April 6, 2015

Applied Geotechnical Engineering & Geologic Consulting
1314-B Center Drive #452
Medford, OR 97501

Attention: Mr. Robin Warren

RE: RESULTS OF THE OPTICAL TELEVIEWER BOREHOLE LOGGING, ASHLAND RESERVOIR DAM, ASHLAND, OREGON

Dear Mr. Warren:

This letter report summarizes the results of the borehole logging conducted in two geotechnical boreholes drilled in the west embankment of the Ashland Reservoir, Ashland, Oregon. The objective of the borehole data collection is to support a geotechnical characterization of the embankment materials.

INTRODUCTION

Northwest Geophysics mobilized to the site on March 17, 2015 and completed optical televiewer logging in the two boreholes on March 18 and 19. Borehole BH-1 was located on the upslope side of the service road about 15 feet from the outcropping granite. BH-2 was located about 60 feet downslope of BH-1. Both boreholes were drilled within 4 degrees of vertical. BH-1 is 36 feet deep and BH-2 is 51 feet deep.

Both boreholes were drilled and cored HQ-diameter, roughly 3.7 inches in the overburden and 2.4 inches core diameter. In general, borehole conditions were not optimal for optical televiewer logging because the rock is very light colored and properly centralizing the televiewer was difficult. Uncased HQ boreholes are very close to the diameter of the optical televiewer. In open holes, particularly in overburden and highly weathered rock, there is a tremendous risk of lodging an optical televiewer in HQ boreholes when centralizers are used. Material knocked off the borehole wall from the centralizer rings is prone to piling up on top of the rings. In these cases, there is no room for the material to pass through the centralizers. With nowhere for this material to go, the probe becomes lodged in the hole. As such, we determined in the field to not use the centralizers. Without centralizers on the probe and a borehole deviating from 3º to 4º from vertical, the televiewer laid against one side of the borehole. This creates a somewhat distorted image. However, both boreholes were flushed well with water and that contributed immensely to collecting logs suitable to assist with the geotechnical characterization.

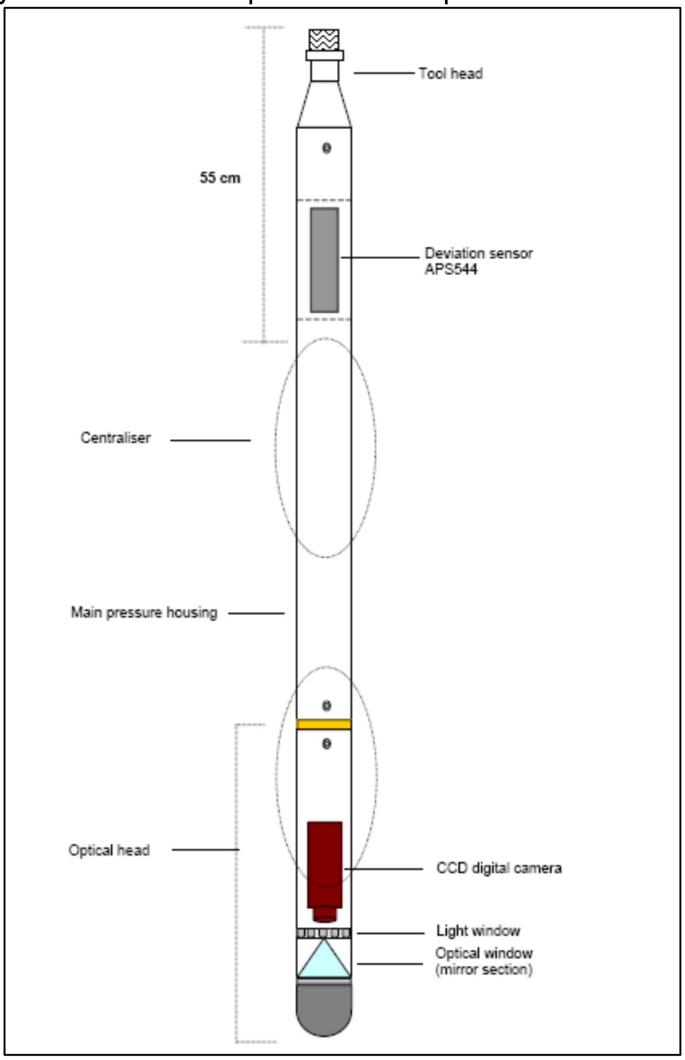
DESCRIPTION OF THE GEOPHYSICAL METHOD

A Mount Sopris Instruments borehole logging system was used for this investigation. Specifically, a MX series winch with 450 meters of 1/8-inch single conductor wireline and a Matrix control console were used to control the Advanced Logic Technology (ALT) OBI-40 (optical televiewer) probe.

Optical scans of the borehole wall were obtained with an Advanced Logic Technology model OBI-40 optical Televiewer (OTV). An oriented video scan of the borehole walls is provided by a high-resolution, high-sensitivity CCD digital camera located above a conical mirror. The light source is an LED light ring assembly located in the optical head. The image is depth encoded, transmitted through the wireline as a digital data stream, and stored digitally on the field computer.

The probe also transmits magnetic field strength, magnetic orientation, probe tilt, and probe temperature data. These are useful for orienting the image log when not in the presence of steel casing. The OTV images shown in the borehole logs are oriented to magnetic north. Figure 1 shows a schematic layout of the OBI-40 probe.

Figure 1. Schematic layout of the Mt. Sopris OBI-40 Optical Televiewer.



(Image source: Advanced Logic Technology SA)

FIELD PROCEDURES

The logging system was installed in the bed of the field truck with a portable tripod positioned directly over the borehole. For BH-1 the field truck was approximately 10 feet from the borehole while for BH-2 the field truck was approximately 20 feet away because the drill rig was still located over the hole. The depth encoder was updated to reflect this offset distance. The boreholes were logged from 5.7 feet below the ground surface (bgs) to the depth where the probe encountered the bottom of the hole. In both cases, the logging depth is shallower than the drilling depth, likely material washed off the borehole wall while the borehole was flushed with water. For BH-1, good quality optical televiewer data was recorded from 5.7 feet to the bottom of the hole; whereas for BH-2, usable data isn't recorded until a depth of approximately 19 feet because of the steel casing. In BH-1, the water table is located at approximately 17.4 feet. In BH-2, logging was done immediately after drilling and flushing, while the borehole was completely filled with water.

Each borehole was logged in both directions, down and up. Following the downward log, camera settings were adjusted based on image quality. The intensity of the LED lights along with the sample rate and radial resolution were among the parameters confirmed or adjusted prior to recording the upward log.

Data was viewed in real-time on a laptop computer screen and raw data files were backed up on a portable hard drive before leaving site.

OPTICAL TELEVIEWER DATA PROCESSING

The optical televiewer logs collected during the field effort are stored as .tfd (tagged field data) files then imported and processed using WellCAD software's interactive Image and Structure Log processing modules.

During the importing process the OTV images are oriented to a global reference which can be either magnetic north or high side of the hole. Magnetic north was chosen as the global reference orientation for this project. Using WellCAD software, orientation to magnetic north is accomplished by rotating the images by magnetometer channels imported from the raw .tfd files.

The OTV image logs are presented in Appendix A of this report. These image logs were used to produce the structural feature database presented in Tables 1 and 2, Appendix B.

RESULTS OF THE GEOPHYSICAL INVESTIGATION

Results of the borehole logging are presented in both graphical format and tabular format. The televiewer image logs are presented in graphical format in Appendix A. The tabular summary of the interpreted structural features are presented in Appendix B. Image quality is better on the BH-1 log than on the BH-2 log. In general, light-colored rocks such as quartz diorite or granite can be difficult to image with an optical televiewer. The minerals reflecting the LED light together with a nearly-white background works to diminish image quality. Even when background images are low quality, fractures and other structural features can still be visible in the log.

Appendix A contains the images logs for each of the holes logged. All logs presented are oriented to magnetic north. The entire optical image log of each hole are presented along with the wrapped, three dimensional virtual borehole wall. Orientation of interpreted features is referenced to magnetic north. However, in close proximity to steel casing, magnetic north readings are distorted and could have an impact on the interpreted dip direction and dip angle.

The National Geophysical Data Center (NGDC) on-line Magnetic Field Calculator (http://www.ngdc.noaa.gov/geomag-web/#igrfwmm) indicates the magnetic declination at the site at the time of televiewer data collection was 14° 53' E. Feature orientation conversion from magnetic north to true north orientation can be accomplished by adding magnetic declination to the azimuth (a.k.a. dip direction) values reported in Tables 1 and 2.

Red colored sinusoidal lines in the structure log indicate a zone of breakout in the borehole wall. This type of feature is often associated with a change in material or degree of weathering. The orange colored sinusoidal lines represent fractures. The green colored sinusoidal lines in the structure logs represent the interpreted transition from weathered granite to granite.

Appendix B contains the dataset of structural features interpreted from the borehole logs presented in Appendix A. Tables 1 (BH-1) and 2 (BH-2) summarize the interpretation of structural features for each of the holes and includes both apparent and true dip and azimuth information.

LIMITATIONS OF GEOPHYSICAL METHODS

The borehole logging services provided have been conducted in a manner consistent with that level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions subject to the time limits, and financial and physical constraints applicable to the services. Optical televiewer probes are remote sensing geophysical instruments that may not detect all subsurface structural features of concern. Furthermore, subsurface horizons or structural discontinuities identified may be found to have been misinterpreted based on lithologic or other intrusive sampling methods.

CLOSURE

We appreciate the opportunity to work with you with on this project. If you have any further questions please call or email.

Sincerely,

Northwest Geophysics, LLC

Matthew A. Benson

Attachments: Appendix A: BH-1 Optical Televiewer Log
BH-2 Optical Televiewer Log
Appendix B: Table 1
Table 2

TELEVIEWER IMAGE LOGS