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Viola Engineering, PC

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220 Imboden Drive, Suite A
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Phone: 540-313-4270
Fax: 540-434-0447

December 2, 2021

Joe Wilder, Director of Public Works [email: jwilder@fcva.us]
Frederick County, Virginia
107 N. Kent Street
Winchester, VA 22601

RE: Revision 1 - Report of Geophysical Investigation
Crystal Lake Sinkhole Investigation (Cherokee Dam)
152 Tomahawk Trail, Winchester, VA
VEPC Project No: PTL-212862

Mr. Wilder:

A three-dimensional (3D) electrical resistivity imaging (ERI) survey was performed at the referenced site to evaluate recently developed karst features located along the southeastern bank of Crystal Lake. Site investigation and report preparation were conducted in accordance with Frederick County Task Order 2017-13 (Date: 10/27/2021) and scope of services developed by our office (Proposal Date: 10/21/2021). The lake and earthen impoundment, Cherokee Dam, are owned and operated by Frederick County with funding provided by the Shawneeland Sanitary District. Site karst hazards are well documented at Crystal Lake, and subsurface topology has impacted the performance of the lake dating back to its construction in the 1960's. Investigation and sinkhole remediation activities have taken place over the past 20 years with fluctuating drainage rates occurring throughout the lakes operational history. Sometime in early October 2021, two (2) well defined sinkholes developed along the eastern shore of the lake; subsequently, accelerating lake drainage to a rate measured at approximately 150 gallons a minute at the spring located north of the historic Council House. As a result, the lake water elevation dropped approximately 10 to 15 feet. This prompted a subsurface evaluation of geologic conditions to ascertain potential remediation scope and estimated costs. A three-dimensional electrical resistivity survey (ERI) was conducted, by our office, to evaluate subsurface sinkhole drainage conditions. A 3D rectangle survey section was established, as shown on the attached Location Plan, with six (6) parallel ERI survey lines conducted with electrode spacing maintained at eight (8) feet.

Figure 1. Dam Construction

Three-dimensional resistivity imaging is a geophysical technique utilized to measure the in-situ resistivity of earth materials, i.e., how difficult it is to pass an induced electrical current through the subsurface. Resistivity is the inverse of conductivity. Therefore, resistivity imaging is a measurement of the conductivity of the subsurface materials at the site. Generally, soils are more conductive than competent bedrock and can be imaged with this technique. Karst terrain soils associated with sinkholes, voids, solution channels, bedrock seeps and incipient sinkholes are typically cohesive and very moist. Therefore, they are more

conductive than the surrounding bedrock or other soils. In addition, voids and caves can possibly be imaged provided a contrasting resistivity gradient exists between the target and the surrounding earth materials.

SITE EXPLORATION

Cherokee Dam is located perpendicular to the strike of bedrock underlain by various geological formations, several of which include soluble limestone. We understand the site and dam embankment is underlain by several geologic formations with limestone inclusions that are solution prone according to published maps, review of previous site study, and grouting program performed by Hayward Baker.

Based on a review of the grouting program, we summarize that grouting began in November 2008 and was terminated in April of 2009. A total of 33 borings were injected with grout to depths of 150 feet, as referenced from the top of the dam, with a cement grout/bentonite additive. Records indicate a total of 2097 cubic yards of grout was injected to develop a subsurface curtain that appeared to minimize water flow through subsurface voids at depth. However, it was stated some leakage is inevitable in this karst geology. We conclude that it is nearly impossible to effectively stop leakage in karst geology nor can any grouting plan guarantee similar future sinkhole development will not occur. However, targeted remediation can significantly reduce the likelihood of drainage through karst development and reduce subsurface drainage rates.

A three-dimensional ERI survey along six (6) parallel lines running east to west along the downstream slope and toe of Cherokee Dam. The study included a dipole-dipole array resistivity survey utilizing the Advanced Geosciences, Inc. (AGI) SuperSting R-8/IP Passive Earth Resistivity System. The ERI lines were spaced approximately 16 feet apart with a length of 664 feet each. The resistivity lines were established with an electrode spacing of 8 feet to gain a maximum resolution and imaging depth of approximately four (4) and 130 feet, respectively. Anomalous resistivity zones were mapped in an effort to identify flow paths which traverse the survey area to distinguish potential remediation areas. Further, resistivity imaging data was processed and inverted using AGI's proprietary 3-D resistivity inversion software, EarthImager 3-D, to generate the inverted resistivity sections. Terrain correction was performed utilizing high resolution elevation data obtained from USGS 3DEP one-meter Light Detection and Ranging (LiDAR) bare earth elevation maps. Electrodes were located in the field with multi-band RTK GNSS receivers with a nominal location accuracy of less than three (3) centimeters.

Figure 2. ERI Field Investigation

SUBSURFACE CONDITIONS

Electrical resistivity imaging is a nondestructive investigation technique that can be utilized to detect large anomalously deep and/or wet soils of the type commonly associated with incipient sinkholes or saturated soils, fractures, or pockets between more competent rock. Resistivity imaging was utilized as an indicator of potential wet soils or flow paths and not as an absolute identifier of the problem. In general, higher

resistivity values are interpreted to represent non-porous competent bedrock or dry soil conditions, and conversely, lower conductivity values are interpreted to represent moist or saturated soils and/or water filled voids, fractures, and other structural discontinuities within the bedrock/soil mass.

Figure 3. Sinkhole Development Along Shoreline

Resistivity imaging of the project site suggests variable moisture conditions beneath estimated top of bedrock likely indicated zones of water infiltration. Zones of higher resistive material likely represent competent bedrock while lower resistivity values were observed along the existing dam outfall barrel and buried piping (siphons). A discontinuous low resistivity zone is noted on all ERI sections along the eastern edge of the ERI data. This area is indicative of fractured bedrock harboring water flow. Further, it is believed the contact between dissimilar geologic formations is closer to the site than is mapped leading to accelerated bedrock degradation. A zone of probable remediation was identified along the eastern extents of the survey area as mapped on the attached Location Plan and Inverted Resistivity Sections. An area of low resistivity subsurface conditions was noted due west of the dam outfall pipe only in a handful of sections. It is believed this hydraulic feature is derived from water infiltration at the surface near the end of the outfall pipe.

CONSTRUCTION RECOMMENDATIONS

We understand Crystal Lake is a prominent feature of the Shawnee Land community and is admired by many residents. However, extensive subsurface remediation of previous karst features has left some weary of significant capital expenses for its continued operation. Multiple remediation options are available with varying probability of long-term success; however, any remediation approach selected will not guarantee the end to sinkhole development within the local geology going forward.

Currently (as revised 12/2/21), Crystal Lake elevation has dropped to a consistent level of 157 inches below normal pool elevation and flow measured at the spring box below the Council House has stabilized to 136 gpm (down from 175 gpm) and flowing with negligible turbidity. These factors may remain constant for a period of time to permit remediation, if so elected. Some well-suited methods, arranged in ascending cost, may include:

1.) Grouting of near-surface voids, deep remediation excluded, in the existing karst features to include backfilling existing sinkholes (2) at the surface to promote public safety leaving existing deep conditions unchecked. This would be economically achieved by rough grading an access lane to near the karst features to permit backfilling with 2000 psi lean concrete with 50 lbs of bentonite metered into the concrete while discharging. The concrete volume may be expanded by including bank boulders to the concrete/grout mix during discharge. We estimate a budget cost of $7,500 to complete this alternative. However, once the sinkholes are backfilled, the advantage of filling with polymer grout is lost without drilling addition holes to inject grout to better fill voids if decided at a later date.

2.) Near surface and drainage path filling with water-activated semi-rigid polyurethane foam injection resin. Dye tracing is conducted to ascertain travel time through karst drainage paths. Specially

formulated foam is pumped into the exposed sinkhole(s) and proportioned to activate at set intervals to plug subsurface conditions. Chemicals are certified to NSF 61-5 (approved for contact with drinking water – see attached Certified Product Listing). Please refer to attached Case History for more information provided by Mr. Stuart Baber of American Concrete Services. We suggest that Mr. Baber be contacted for additional Case Histories of grouting sinkholes in karst geology for further consideration.

3.) Deep chemical grouting to develop drainage curtain walls downstream from the dam. Areas noted on attached location plans.

4.) Extensive grouting similar to remediation activities conducted for previous karst feature remediation downstream and/or within reservoir. Areas noted on attached location plans.

Based on the 2009 remediation history and existing subsurface flow that developed after a period of 13 years, we recommend injecting a polyurethane resin at this time to minimize subsurface flows as mentioned. This approach incorporates additional deep remediation at a fraction of the cost of conventional pressure grouting. The resin can be properly mixed with an accelerant to cause a solid plug to set at a precise time to effectively fill the karst void(s) along the drainage path. Further, our review of products and procedures indicates that the resin can be pumped into the existing sinkhole, which avoids drilling injection borings along the dam embankment thereby reducing cost and time for completion. We suggest that a preferred Contractor be contacted to evaluate the site to determine a budget cost to restore the lakes level to near normal utilizing a polyurethane resin. Based on a quote for 500 gallons of bulk material, we estimate a cost to remediate Crystal Lake ranging between $60,000 and $380,000 depending on the severity of voids in the underlying karst geology. Upon completion, we recommend that the exposed throat of the sinkhole(s) be backfilled with a lean concrete (2000 psi concrete) amended with high yield bentonite gel (powder) at a typical rate of 50 pounds/cubic yard of concrete. This will provide a tight sealing plug that will promote public safety. Further site remediation work may be required in the future, as this approach will plug the current karst drainage path. Active maintenance, incorporating this or comparable techniques, may likely result in a lower total site remediation cost if future subsurface leaks develop. We recommend that Mr. Stuart Baber be invited to speak of this process at the next Homeowners Board Meeting based on his expertise and to answer questions accordingly.

VIOLA ENGINEERING, PC

LIMITATIONS

This report has been prepared in order to aid in the evaluation of this site and to assist remediation activities related to existing karst conditions. Our scope is limited to the specific project and location described, and the project description represents our understanding of the significant aspects relevant to soil and geologic characteristics. The interpretations and recommendations in this report are based solely on the information available at the time this report was prepared. Subsurface conditions may vary from those encountered at the survey locations.

Further exploration activities can be provided to aid in targeted remediation activities as site planning progresses. We appreciate the opportunity to provide engineering exploration services on this project. If we can be of any other assistance, please do not hesitate to contact us.

Respectfully,

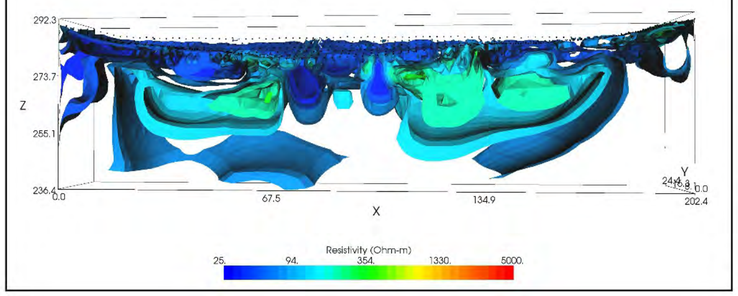
Mark A. Viola, PE
Owner, Principal Engineer

Timothy P. Viola, PE
Project Engineer

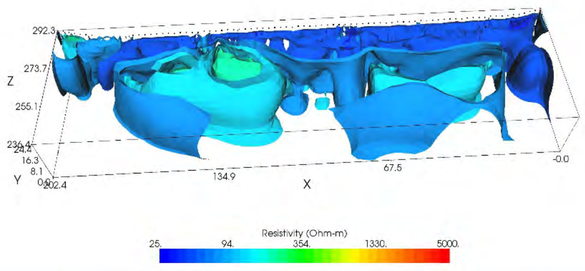
Attachments: Location Plan (1 Sheet, Raster)
Inverted Resistivity Sections (8 Sheets, Raster)
Location Plan & Inverted Resistivity Sections (External Link, Vector)
Certified Product Listing & SDS - AP Fill 720-Polyurethane Injection Resin
Case History - 2016 Leon Lake Emergency Seepage Repair Plan & Grout Plan

Location Plan &
Inverted Resistivity Sections

3D Resistivity Contour Plot



3D Resistivity Contour Plot



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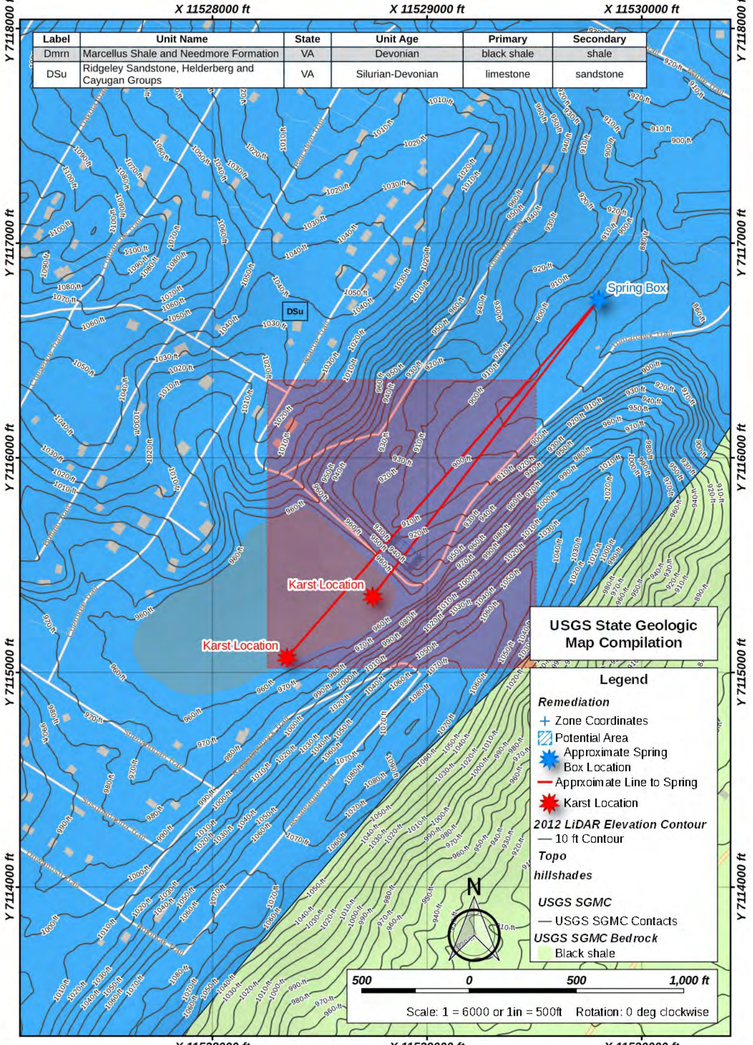
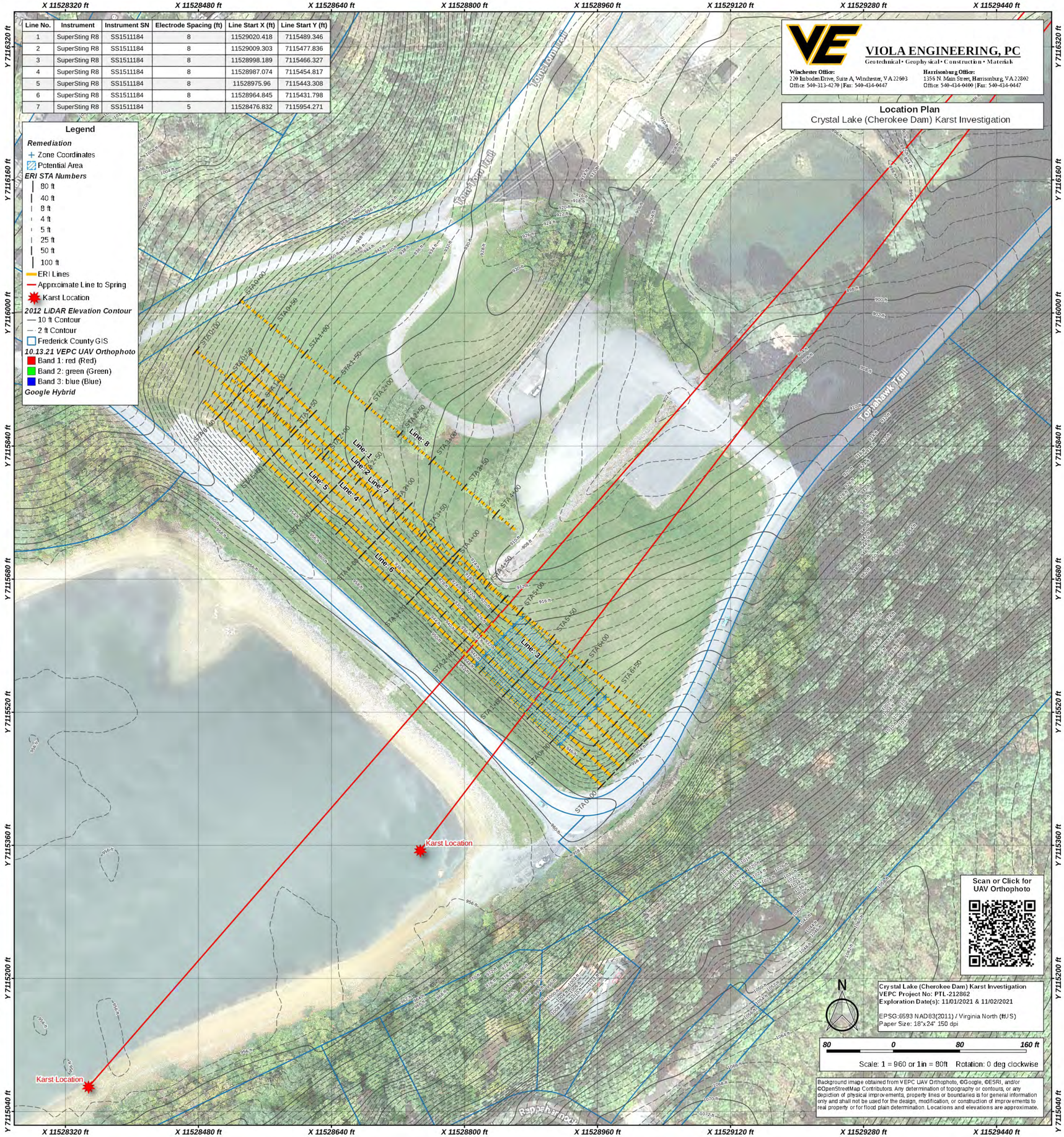
3	SuperSting R8	SS1511184	8	11528998.189	7115466.327
4	SuperSting R8	SS1511184	8	11528987.074	7115454.817
5	SuperSting R8	SS1511184	8	11528975.96	7115443.308
6	SuperSting R8	SS1511184	8	11528964.845	7115431.798
7	SuperSting R8	SS1511184	5	11528476.832	7115954.271

Label	Unit Name	State	Unit Age	Primary	Secondary
Dmrn	Marcellus Shale and Needmore Formation	VA	Devonian	black shale	shale
DSu	Ridgeley Sandstone, Helderberg and Cayugan Groups	VA	Silurian-Devonian	limestone	sandstone





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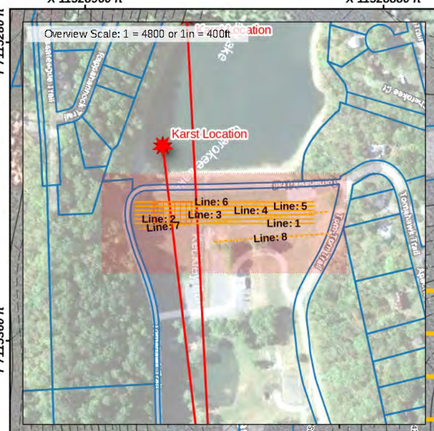
Location Plan
Crystal Lake (Cherokee Dam) Karst Investigation

X 11528960 ft | X 11528880 ft | X 11528800 ft | X 11528720 ft | X 11528640 ft | X 11528560 ft | X 11528480 ft | X 11528400 ft

Y 7115280 ft | Y 7115360 ft | Y 7115440 ft | Y 7115520 ft | Y 7115920 ft | Y 7116000 ft | Y 7116080 ft | Y 7116160 ft



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Inverted Resistivity Sections Line 1 of 8
Crystal Lake (Cherokee Dam) Karst Investigation

Legend

Remediation
- Zone Coordinates
- Potential Area

ERI STA Numbers
- 80 ft
- 40 ft
- 8 ft
- 4 ft
- 5 ft
- 25 ft
- 50 ft
- 100 ft

- ERI Lines
- Approximate Line to Spring
- Karst Location

2012 LiDAR Elevation Contour
- 10 ft Contour
- 2 ft Contour
- Frederick County GIS

Google Hybrid

Line: 1 | Line: 2 | Line: 3 | Line: 4 | Line: 5 | Line: 6 | Line: 7 | Line: 8

Tomahawk Trail | Keckley Run | Tuscarora Trail | Cherokee Trail

X 11529200 ft | X 11529120 ft | X 11529040 ft | X 11528960 ft | X 11528880 ft | X 11528800 ft | X 11528720 ft | X 11528640 ft

Crystal Lake (Cherokee Dam) Karst Investigation
VEPC Project No: PTL-212862
Exploration Date(s): 11/01/2021 & 11/02/2021

EPSG:6593 NAD83(2011) / Virginia North (ftUS)
Paper Size: 18"x24" 150 dpi

Line 1 - Inverted Resistivity Section
11/01/2021 - 11/02/2021 Viola Engineering, PC

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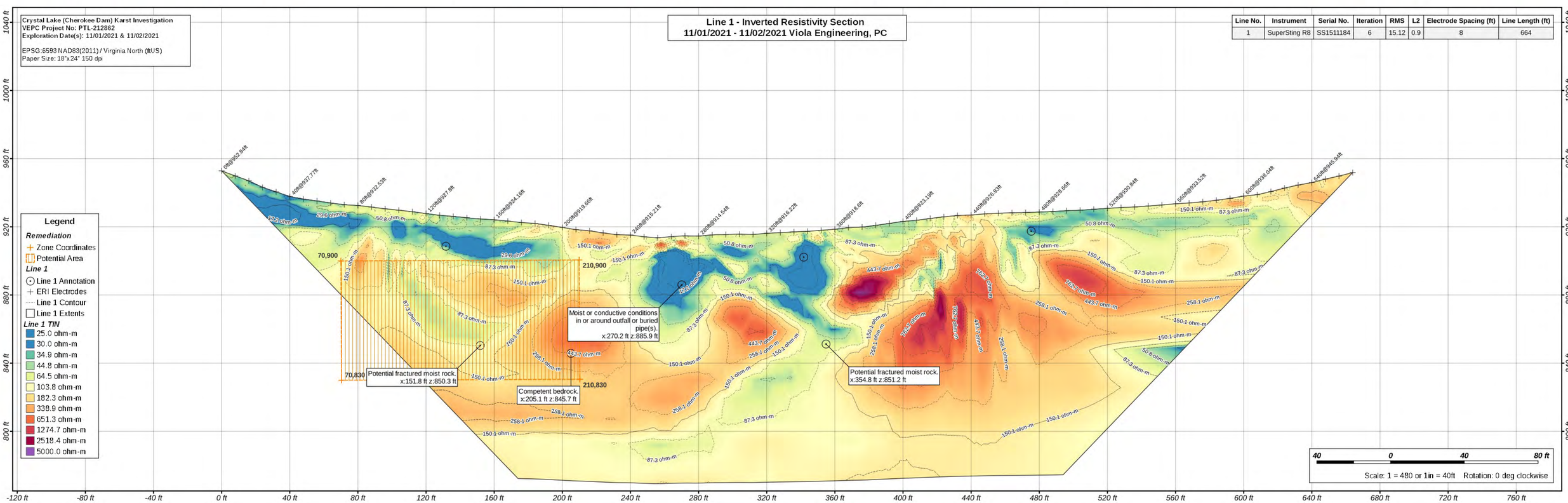


Legend

Remediation
- Zone Coordinates
- Potential Area

Line 1
- Line 1 Annotation
- ERI Electrodes
- Line 1 Contour
- Line 1 Extents

Line 1 TIN
- 25.0 ohm-m
- 30.0 ohm-m
- 34.9 ohm-m
- 44.8 ohm-m
- 64.5 ohm-m
- 103.8 ohm-m
- 182.3 ohm-m
- 338.9 ohm-m
- 651.3 ohm-m
- 1274.7 ohm-m
- 2518.4 ohm-m
- 5000.0 ohm-m

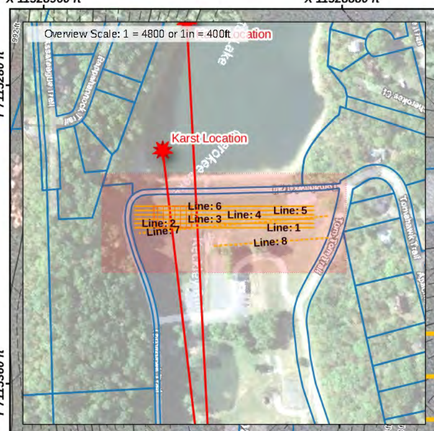
40 0 40 80 ft
Scale: 1 = 480 or 1in = 40ft Rotation: 0 deg clockwise

1040 ft | 1000 ft | 960 ft | 920 ft | 880 ft | 840 ft | 800 ft

-120 ft | -80 ft | -40 ft | 0 ft | 40 ft | 80 ft | 120 ft | 160 ft | 200 ft | 240 ft | 280 ft | 320 ft | 360 ft | 400 ft | 440 ft | 480 ft | 520 ft | 560 ft | 600 ft | 640 ft | 680 ft | 720 ft | 760 ft

X 11528960 ft | X 11528880 ft | X 11528800 ft | X 11528720 ft | X 11528640 ft | X 11528560 ft | X 11528480 ft | X 11528400 ft | X 11528320 ft

Y 7115280 ft | Y 7115360 ft | Y 7115440 ft | Y 7115520 ft | Y 7115920 ft | Y 7116000 ft | Y 7116080 ft



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Inverted Resistivity Sections Line 2 of 8
Crystal Lake (Cherokee Dam) Karst Investigation

Legend

Remediation
- Zone Coordinates
- Potential Area

ERI STA Numbers
- 80 ft
- 40 ft
- 8 ft
- 4 ft
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Line: 1 | Line: 2 | Line: 3 | Line: 4 | Line: 5 | Line: 6 | Line: 7 | Line: 8

Tomahawk Trail | Cherokee Run | Tomahawk Trail

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X 11529200 ft | X 11529120 ft | X 11529040 ft | X 11528960 ft | X 11528880 ft | X 11528800 ft | X 11528720 ft | X 11528640 ft

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11/01/2021 - 11/02/2021 Viola Engineering, PC

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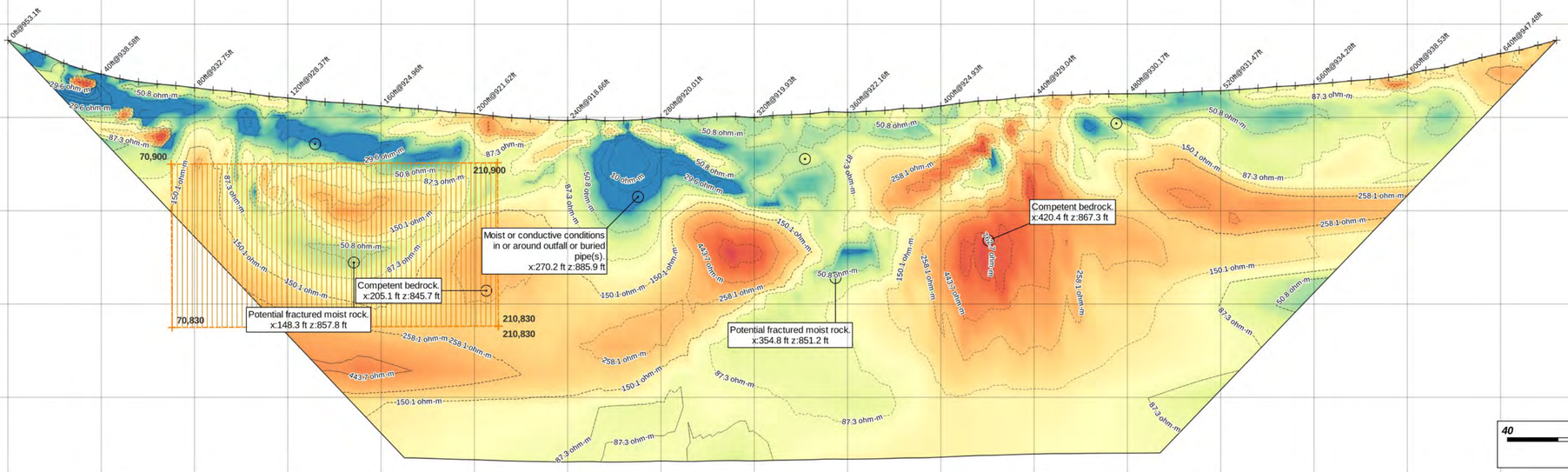

Legend

Remediation
- Zone Coordinates
- Potential Area

Line 2
- Line 2 Annotation
- ERI Electrodes
- Line 2 Contour
- Line 2 Extents

Line 2 TIN
- 25.0 ohm-m
- 30.0 ohm-m
- 34.9 ohm-m
- 44.8 ohm-m
- 64.5 ohm-m
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1040 ft | 1000 ft | 960 ft | 920 ft | 880 ft | 840 ft | 800 ft

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Inverted Resistivity Sections Line 3 of 8
Crystal Lake (Cherokee Dam) Karst Investigation

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Paper Size: 18"x24" 150 dpi

Line 3 - Inverted Resistivity Section
11/01/2021 - 11/02/2021 Viola Engineering, PC

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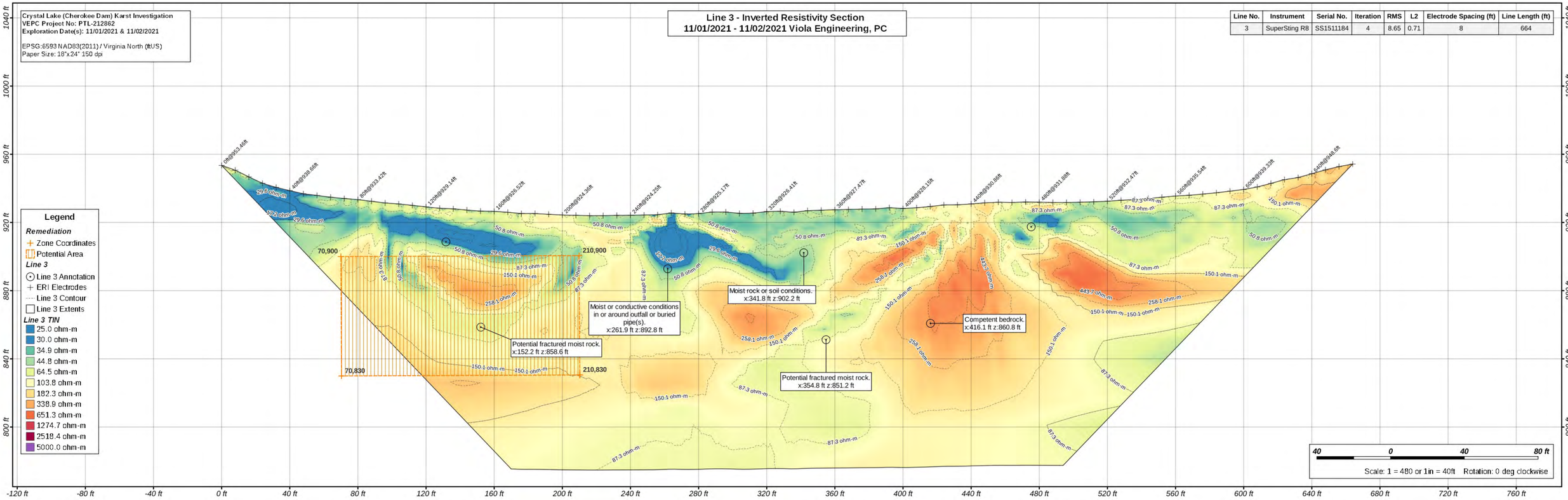

Legend

Remediation
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Line 3
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- Line 3 Contour
- Line 3 Extents

Line 3 TIN
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- 64.5 ohm-m
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Inverted Resistivity Sections Line 4 of 8
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Tomahawk Trail | Tomahawk Trail | Tomahawk Trail | Tomahawk Trail | Tomahawk Trail

Cherokee Run | Cherokee Run

STA0+80 | STA1+60 | STA2+40 | STA3+20 | STA4+00 | STA4+80 | STA5+60 | STA6+40

STA0+00 | STA0+50 | STA1+00 | STA1+50 | STA2+00 | STA2+50 | STA3+00 | STA3+50 | STA4+00 | STA4+50 | STA5+00 | STA5+50 | STA6+00 | STA6+50

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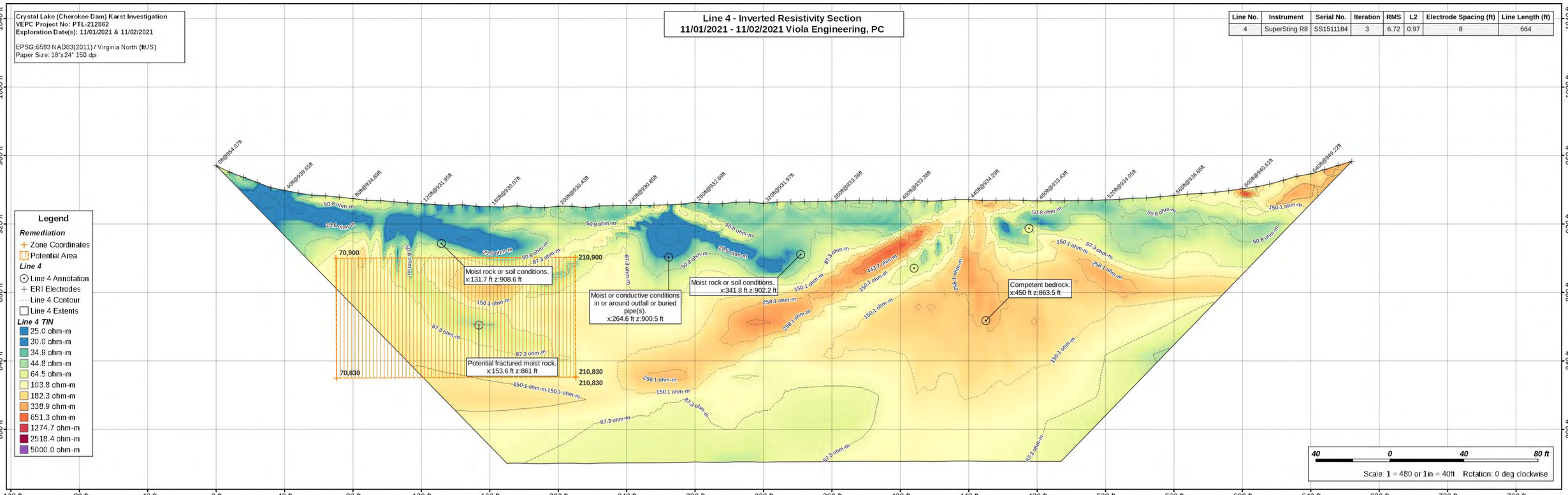
Line 4 - Inverted Resistivity Section
11/01/2021 - 11/02/2021 Viola Engineering, PC

Line No.	Instrument	Serial No.	Iteration	RMS	L2	Electrode Spacing (ft)	Line Length (ft)
4	SuperSting R8	SS1511184	3	6.72	0.97	8	664



Legend

Remediation
- Zone Coordinates
- Potential Area

Line 4
- Line 4 Annotation
- ERI Electrodes
- Line 4 Contour
- Line 4 Extents

Line 4 TIN
- 25.0 ohm-m
- 30.0 ohm-m
- 34.9 ohm-m
- 44.8 ohm-m
- 64.5 ohm-m
- 103.8 ohm-m
- 182.3 ohm-m
- 338.9 ohm-m
- 651.3 ohm-m
- 1274.7 ohm-m
- 2518.4 ohm-m
- 5000.0 ohm-m

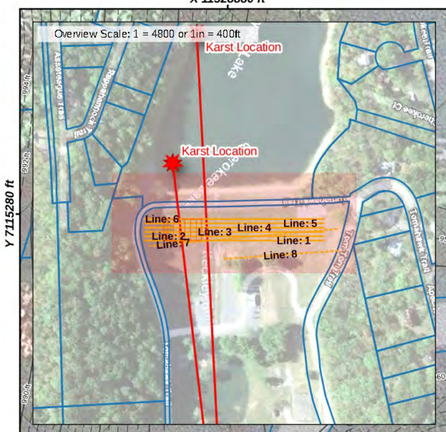
40 0 40 80 ft
Scale: 1 = 480 or 1in = 40ft Rotation: 0 deg clockwise

1040 ft | 1000 ft | 960 ft | 920 ft | 880 ft | 840 ft | 800 ft

-120 ft | -80 ft | -40 ft | 0 ft | 40 ft | 80 ft | 120 ft | 160 ft | 200 ft | 240 ft | 280 ft | 320 ft | 360 ft | 400 ft | 440 ft | 480 ft | 520 ft | 560 ft | 600 ft | 640 ft | 680 ft | 720 ft | 760 ft

X 11528880 ft | X 11528800 ft | X 11528720 ft | X 11528640 ft | X 11528560 ft | X 11528480 ft | X 11528400 ft | X 11528320 ft

Y 7115280 ft | Y 7115360 ft | Y 7115440 ft | Y 7115920 ft | Y 7116000 ft | Y 7116080 ft



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Office: 540-313-4270 | Fax: 540-434-0447

Harrisonburg Office:
1356 N. Main Street, Harrisonburg, VA 22802
Office: 540-434-0400 | Fax: 540-434-0447

Inverted Resistivity Sections Line 5 of 8
Crystal Lake (Cherokee Dam) Karst Investigation

Legend

Remediation
- Zone Coordinates
- Potential Area

ERI STA Numbers
- 80 ft
- 40 ft
- 8 ft
- 4 ft
- 5 ft
- 25 ft
- 50 ft
- 100 ft

- ERI Lines
- Approximate Line to Spring
- Karst Location

2012 LiDAR Elevation Contour
- 10 ft Contour
- 2 ft Contour
- Frederick County GIS

Google Hybrid

Line: 6 | Line: 5 | Line: 4 | Line: 3 | Line: 2 | Line: 1 | Line: 7 | Line: 8

Tomahawk Trail | Keokee Run | Crystal Lake

X 11529120 ft | X 11529040 ft | X 11528960 ft | X 11528880 ft | X 11528800 ft | X 11528720 ft | X 11528640 ft | X 11528560 ft

Crystal Lake (Cherokee Dam) Karst Investigation
VEPC Project No: PTL-212862
Exploration Date(s): 11/01/2021 & 11/02/2021

EPSG:6593 NAD83(2011) / Virginia North (ftUS)
Paper Size: 18"x24" 150 dpi

Line 5 - Inverted Resistivity Section
11/01/2021 - 11/02/2021 Viola Engineering, PC

Line No.	Instrument	Serial No.	Iteration	RMS	L2	Electrode Spacing (ft)	Line Length (ft)
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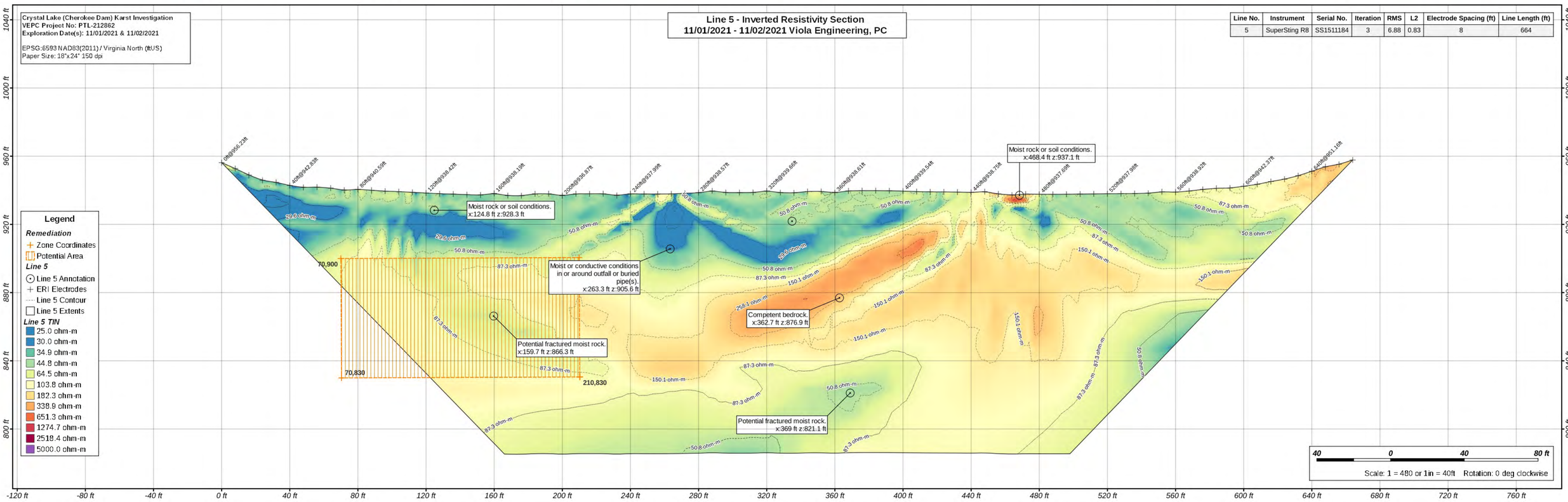

Legend

Remediation
- Zone Coordinates
- Potential Area

Line 5
- Line 5 Annotation
- ERI Electrodes
- Line 5 Contour
- Line 5 Extents

Line 5 TIN
- 25.0 ohm-m
- 30.0 ohm-m
- 34.9 ohm-m
- 44.8 ohm-m
- 64.5 ohm-m
- 103.8 ohm-m
- 182.3 ohm-m
- 338.9 ohm-m
- 651.3 ohm-m
- 1274.7 ohm-m
- 2518.4 ohm-m
- 5000.0 ohm-m

1040 ft | 1000 ft | 960 ft | 920 ft | 880 ft | 840 ft | 800 ft

-120 ft | -80 ft | -40 ft | 0 ft | 40 ft | 80 ft | 120 ft | 160 ft | 200 ft | 240 ft | 280 ft | 320 ft | 360 ft | 400 ft | 440 ft | 480 ft | 520 ft | 560 ft | 600 ft | 640 ft | 680 ft | 720 ft | 760 ft

40 0 40 80 ft

Scale: 1 = 480 or 1in = 40ft Rotation: 0 deg clockwise

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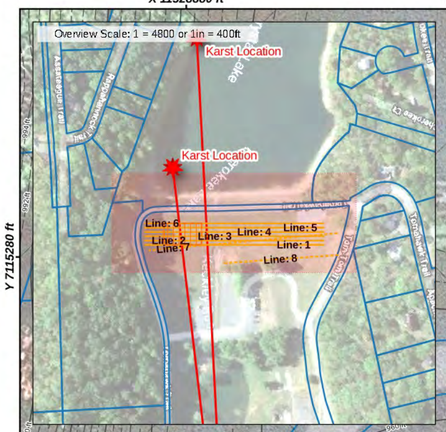
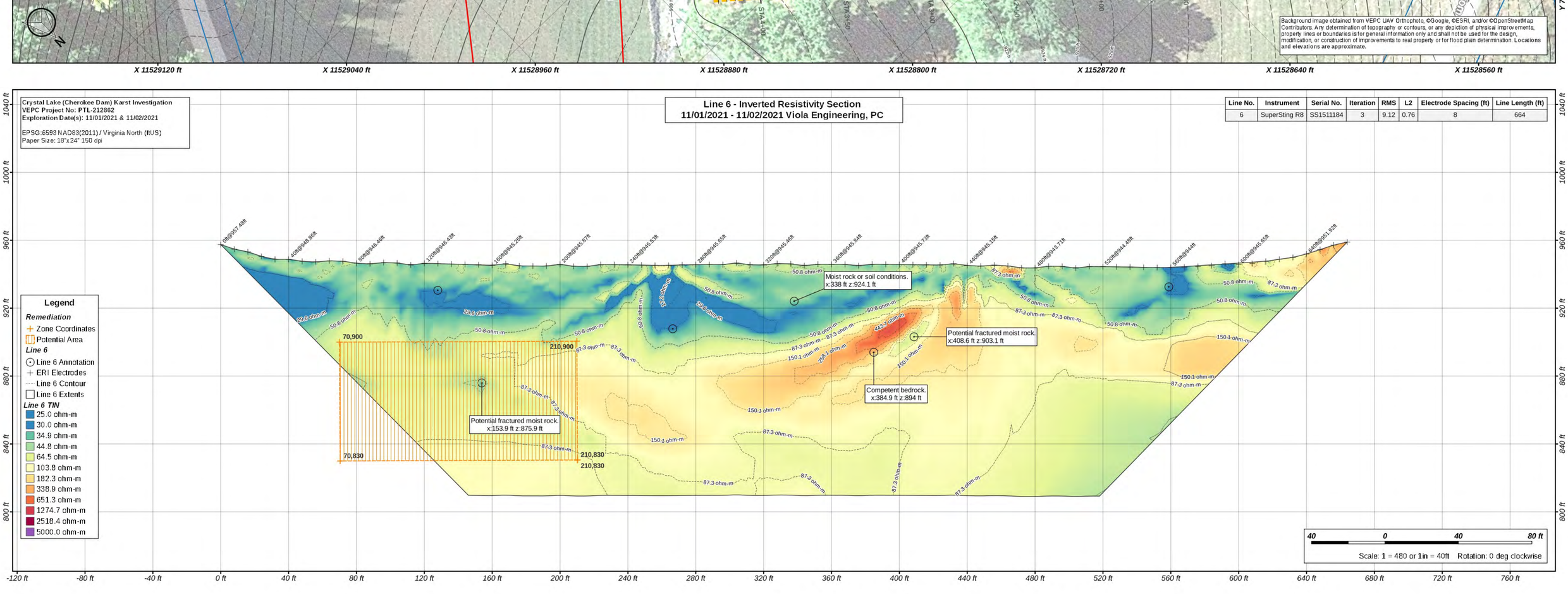
Inverted Resistivity Sections Line 6 of 8
Crystal Lake (Cherokee Dam) Karst Investigation

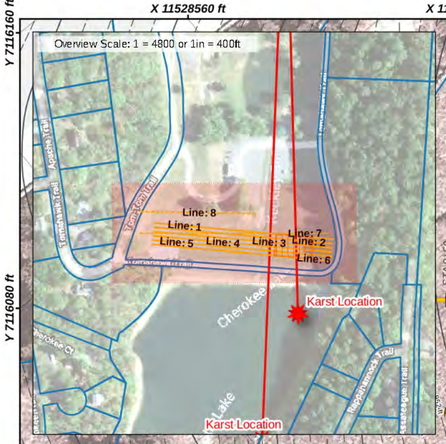




Line No.	Instrument	Serial No.	Iteration	RMS	L2	Electrode Spacing (ft)	Line Length (ft)
6	SuperSting R8	SS1511184	3	9.12	0.76	8	664

X 11528560 ft | X 11528640 ft | X 11528720 ft | X 11528800 ft | X 11528880 ft | X 11528960 ft | X 11529040 ft | X 11529120 ft | X 11529200 ft

Y 7116160 ft | Y 7116080 ft | Y 7116000 ft | Y 7115920 ft | Y 7115520 ft | Y 7115440 ft | Y 7115360 ft



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Inverted Resistivity Sections Line 7 of 8
Crystal Lake (Cherokee Dam) Karst Investigation

Legend

ERI STA Numbers
- 80 ft
- 40 ft
- 8 ft
- 4 ft
- 5 ft
- 25 ft
- 50 ft
- 100 ft

ERI Lines
Approximate Line to Spring
Karst Location

2012 LiDAR Elevation Contour
- 10 ft Contour
- 2 ft Contour
- Frederick County GIS

B-1 | B-2 | B-3

RL-1 | RL-2 | RL-3 | RL-4 | RL-5

270°

Line: 1 | Line: 2 | Line: 3 | Line: 4 | Line: 5 | Line: 6 | Line: 7 | Line: 8

Location plan is approximate
Base plan provided by County

Background image obtained from VEPC UAV Orthophoto, ©Google, ©ESRI, and/or ©OpenStreetMap Contributors. Any determination of topography or contours, or any depiction of physical improvements, property lines or boundaries is for general information only and shall not be used for the design, modification, or construction of improvements to real property or for flood plain determination. Locations and elevations are approximate.

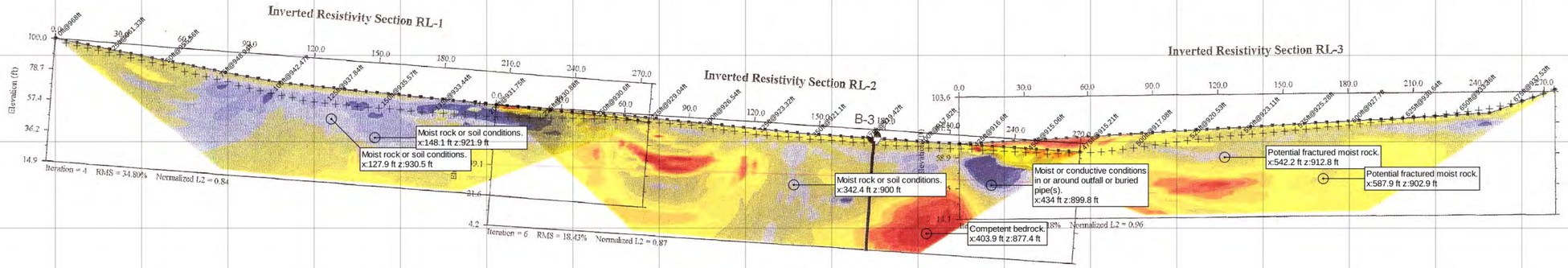
X 11528320 ft | X 11528400 ft | X 11528480 ft | X 11528560 ft | X 11528640 ft | X 11528720 ft | X 11528800 ft | X 11528880 ft | X 11528960 ft

Crystal Lake (Cherokee Dam) Karst Investigation
VEPC Project No: PTL-212862
Exploration Date(s): 11/01/2021 & 11/02/2021

EPSG:6593 NAD83(2011) / Virginia North (ftUS)
Paper Size: 18"x24" 150 dpi

Line 7 - Inverted Resistivity Section
11.14.07 Triad Engineering, Inc.

Line No.	Instrument	Serial No.	Iteration	RMS	L2	Electrode Spacing (ft)	Line Length (ft)



Legend

Line 7
- Line 7 Annotation
- ERI Electrodes

40 0 40 80 ft

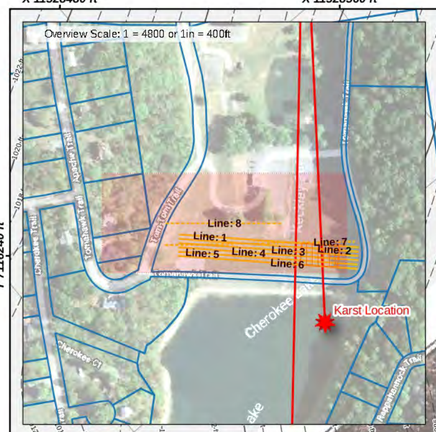
Scale: 1 = 480 or 1in = 40ft Rotation: 0 deg clockwise

1040 ft | 1000 ft | 960 ft | 920 ft | 880 ft | 840 ft | 800 ft

-80 ft | -40 ft | 0 ft | 40 ft | 80 ft | 120 ft | 160 ft | 200 ft | 240 ft | 280 ft | 320 ft | 360 ft | 400 ft | 440 ft | 480 ft | 520 ft | 560 ft | 600 ft | 640 ft | 680 ft | 720 ft | 760 ft | 800 ft

X 11528480 ft | X 11528560 ft | X 11528640 ft | X 11528720 ft | X 11528800 ft | X 11528880 ft | X 11528960 ft | X 11529040 ft | X 11529120 ft

Y 7116240 ft | Y 7116160 ft | Y 7116080 ft | Y 7115680 ft | Y 7115600 ft | Y 7115520 ft



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Inverted Resistivity Sections Line 8 of 8
Crystal Lake (Cherokee Dam) Karst Investigation

Legend

ERI STA Numbers
- 80 ft
- 40 ft
- 8 ft
- 4 ft
- 5 ft
- 25 ft
- 50 ft
- 100 ft

ERI Lines
Approximate Line to Spring
Karst Location

2012 LiDAR Elevation Contour
- 10 ft Contour
- 2 ft Contour
- Frederick County GIS

B-1 | B-2 | B-3
RL-1 | RL-2 | RL-3 | RL-4 | RL-5
Line: 8 | Line: 1 | Line: 2 | Line: 3 | Line: 4 | Line: 5 | Line: 6 | Line: 7
270°

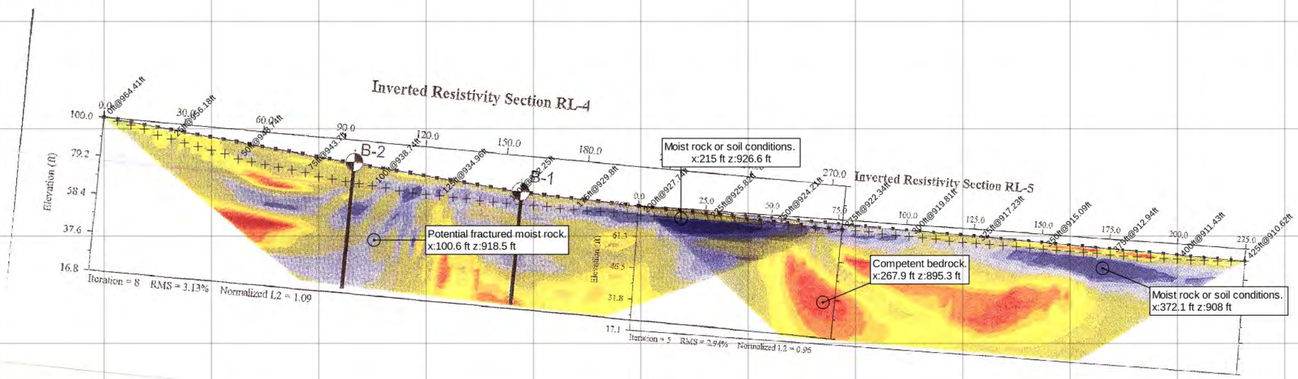
X 11528240 ft | X 11528320 ft | X 11528400 ft | X 11528480 ft | X 11528560 ft | X 11528640 ft | X 11528720 ft | X 11528800 ft | X 11528880 ft

Crystal Lake (Cherokee Dam) Karst Investigation
VEPC Project No: PTL-212862
Exploration Date(s): 11/01/2021 & 11/02/2021

EPSG:6593 NAD83(2011) / Virginia North (ftUS)
Paper Size: 18"x24" 150 dpi

Line 8 - Inverted Resistivity Section
11.14.07 Triad Engineering, Inc.

Line No.	Instrument	Serial No.	Iteration	RMS	L2	Electrode Spacing (ft)	Line Length (ft)



Legend

Line 8
- Line 8 Annotation
- ERI Electrodes

1040 ft | 1000 ft | 960 ft | 920 ft | 880 ft | 840 ft | 800 ft

-200 ft | -160 ft | -120 ft | -80 ft | -40 ft | 0 ft | 40 ft | 80 ft | 120 ft | 160 ft | 200 ft | 240 ft | 280 ft | 320 ft | 360 ft | 400 ft | 440 ft | 480 ft | 520 ft | 560 ft | 600 ft | 640 ft

40 0 40 80 ft

Scale: 1 = 480 or 1in = 40ft Rotation: 0 deg clockwise

Certified Product Listing & SDS

TRUESDAIL LABORATORIES, INC.
3337 MICHELSON DRIVE, SUITE CN 750, IRVINE, CA 92612

Certified Product Listing

For:
Drinking Water System Components – Health Effects

Company:
Alchemy Spetec, LLC
4508 Bibb Blvd
Suite B-5
Tucker, GA 30084, United States

Plant Location:
Tucker, GA, United States

Standards:
NSF/ANSI/CAN 61 - 2018

Certificate:
Issued Date: 06/19/2018

Material/Product:
AP Fill 720- Polyurethane Injection resin

Contact Temperature:
23 ± 2°C

Models:
AP Fill 720

Maximum surface area in contact with water shall not exceed more than 1% of the total surface area.

Material Characteristics:

Minimum tank size (gallons): 4000

Maximum tank surface area/volume ratio (sq in/L): 3.6

Is additional coating required (e.g. top coat, primer, intermediate coat)? (Y/N): Select

Total cure time and temperature: 24 hrs at 23 ± 2 °C

Final cure time: 24 hrs at 23 ± 2 °C

Mix ratio: 18:1:1

Is this paint/coating system intended to be applied to a pipe? (Y/N): No

Safety Data Sheet
AP Fill 720

SECTION 1: Identification

Product identifier

Product name	AP Fill 720

Recommended use of the chemical and restrictions on use
Stabilization and cut-off of large water leaks

Supplier's details

Name	Alchemy-Spetec
Address	4508 Bibb Blvd Tucker GA 30084
Telephone	(404) 618-0438

Emergency phone number(s)

Call CHEMTREC Day or Night
1-800-424-9300 / +1 703-527-3887

SECTION 2: Hazard identification

Classification of the substance or mixture

GHS classification in accordance with: OSHA (29 CFR 1910.1200)

- Acute toxicity, inhalation, Cat. 4
- Carcinogenicity, Cat. 2
- Sensitization, respiratory, Cat. 1
- Eye damage/irritation, Cat. 2A
- Skin corrosion/irritation, Cat. 2
- Sensitization, skin, Cat. 1
- Specific target organ toxicity (repeated exposure), Cat. 2
- Specific target organ toxicity (single exposure), Cat. 3

GHS label elements, including precautionary statements

Pictogram

Signal word **Danger**

Hazard statement(s)

H315	Causes skin irritation
H317	May cause an allergic skin reaction
H319	Causes serious eye irritation
H332	Harmful if inhaled
H334	May cause allergy or asthma symptoms or breathing difficulties if inhaled
H335	May cause respiratory irritation
H351	Suspected of causing cancer
H373	May cause damage to organs (Respiratory system) through prolonged or repeated exposure

Precautionary statement(s)

P201	Obtain special instructions before use.
P202	Do not handle until all safety precautions have been read and understood.
P260	Do not breathe dust/fume/gas/mist/vapors/spray.
P264	Wash hands thoroughly after handling.
P271	Use only outdoors or in a well-ventilated area.
P272	Contaminated work clothing must not be allowed out of the workplace.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P284	[In case of inadequate ventilation] wear respiratory protection.
P302+P352	IF ON SKIN: Wash with plenty of water.
P304+P340	IF INHALED: Remove person to fresh air and keep comfortable for breathing.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present and easy to do. Continue rinsing.
P308+P313	IF exposed or concerned: Get medical advice/attention.
P312	Call a POISON CENTER or doctor if you feel unwell.
P314	Get medical advice/attention if you feel unwell.
P333+P313	If skin irritation or rash occurs: Get medical advice/attention.
P337+P313	If eye irritation persists: Get medical advice/attention.
P342+P311	If experiencing respiratory symptoms: Call a POISON CENTER or doctor.
P362+P364	Take off contaminated clothing and wash it before reuse.
P363	Wash contaminated clothing before reuse.
P403+P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

SECTION 3: Composition/information on ingredients

Mixtures

Hazardous components

Component	Concentration
Diphenylmethane Diisocyanate (MDI) Mixed Isomers (CAS no.: 26447-40-5; EC no.: 247-714-0)	**5 - 25 % (weight)***
4,4' Diphenylmethanediisocyanate, isomere, homologe and mixtures (pMDI) (CAS no.: 9016-87-9)	**5 – 25 % (weight)***
Propylene carbonate (CAS no.: 108-32-7; EC no.: 203-572-1; Index no.: 607-194-00-1)	**5 – 15 % (weight)***
4,4'-Methylenediphenyl diisocyanate (MDI) (CAS no.: 101-68-8; EC no.: 202-966-0)	**1 – 5 % (weight)***
Benzene, 1,1'-methylenebis[isocyanato-, homopolymer (CAS no.: 39310-05-9)	**0.5 - 3 % (weight)***
2,4'-Diphenylmethane diisocyanate (CAS no.: 5873-54-1; EC no.: 227-534-9)	**0.< 1 % (weight)***

Trade secret statement (OSHA 1910.1200(i))

*The specific chemical identities and/or actual concentrations or actual concentration ranges for one or more listed components are being withheld as trade secrets under the US regulation 29 CFR 1910.1200(i).

SECTION 4: First-aid measures

Description of necessary first-aid measures

General advice	Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area. First Aid responders should pay attention to self-protection and use the recommended protective clothing (chemical resistant gloves, splash protection). If potential for exposure exists refer to Section 8 for specific personal protective equipment.
If inhaled	If inhaled: Remove person to fresh air and keep comfortable for breathing. If not breathing, give artificial respiration; if by mouth to mouth use rescuer protection (pocket mask, etc). If breathing is difficult, oxygen should be administered by qualified personnel. Call a physician or transport to a medical facility. Acute and delayed symptoms: Harmful if inhaled. May cause allergy or asthma symptoms or breathing difficulties if inhaled. May cause respiratory irritation.
In case of skin contact	Remove from skin immediately with soap and plenty of water. Take off immediately all contaminated clothing while washing. Wash contaminated clothing before reuse. Discard items which cannot be decontaminated, including leather articles such as shoes, belts and watchbands. If skin irritation or rash occurs: Get medical advice/attention. Acute and delayed symptoms and effects: Causes skin irritation. Signs/symptoms may include localized redness, swelling, and itching. May cause an allergic skin reaction.
In case of eye contact	Rinse cautiously with water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Product reacts with moisture in eye! Immediately seek medical attention. Suitable emergency eye wash facility should be immediately available. Acute and delayed symptoms and effects: Causes serious eye damage. Product reacts with moisture in eye! Signs/symptoms may include cloudy appearance of the cornea, chemical burns, severe pain, tearing, ulcerations, significantly impaired vision or complete loss of vision.
If swallowed	SEEK IMMEDIATE MEDICAL ATTENTION! DELAYED TREATMENT MAY RESULT IN FATALITY. Do Not Induce Vomiting. Rinse mouth out with water. Aspiration of material into the lungs due to vomiting can cause chemical pneumonitis which can be fatal.

Most important symptoms/effects, acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2) and/or in section 11

Indication of immediate medical attention and special treatment needed, if necessary
Maintain adequate ventilation and oxygenation of the patient. May cause respiratory sensitization or asthma-like symptoms. Bronchodilators, expectorants and antitussives may be of help. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids. Respiratory symptoms, including pulmonary edema, may be delayed. Persons receiving significant exposure should be observed 24-48 hours for signs of respiratory distress. If you are sensitized to diisocyanates, consult your physician regarding working with other respiratory irritants or sensitizers. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

Excessive exposure may aggravate preexisting asthma and other respiratory disorders (e.g. emphysema, bronchitis, reactive airways dysfunction syndrome).

SECTION 5: Fire-fighting measures

Suitable extinguishing media
Use water fog, carbon dioxide or dry chemical. Water contamination in a closed container or a confined area is to be avoided due to the exothermic CO2 evolution upon water contamination.

Specific hazards arising from the chemical
During a fire, smoke may contain the original material in addition to combustion products of varying composition which may be toxic and/or irritating. Combustion products may include and are not limited to: Nitrogen oxides. Isocyanates. Hydrogen cyanide. Carbon monoxide. Carbon dioxide.

Special protective actions for fire-fighters
Do not scatter material with high pressure water streams. Firefighters should wear NFPA compliant structural firefighting protective equipment, including self-contained breathing apparatus and NFPA compliant helmet, hood, boots and gloves. Avoid contact with product. Decontaminate equipment and protective clothing prior to reuse. During a fire, isocyanate vapors and other irritating, highly toxic gases may be generated by thermal decomposition or combustion. Exposure to heated diisocyanate can be extremely dangerous. Closed container may forcibly rupture under extreme heat or when contents are contaminated with water (CO2 formed). Use cold-water spray to cool fire-exposed containers to minimize the risk of rupture. Large fires can be extinguished with large volumes of water applied from a safe distance, since reaction between water and hot diisocyanate can be vigorous.

Further information
Use water spray to cool unopened containers.

SECTION 6: Accidental release measures

Personal precautions, protective equipment and emergency procedures
Isolate area. Keep unnecessary and unprotected personnel from entering the area. Keep personnel out of low areas. Keep upwind of spill. Spilled material may cause a slipping hazard. Ventilate area of leak or spill. Where exposure level is known, wear approved respirator suitable for the level of exposure. If exposure level is unknown, wear approved, positive pressure, self-contained respirator. In addition to the protective clothing in section 8, wear impermeable boots.

Environmental precautions
Prevent unreacted product from entering into soil, ditches, sewers, waterways and/or groundwater. See Section 12, Ecological Information.

Methods and materials for containment and cleaning up
Remove sources of ignition. Stop and contain / dam the spill. Absorb spill with inert material (vermiculite / diatomaceous earth). Shovel material into appropriate container for disposal. Do not place in sealed containers as it may still be reacting and could rupture.

SECTION 7: Handling and storage

Precautions for safe handling
Do not breathe vapors, mists, or dusts. Use adequate ventilation to keep airborne isocyanate levels below the exposure limits. Wear respiratory protection if material is heated, sprayed, used in a confined space, or if the exposure limit is exceeded. Warning properties (irritation of the eyes, nose and throat or odor) are not adequate to prevent overexposure from inhalation. This material can produce asthmatic sensitization upon either single inhalation exposure to a relatively high concentration or upon repeated inhalation exposures to lower concentrations. Individuals with lung or breathing problems or prior allergic reactions to isocyanates must not be exposed to vapor or spray mist. Avoid contact with skin and eyes. Wear appropriate eye and skin protection.

Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Wash thoroughly after handling. Do not breathe smoke and gases created by overheating or burning this material. Decomposition products can be highly toxic and irritating. Store in tightly closed containers to prevent moisture contamination. Do not reseal if contamination is suspected.

Conditions for safe storage, including any incompatibilities
Keep in manufacturer's sealed nitrogen packed pail. Maintain storage temperatures between 65˚F to 86˚F (18˚C to 30˚C). Store in a dry place. Protect from atmospheric moisture. Do not store product contaminated with water to prevent potential hazardous reaction. See Section 10 for more specific information.

Specific end use(s)
See the technical data sheet on this product for further information.

SECTION 8: Exposure controls/personal protection

Control parameters

CAS: 101-68-8
Methylene bisphenyl isocyanate (MDI)
ACGIH: 0.005 ppm TLV® inhalation; Cal/OSHA: 0.005 ppm PEL inhalation; NIOSH: 0.05 mg/m3, (C) 0.2 mg/m3 [10-min] REL inhalation; OSHA: (C) 0.02 ppm PEL inhalation; (C) 0.2 mg/m3 PEL inhalation

CAS: 26447-40-5 (EC: 247-714-0)
Diphenylmethane Diisocyanate (MDI) Mixed Isomers
OSHA: 0.005 ppm; 0.051 mg/m3 PEL-TWA inhalation; 0.005 ppm; 0.051 mg/m3 TLV® inhalation

Appropriate engineering controls
Use only with adequate ventilation. Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines. Exhaust systems should be designed to move the air away from the source of vapor/aerosol generation and people working at this point. The odor and irritancy of this material are inadequate to warn of excessive exposure. Local exhaust ventilation may be necessary for some operations.

Individual protection measures, such as personal protective equipment (PPE)

Eye/face protection
Safety glasses. If splash hazard, wear faceshield (8-inch minimum). Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU). Ensure that eyewash stations and/or safety showers are close to the workstation location if working with concentrated product.

Skin protection
Wear protective gloves. Consult manufacturer specifications for further information. In cured form, the product is difficult to remove from skin and hair.

Body protection
Wear protective clothing. Clothing with full length sleeves and pants should be worn. Selection of additional items such as face shield, boots, apron, or full body suit will depend on the task.

Respiratory protection
Atmospheric levels should be maintained below the exposure guideline. When atmospheric levels may exceed the exposure guideline, use an approved air-purifying respirator equipped with an organic vapor sorbent and a particle filter. For situations where the atmospheric levels may exceed the level for which an air-purifying respirator is effective, use a positive-pressure air-supplying respirator (air line or self-contained breathing apparatus). For emergency response or for situations where the atmospheric level is unknown, use an approved positive-pressure

self-contained breathing apparatus or positive pressure air line with auxiliary self-contained air supply. Use the following CE approved air-purifying respirator: Organic vapor cartridge with a particulate pre-filter, type AP2.

Environmental exposure controls
Do not let uncured product enter drains.

SECTION 9: Physical and chemical properties

Information on basic physical and chemical properties

Appearance/form (physical state, color, etc.)	Liquid
Odor	Characteristic
Odor threshold	No data available.
pH	No data available.
Melting point/freezing point	No data available.
Initial boiling point and boiling range	242 °C
Flash point	No data available.
Evaporation rate	No data available.
Flammability (solid, gas)	Non-flammable
Upper/lower flammability limits	No data available.
Upper/lower explosive limits	No data available.
Vapor pressure	3 Pa
Vapor density	No data available.
Relative density	1.046
Solubility(ies)	Not soluble in water
Partition coefficient: n-octanol/water	No data available.
Auto-ignition temperature	330 °C
Decomposition temperature	No data available.
Viscosity	Dynamic: 198 mPa.s (20 °C) Kinematic: 189 mPa.s (20 °C)
Explosive properties	No data available.
Oxidizing properties	No data available.

SECTION 10: Stability and reactivity

Reactivity
Contact with moisture or temperatures above 350˚ F (177˚ C) will cause polymerization.

Chemical stability
Stable under recommended storage conditions. See Storage, Section 7.

Possibility of hazardous reactions
Can occur. Exposure to elevated temperatures can cause product to decompose and generate gas. This can cause pressure build-up and/or rupturing of closed containers. Polymerization can be catalyzed by: Strong bases. Water.

Conditions to avoid
Exposure to elevated temperatures can cause product to decompose. Generation of gas during decomposition can cause pressure in closed systems. Pressure build-up can be rapid. Avoid moisture. Material reacts slowly with water, releasing carbon dioxide which can cause pressure buildup and rupture of closed containers. Elevated temperatures accelerate this reaction.

Incompatible materials
Acids. Alcohols. Amines. Water. Ammonia. Bases. Metal compounds. Moist air. Strong oxidizers.

Hazardous decomposition products
Decomposition products depend upon temperature, air supply and the presence of other materials. Gases are released during decomposition.

SECTION 11: Toxicological information

Information on toxicological effects

Acute toxicity
Likely Routes of Exposure: Eye contact. Skin contact. Inhalation. Ingestion.

Components:

4,4’ diphenylmethanediisocyanate, isomere, homologue and mixtures
LD50 Inhalation - Rat - 0.49 mg/l - 4 h
LD50 Skin - Rabbit - > 9400 mg/kg
LD50 Oral - Rat - 49000 mg/kg

4,4′-Methylenebis(phenyl isocyanate)
LD50 Oral - Rat - 9,200 mg/kg
LC50 Inhalation - Rat - > 2.24 mg/l - 1 hr

Benzene, 1,1'-methylenebis[isocyanato-, homopolymer
LD50 Oral - Rat - > 5,000 mg/kg
LD50 Skin - Rabbit - > 9,400 mg/kg

Diphenylmethane Diisocyanate (MDI) Mixed Isomers
LD50 Oral - Rat - > 2,000 mg/kg
LD50 Skin - Rabbit - > 9,400 mg/kg
LC50 Inhalation - Rat - 2.24 mg/l - 1 h

Propylene carbonate
LD50 Oral - Rat - > 5,000 mg/kg
LD50 Skin - Rabbit - > 2,000 mg/kg

Acute oral toxicity
Low toxicity if swallowed. Small amounts swallowed incidentally as a result of normal handling operations are not likely to cause injury; however, swallowing larger amounts may cause injury.

Acute dermal toxicity
Prolonged skin contact is unlikely to result in absorption of harmful amounts.

Acute inhalation toxicity
At room temperature, vapors are minimal due to low volatility. However, certain operations may generate vapor or mist concentrations sufficient to cause respiratory irritation and other adverse effects. Such operations include those in which the material is heated, sprayed or otherwise mechanically dispersed such as drumming, venting or pumping. Excessive exposure may cause irritation to upper respiratory tract (nose and throat) and lungs. May cause pulmonary edema (fluid in the lungs.) Effects may be delayed. Decreased lung function has been associated with overexposure to isocyanates.

Skin corrosion/irritation
Causes skin irritation. Signs/symptoms may include localized redness, swelling, and itching.

Serious eye damage/irritation
Causes serious eye irritation. Signs/symptoms may include redness, swelling, pain, tearing, and blurred or hazy vision.

Respiratory or skin sensitization
May cause an allergic skin reaction. May cause allergy or asthma symptoms or breathing difficulties if inhaled.

Germ cell mutagenicity
4,4′-Methylenebis(phenyl isocyanate)
Laboratory experiments have shown mutagenic effects

Carcinogenicity
IARC: 4,4’ diphenylmethanediisocyanate, isomere, homologue and mixtures. Group 3.
ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available.

STOT-single exposure
May cause respiratory irritation.

STOT-repeated exposure
May cause damage to organs (Respiratory system) through prolonged or repeated exposure

Aspiration hazard
No data available.

SECTION 12: Ecological information

Toxicity
No data available on product

Components:

2,4'-Diphenylmethane diisocyanate
LC50 - Brachydanio rerio (zebrafish) - > 1,000 mg/l - 96 h
EC50 - Daphnia magna (water flea) - > 1,000 mg/l - 48 h

4,4′-Methylenebis(phenyl isocyanate)
EC50 - Daphnia magna (water flea) - 0.35 mg/ - 24 hr

Benzene, 1,1'-methylenebis[isocyanato-, homopolymer
LC50 - Brachydanio rerio (zebrafish) - > 1,000 mg/l - 96 h
EC50 - Daphnia magna (water flea) - > 1,000 mg/l - 48 h

Propylene carbonate
LC50 - Cyprinus carpio (Carp) - > 1,000 mg/l - 96 h
EC50 - Daphnia magna (water flea) - > 1,000 mg/l - 48 h
EC19 - Pseudomonas putida - 7400 mg/l - 16 h
EC50 - Pseudokirchneriella subcapitata (green algae) - 900 mg/l - 72 h

Persistence and degradability
No data available.

Bioaccumulative potential
No data available.

Mobility in soil
No data available.

Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

Other adverse effects
No data available.

SECTION 13: Disposal considerations

Disposal of the product
Disposal should be in accordance with applicable Federal, State and local laws and regulations. Local regulations may be more stringent than State or Federal requirements.

Disposal of contaminated packaging
Dispose of as unused product.

Empty Container Precautions:
Empty containers retain product residue; observe all precautions for product. Do not heat or cut empty container with electric or gas torch because highly toxic vapors and gases are formed. Do not reuse without thorough commercial cleaning and reconditioning. If container is to be disposed, ensure all product residues are removed prior to disposal. Dispose of per local, state and federal guidelines as required by your specific local. This product in its cured foam state is inert and non-toxic.

SECTION 14: Transport information

DOT (US)
Not regulated
Reportable quantity (RQ): 5000 lb (4,4'- Diphenylmethane Diisocyanate)

IMDG
Not regulated

IATA
Not regulated

SECTION 15: Regulatory information

Safety, health and environmental regulations specific for the product in question

SARA 302 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 311/312 Hazards
Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components
Chemical name: MDI
CAS number: 101-68-8

Chemical name: Polymeric diphenylmethane diisocyanate
CAS number: 9016-87-9

New Jersey Right To Know Components
Common name: METHYLENE BISPHENYL ISOCYANATE
CAS number: 101-68-8

Common name: METHYLENE DIPHENYL DIISOCYANATE (POLYMERIC)
CAS number: 9016-87-9

Propylene carbonate
CAS-No. 108-32-7

Pennsylvania Right To Know Components
Chemical name: Benzene, 1,1'-methylenebis[4-isocyanato-
CAS number: 101-68-8

Propylene carbonate
CAS-No. 108-32-7

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

SECTION 16: Other information

Further information/disclaimer
DISCLAIMER: The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigation to determine the suitability of information for their particular purposes. In no event shall Alchemy-Spetec be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, whatsoever arising, even if Alchemy-Spetec has been advised of the possibility of such damages.

Case History

RESOURCE ENGINEERING INC.

Robyn Brown, P.E.
Dam Safety Engineer
Colorado Division of Water Resources
202 Center Drive
Glenwood Springs, CO 801601
robyn.brown@state.co.us

September 27, 2016

Via Email

RE: Emergency Seepage Repairs, Leon Lake (DAMID 720308), Water Division 5

Dear Robyn,

This letter sets forth the proposed plan for emergency seepage repairs at Leon Lake (DAM ID 720308) located in Section 29, Township 11 South, Range 93 West of the 6th Principal Meridian in Mesa County, Colorado. Specifically, Leon Lake Ditch and Reservoir Company (Owner of storage water rights at Leon Lake) proposes to conduct an emergency repair action to repair a leak on the upstream slope of the dam. General maintenance, ordinary repairs, and emergency actions of jurisdictional reservoirs is addressed under Rule 12 of the Division of Water Resource's "Rules and Regulations for Dam Safety and Dam Construction".[1] Specifically, Rule 12.3.4 allows for the plugging of entrances on the upstream slope. The proposed seepage repair plan is further described below.

Site Conditions

On September 20, 2016, Resource Engineering, Inc. (RESOURCE) conducted a site visit with Gerry Figueroa and Erik Fritchman. The purpose of the site visit was to investigate a recently formed seepage hole near the liner system patch that was installed in 2009 and to determine the best course of action. The reservoir was drawn down several feet below the seep hole and not active seepage was occurring during the site visit.

The seepage area is on the right shoreline in natural material some distance away from the left groin and approximately 4 to 6 feet east (or right looking downstream) of the 2009 liner patch and seepage repair. It is likely that seepage in this area is following in the natural factures of the basalt or is simply flowing between basalt boulders. According to Gerry Figueroa, the flow was observed to emanate below the toe of the embankment. From previous observations, it is also known that some seepage shows up in Leon Creek at higher reservoir levels, suggesting multiple natural seepage paths. Reportedly, no soil deposition has been observed at the measurement points below the dam suggesting that the removal of fines may be a near surface phenomenon. It is feasible that the near surface fine grained material in the factures or between the boulders has washed out and the previous seepage flow path has been restored.

Recommended Repair

The recommend repair is to extend the liner system patch approximately 20 to 25 feet to the east by carefully exposing the right side anchor trench. The new liner system patch will be installed in a similar fashion to the 2009 seepage repair and utilizing the adjoining anchor trench as shown on Sheet 1 and Sheet 2. To try and eliminate the previous seepage flow path, a two

[1] Effective Date: January 1, 2007 (2-CCR 402-1).

phase approach is suggested by the Owner. Phase I will involve the use of a polyurethane chemical resin grout (grout) and Phase II, as noted above, will involve extending the 2009 liner patch over the newly formed seepage area.

The use of grout usually does not work well unless there is a clearly defined seepage path as water typically finds a way around the grout and forms a new seepage path. In other words, pouring of grout may only seal a small fraction of the flow pathway(s). It is unknown whether or not there is a clearly defined seepage path. However, the Owner desires to use the grout to try and seal off the seepage patch and prevent further seepage. Phase I will only be conducted if time allows and is further detailed below.

Phase I – Polyurethane Chemical Resin Grout

Grout is generally applied under a low reservoir pool and under dry conditions so that the grout can set up properly. A recent technical note was written by AECOM with regards to grout use and for a case study at Fish Lake, Colorado.[2] At Fish Lake, a sinkhole formed on the upstream side of the dam near the left abutment. After further inspection by a geotechnical engineer and a dye test, the entrance and exit point of seepage flowing from the toe of the embankment were identified. The geotechnical engineer recommended the use of urethane grout to fill the sinkhole. The procedure was generally described as follows:

1) Lower the reservoir below the sinkhole;

2) Clear the sinkhole of rock and debris and flush with approximately 5 gallons of water to obtain through pre-wetting for the grout application;

3) Apply grout mixtures (Stratathane ST-504 Vari-Gel or approved equal mixed with water) into the sinkhole with the aid of a steel pipe and tarp to funnel the material as follows:

    - 15 water to 1 grout mixture: 30 gallons applied, grout completely absorbed, poured easily.
    - 10 water to 1 grout mixture: 30 gallons applied, grout completely absorbed, some backing up during pouring.
    - 5 water to 1 grout mixture: 5 gallons of water applied, grout was not entirely absorbed, and pipe containment half full.

    More fluid mixtures take longer to set up before the next application can be poured; however, these mixtures obtain the greatest penetration into the voids or cracks related to the sinkhole and seepage path. This is because the ST-504 product reacts with water to form an expansive flexible foam or non-expansive gel that hardens. In other words, mixtures with less water react quicker.

At Fish Lake, mixtures with higher water ratios were initially used to penetrate the cracks and voids by gravity. As the gel forms, it will fill the cracks and voids and encapsulate any vegetative roots. The gel is inert (nontoxic) and is can be easily dug up (if needed) when the

[2] Western Dam Engineering Technical Note Volume 3, Issue 1 – February 2015

dam is fully rehabilitated. The data sheet for the ST-504 Vari-Gel is attached to this repair plan. ST-504 is approximately $400 per gallon. Alternative grout products following manufacturer recommendations may be considered and will be reviewed by RESOURCE prior to their use.

Phase II, the liner patch extension and overall recommend repair plan, is outlined below.

Phase II – Liner Patch

As noted above, the recommend repair is to extend the liner system patch approximately 20 to 25 feet to the east by carefully exposing the right side anchor trench. The new liner system patch will be installed in a similar fashion to the 2009 seepage repair and utilizing the adjoining anchor trench as shown on Sheet 1 and Sheet 2. A 45 mil EDPM Pondgard Liner and 8 oz. filter fabric will be cut and/or seamed inside a workshop (controlled environment). These materials will then be brought to the site for subsequent installation.

The repair sequence is generally described as follows:

Repair Sequence

1) Notify Division 5 Dam Safety Engineer (Robyn Brown) more than 72 hours' notice prior to either phase of the work;
2) Further draw down the reservoir to 3.6 feet to further expose the area below the seep and to allow better equipment access for importing fill;
3) Over-excavate the seepage repair area to an approximate depth of 3 feet below existing grade;
4) If time allows, conduct Phase I grouting procedure as outlined above;
5) After grout has sufficient time to cure (based on manufacturer recommendations), place approximately 2 feet of native soil free of rocks and organic material in 8-inch loose lifts and compact[3] over the exposed rock to create a smooth surface for placing liner material (See Step 1 on Sheet 2);
    a. If the exposed rock has obvious voids or factures, a minimum 6-inch layer of granular soil material should be placed over the rock and compacted prior to placing the soil;
6) Place 8 oz. non-woven filter fabric underneath the 45 mil EPDM Pondgard liner. Estimated dimensions are approximately 20 feet by 30 feet as shown on the drawings (See Steps 2 and 3 on Sheet 2);
7) Key the liner into the imported native soil all around as a cut off;
8) Backfill over the liner with 12-inch minimum of native soil and compact (See Steps 4 and 5 on Sheet 2); and

[3] Grade and compact fill to 95 percent of maximum dry density for ASTM D698 (Standard Proctor). The water content of the satisfactory fill material prior to and during compaction shall be distributed uniformly throughout each layer of the material. Do to the U.S. Forest Service requirement that any onsite fill material be obtained below the high water line of the reservoir, the desired water content is at or up to 5 percent above the optimum moisture content determined by ASTM D698 standard Proctor moisture density test.

9) Grade embankment as directed by Owner and replace the existing rock over the backfill (See Step 6 on Sheet 2).

A licensed Geotechnical Engineer test the borrow materials for suitability and will test the compacted fill in accordance with ASTM D698. A minimum of 2 test will be required above and below the line. Moisture content testing frequency shall be determined based on the materials obtained from each density sample location.

Monitoring Plan

The seepage will continue to be monitored twice weekly commencing with the reservoir fill next spring and will continue to until the reservoir falls below 7.5 feet or seepage ceases. Seepage flows will be measured at the #1 collection point below the road and at the #3 collection point below the toe of the dam as shown on Sheet 1. The reservoir gage height will be noted as will any observations related to seepage (i.e. changes in rate, location of seepage, discharge of soil, etc.). These measurements and observations will be provided to your office weekly while the reservoir is at or above gage level 16 feet and bi-weekly thereafter. If the seepage rate exceeds 25 gallons per minute (gpm) at the #3 collection point, the reservoir shall be immediately drawn down to a gage level of 16 feet and not refilled above this level until any additional sources of seepage are found and repaired.

It is proposed that the seepage monitoring will continue to be conducted jointly by Leon Ditch and Reservoir Company and Division of Water Resources (DWR) personnel since DWR on-site water commissioner will likely take the majority of the measurements as he resides most of the summer at the Leon Lake cabin located about 5 minutes from the Leon Lake dam.

After the emergency seepage repair work on the dam is completed, a completion report will be prepared certifying that the work has been completed in accordance this plan.

I will be the primary contact person for this work. As such, please contact me if you have any questions or need additional information.

Sincerely,

RESOURCE ENGINEERING, INC.

Eric F. Mangeot, P.E.
Water Resources Engineer
1160-5.0/EFM
K:\Clients\1160 LEON LAKE RSVR\5.0 Seepage Repair\2016 Leon Lake Emergency Seepage Repairs.doc

cc: Gerry Figueroa
Erik Fritchman
Jason Ward, P.E.

ST-504

VARI-GEL INJECTION RESIN

Return to ST-504

INTRODUCTION

Stratathane ST-504 Vari-Gel Injection Resin is a solvent-free, MDI-based water control and soil stabilization system. ST-504 is hydrophilic and reacts with water to form either a flexible gel or an elastomeric foam depending on the amount of reaction water added to the mix.

Stratathane ST-504 contains no measurable amount of TDI as performed by the Modified Analysis for Diisocyanates. ST-504 is non-flammable, non-carcinogenic, and non-corrosive as defined by 40 CFR and as described in the *NIOSH Pocket Guide for Hazardous Materials.*

ST-504 has NSF 61 approval for potable water contact and carries the Underwriters Laboratories UL seal.

Stratathane ST-504 is mixed with water at the work site to form a single injection material. The inert end product forms a water barrier which is essentially unaffected by acids, gasses, and organisms usually found in soil. A minimum of water (around 5% by volume) is needed for a reaction to occur, but large amounts can be accommodated through reaction or displacement.

Stratathane ST-504 is useful for a wide range of water control and soil stabilization applications, including grout curtains, stabilizing water-bearing soils, and sealing cracks or joints in concrete walls, buildings, dams and utility vaults.

Stratathane ST-504 may be placed by hand pumps or multi- ratio power pumps. Stainless steel fittings are recommended but not strictly required because ST-504 is no more corrosive than water. Cleanup of solidified material in the system, however, is often accomplished with caustic cleaning compounds, making stainless steel advisable.

The low viscosity of ST-504 makes it easy to inject. Once cured, its impermeability makes it an effective water shut-off system. The permeability of soil grouted with ST-504 depends on how well its voids are filled with grout. Values in the 10-7 cm/sec range should be obtained using *ASTM Constant Head Permeability Test Method D-2434.*

A three stage reaction takes place when ST-504 mixes with an equal volume of water and foams. The mixture first thickens and becomes creamy. Then, carbon dioxide gas evolves rapidly and the mixture expands as it cures. The expanded ST-504 volume then sets into a strong impermeable water barrier. Unrestrained ST-504 foam may expand up to 10 times its starting volume depending upon the degree of confinement applied to the expanding mass.

When ST-504 mixes with a large volume of water (i.e. 10:1 or greater), the three stages of the foam reaction cycle are not visible in the reacting mass. Instead, a marked viscosity increase will be seen just before the mass solidifies.

The reaction sequence with water takes place continuously during injection as product exits the packer. Initial penetration of the ST-504 grout mixture is facilitated by its low viscosity. After setting (in the case of the foam sequence), the expansive mixture pressure induces further filling of the grout zone. An ST-504 seal will tolerate freeze-thaw, wet-dry cycling, extrusion, and compression to a substantial degree.

DESCRIPTION

Uncured ST-504 is a dark brown liquid with a viscosity of about 700 cps at 25 C (77 F). This low viscosity is reduced even further after water is added. ST-504 contains non-volatile materials making up almost 100% of its total weight. Cured ST-504 is very firm and flexible. Its solid is a three dimensional cross-linked molecular structure which is insoluble in water.

PHYSICAL PROPERTIES

Color	Dark brown	
Viscosity	700 cps at 25 C	ASTM D1838
Specific Gravity	1.1 g/cc	9.25 lbs/gal
Flash Point	>220 F	ASTM D-93
Solids Content	>85%	ASTM D2832
Tensile Strength	>250 psi	ASTM 3574
Elongation	>400%	ASTM 3574
Shrinkage	<11%	ASTM D-1042
Vapor Pressure	0.0000002 psi	
Vapor Density	8.5 (Air = 1.0)	
Solubility	Insoluble; Reacts with water	

3601 104th Street Des Moines, Iowa 50322 PHONE 515/251.7770 FAX 515/251.7705
WEB SITE www.strata-tech.com EMAIL Info@strata-tech.com

Set time is the period from first contact of ST-504 with water to the point where the mix becomes too thick for gravity flow. The set time (sometimes called foam time) is influenced primarily by the mix temperature and the ratio of ST-504 to water. Set times are longest at low temperatures and ST-504 ratios, and vary a little with the age of the resin and mineral content of the water. The viscosity of mixed ST-504 is lowest for the first 40% to 50% of the set time and increases rapidly as the mix approaches set.

SET TIME
Seconds at 20 Degrees C

WATER RESIN	GEL	RISE	TACK FREE
9:1	150	-	-
4:1	95		110
2:1	85	95	100
1:1	95	110	160
1:2	100	120	170
1:3	100	120	180

CLEANUP

ST-504 should not stand in equipment more than 12 hours without precautions because the possibility of moisture contamination is high. Flush equipment with ST-590 purging fluid and ST-522 Cleaner soon after use. The most common solvent for removal of liquid ST-504 is methylene chloride. Check solvents for water content prior to use.

When using solvents during cleanup, extinguish all ignition sources and observe proper precautions for handling such materials. For cleanup of cured ST-504, soak in a 100% solution of ST-522 Veri-Kleen Grout Cleaner using a covered polyethylene container. Grout spills on clothing are permanent, so disposable coveralls are recommended.

HANDLING AND STORAGE

Use reasonable care in handling and storing ST-504. The material is moderately sensitive to high storage temperatures. Under optimum storage of 40 - 60 F in dry conditions, the material should have a useful shelf life of one year. Storage temperature should not exceed 80 F. Once a container has been opened, the life of the material is reduced. Let container stand and adjust to ambient temperature before opening to prevent contamination by condensation. Test a resealed container to assure that moisture contamination has not occurred. Before handling this product, read and understand the Material Safety Data Sheet (MSDS). Instruction in sound safety practices is beyond the scope of this publication.

Direct contact of ST-504 liquid may cause skin and eye irritation. If ST-504 comes in contact with skin, wash with soap and water. For eye contact, flush immediately with water and consult a physician. ST-504 must not be ingested. Before eating, smoking or drinking, remove protective clothing, wash with soap and water, and stand away from the immediate work site. Do not smoke while working with ST-504. If respiratory difficulties occur, seek medical attention. Avoid exposure to vapors created from this product when it is heated. Gloves, goggles, respirator and protective clothing are recommended. Ventilate the work area as a matter of good practice, although hazardous levels of toxic vapors are not generally given off of the bulk product below 90 degrees F. Small amounts of MDI may be present and some users may be sensitive to MDI.

Summary of Handling Precautions:

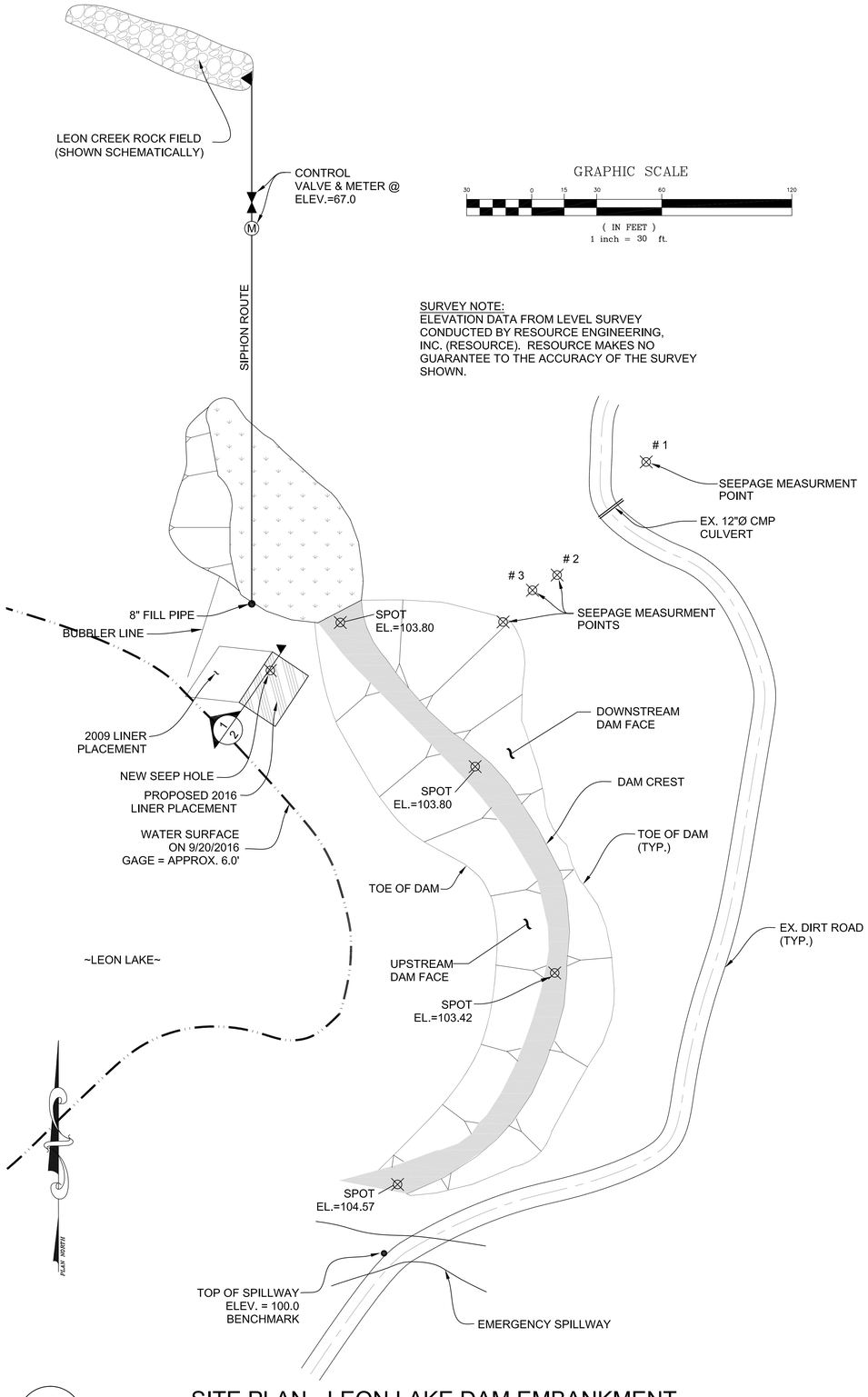
1. Wear goggles and rubber gloves.
2. Wash any body contact area throughly with water.
3. In case of eye contact, wash immediately with water and seek medical attention.
4. Keep material away from heat and flame.
5. Ventilate and use respirator in hot or closed spaces.

Back to ST-504 Urethane Grout

STATEMENT

Strata Tech believes that the information herein is an accurate description of the general properties and characteristics of the product(s), but the user is responsible for obtaining current information because the body of knowledge on these subjects is constantly enlarged. Information herein is subject to change without notice. Field conditions also vary widely, so users must undertake sufficient verification and testing of the product or process herein to determine performance, safety, usefulness, and suitability for their own particular use.

Strata Tech warrants only that the product will meet Strata Tech's then-current specification. NO WARRANTY OF SUITABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE. Users should not assume that all safety requirements for their particular application(s) have been indicated herein and that other or additional actions and precautions are not necessary. Users are responsible for always reading and understanding the Material Safety Data Sheet, the product technical literature, and the product label before using any product or process mentioned herein and for following the instructions contained therein.



1/1 SITE PLAN - LEON LAKE DAM EMBANKMENT

SCALE: 1"=30'

NEW SEEP HOLE

POND AND UPSTREAM DAM FACE

2/1 EXISTING CONDITION PHOTOS - 9/20/2016

ISSUED FOR BIDDING — DATE — BY

ADDENDUM REVISIONS

ADDENDUM NO	ADDENDUM DATE	BY

ISSUED FOR CONSTRUCTION — DATE — BY

REVISIONS

NO.	DESCRIPTION		

RECORD DRAWINGS — DATE — BY

DRAWN EFM	DATE 09/27/2016
CHECKED MJE	JOB NO 1160-5.0
SCALE SEE SHEET	

LEON LAKE FALL 2016
LEFT ABUTMENT
SEEPAGE REPAIR

LEON DITCH & RES. CO.
MESA COUNTY, CO

RESOURCE ENGINEERING, INC.
909 COLORADO AVE. ■ GLENWOOD SPRINGS, CO 81601
(970) 945-6777 ■ FAX (970) 945-1137

SHEET 1 OF 2

DAM ID 720308

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EARTHWORK NOTES

1. SATISFACTORY COMMON FILL (CLEAN NATIVE SOIL). SATISFACTORY FILL WILL BE CAPABLE OF FORMING A STABLE SUBGRADE WHEN COMPACTED AND SHALL COMPRISE OF ANY MATERIALS CLASSIFIED IN ASTM D 2487, AS SG, GC AND CL. SATISFACTORY MATERIALS WILL BE CHARACTERIZED AS ND3–SLIGHTLY DISPERSIVE OR LOWER WHEN IN ACCORDANCE WITH THE PINHOLE TEST (ASTM 4647). MAXIMUM PARTICLE SIZE OF 4 INCHES OR LESS. MIX FILL WITH 10% BENTONITE.

2. IMPORT FILL MATERIAL MAY BE SUBSTITUTED FOR SATISFACTORY COMMON FILL. IMPORT FILL MATERIAL SHALL MEET THE SATISFACTORY COMMON FILL REQUIREMENTS WITH AT LEAST 50% PASSING NO. 40 SIEVE AND AT LEAST 35% PASSING NO. 200 SIEVE MIXED WITH 10% BENTONITE. BENTONITE IS OPTIONAL.

3. UNSATISFACTORY COMMON FILL. UNSATISFACTORY FILL SHALL COMPRISE ANY MATERIALS CLASSIFIED IN ASTM D 2487, AS ORGANIC SOILS (PT, OH, OL, ML, AND MH), AND CLEAN GRANULAR SOILS (GW, GP, SW, SP WITH LESS THAN 10 PERCENT PASSING THE U.S. NO. 200 SIEVE). ORGANIC SOILS ARE NOT TO BE USED IN THE EMBANKMENT, OUTLET OR SERVICE SPILLWAY BACKFILL. UNSATISFACTORY FILL SHALL ALSO INCLUDE INDIVIDUAL ROCK OR SOIL PARTICLES GREATER IN AVERAGE DIMENSION THAN 4 INCHES

4. BOTTOM PREPARATION. THE BOTTOM OF EXCAVATIONS SHALL BE COMPACTED TO 95% ASTM D698 AND ACCURATELY GRADED TO PROVIDE UNIFORM BEARING AND SUPPORT.

5. REMOVAL OF UNYIELDING MATERIAL. UNYIELDING MATERIAL CONSISTS OF ROCK AND GRAVELLY SOILS WITH STONES GREATER THAN 3 INCHES IN ANY DIMENSION OR AS DEFINED BY THE PIPE MANUFACTURER, WHICHEVER IS SMALLER. WHERE UNYIELDING MATERIAL IS ENCOUNTERED IN THE BOTTOM OF PIPE EXCAVATIONS, SUCH MATERIAL SHALL BE REMOVED 4 INCHES BELOW THE REQUIRED GRADE AND REPLACED WITH PROPERLY COMPACTED FILL.

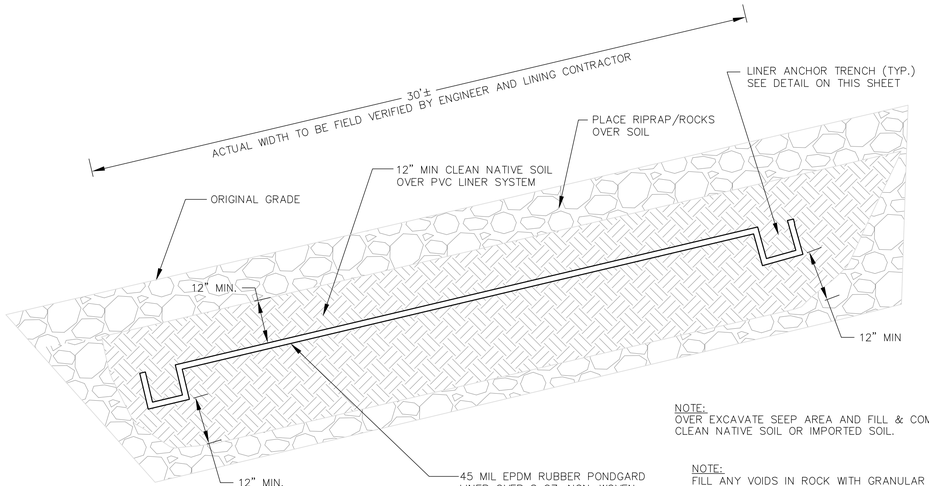
6. REMOVAL OF UNSTABLE MATERIAL. UNSTABLE MATERIAL CONSISTS OF MATERIALS TOO WET TO PROPERLY SUPPORT THE UTILITY PIPE, CONDUIT, OR APPURTENANT STRUCTURE. WHERE UNSTABLE MATERIAL IS ENCOUNTERED IN THE BOTTOM OF THE EXCAVATION, SUCH MATERIAL SHALL BE REMOVED TO THE DEPTH DIRECTED BY THE OWNER'S REPRESENTATIVE AND REPLACED TO THE PROPER GRADE WITH PROPERLY COMPACTED FILL AS SPECIFIED HEREIN.

7. PREPARATION OF GROUND SURFACE FOR FILL. VEGETATION, SUCH AS ROOTS, BRUSH, HEAVY SODS, HEAVY GROWTH OF GRASS, AND ALL DECAYED VEGETABLE MATTER AND OTHER UNSATISFACTORY MATERIAL WITH THE AREA UPON WHICH FILL IS TO BE PLACED SHALL BE STRIPPED OR OTHERWISE REMOVED BEFORE THE FILL IS STARTED. IN NO CASE SHALL UNSATISFACTORY MATERIAL REMAIN IN OR UNDER THE FILL AREA. SLOPED GROUND SURFACES STEEPER THAN 1 VERTICAL TO 4 HORIZONTAL ON WHICH FILL IS TO BE PLACED SHALL BE PLOWED, STEPPED OR BENCHED, OR BROKEN UP AS DIRECTED, IN SUCH MANNER THAT THE FILL MATERIAL WILL BOND WITH THE EXISTING SURFACE. PREPARED SURFACES ON WHICH COMPACTED FILL IS TO BE PLACED SHALL BE SCARIFIED, WETTED, OR DRIED, AS MAY BE REQUIRED TO OBTAIN THE COMPACTION SPECIFIED.

8. MOISTURE CONTROL. THE WATER CONTENT OF COMMON FILL MATERIALS PRIOR TO AND DURING COMPACTION SHALL BE DISTRIBUTED UNIFORMLY THROUGHOUT EACH LAYER OF THE MATERIAL. THE WATER CONTENT SHALL BE AT OR ABOVE THE OPTIMUM MOISTURE CONTENT DETERMINED BY ASTM D 698 STANDARD PROCTOR MOISTURE DENSITY TEST. THE COMPACTION TESTS SHALL BE MADE BY THE GEOTECHNICAL ENGINEER IN ACCORDANCE WITH ASTM DESIGNATION D 698.

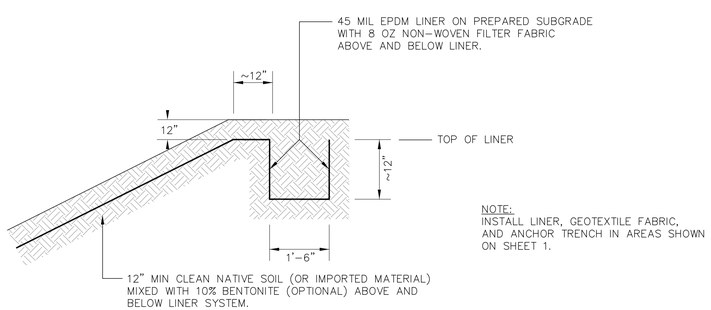
9. COMPACTION. ALL FILL SHALL BE COMPACTED TO 95% PER ASTM D698 IN A MAXIMUM OF 8–INCH LIFTS.

10. TESTING. TESTING SHALL BE THE RESPONSIBILITY OF THE OWNER. TESTING SHALL BE PERFORMED BY AN APPROVED COMMERCIAL TESTING LABORATORY OR MAY BE PERFORMED BY THE GEOTECHNICAL ENGINEER. THE NUMBER OF TEST SHALL BE AT THE DISCRETION OF THE ENGINEER. WHEN TEST RESULTS INDICATE, AS DETERMINED BY THE ENGINEER, THAT COMPACTION IS NOT SPECIFIED, THE MATERIAL SHALL BE REMOVED, REPLACED AND RECOMPACTED TO MEET SPECIFICATION REQUIREMENTS, AT NO ADDITIONAL EXPENSE TO THE OWNER. TESTS ON RECOMPACTED AREAS SHALL BE PERFORMED TO DETERMINE CONFORMANCE WITH SPECIFICATION REQUIREMENTS. THE CONTRACTOR SHALL COOPERATE IN THE TAKING OF TESTS.



1/2 CROSS SECTION OF SEEPAGE AREA

SCALE: NOT TO SCALE



2/2 LINER ANCHOR TRENCH (TYP.)

SCALE: NOT TO SCALE

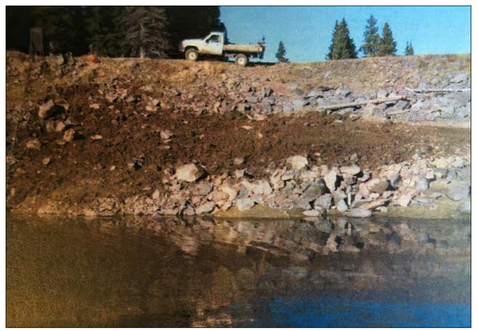

STEP 1: Clear & Grub Upstream Slope of Embankment in proposed Liner Area, Expose Existing Liner Anchor Trench, Compact, and Prepare Subgrade for New Liner System. Dig remaining anchor trenches.


STEP 2: Install 8 oz. Mirafi 140N (or approved equal) Filter Fabric.


STEP 3: Install 45-mil EPDM Liner.


STEP 4: Place 12-inches of backfill over liner and compact.


STEP 5: Compact backfill to 95% ASTM D698. Minimum 12-inch cover required over liner system.


STEP 6: Grade embankment (final grade) as directed by the Owner.

3/2 LINER INSTALLATION STEPS WITH EXAMPLE PHOTOGRAPHS

SCALE: NOT TO SCALE

ISSUED FOR BIDDING — DATE — BY

ADDENDUM REVISIONS

ADDENDUM NO	ADDENDUM DATE	BY

ISSUED FOR CONSTRUCTION — DATE — BY

REVISIONS

NO.	DESCRIPTION		

RECORD DRAWINGS — DATE — BY

DRAWN	EFM	DATE	09/27/2016
CHECKED	MJE	JOB NO	1160–5.0
SCALE	SEE SHEET		

LEON LAKE FALL 2016
LEFT ABUTMENT
SEEPAGE REPAIR

LEON DITCH & RES. CO.
MESA COUNTY, CO

RESOURCE ENGINEERING, INC.
909 COLORADO AVE. ■ GLENWOOD SPRINGS, CO 81601
(970) 945–6777 ■ FAX (970) 945–1137

SHEET 2 OF 2

DAM ID 720308

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June 6, 2017

Leon Lake Dam Abutment Seepage Repair – Grout Plan

Proposed Material – AP Fill 700, AP Cat 107

AP Fill 700 is a low viscosity, single component polyurethane injection resin with an adjustable set time. It is pre-mixed with a catalyst, AP Cat 107, and then injected as a single component. It reacts when it comes in contact with moisture or water, then expands and cures as a semi-rigid foam. AP Fill 700 has an expansion of 30X by volume.

The Cat to Resin mix ratio is determined by job conditions. With very low catalyst to resin ratios (0.5% – 1%) the 700 works as a permeation grout that can bind and tighten loose soils. In the mid-range of catalyst to resin ratios (4%-7%), the 700 can be used to grout moderate leaks, inject cracks, fill voids, and seal structures. At the highest rates of catalyst (10%) the 700 is used to shut down gushing leaks in mines and dams. Higher rates of catalyst are also used to overcome slow reaction times caused by cold water.

Suggested procedure for Leon Lake

1. Lower reservoir below sinkhole to allow access to the site.
2. Make sure workers are wearing safety glasses or face shields, and gloves.
3. Clear the sinkhole of rock and debris and begin pumping water; 5 – 10 gallons per minute
4. Condition materials AP Fill 700 and Cat 107 above 60 degrees F and read instructions on labels
5. Pre-mix 5 Gallons of AP Fill 700 with 1 Quart of AP Cat 107. This is 5% Cat to Resin ratio.
6. Using an airless pump or diaphragm pump, begin introducing the AP 700 mixture into the sinkhole at a rate of approx 1 gal per minute. Continue pumping water simultaneously.
7. Observe the seepage outlets to monitor for reacting material.
8. If un-reacted material is observed at seepage monitoring points, decrease water pumping by 50% and increase Cat to Resin ratio to 7-1/2%
9. Continue monitoring at seepage outlets. Adjust accordingly (water reduction and Cat %) until seepage output stops.
10. When flow of water at monitoring points dries up, reduce back to 5% Cat to Resin ratio.
11. Continue pumping AP Fill 700 until refusal is observed (reacting foam coming out of sinkhole)

Recommendations for Cat to Resin ratio and GPM of both water and resin mixture may be modified after the July 1st site visit by Gerry and Eric. They are going to pump water and record the amount of time for it to travel from sinkhole to seepage monitoring points.

Equipment Required

Small Generator 2000 – 4000 watts
Electric Air Compressor – We use a small 6.4 CFM with a 10 Gal Tanks (California Air Tools 100020C

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Tucker, GA 30084 USA
Office: 404-618-0438

available at Home Depot)
3/8" – ½" Air Powered Diaphragm Pump – braided hose – 20' suction, 50' output
Titan 440 Airless Sprayer – 50' hose, high pressure injection valve
Miscellaneous fittings and tools
Injection tube or pipe

Materials

AP Fill 700 – 100 Gallons – available in 5 gal pails or 50 gal drums
AP Cat 107 – 10 Gallons
AP Flush 121 – pump flush and lubricant

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