
ULTIMATE DEVIATOR STRESS (15% STR), psi		9.7	15.8	33.0
TIME TO 50% PRIMARY CONSOLIDATION, min		11.00	9.30	24.00
STRAIN RATE, % / hour		0.74	0.73	0.73
INITIAL DIAMETER, inch		2.791	2.791	2.838
INITIAL HEIGHT, inch		5.415	5.867	5.678
AREA AFTER CONSOLIDATION, inch2		6.112	6.048	6.219

CONTROLLED - STRAIN TEST

SAMPLE TYPE: 3" SHELBY TUBE

DESCRIPTION OF SPECIMENS:
FAT CLAY, DARK OLIVE WITH YELLOWISH BROWN AT THE BOTTOM CHANGING TO VERY DARK GRAY

LL	PL	PI	Gs
55	22	33	2.7 EST.

PROJECT NO. 02171004

PROJECT: KANSAS CITY TESTING
LONGVIEW DAM G20-16-310

BORING #: B-1

LABORATORY: TERRACON - LENEXA

SAMPLE #:

DATE: 1/24/2017

DEPTH, feet: 8.5 - 11.0

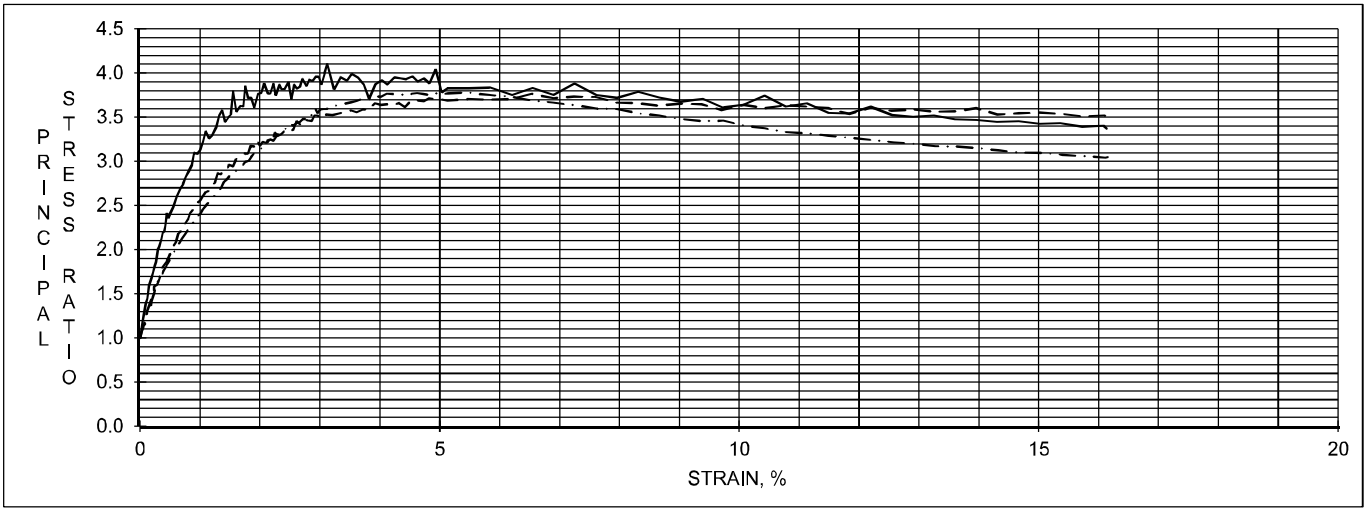
PROCEDURE: ASTM D4767, CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST ON COHESIVE SOILS

Terracon

N:\Projects\2017\02171004\Working Files\Laboratory-Field Data-Boring Logs\[02171004 Triaxial CU B1-8.5.xlsx]REPORT

KANSAS CITY TESTING

02171004 B-1 8.5 - 11.0



FAILURE SKETCH

SPECIMEN A

FAILURE SKETCH

SPECIMEN B

FAILURE SKETCH

SPECIMEN C

REMARKS:

SPECIMENS SATURATED BY THE WET METHOD.

EFFECTIVE STRESS FAILURE DATA BASED ON PEAK PRINCIPAL STRESS RATIO % STRAIN.

EFFECTIVE STRESS MOHR'S CIRCLES DRAWN AT PEAK PRINCIPAL STRESS RATIO % STRAIN.

TOTAL STRESS FAILURE DATA BASED ON PEAK PRINCIPAL STRESS RATIO % STRAIN.

TOTAL STRESS MOHR'S CIRCLES DRAWN AT PEAK PRINCIPAL STRESS RATIO % STRAIN.

DEVIATOR STRESSES CORRECTED FOR MEMBRANE AND FILTER PAPER EFFECTS.

AREA AFTER CONSOLIDATION CALCULATED AS PER SECTION 10.3.2.1 METHOD A

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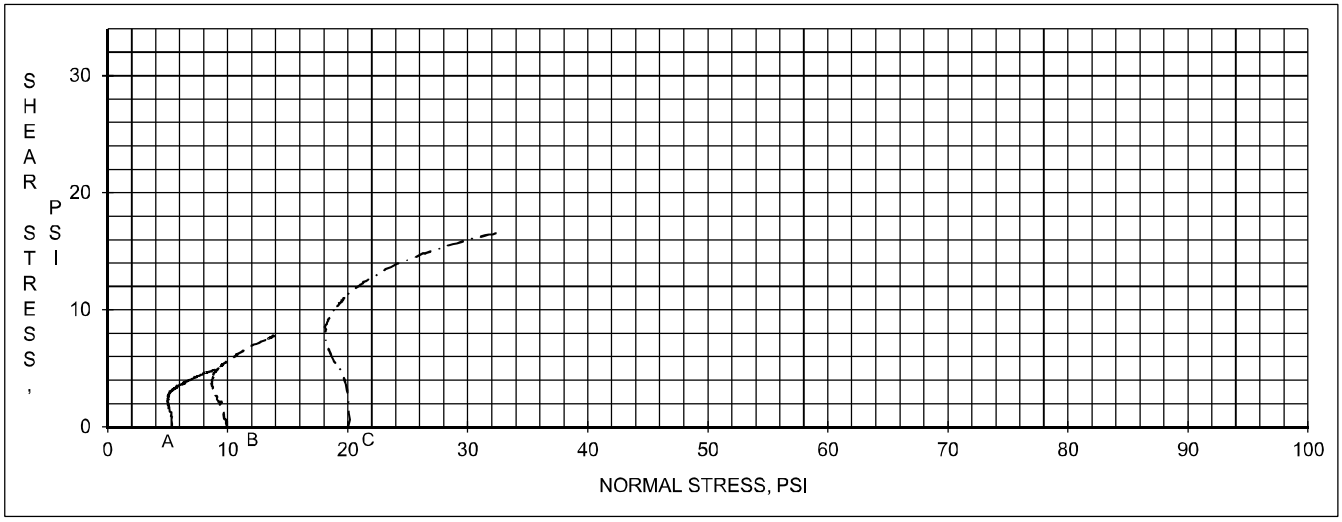
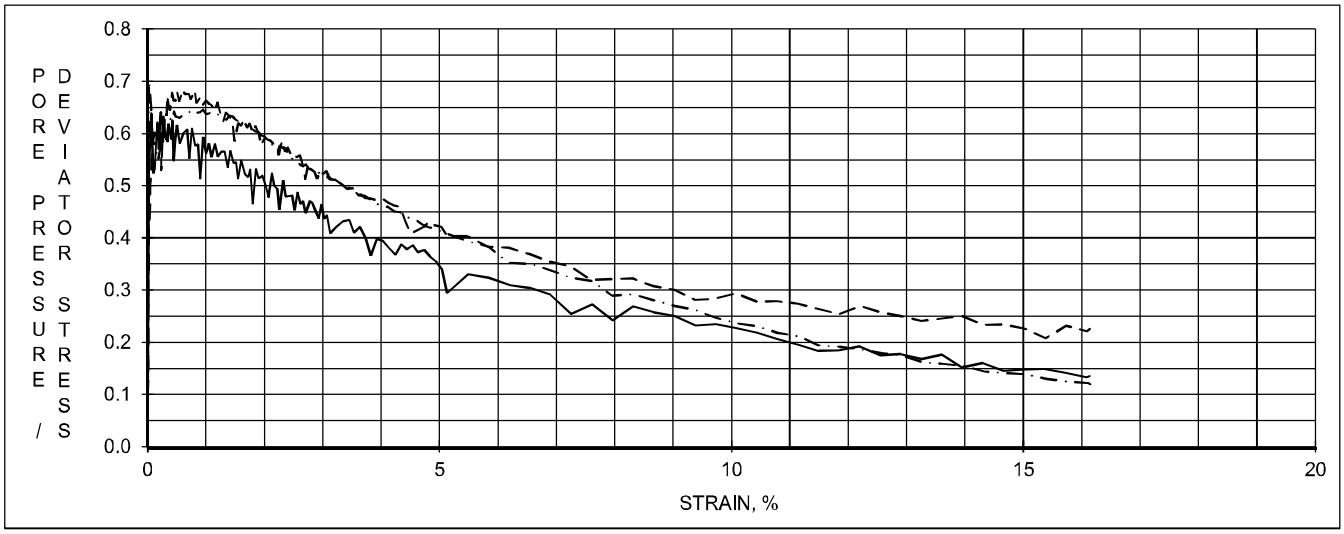
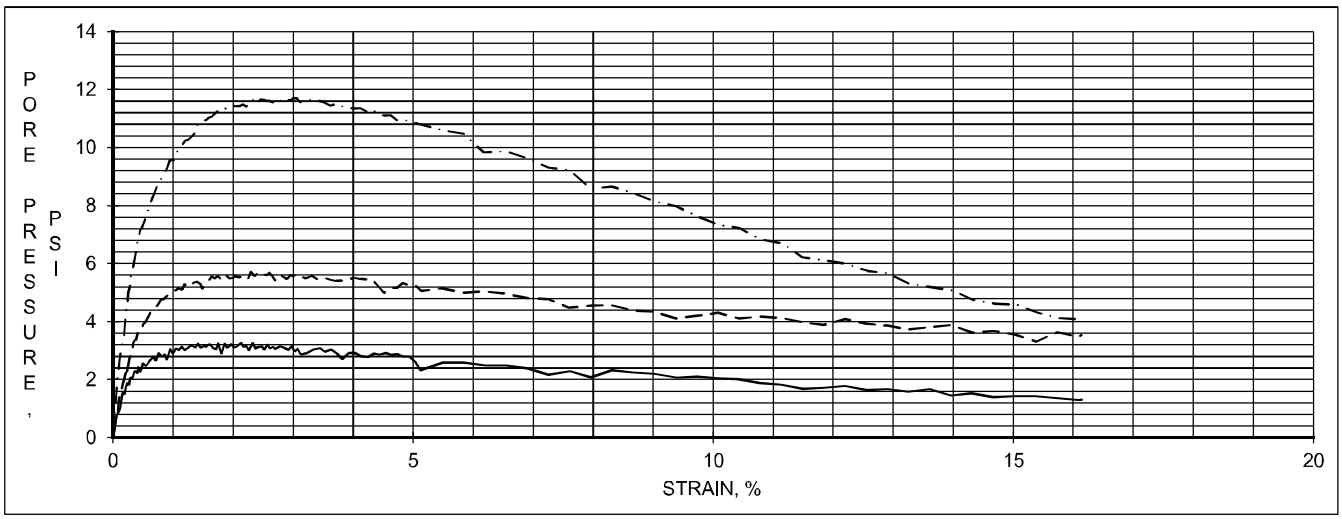
KANSAS CITY TESTING

02171004 B-1 8.5 - 11.0





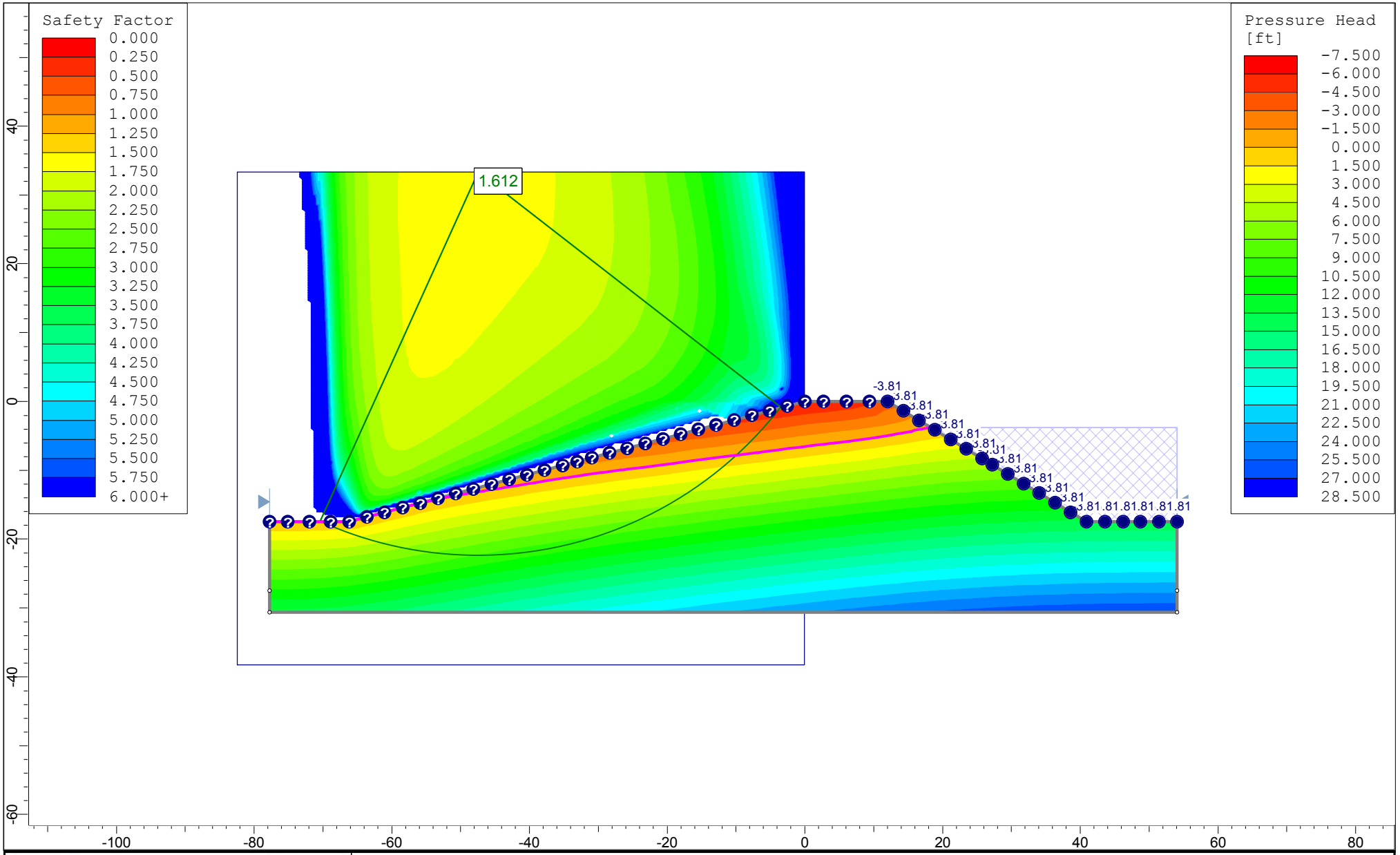


Terracon

KANSAS CITY TESTING & ENGINEERING, LLC

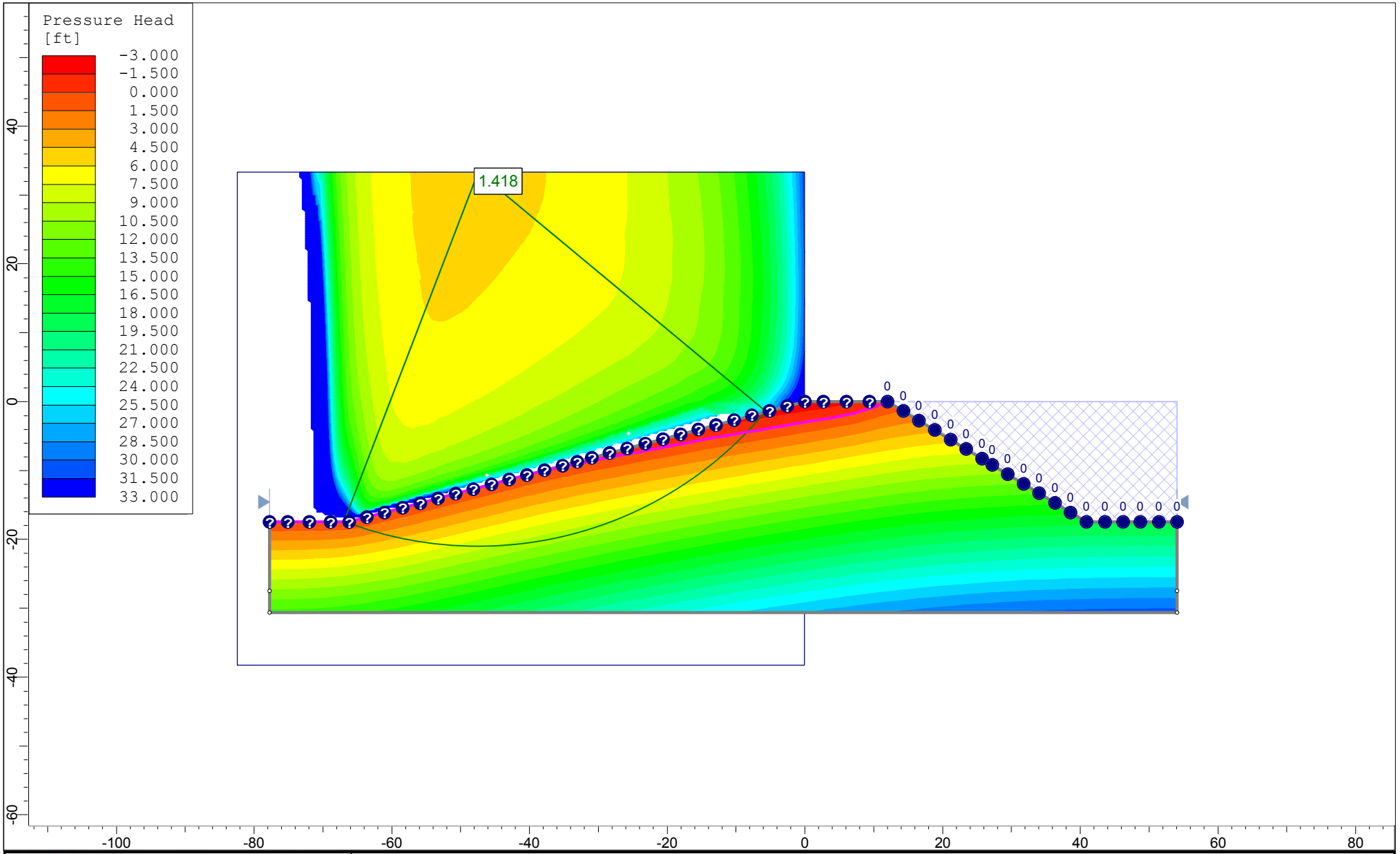
APPENDIX C

RESULTS OF EMBANKMENT STABILITY RESULTS



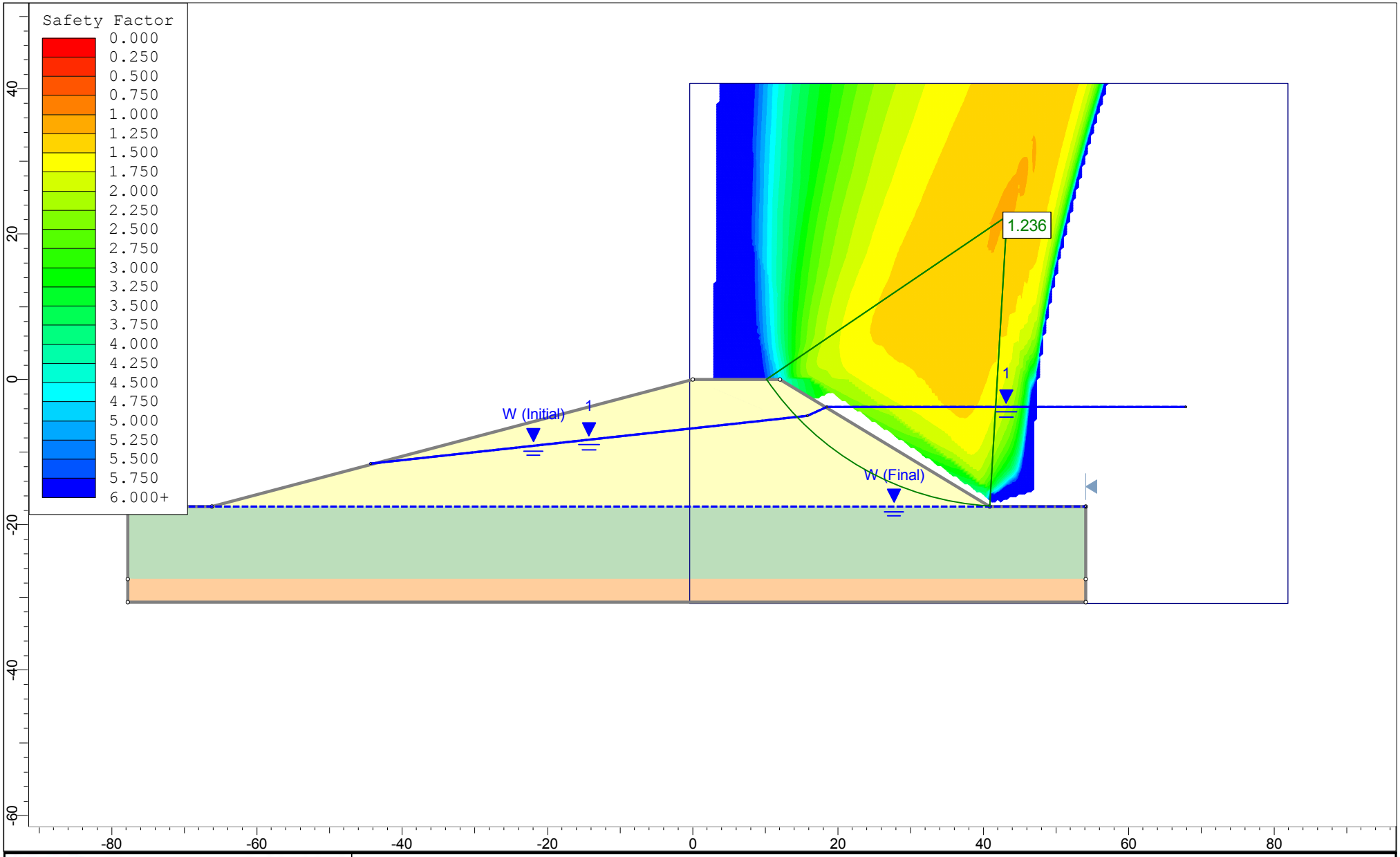
KANSAS CITY TESTING & ENGINEERING, LLC
1308 Adams Street
Kansas City, Kansas 66103

Project	G20-16-310 Old Longview Dam		
Analysis Description	Steady State - Full Reservoir		
Drawn By BW	*Scale* 1:231	*Company*	
Date	2/9/2017, 1:32:51 PM	*File Name*	Global Stability Analysis



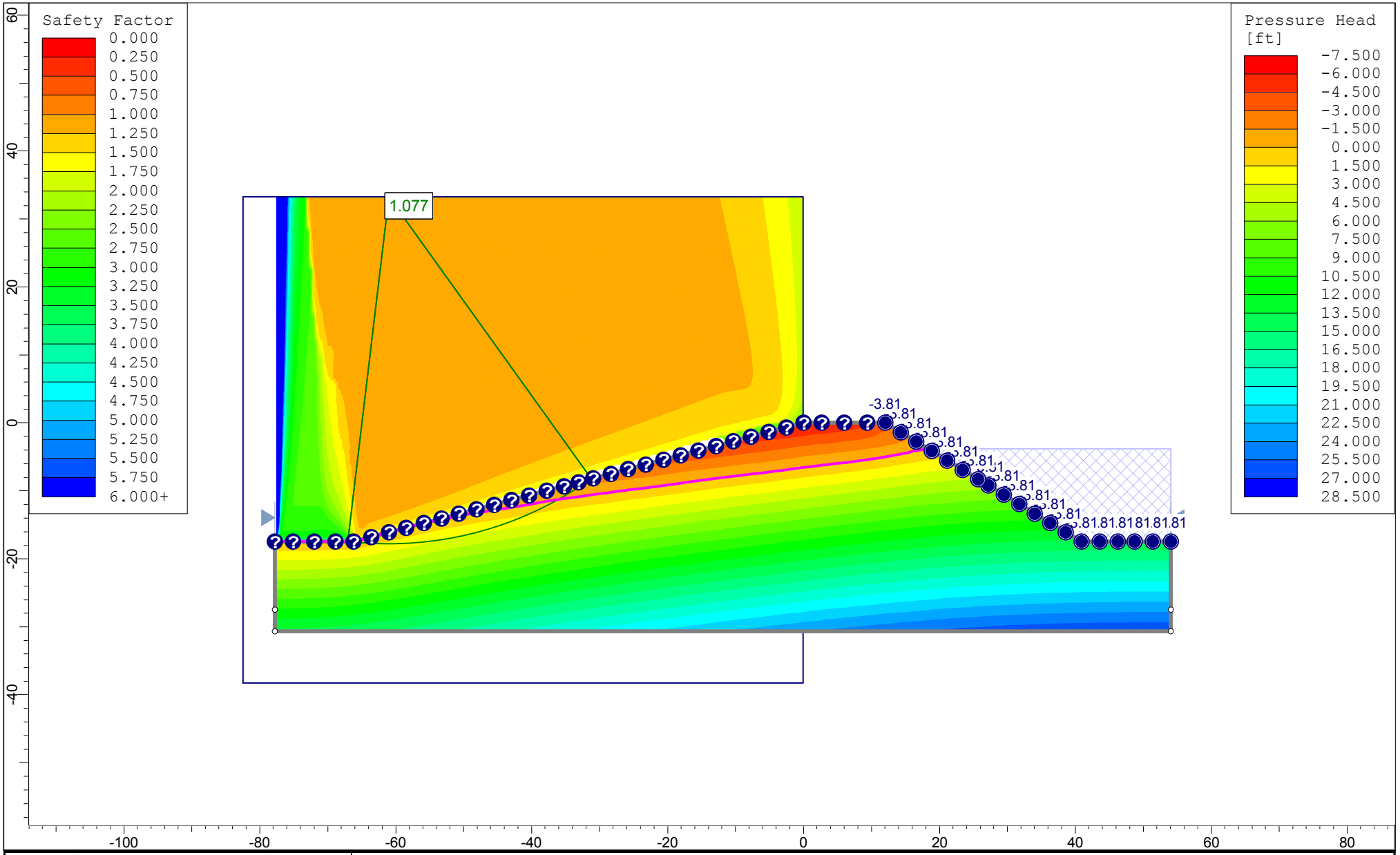
KANSAS CITY TESTING & ENGINEERING, LLC
1308 Adams Street
Kansas City, Kansas 66103

Project	G20-16-310 Old Longview Dam		
Analysis Description			
Drawn By		Scale 1:231	Company
Date	2/9/2017, 1:32:51 PM		File Name Global Stability Analysis



KANSAS CITY TESTING & ENGINEERING, LLC
1308 Adams Street
Kansas City, Kansas 66103

Project	G20-16-310 Old Longview Dam		
Analysis Description	Sudden Drawdown		
Drawn By: BW	Scale: 1:219	Company	
Date: 2/9/2017, 1:32:51 PM		File Name: Global Stability Analysis	



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1308 Adams Street
Kansas City, Kansas 66103

Project	G20-16-310 Old Longview Dam		
Analysis Description	Earthquake		
Drawn By: BW	Scale: 1:234	Company	
Date: 2/9/2017, 1:32:51 PM		File Name: Global Stability Analysis	

APPENDIX D

SITE PHOTOGRAPHS

Typical view of dam crest looking west.

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1308 Adams Street
Kansas City, Kansas 66103
www.kctesting.com

Site Photograph #1
Longview Dam - North
Lee's Summit, Missouri

KCTE Project No. G20-16-310

Typical view of woody growth on downstream face of eastern portion of dam.

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Kansas City, Kansas 66103
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Site Photograph #2
Boring B-4
Metcalf 108 Redevelopment
Overland Park, Kansas
KCTE Project No. G10-17-015

Typical view of downstream face in western portion of dam, looking east.

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Site Photograph #3
Longview Dam - North
Lee's Summit, Missouri

KCTE Project No. G20-16-310

Typical view of spillway structure, looking downstream from reservoir.

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1308 Adams Street
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Site Photograph #4
Longview Dam - North
Lee's Summit, Missouri

KCTE Project No. G20-16-310

Typical view of spillway structure, looking upstream from spillway channel.

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Site Photograph #5
Longview Dam - North
Lee's Summit, Missouri

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Typical view of erosional channel adjacent to spillway structure.

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Site Photograph # 6
Longview Dam - North
Lee's Summit, Missouri

KCTE Project No. G20-16-310

Typical view of intake / gate house structure.

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Site Photograph #7
Longview Dam - North
Lee's Summit, Missouri

KCTE Project No. G20-16-310

Typical view of water seepage at toe of dam.

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Site Photograph #8
Longview Dam - North
Lee's Summit, Missouri

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