



US Army Corps
of Engineers ®



CLEARWATER DAM

Sinkhole Repair

Foundation Investigation and Grouting Project

Mark Harris, P.G. – USACE-SWL

One Corps Serving The Army and the Nation





Completed 1948

Crest Length 4,225 feet

Maximum Height 154 feet

Top of Conservation Pool Elevation 494 Feet

Top of Flood Pool Elevation 567 Feet

**Clearwater Dam
Pool of Record – May 2002
Elevation 566.7**



**Clearwater Emergency Spillway
Pool of Record – May 2002
Elevation 566.7**



Sinkhole - 15 January 2003

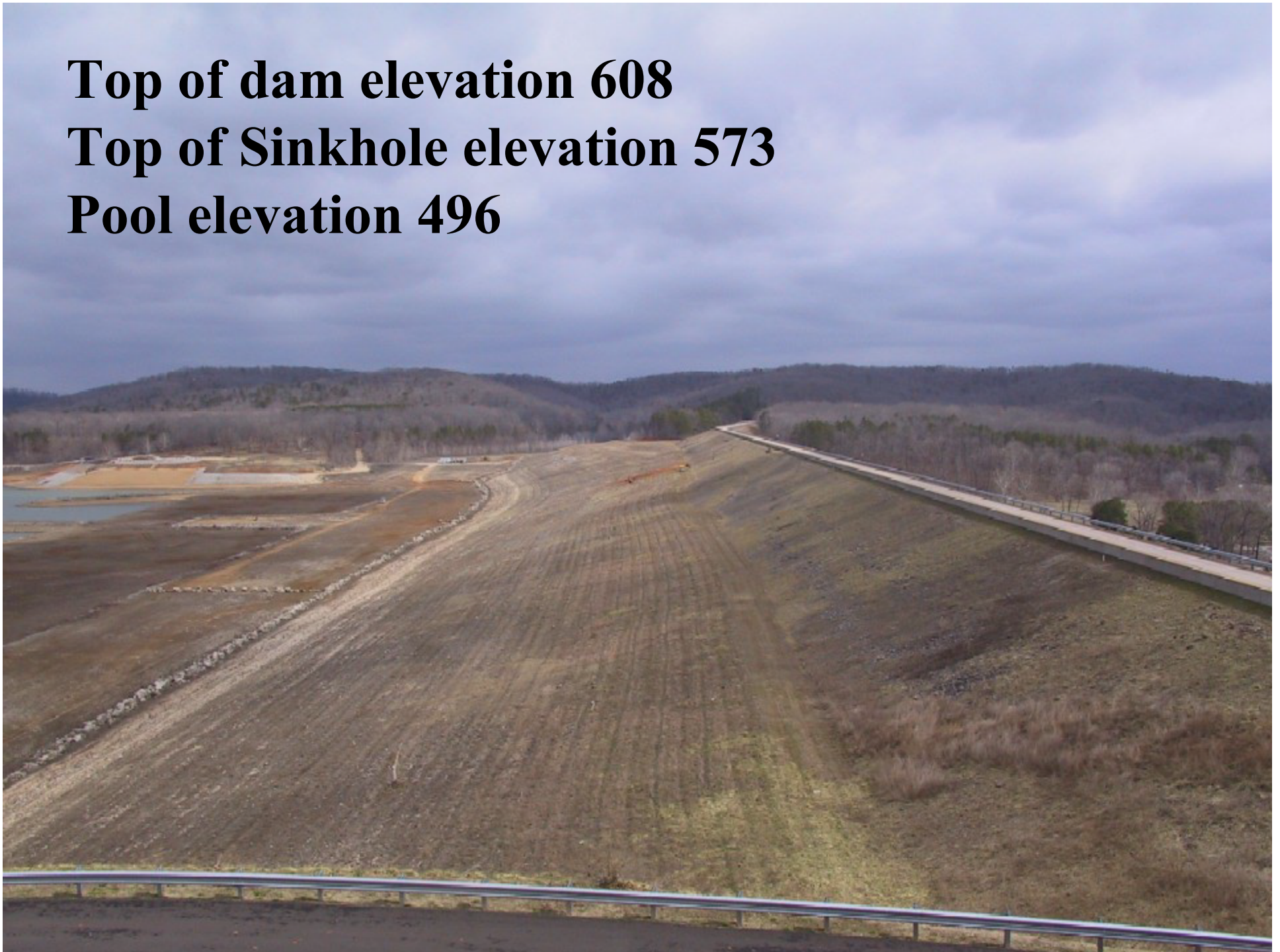


Clearwater Dam - Sinkhole

16 January 2003

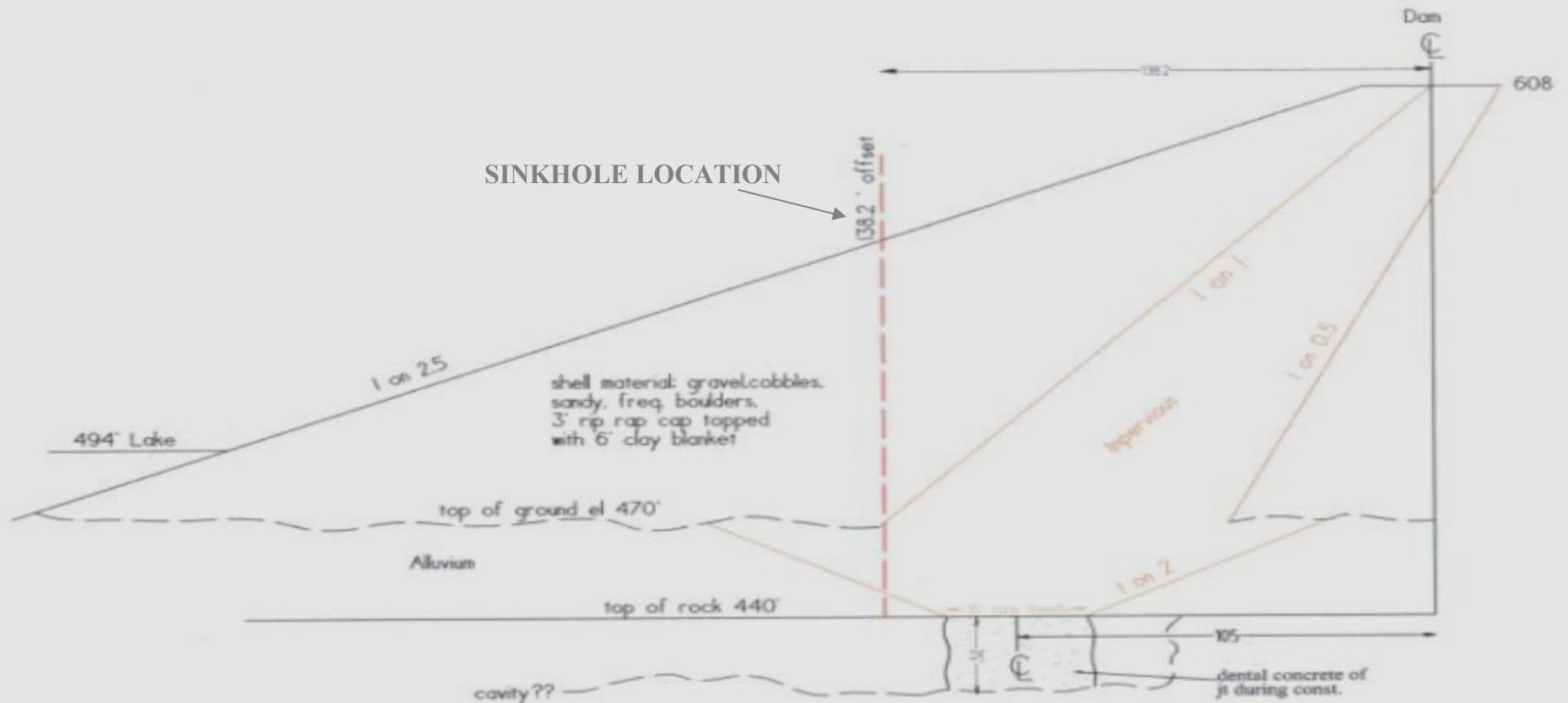


Top of dam elevation 608
Top of Sinkhole elevation 573
Pool elevation 496



Clearwater Dam

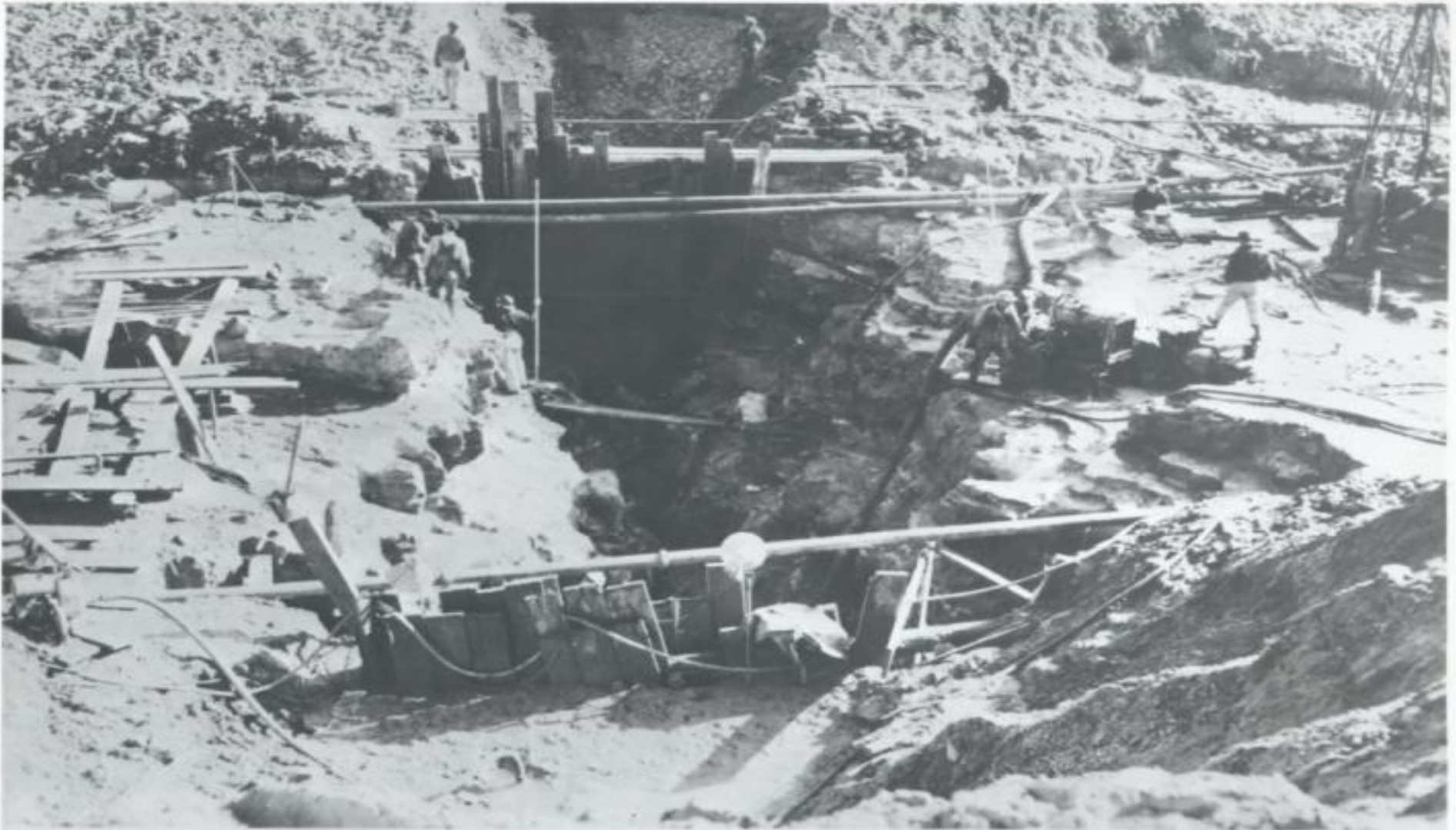
Embankment Cross Section





Looking E from 150' U.S. of station 41 / 68: General view of cut-off trench operations.

Original Construction – STA 39+20

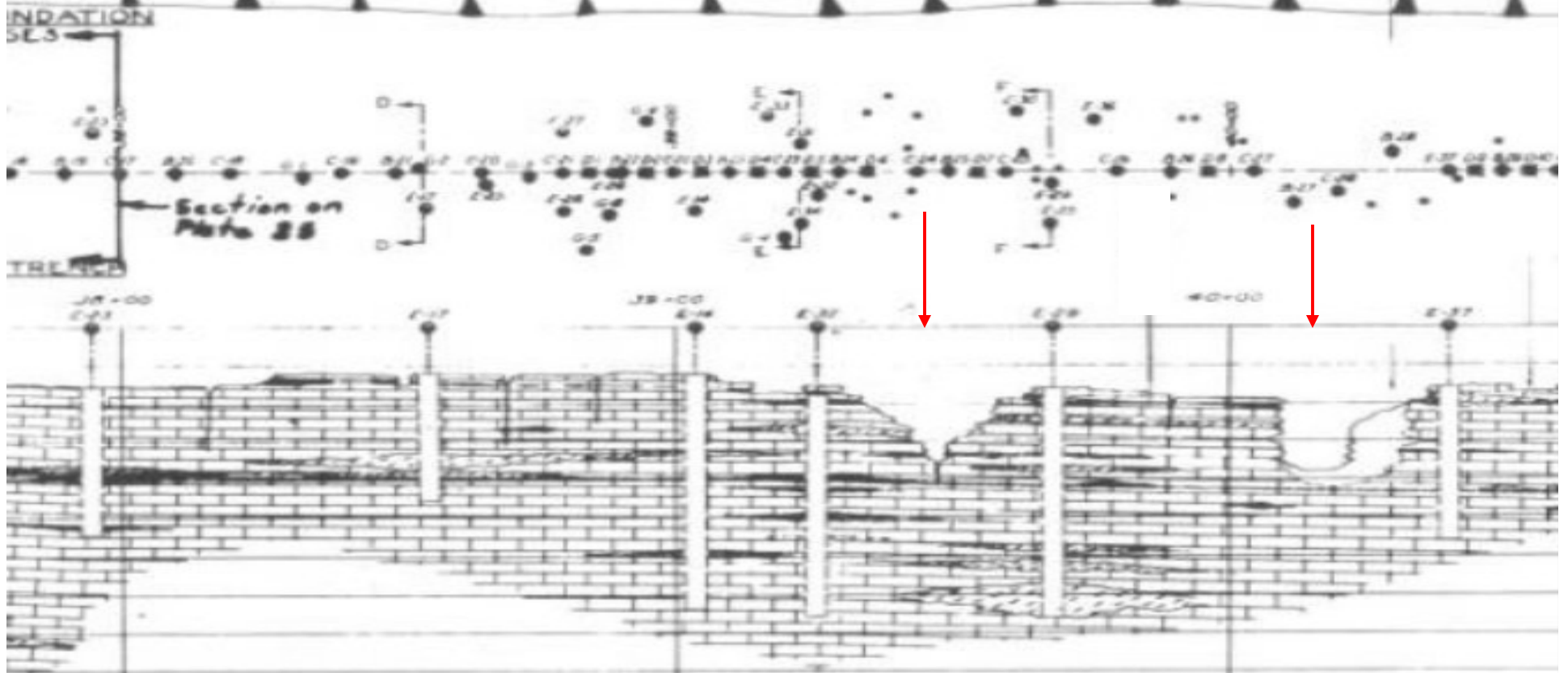
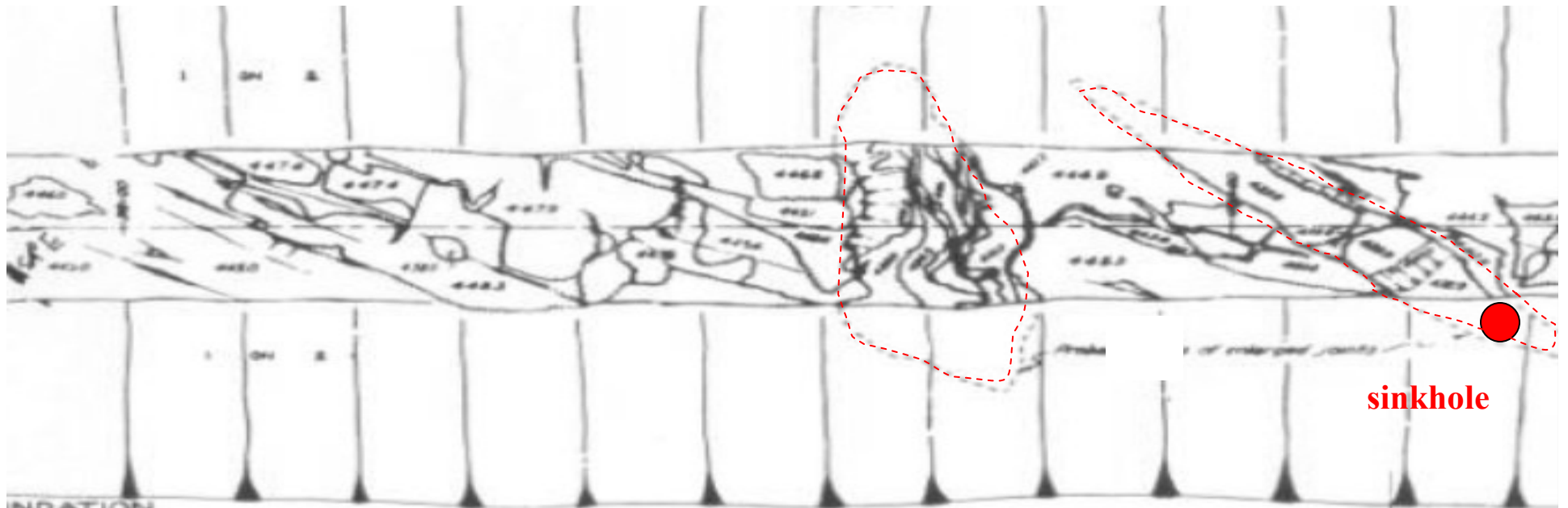


Looking S from 175' US of station 39 / 20: Open joint in cut-off trench foundation.

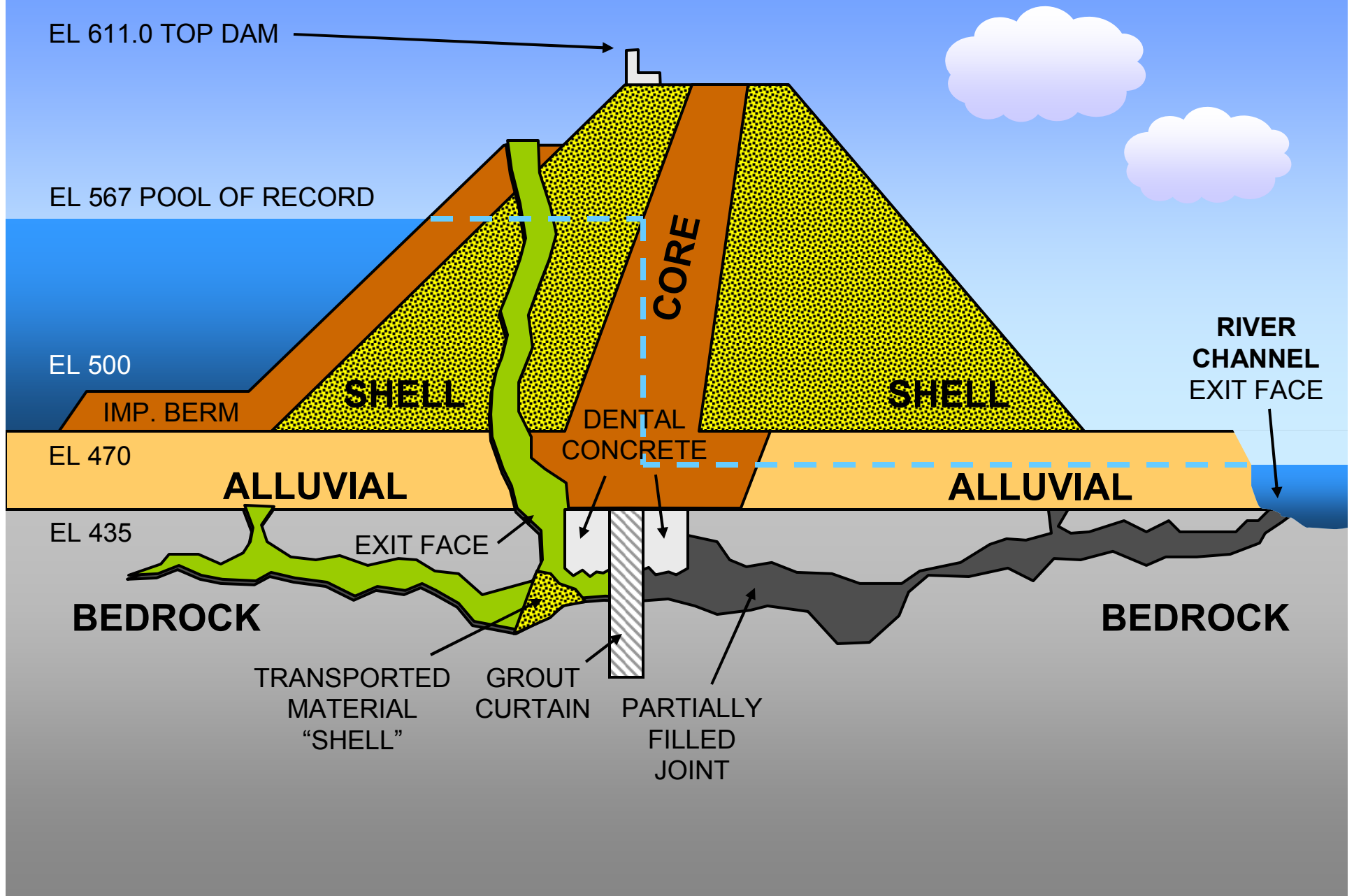
Original Construction – STA 40+15



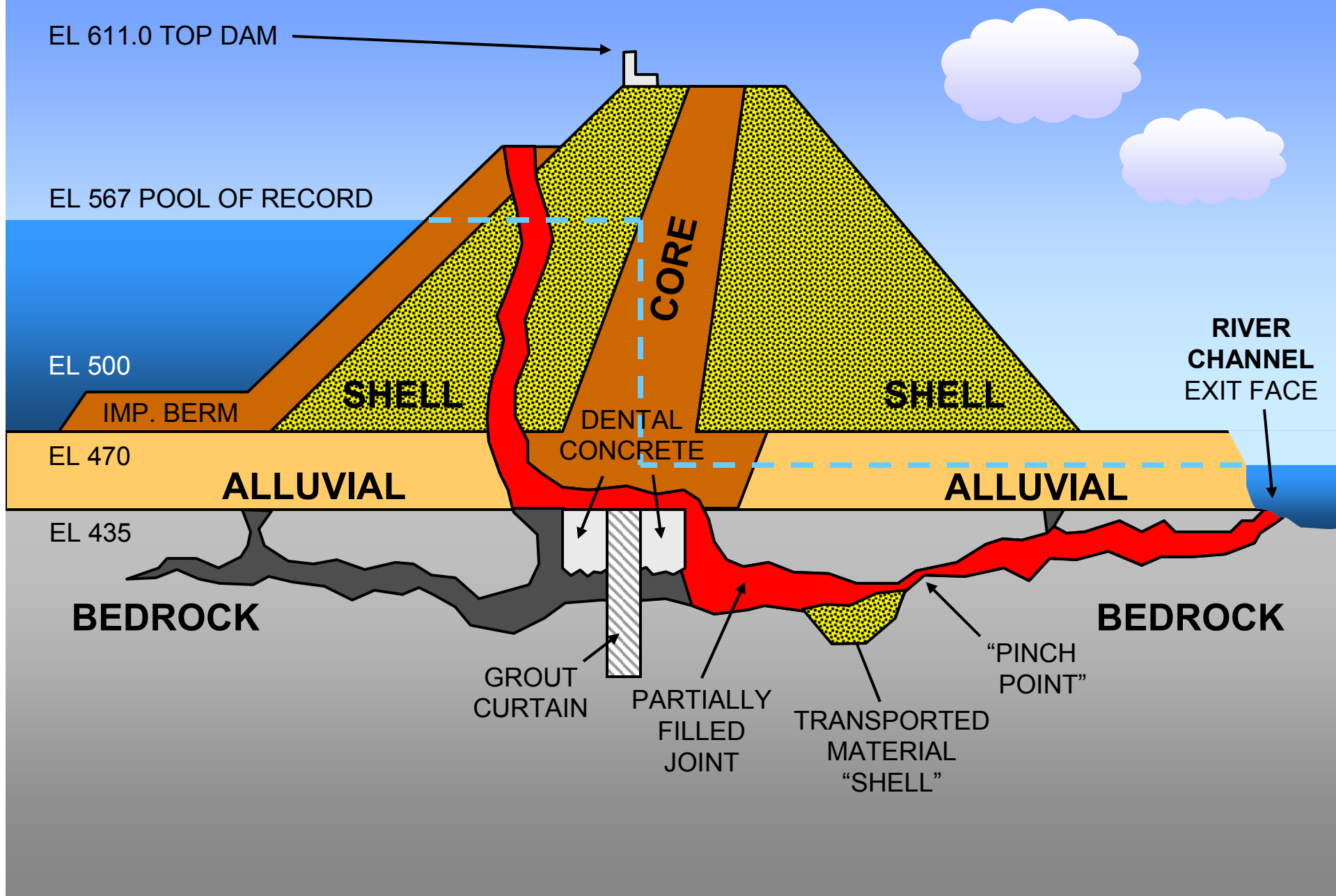
Looking NW from 35' U.S. of station 40 / 15: Open joint in cut-off trench foundation.



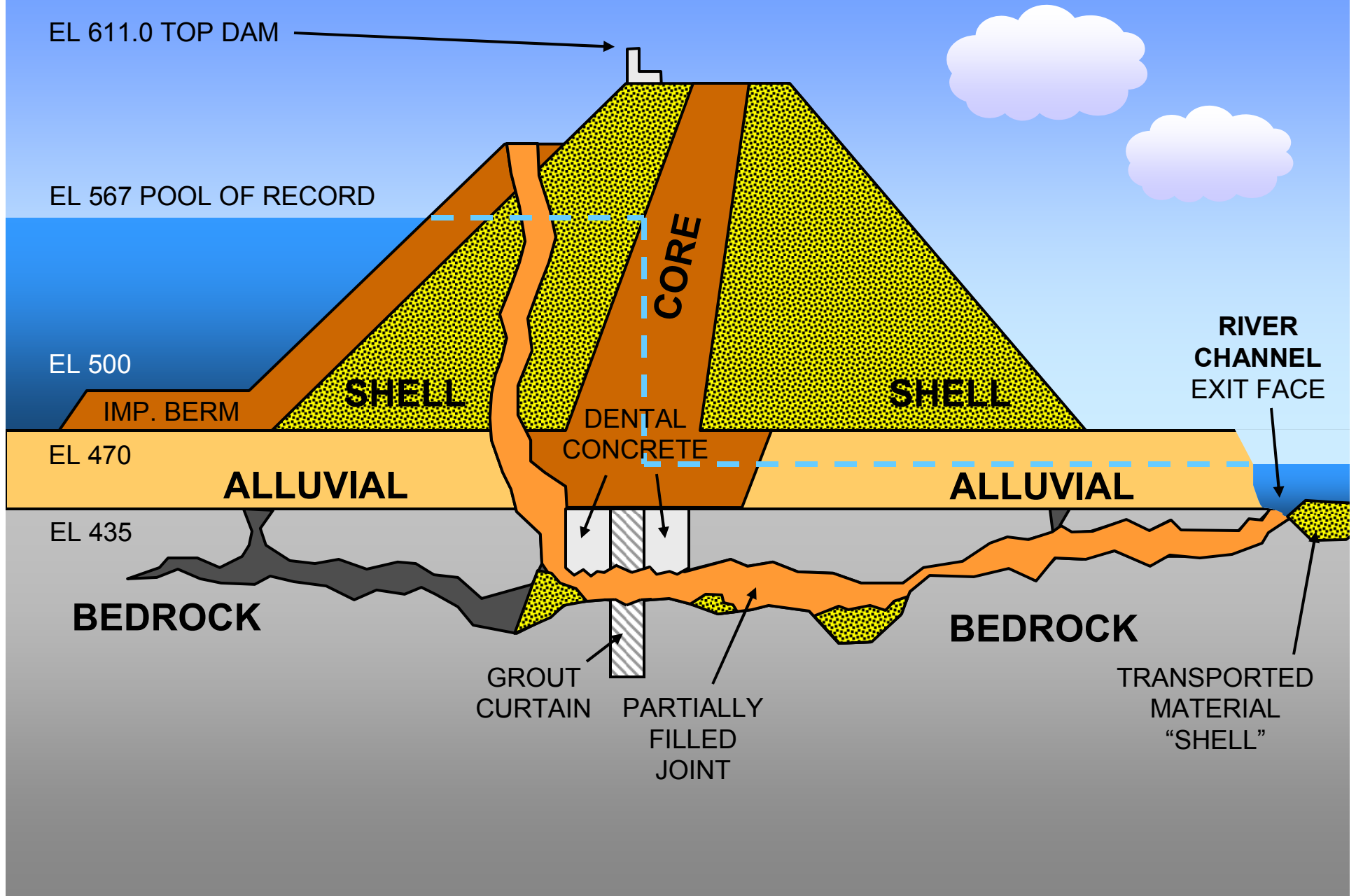
COLLAPSE INTO FOUNDATION ROCK



PIPE THROUGH CORE



COLLAPSE AND EXIT DOWNSTREAM



Investigations Prior to Grouting

- Performed Geophysical Surveys
 - Kansas Geological Survey – surface wave, reflection
 - Sonic Drilling – 6 borings, 50' into rock
 - Bureau of Reclamation – crosshole tomography
 - ERDC – SP, EM conductivity, ER
- Geotechnical Consultation
 - Dr. Steve J. Poulos - GEI
 - Analysis Assistance - ERDC
- Prepared Investigation/Grouting Contract P&S
 - computer monitored, balanced/stabilized grout
 - awarded to Advanced Construction Techniques, LTD.
(ACT)

FY 04-05 Grouting Contract

- Nov 2003 - ACT/Gannett-Fleming/Boart-Longyear selected as contractor.
- Jan 2004 – begin Sonic drilling - clay core/foundation rock/dental concrete good.
- April 2004 – begin grouting.
- May 2005 – completed grouting w/ modification

Legend

● sinkhole

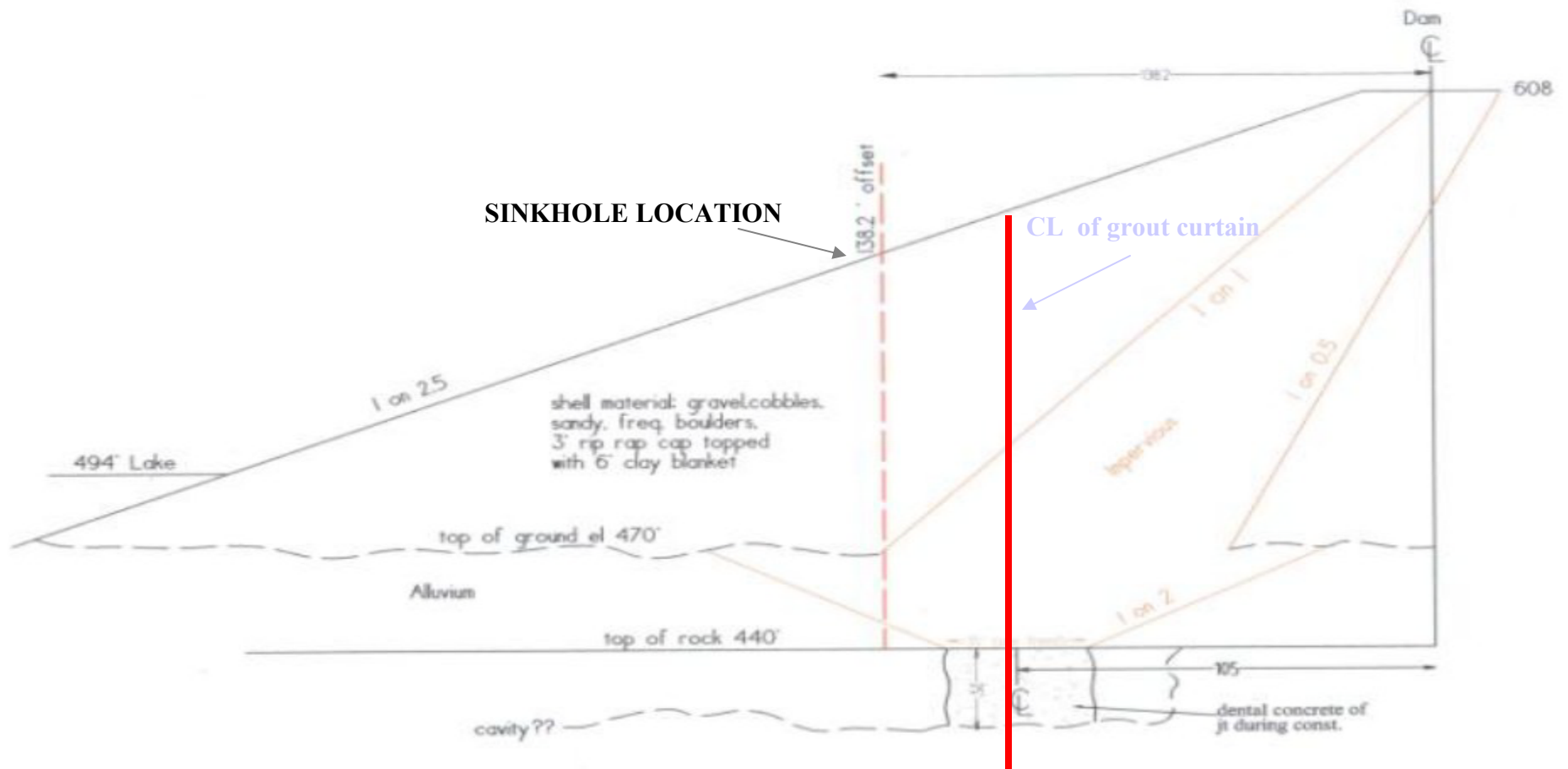
Sinkhole

Grouting project



Clearwater Dam

Embankment Cross Section



Clearwater Dam – Sonic Drilling



Clearwater Dam – Grout Line



25/08/2004



IntelliGrout™
The Science of Grouting



Grouting Operation

22:00:30

Stack Information

Line:

Hole Series:

Hole ID:

Stage ID:

Cart ID:

Recommended:

Mix Type:

Grout Time:

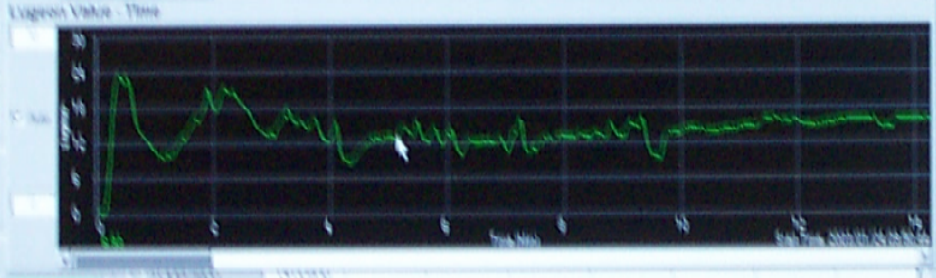
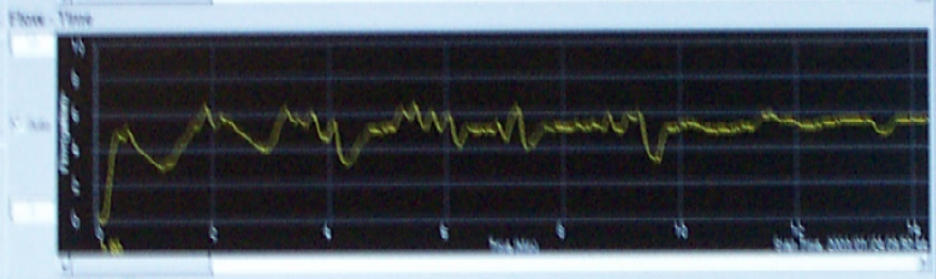
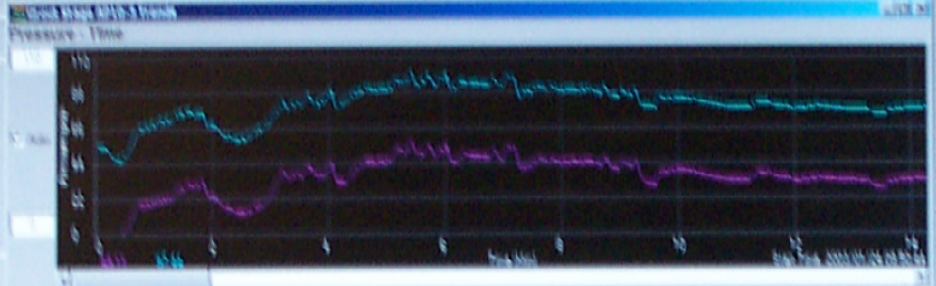
Acc Grout Factor:

Acc Factor:

Initial Access:

Flow Rate:

Pressure:



Refused Warning
(1/1) (Time Left: 00:00)

Comments (max 24 chars)

Stage ID	A101.1
Top Depth	104.5
Bottom Depth	110.5
Mix Type	1

- Project View
- Hole Definition
- Cart Parameters
- Headloss Factors
- Mix Type Controller
- Cart Calibration
- Water Test Operation
- Grouting Operation
- Database Admin
- Alarm Information

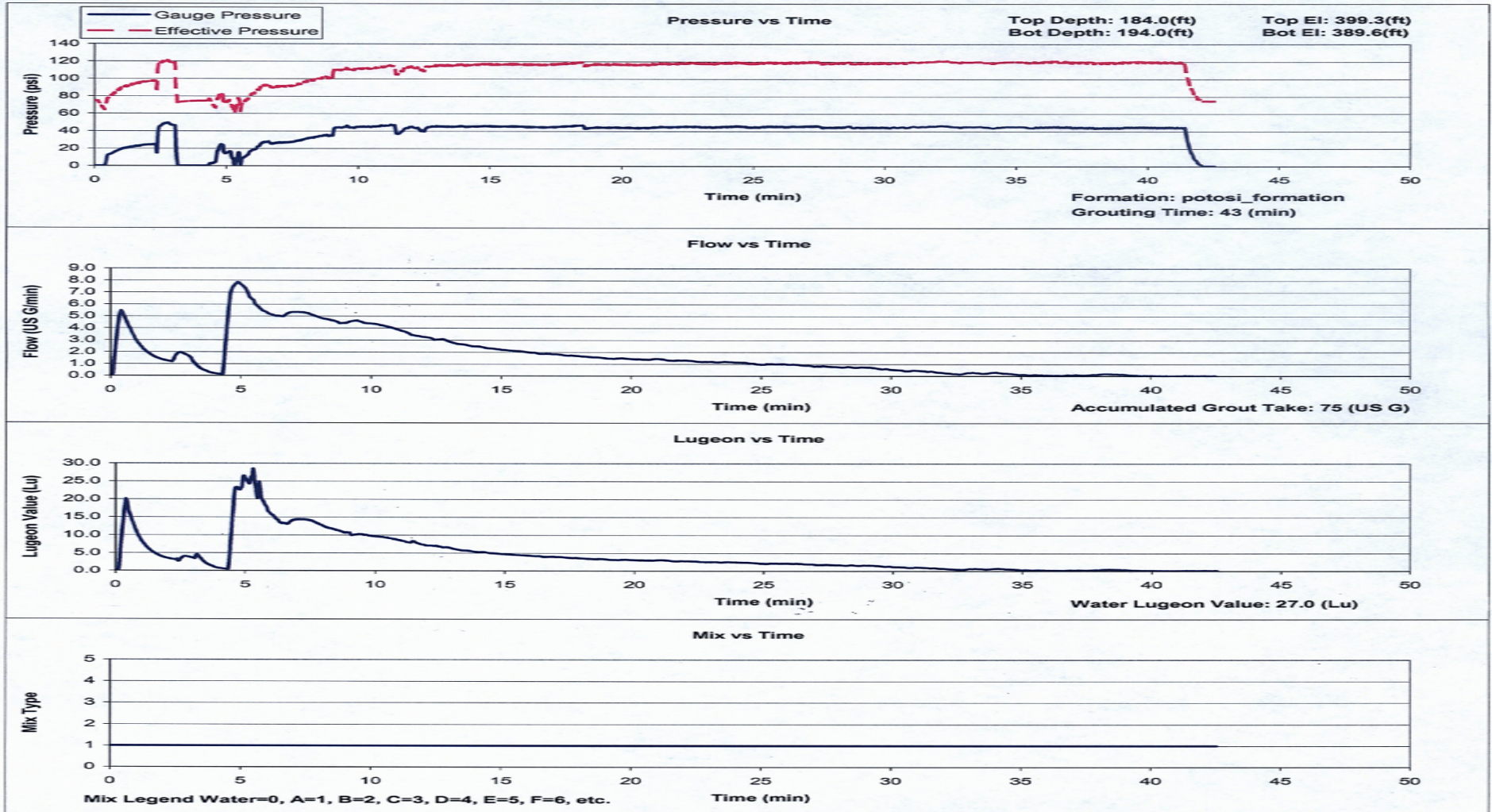
NEC

MultiSync LCD1700V

Moderately High Lugeon

Trend Plots: Grouting Operation, Stage: AP10-7

Project Name: Clearwater Dam Sinkhole Repair
Start Time: 2004/09/13 07:36:42



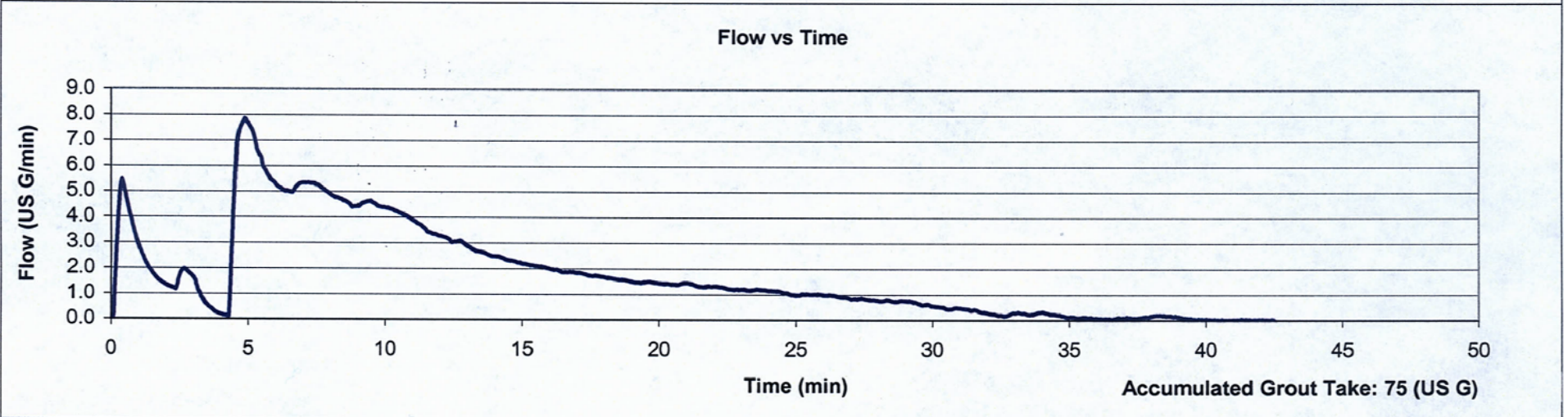
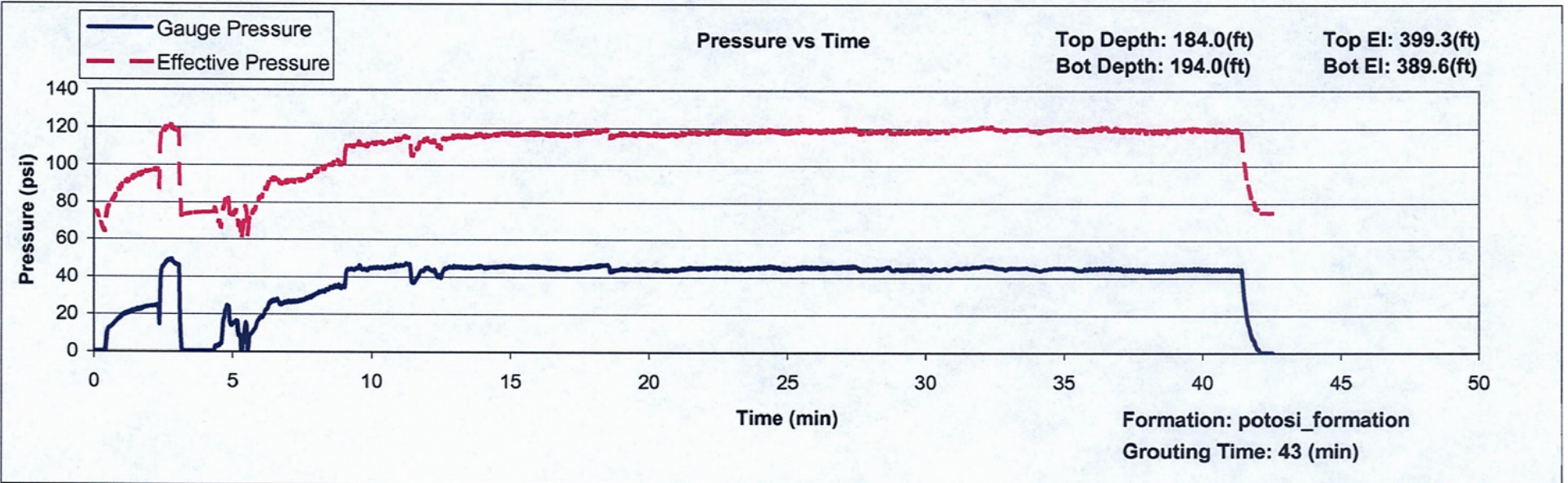
AP10-7	9/13/2004 07:41	Gator header station - Cart 1. Tremied 10 gallons. Packer set at 175'.
AP10-7	9/13/2004 07:41	Began pressure grouting at 4 minutes.
AP10-7	9/13/2004 08:18	Stage complete.

Moderately High Lugeon

Trend Plots: Grouting Operation, Stage: AP10-7

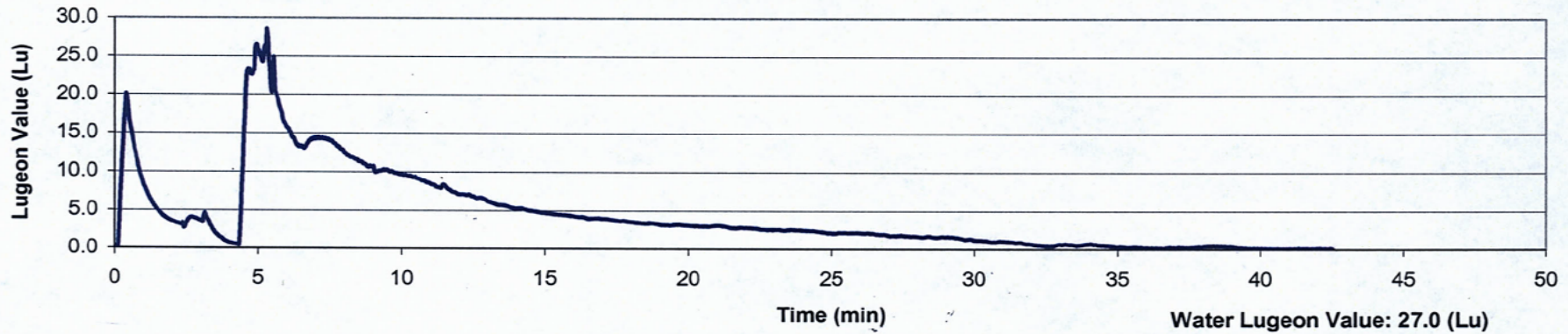
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Start Time: 2004/09/13 07:36:42

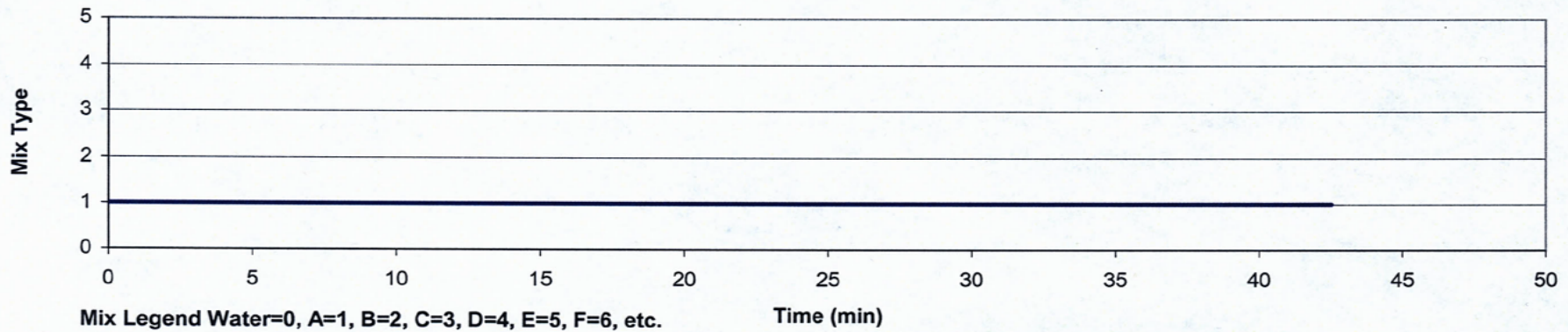


Moderately High Lugeon

Lugeon vs Time



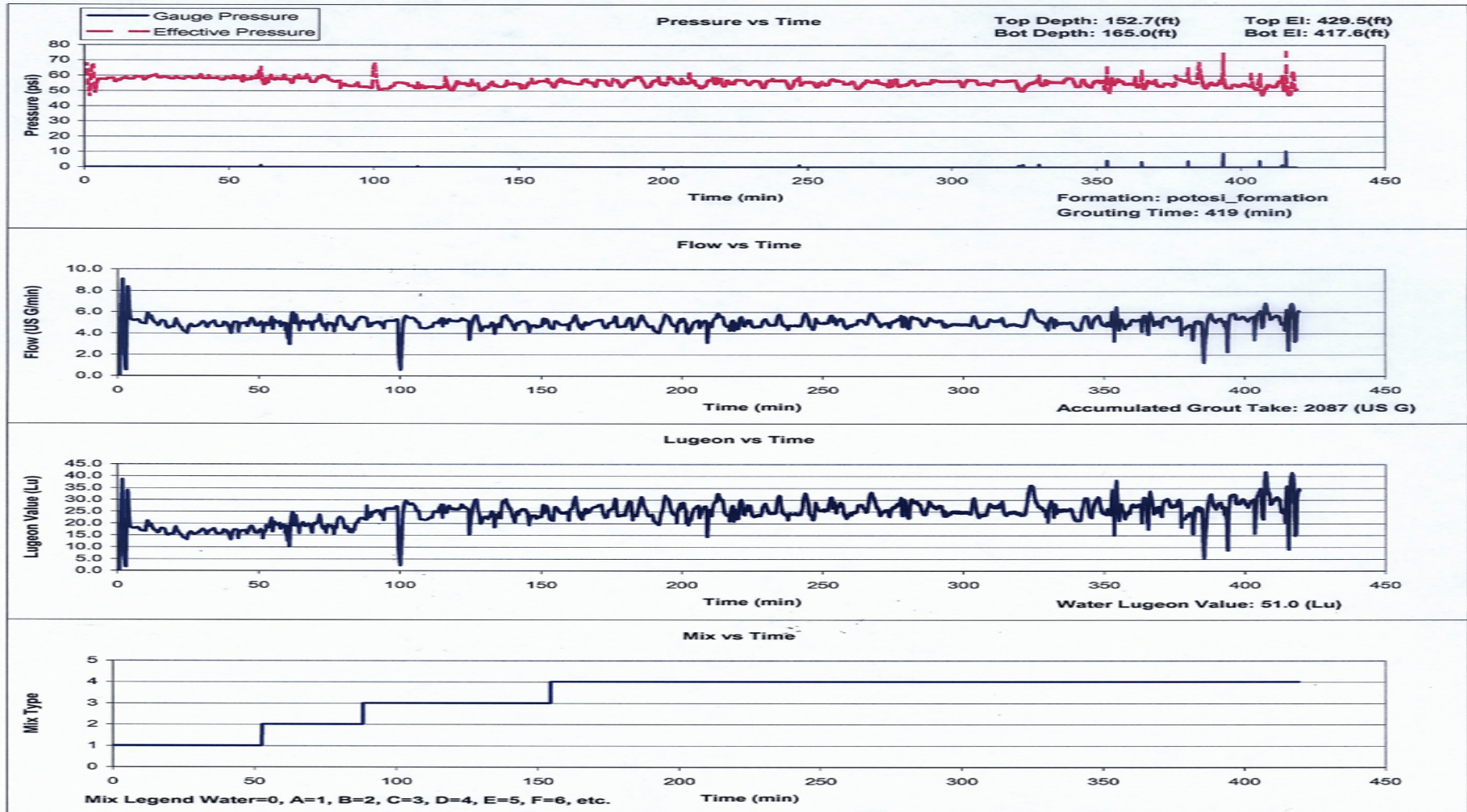
Mix vs Time



AP10-7	9/13/2004 07:41	Gator header station - Cart 1. Tremied 10 gallons. Packer set at 175'.
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AP10-7	9/13/2004 08:18	Stage complete.

High Take – No Pressure

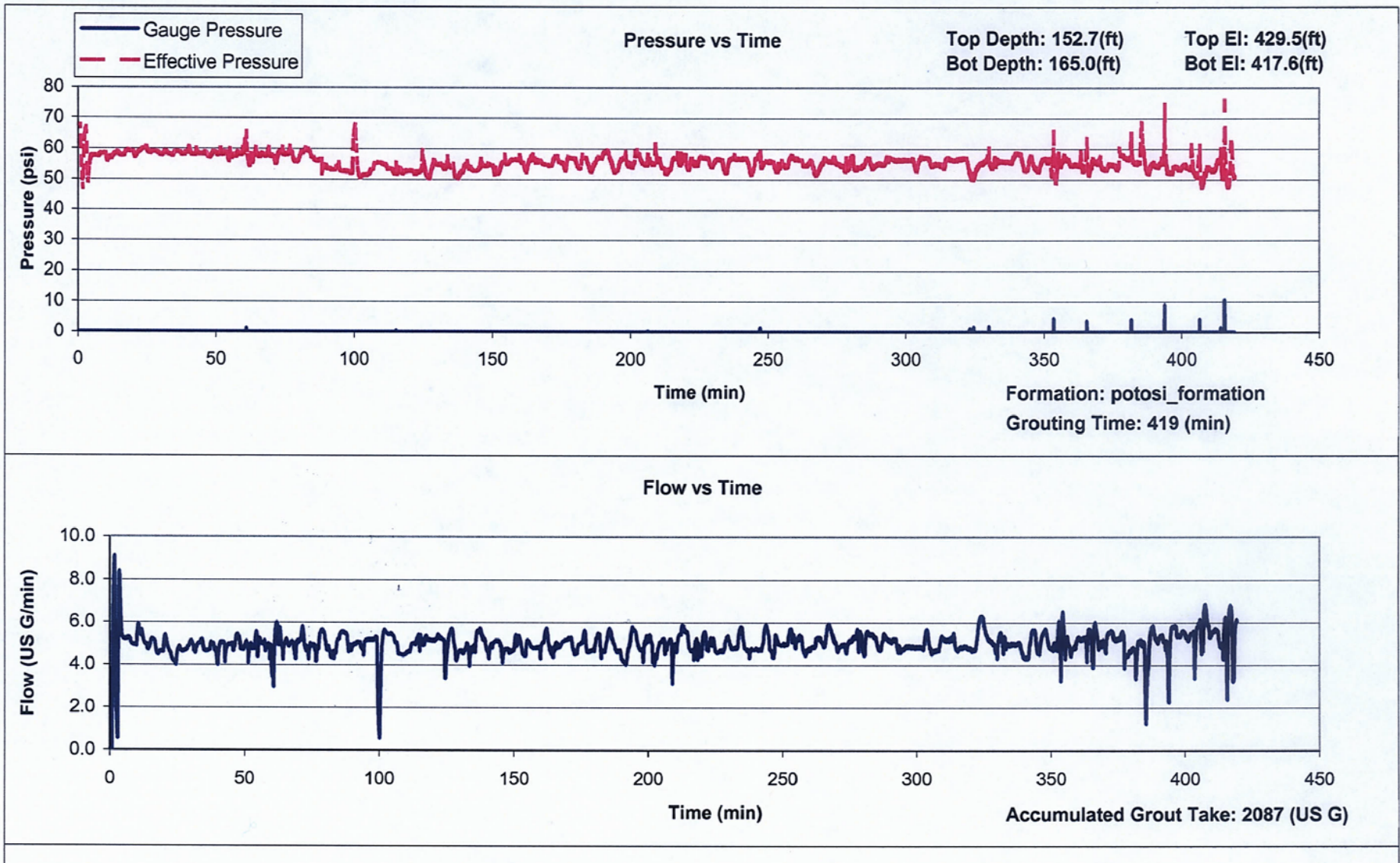
Trend Plots: Grouting Operation, Stage: AP12-4
 Project Name: Clearwater Dam Sinkhole Repair
 Start Time: 2004/07/06 07:18:44



AP12-4	7/7/2004	Mobile-Blue Header Station - Cart 2.
AP12-4	7/7/2004	Packer set at 145'
AP12-4	7/7/2004	Stopped at approximately 2000 gallons for the day as agreed upon by ACT and COE.
AP12-4	7/7/2004	Stage NOT Complete.
AP12-4	7/7/2004	Tremied 10 gallons from time 0 to 1 minute. Inflated packer and started to Re-Grout at 2.5 minutes.

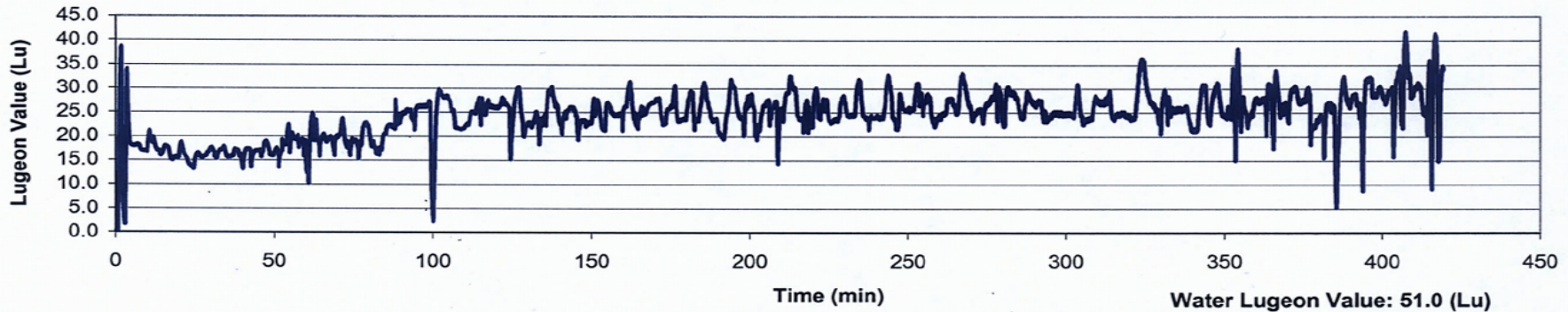
High Take – No Pressure

Trend Plots: Grouting Operation, Stage: AP12-4
Project Name: Clearwater Dam Sinkhole Repair
Start Time: 2004/07/06 07:18:44

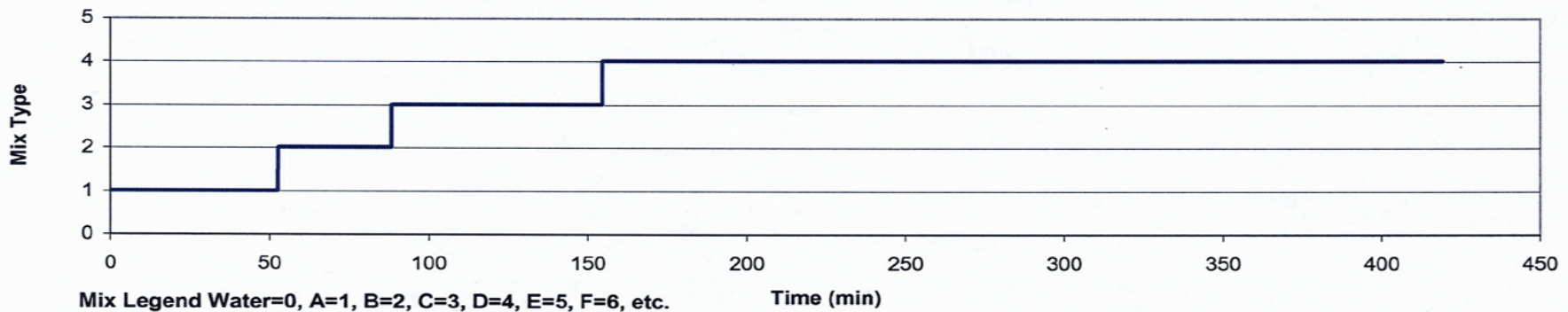


High Take – No Pressure

Lugeon vs Time



Mix vs Time



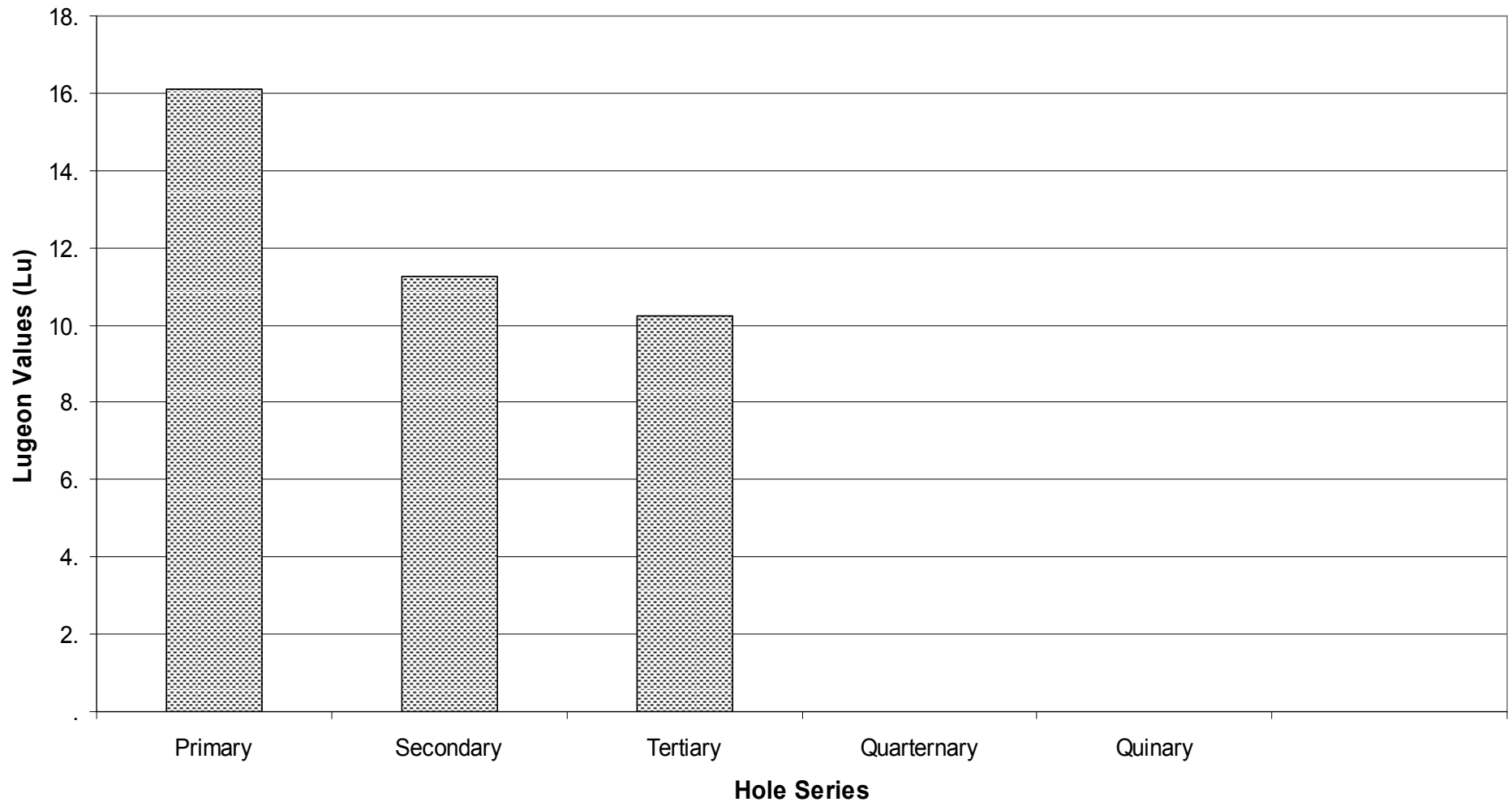
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A - Line Closure Analysis

AP13 to AP17 - Elevation 390

Mean Water Lugeon Values Plot

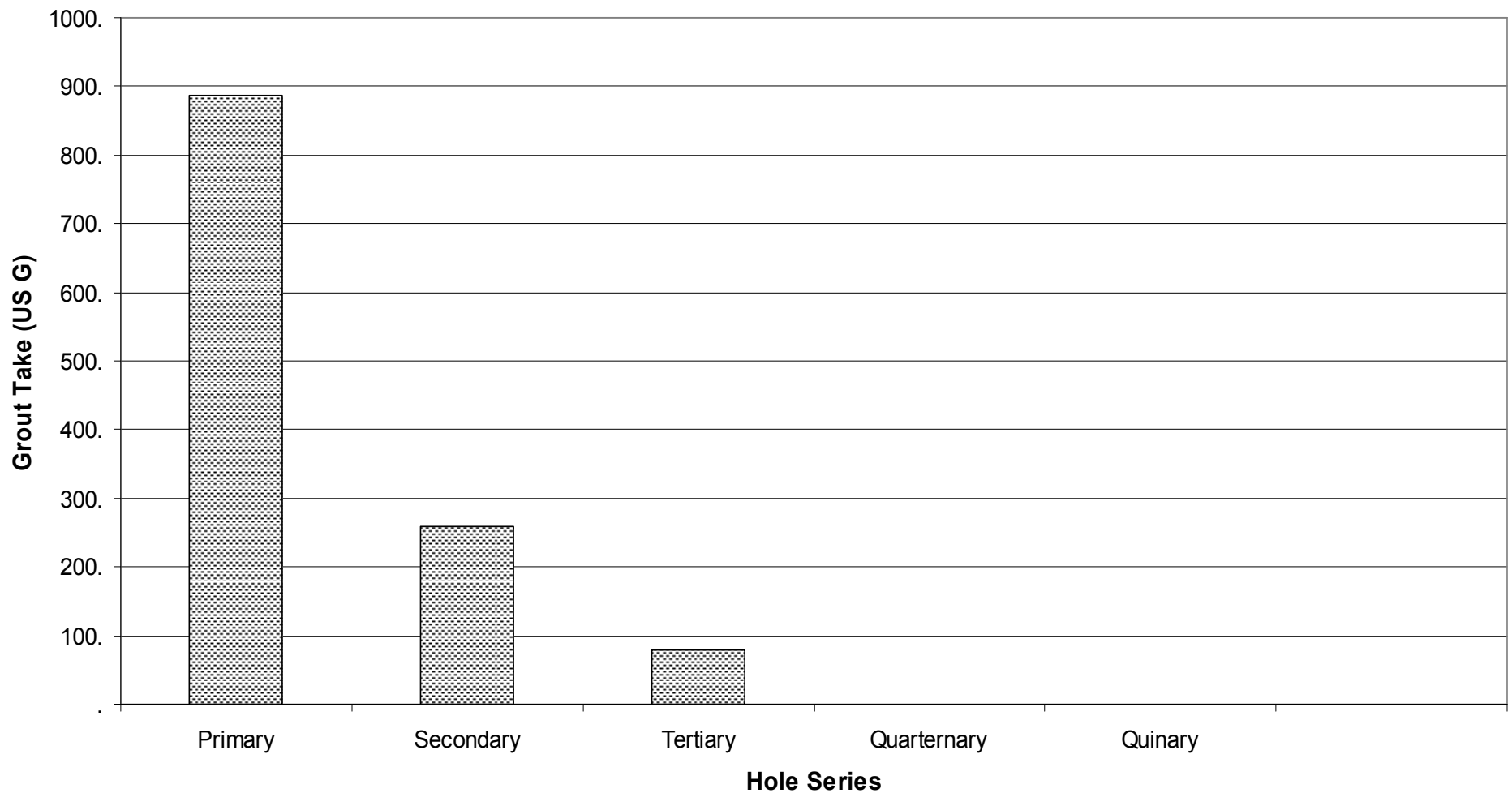
Line: All , Hole Series: All , Hole ID: AP13 To AP17 , Elevation: 390



A – Line Closure Analysis

AP13 to AP17 - Elevation 390

Mean Grout Take Values Plot
Line: All , Hole Series: All , Hole ID: AP13 To AP17 , Elevation: 390



Clearwater Dam Sinkhole Repair

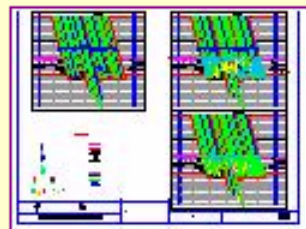
Copyright 2003



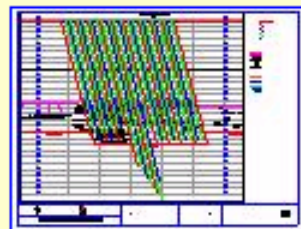
Preliminary IntelliGrout Drawings (Updated as of 09-21-04)



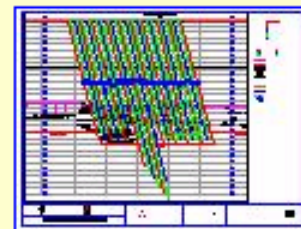
[A-Line Plan View](#)



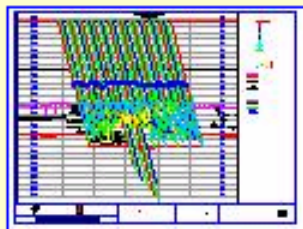
[A-Update](#)



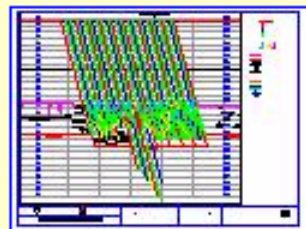
[A-Geology](#)



[A-Characteristics](#)



[A-Pres Test](#)

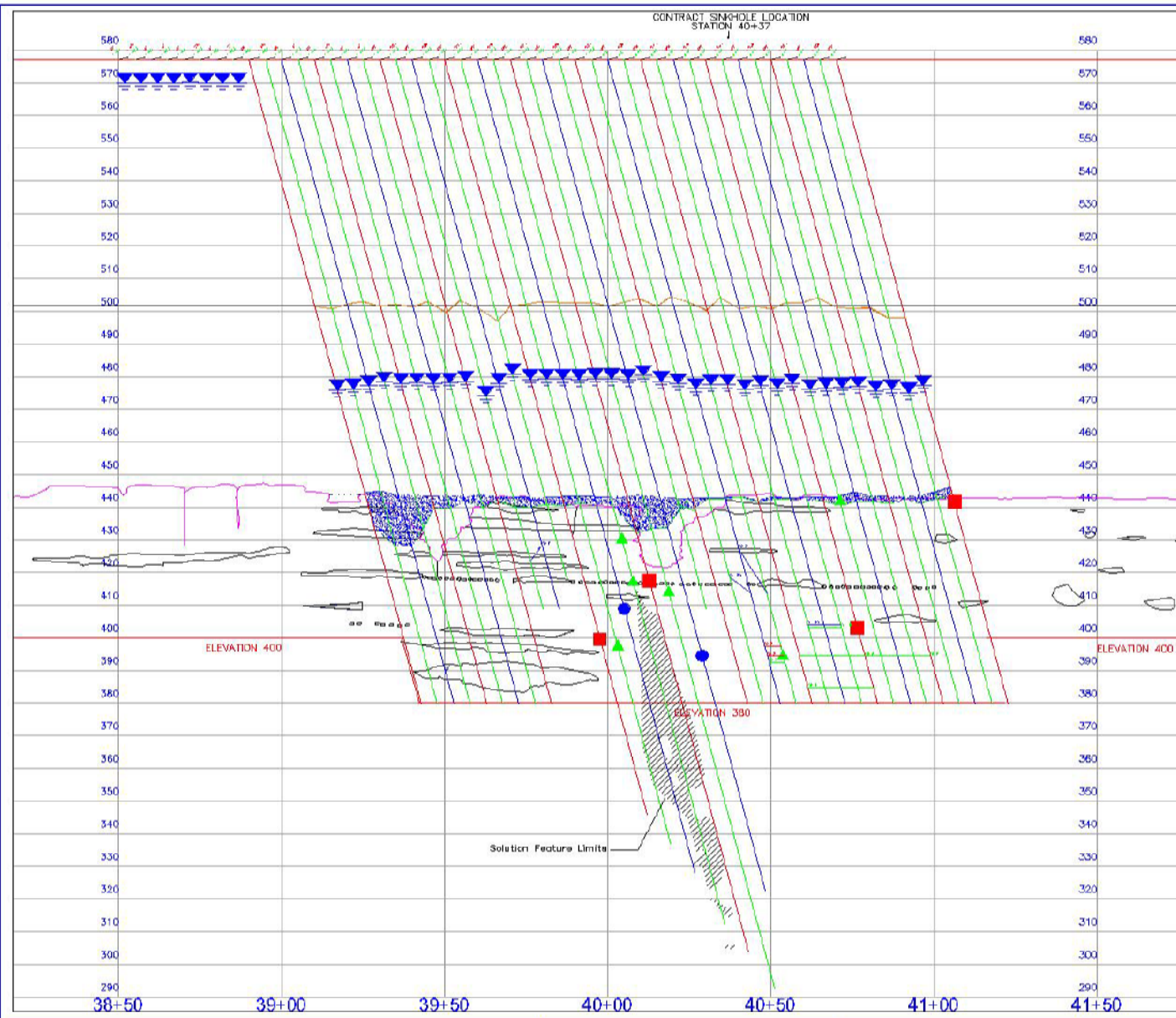


[A-Grout](#)

Notes:

1. Update drawings are not record drawings. Information shown is preliminary based on work in progress and is subject to revision.

2. Efforts will be made to provide update drawings on approximately a weekly basis.



LEGEND

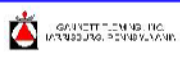
- PRE WATER LEVEL
- POST WATER LEVEL
- PRE WATER LEVEL
- POST WATER LEVEL

- | | |
|--|---|
| ■ WATER LOG | — HOLE LOGGING |
| ● WATER LOG | — HOLE LOGGING |
| ▲ WATER LOG | — HOLE LOGGING |

- CONTRACT FOR ROCK
- CONTRACT FOR SANDSTONE
- CONTRACT FOR SANDSTONE
- CONTRACT FOR SANDSTONE
- CONTRACT FOR SANDSTONE

GEOLOGY AS CLASSIFIED BY THE

- TOP OF SANDSTONE
- TOP OF SANDSTONE
- TOP OF ROCK
- SANDSTONE



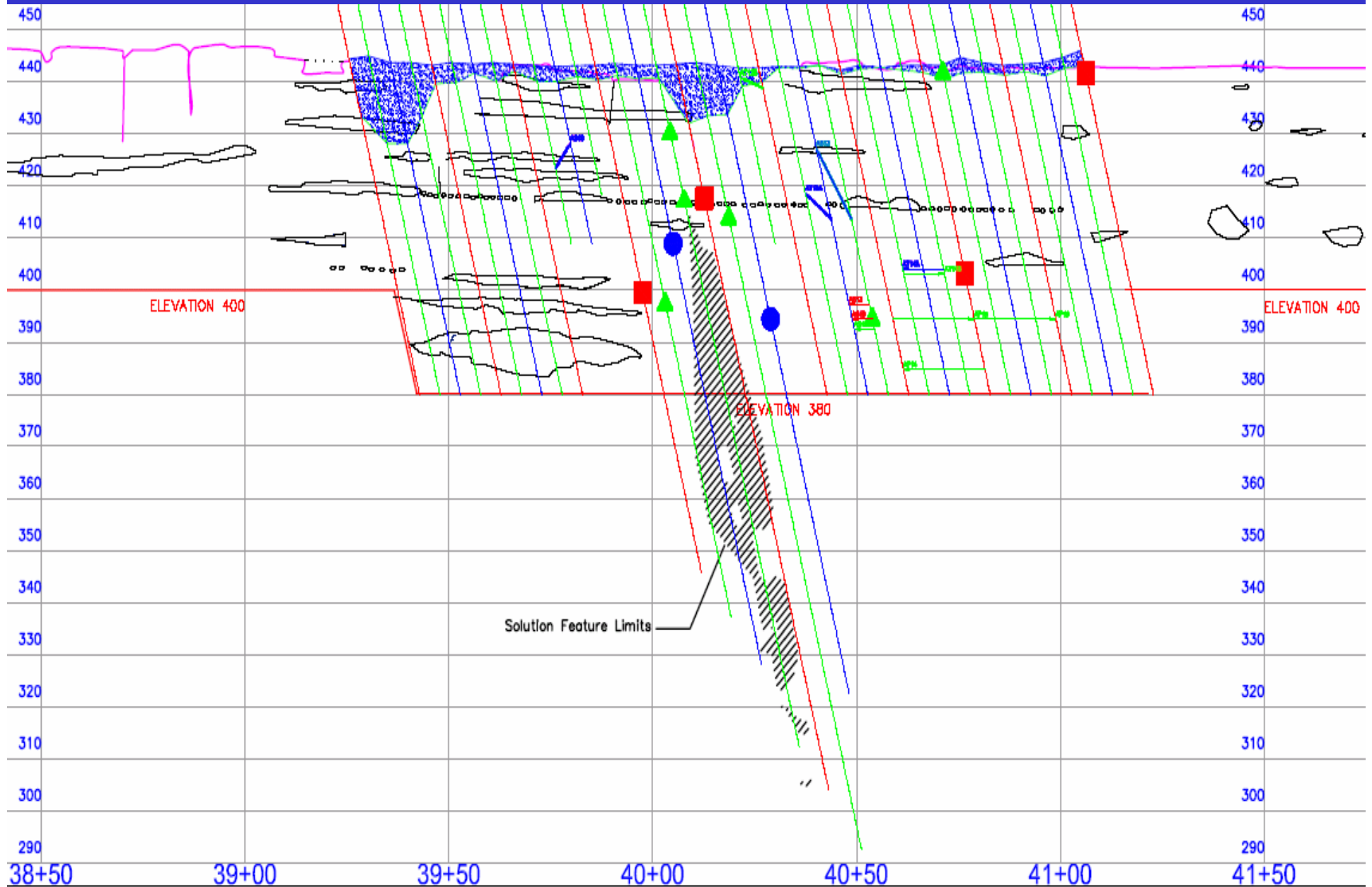
A - LINE HOLE CHARACTERISTICS
October 5, 2004



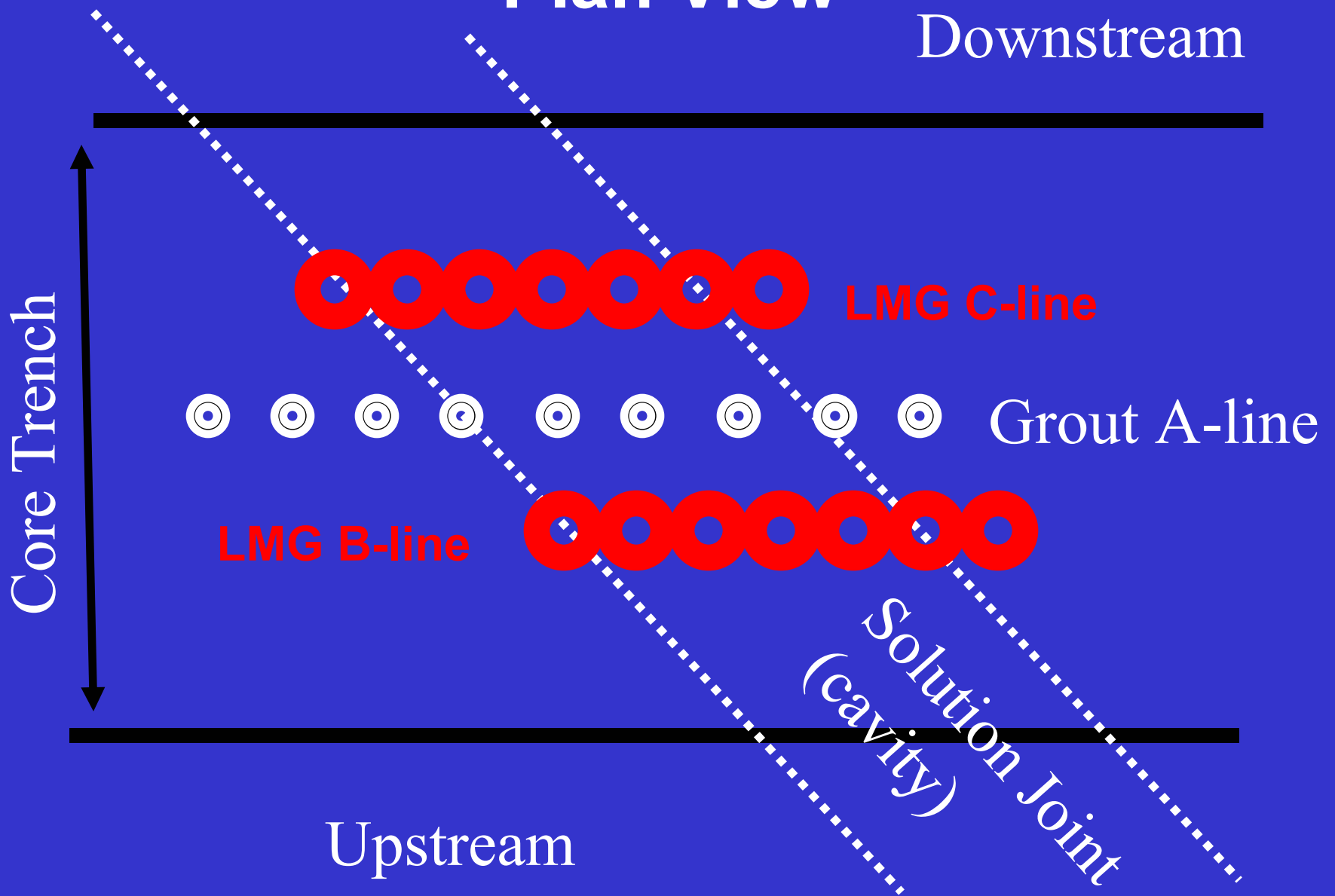
CLEARWATER DAM SINKHOLE REPAIR
8350 N. VADO
FOUNDATION DRILLING AND GROUTING
CONTRACT NO. WFL2501-0000

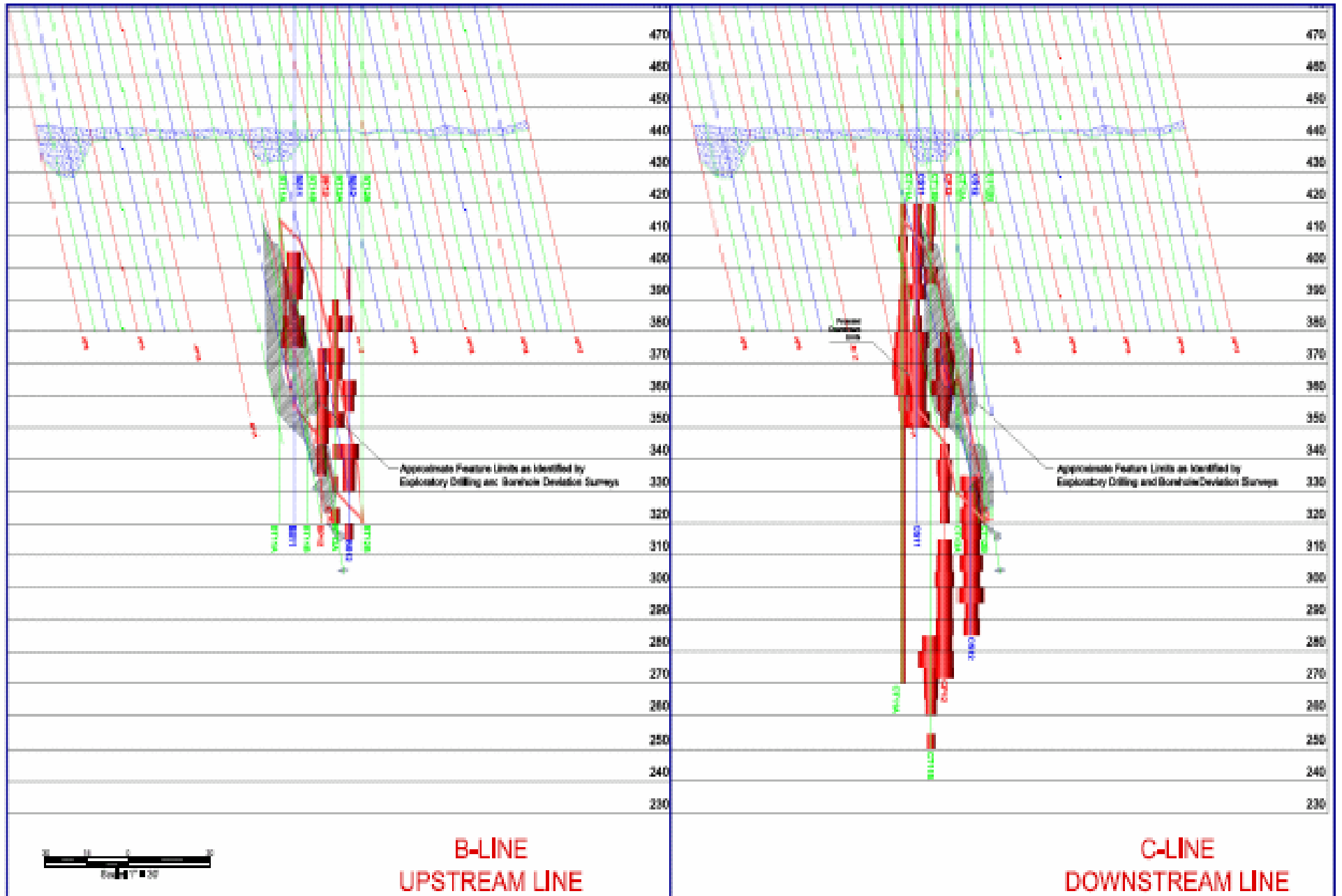


Location of Cavity under Core Trench



Low Mobility Grout Holes Plan View





**B-LINE
UPSTREAM LINE**

**C-LINE
DOWNSTREAM LINE**

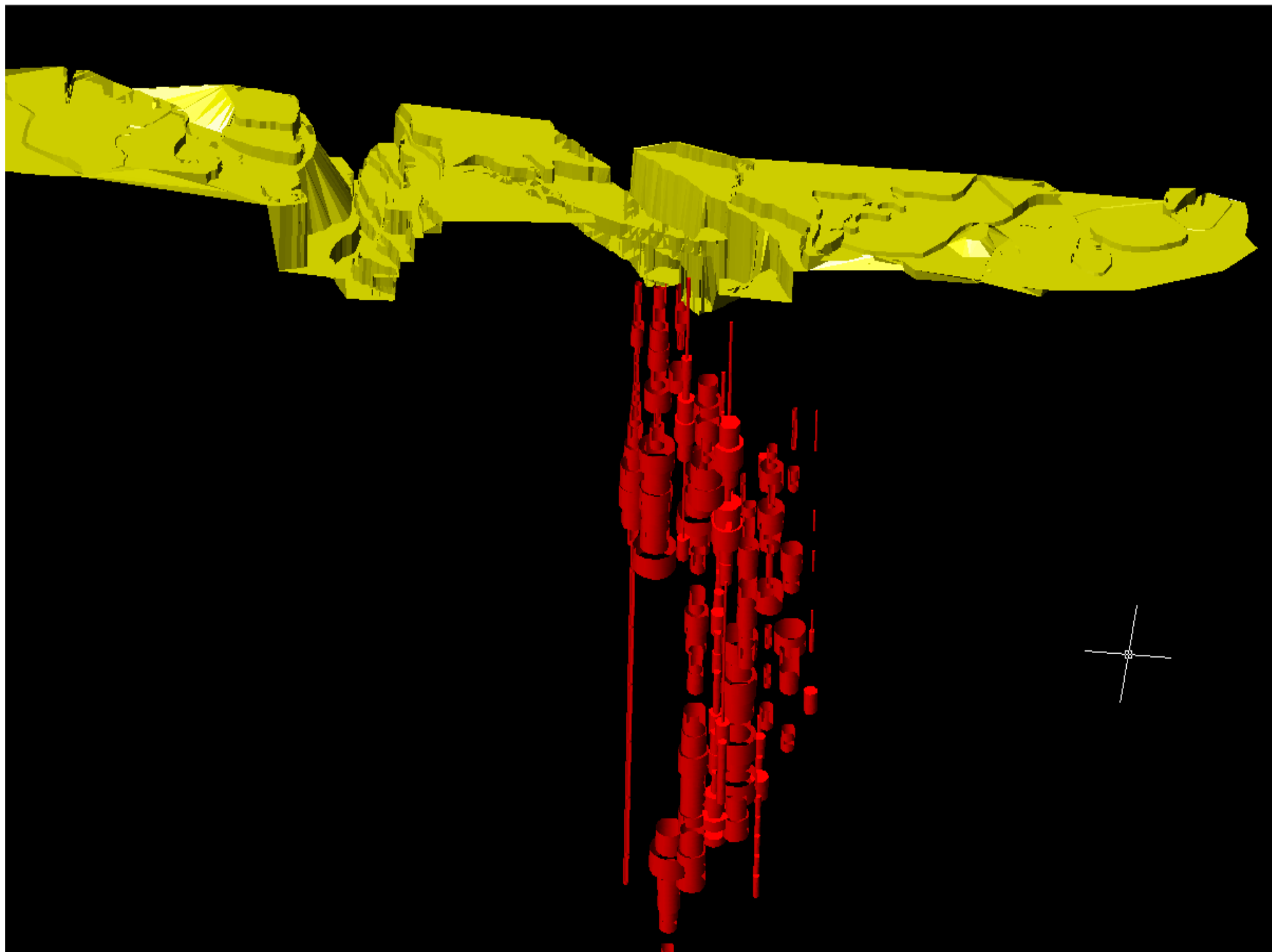


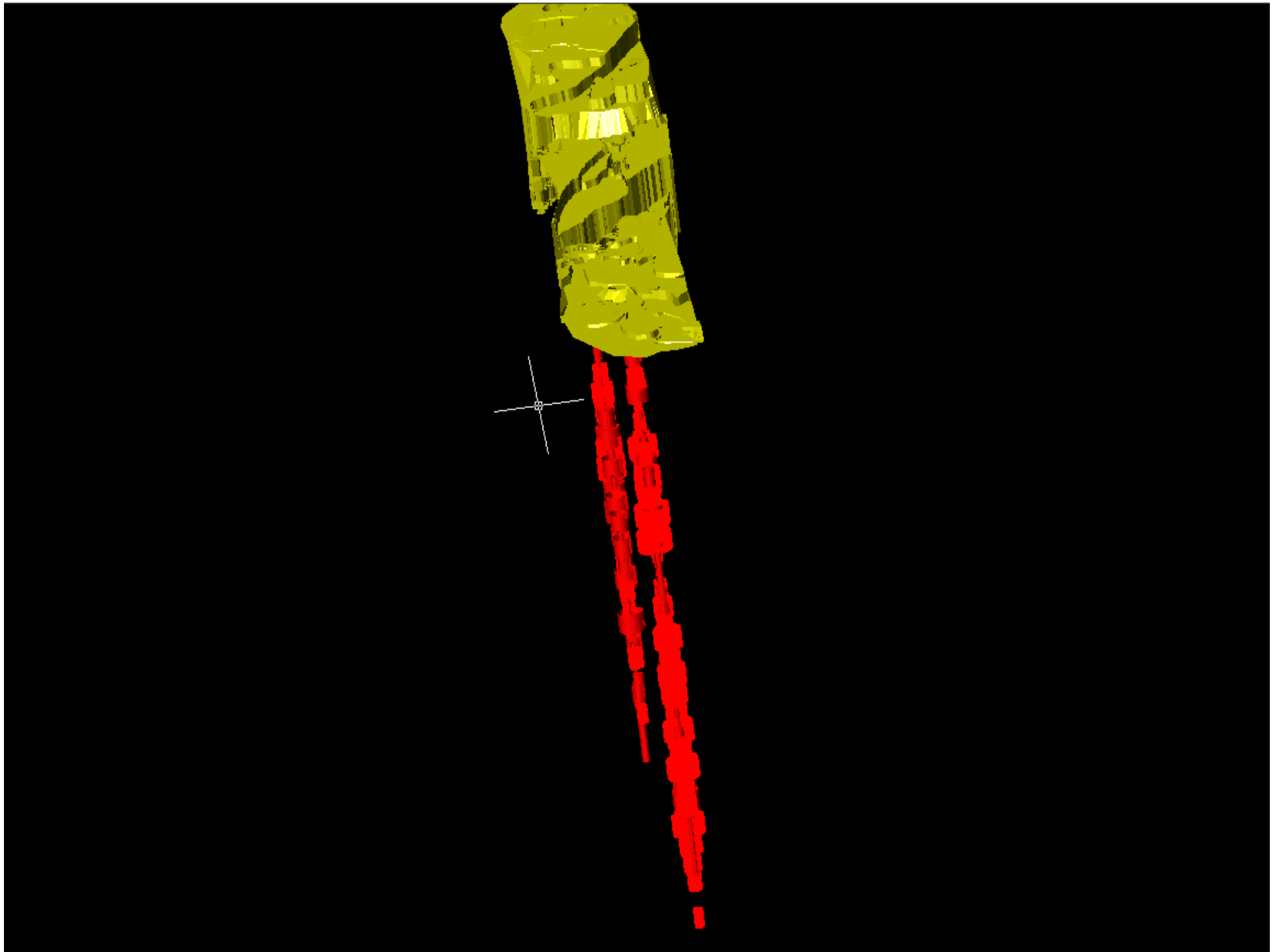
IntelliGrout™
The Science of Grouting

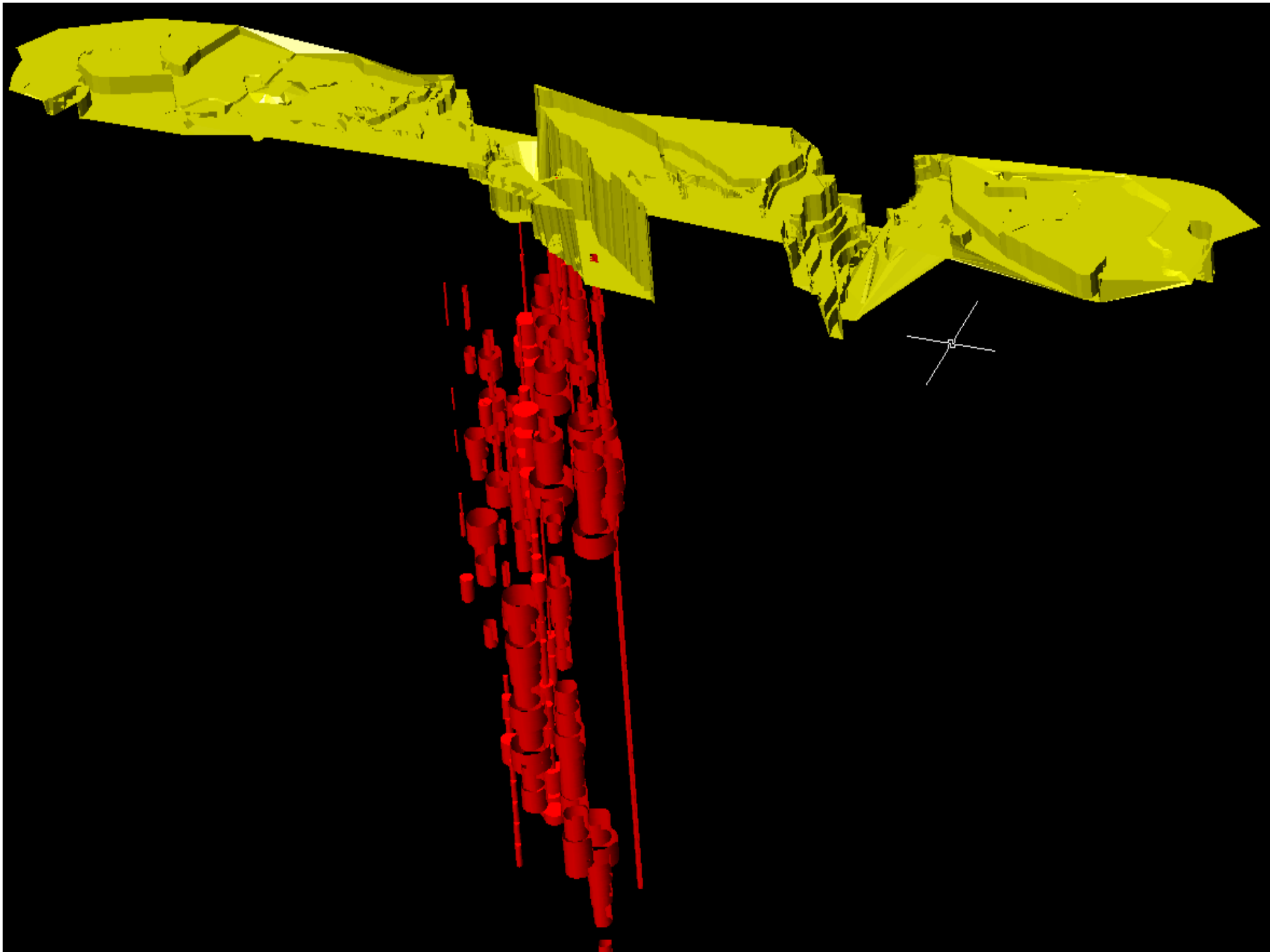
CLEARWATER DAM SINKHOLE REPAIR
PIEDMONT, MISSOURI
FOUNDATION DRILLING AND GROUTING
CONTRACT NO.: W9127S-04-C-0003



FIGURE 3
PROFILE VIEW OF LMG HOLES
Updated as of 3-15-05



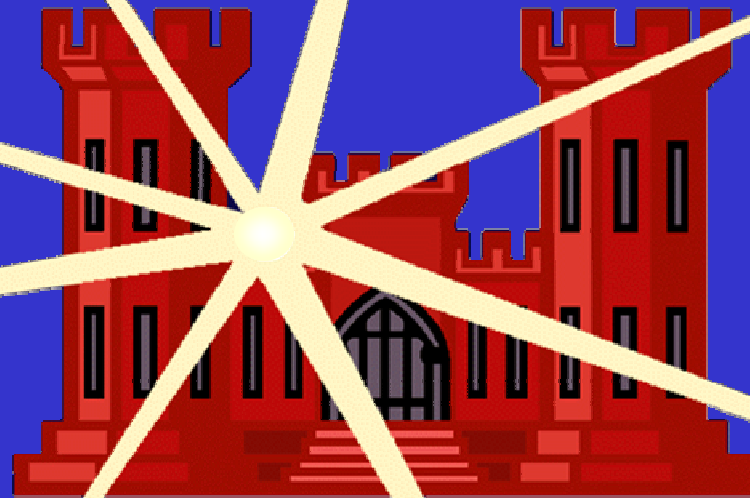




Clearwater Dam Major Rehabilitation Project

- **PHASE I – Full length of dam, close spaced exploratory drilling and grouting.**
- **PHASE II – seepage cutoff wall through embankment and into rock (design dependent upon Phase I).**

Little Rock



District