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Chicago Underflow Plan – CUP
McCook Reservoir Test Grout Program

Joseph A. Kissane, P.G.
Geotechnical Engineer / District Geologist
Geotechnical Branch
U.S. Army Corps of Engineers
Chicago District

CELRC-TS-DG
111 N. Canal St. Suite 600
Chicago, IL 60606
(312) 846-5453
joseph.a.kissane@usace.army.mil

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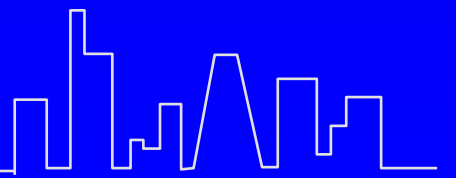
Project Description

- Flood control/CSO reservoir
- Captures CSO from Chicago and 37 suburbs
- Routed through Mainstream and Des Plaines Tunnels and Stickney Plant
- 2 Stages - 21,000 acre-ft (7B gallons)
- 300 ft deep (50 ft soil, 250 ft rock)
- Operational – 2010 (?)
- Project Completion - 2012



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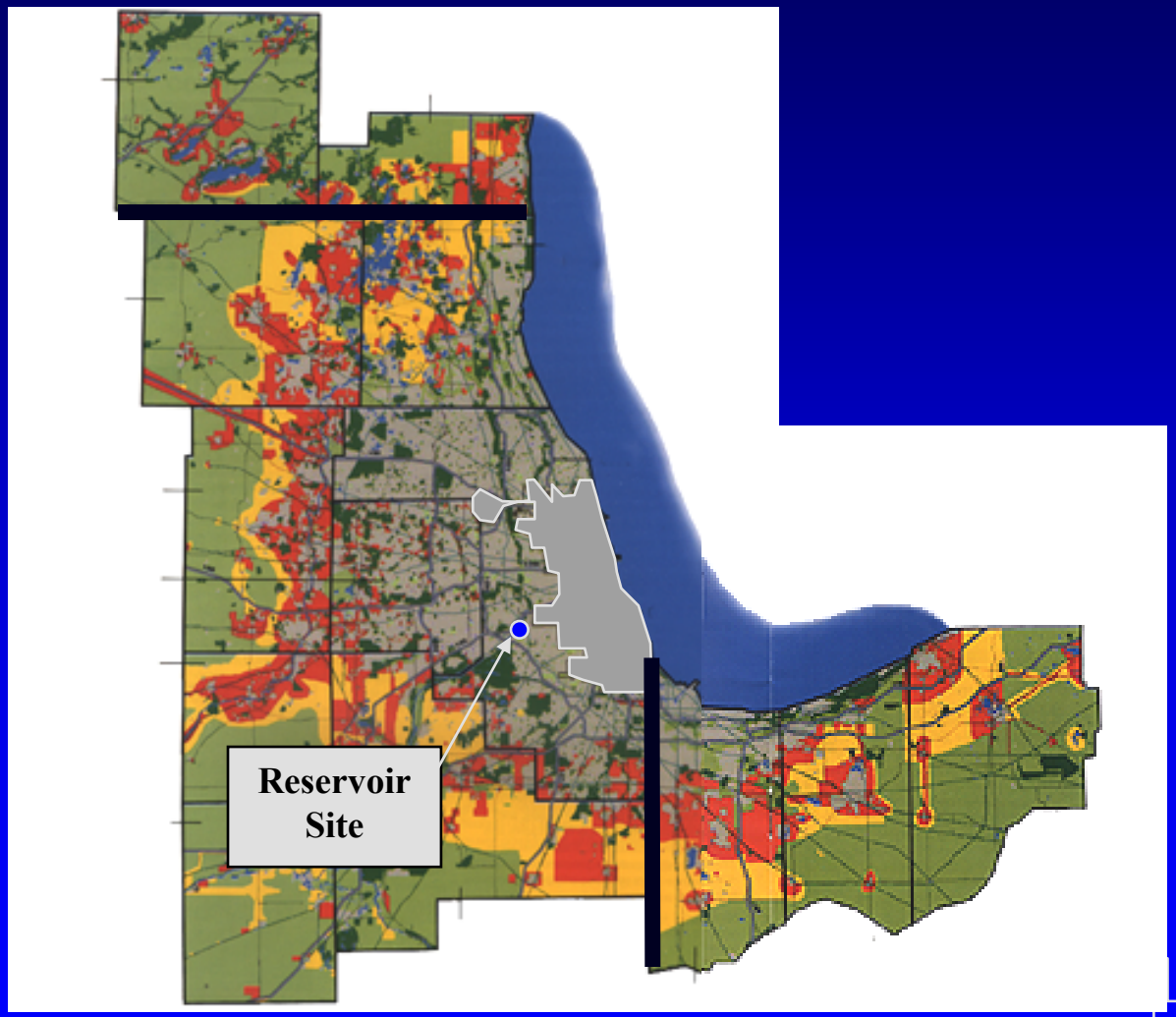
Project Overview



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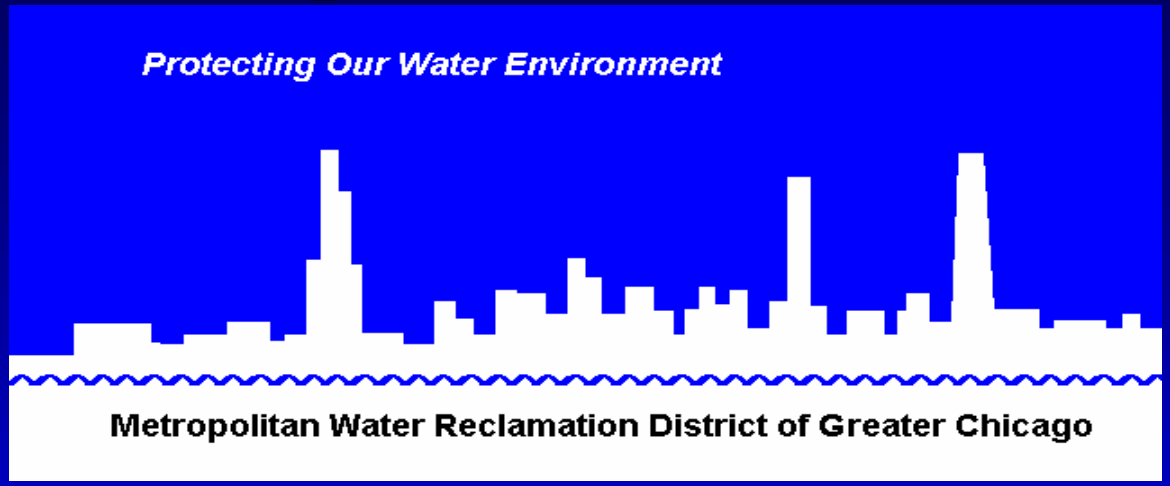
Local Sponsor - MWRDGC



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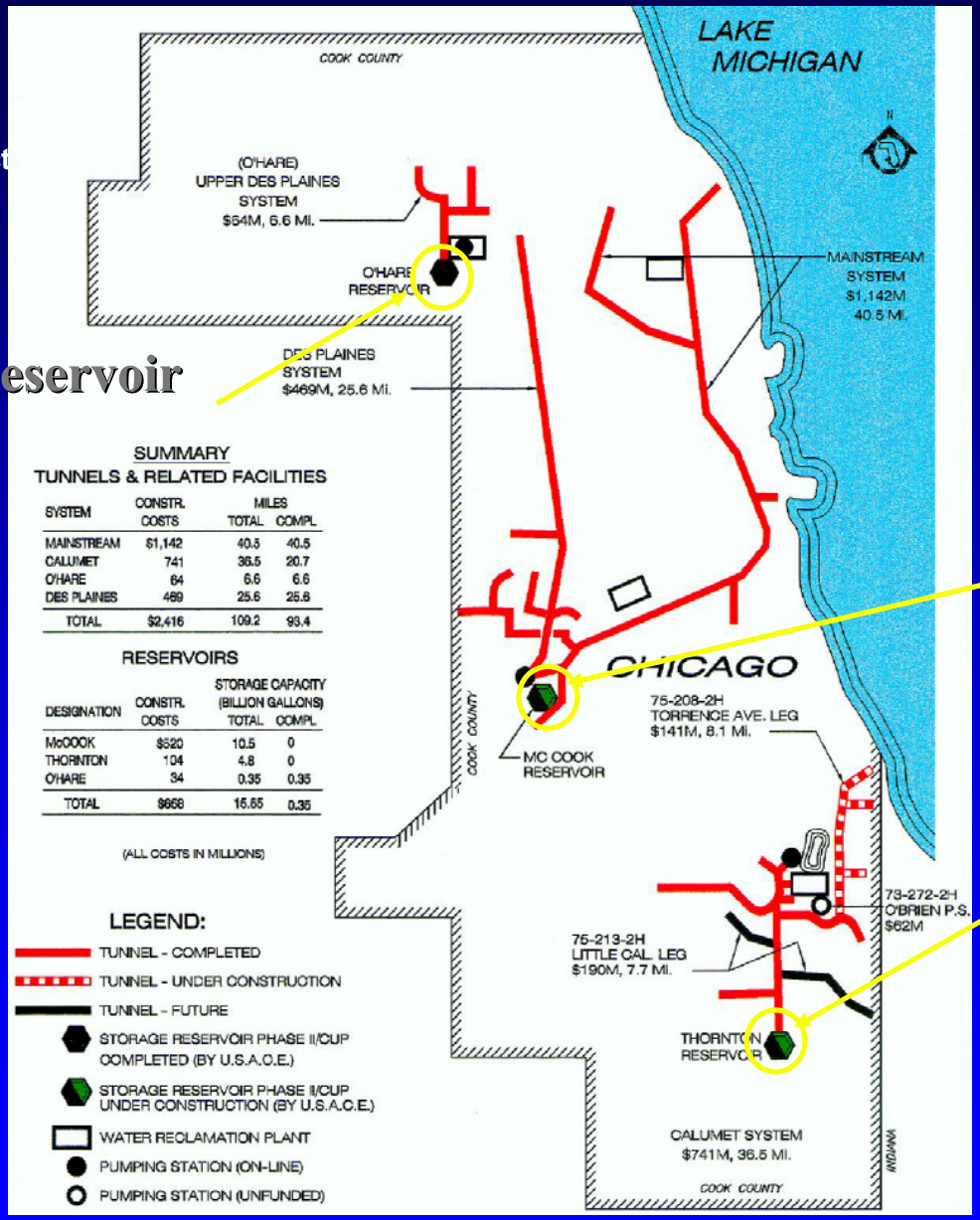
Chicago Underflow Plan CUP

Tunnel and Reservoir Project - TARP

O'Hare Reservoir



McCook Reservoir

Thornton Reservoir

110 miles of tunnels within system beneath Chicago and surrounding suburbs

Site Layout

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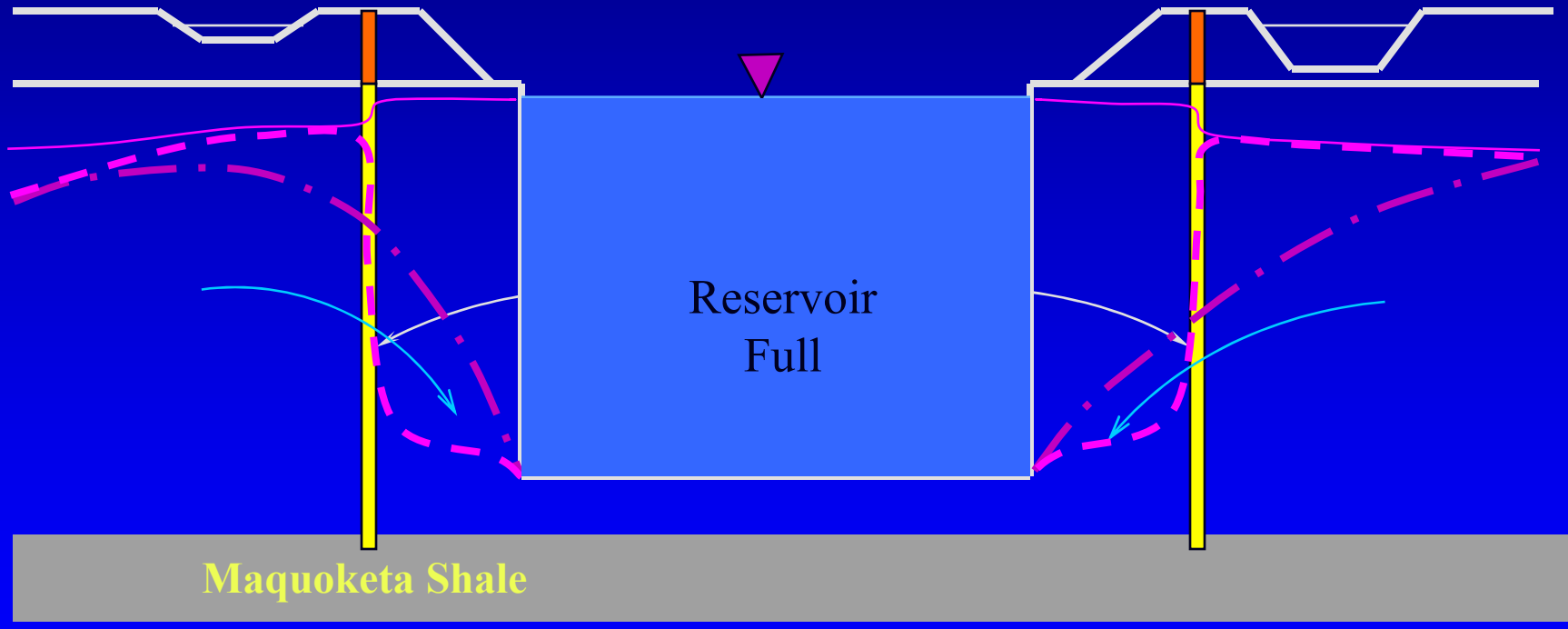
Groundwater Schematic



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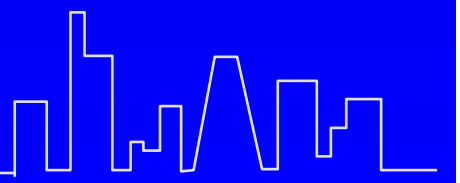
Grout Curtain Design

Design parameters under consideration:

- Drilling Method
- Hole Size
- Hole Inclination
- Hole Spacing
- Grouting Method
- Grout Mix Design



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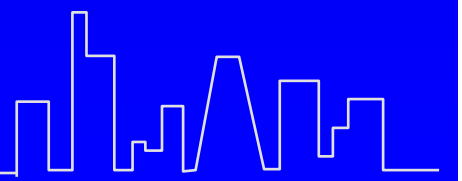
Test Grout Curtain Design

Contractual Vehicle

- Best-Value Contract – RFP
- Technical Factors Outweigh Cost

Technical Evaluation Criteria are Critical

- Too tight and no one qualifies, too vague and everyone qualifies
- Technical Approach
  - Computerized System, Drilling Approach, Grouting Approach
- Experience
- Equipment
- Safety



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Test Grout Curtain Design

Contract Details

- Value Based Contract – not traditional "Low Bid"
- Contractor-Proposed methods
- Base Bid + Option (if executed)
- Base Bid – 2 parallel legs of curtain
- Option – Optional section to be drilled using one of the two methods demonstrated in Base-Bid
- Cost driven by drilling – up to 130,000 linear feet:
  - 10,000 linear feet overburden (base-bid)
  - 16,000 linear feet overburden (optional phase)
  - Appr. 50,000 linear feet rock drilling (base bid)
  - Appr. 67,000 linear feet rock drilling (optional phase)

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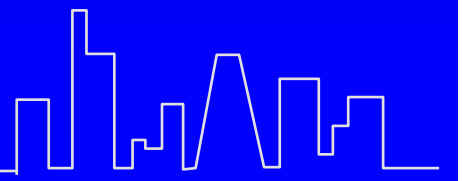
Design Issues

- **Alignment - double-row curtain vs. single row**
- **Drilling Method (Water DTH and Rotary)**
- **Mix Design - Balanced-Stabilized Grout**
  - Permits high solids/water ratio with lower viscosity
  - Include demonstration of Ultra-fine/Micro-fine cement
- **Computer Control of Grouting**



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Test Grout Curtain Design

- **Two double row test grout curtain sections**
  - 1 for testing of percussion and 1 for rotary drilling
  - "Chain link fence" or "lattice" array – rows oriented opposite each other
- **Parallel sections with similar geologic and joint orientations**
- **Each 200-ft long, 15-ft wide**
- **Grout holes angled 15° from vertical, 7.5 ft from centerline of cutoff wall on each side**
- **Primaries 40-ft apart – split spacing down to 5-ft**

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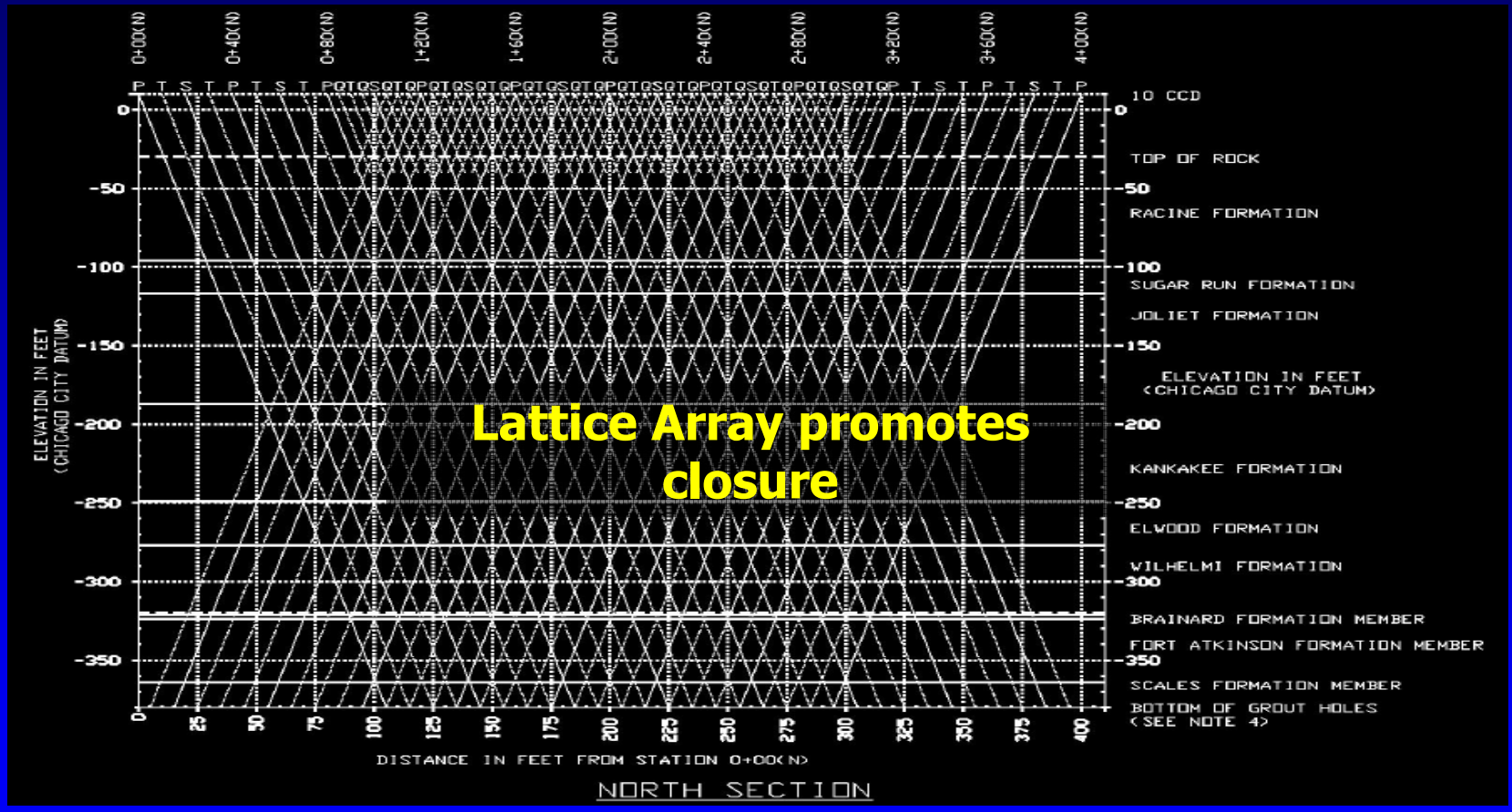
Test Grout Curtain Design



Lattice Array promotes closure

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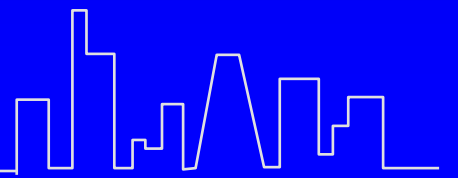
Design (continued)

- Fully automated (computerized) grouting control and monitoring
- Demonstration section (10-ft rock grouting below overburden-rock interface)
- Verification boreholes (before and after)
- Rock coring
- Borehole camera logs
- Max. allowable deviation < 0.5 inch per foot (inclined) measured by precision instruments



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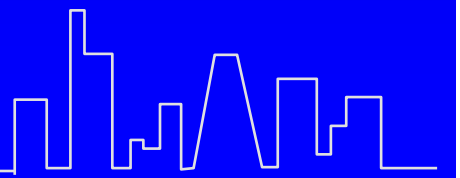
Design (continued)

- Primarily upstage (bottom up) grouting
- Downstage grouting for top 10-ft and zones of lost circulation
- Grout mix – balanced-stabilized mix, adjusted based on "Apparent Lugeon" value
- Criteria - no take for 5 min. at max. pressure
- Expected closure = 1 Lugeon or less
  - (1 Lugeon = 1.4 x E-5 cm/sec)
- Optional section (~ 800 ft)
- Lessons-Learned Report



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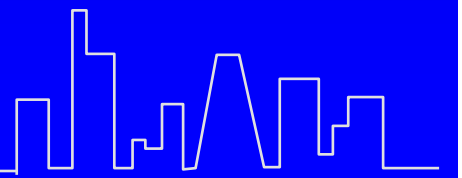
Construction

- **Contractor: Advanced Construction Techniques (ACT) / Gannett-Fleming**
- **Started in January 2003**
- **Pad construction completed**
- **Intelligrout™ System Setup**
- **Drill Rig: Cubex-Wassara – Water driven, down-hole hammer**
- **Grout Plant: Fully automated (ACT-Thiessen)**



Full-Scale Test Layout

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Site Access and Curtain Alignment

Unusually good access

Contractor paved surface to assist alignment of drill rig

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Drill Rigs

JKS Boyles Rig – HQ diamond tooling

Cubex-Wassara Rig – 4-inch Water-actuated down-hole-hammer

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Rig Control

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Grout Plant – ACT

Self-contained mobile plant and control center

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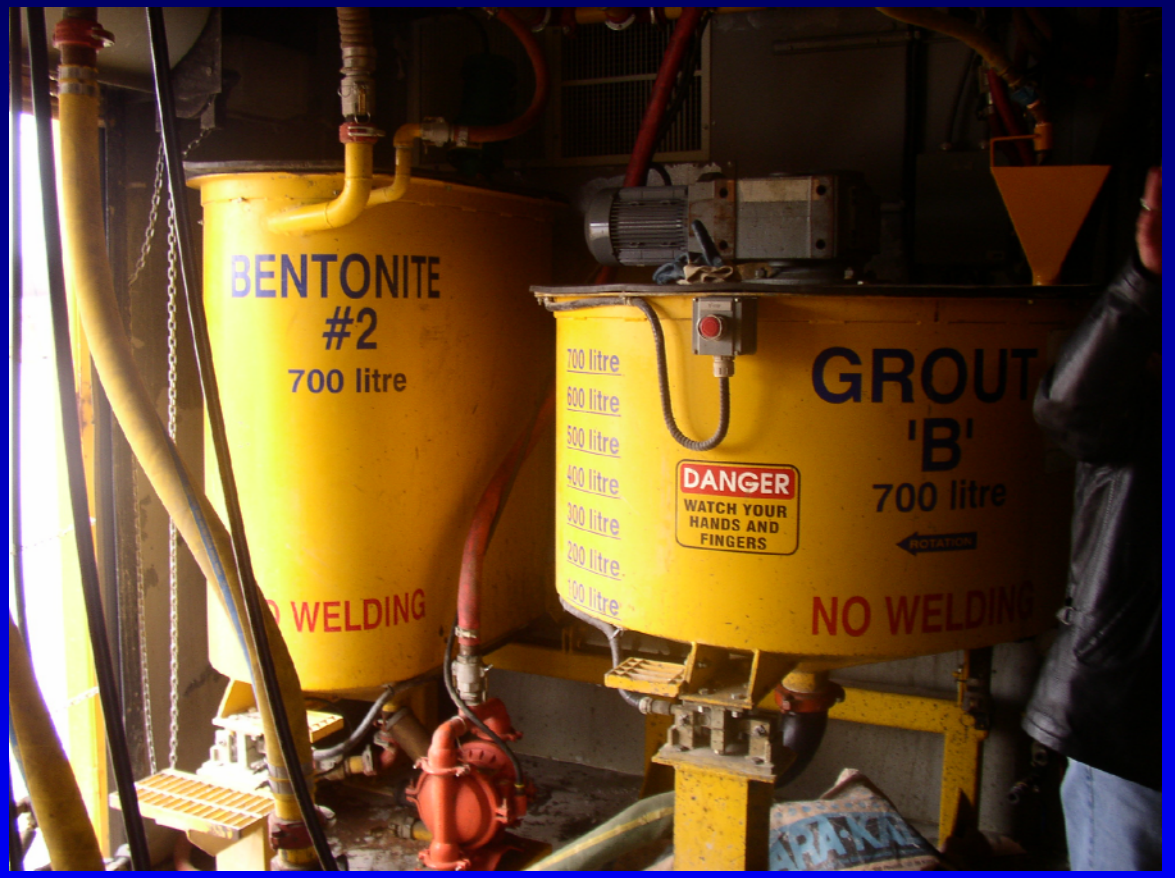
Batching and Mixing



- Tanks designated by mixes and components
- Mixes checked for viscosity and sp. Gravity
- Flow measured by magnetic flow meters
- Mixing tanks equipped with load cells to monitor flow and supply

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Pumps and Control Panel

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Self-contained Mobile Grout Buggy with Flexible-Line Packer Assembly

- Constant in-line volume
- Highly portable
- Insulated lines
- Additional flow meter for Q/C at borehole

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IntelliGrout System:

- **Real-time monitoring and controls**
- **Continuous data acquisition**
- **Web-capable**
- ***Computer –linked data presentation system***

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Summary

- **Complete Test Grout Construction in 2004**
  - Option section deleted due to funding shortfall
- **Lessons-Learned Report**
  - Combined with groundwater model for design of groundwater control system
- **Complete Design for Entire Perimeter (7,500 ft Stage I and 6,000 ft Stage II) begin 2005**

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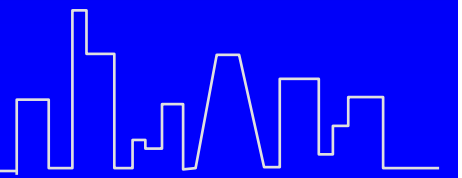
Summary

Lessons-Learned

- No detrimental effects on borehole quality by using down-hole water hammer
- 1.0 Lugeon achievable at the site
- Computer system grouting advantages are essential for project of this scale
- Balanced-stabilized mixes improve grout effectiveness



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Summary

Lessons-Learned Report Combined with Comprehensive Groundwater Model

- Full-perimeter double-row grout curtain
- Curtain grouted to shale unit below base of reservoir
- Opposing orientation of double-rows for improved closure
- 1.0 Lugeon target closure criterion

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Questions/Comments/Feedback???

Joseph A. Kissane, P.G.
CELRC-TS-DG
111 N. Canal St. Suite 600
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