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 our subsurface exploration and provides geotechnical recommendations for the design and construction of foundations for the porch roof addition.

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.

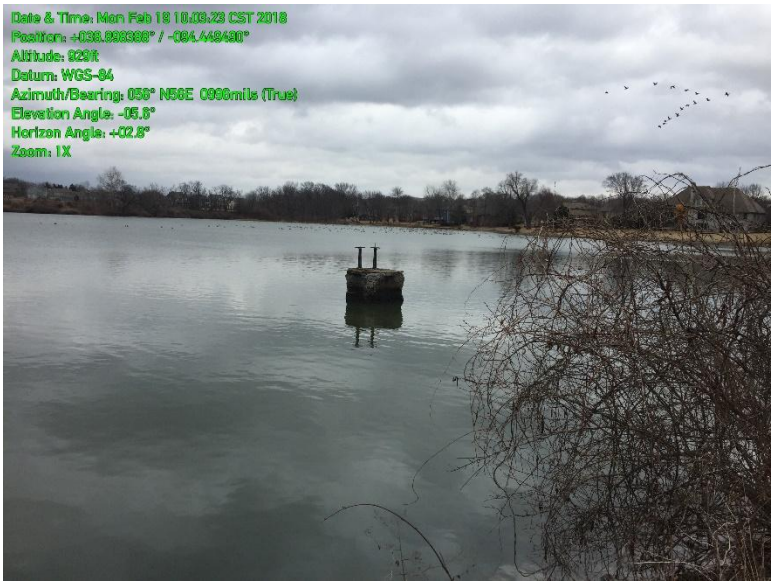

Photo 4- Primary spillway and outlet works

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