Use of Concrete Mixtures with 50% or Greater Supplemental Cementitious Materials Replacement for the Table Rock Auxiliary Spillway

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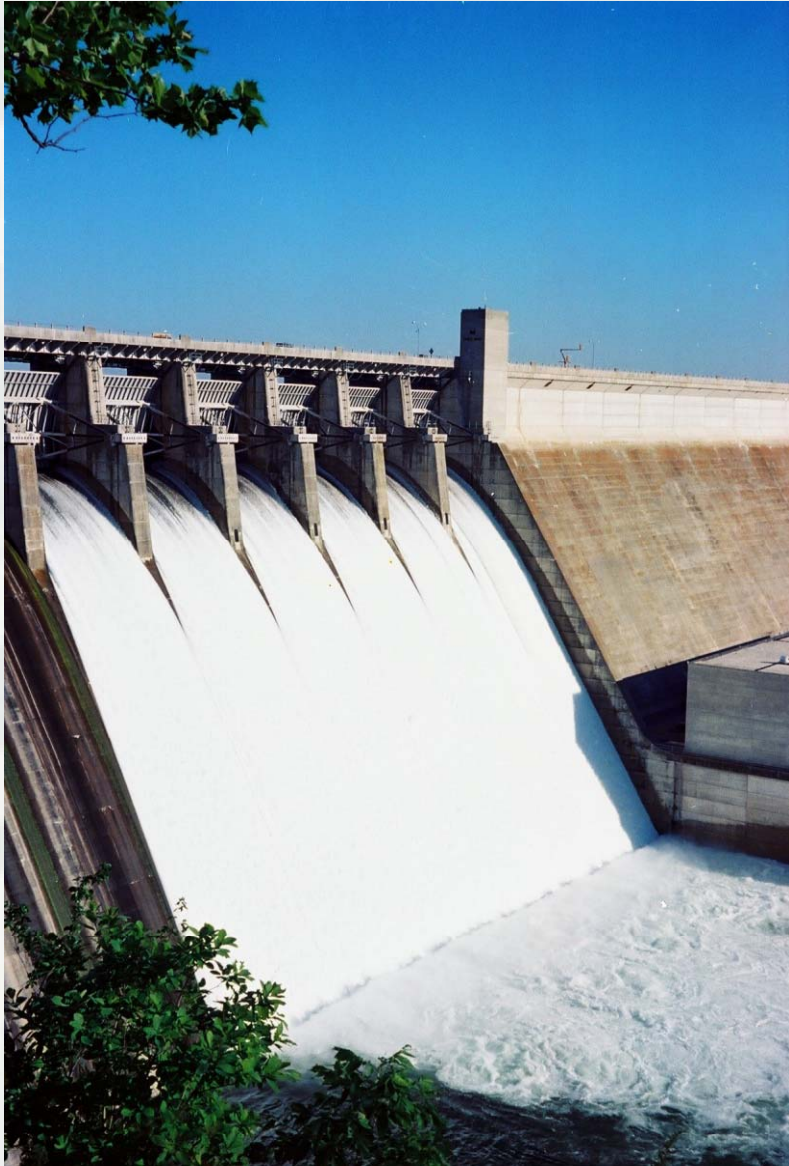US Army Engineer Research & Development Center

Anna Maria Workshop XII

9-11 November 2011

US Army Corps of Engineers
BUILDING STRONG®

Table Rock Lake & Dam

- Dedicated in 1959
- Located on the White River in southwest Missouri
- Forms Table Rock Lake
  - 3,462,000 acre-feet
- Flood Control and Power Generation
  - 6,423 Feet in Length
    - Concrete section: 1,602 Ft
      - 1,230,000 cubic yards
    - Earth embankment: 4,821 Ft
      - 3,320,000 cubic yards
  - Four 50,000 kilowatt generating units

WHITE RIVER BASIN
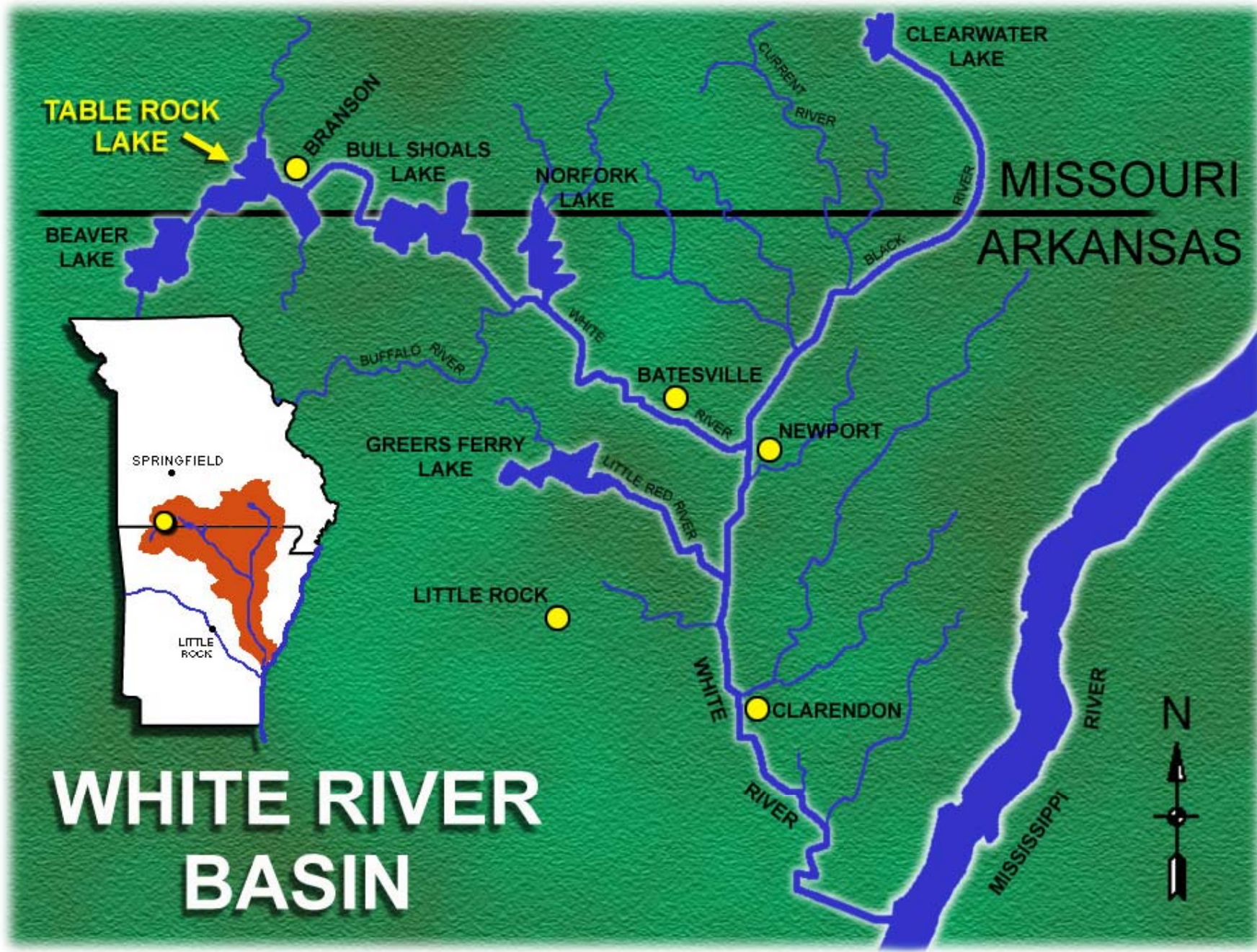
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Concrete and Earth Embankment Dam

Why is the Auxiliary Spillway Needed?

Existing Spillway - Inadequate for Maximum Probable Flood

• Concerns with overtopping earth embankment section

• With potential to flood Branson, MO

• 10 Existing Spillway Gates
• 45 x 37 feet each
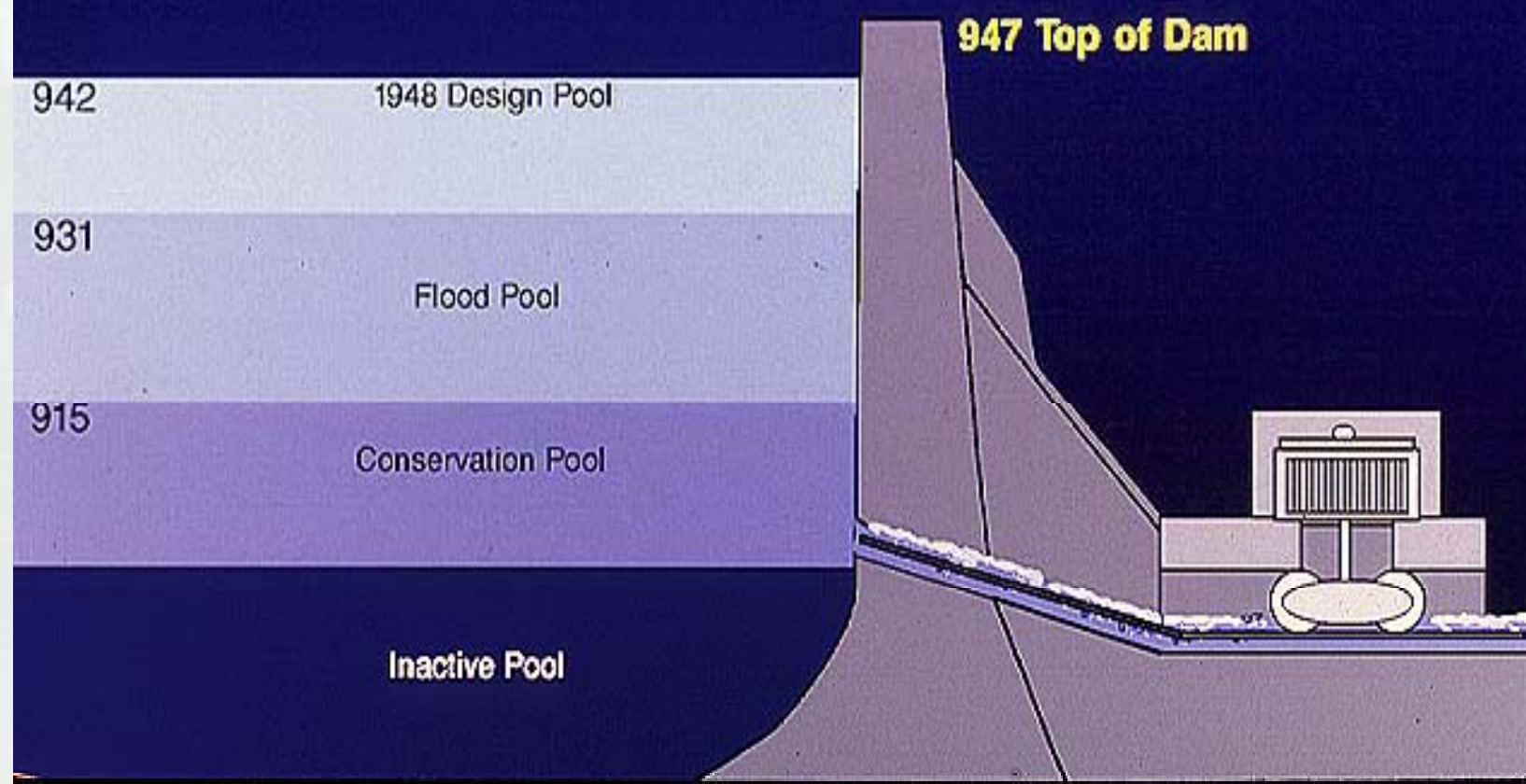
Table Rock Dam & Lake
Dam Safety Assurance
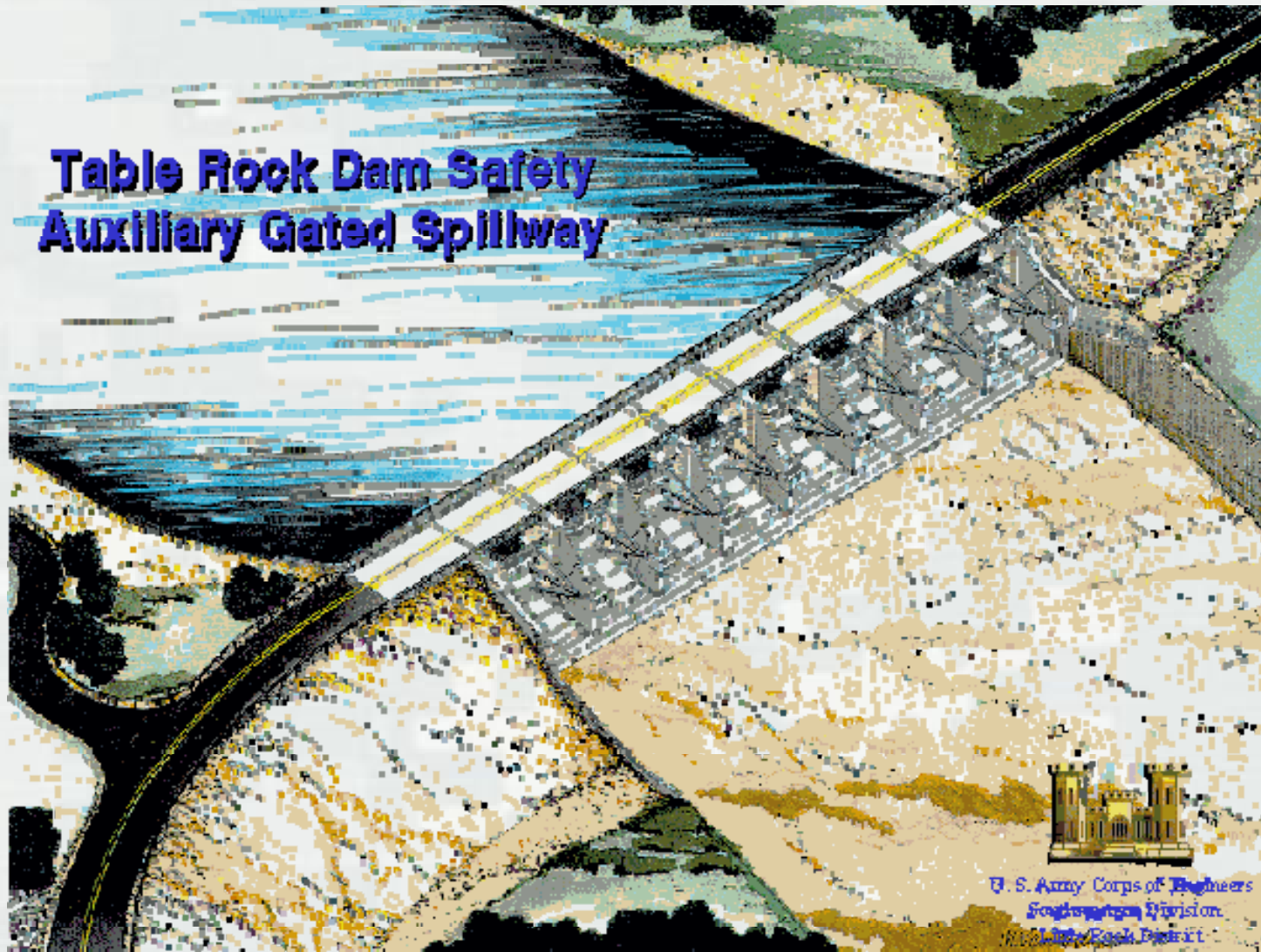
952 — Current Design Pool

947 Top of Dam

942 — 1948 Design Pool

936 — Easement Upper Limit

931

Flood Pool

915

Conservation Pool

Inactive Pool

Table Rock Auxiliary Spillway

Table Rock Auxiliary Spillway

TABLE ROCK DAM SAFETY PROJECT
AUXILIARY GATED SPILLWAY

Spillway Cross Section

Bridge Crown EL. 288.95 (947.0)

Top to Gates EL. 286.21 (939.0)
Equal to bottom lip of fully
raised gates on existing spillway

Seasonal Pool EL. 279.50 (917.0)

Table Rock Lake

EL. 273.10 (896.0)

Trunnion Beam

Operating Cylinder

Valley Below

Grout Curtain

Solid Bedrock
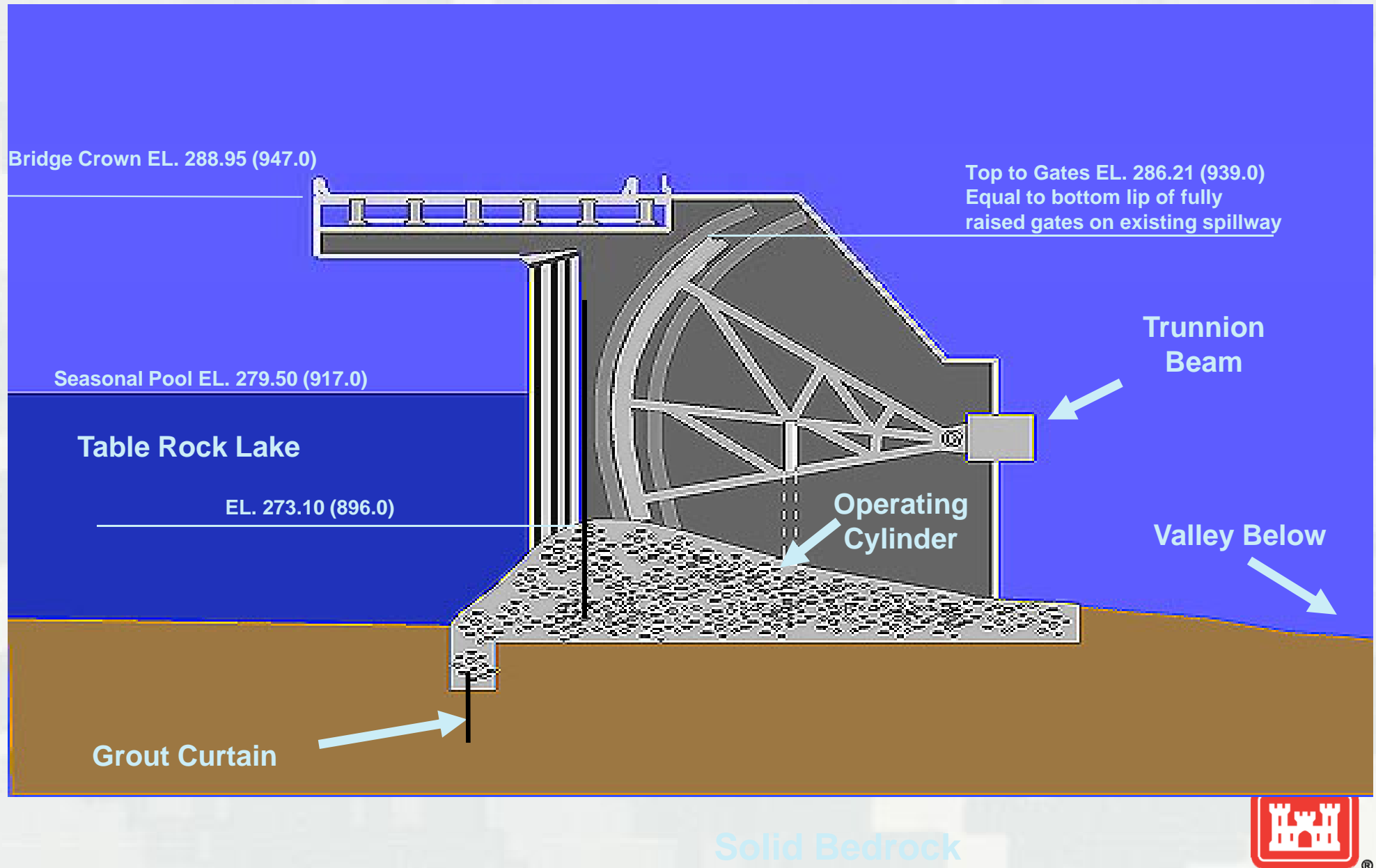
Engineer Research and Development Center

- Hired by Little Rock District
  - ▶ Constituent Materials Qualifying
    - Aggregates
      - ▷ ASTM C 33,88, 131,142, 457, 535, 1260
      - ▷ Freeze & Thaw CRD-C 114, Petrographic analysis
    - Cement
      - ▷ ASTM C 150, 451, 359
    - Admixtures
      - ▷ ASTM C 233, 260, 494
    - Water
    - Supplemental Cementitious Materials
      - ▷ ASTM C 618, 989
    - Waterstop
      - ▷ CRD-C 513 and 572

Required Concrete Mixtures

Mixture 1, (Mass): 75-mm (3-in.) NMSA, 20.7 MPa (3,000 psi) at 90-days age

Mixture 2: 37.5-mm (1 ½-in.) NMSA, 20.7 MPa (3,000 psi) at 90-days age

Mixture 3: 19.0-mm NMSA (¾-in.), 27.6 MPa (4,000 psi) at 28-days age

Mixture 4: 19.0-mm NMSA (¾-in.), 34.5 MPa (5,000 psi) at 28-days age

Mixture 5: 37.5-mm NMSA (1 ½-in.), 27.6 (4,000 psi) at 28-days age

Three Mass Concrete Mixtures
Cementitious Amounts by Volume of Total Cement

▶ TR 3-9 0.42 w/cm & TR 3-10 0.46 w/cm

- 50% portland cement 42%
- 30% slag cement 25%
- 20% fly ash 33% filler addition

▶ TR 3-14 0.49 w/cm
- 40% portland cement 33%
- 40% slag cement 33%
- 20% fly ash 34% filler addition

Concrete Requirements

- 2- to 4-inch slump

- 0.50 maximum w/cm

- 70cal/gm heat limit

- ASR mitigation

TR-3-14 Mass Concrete

Materials	Mass in pounds, SSD 1- cubic yard
Portland cement	106
ASTM Class F fly ash	44
Slag Cement, Grade 120	98
Fly ash as fine aggregate filler	47
Natural, siliceous, fine aggregate	1159
4.75 to 19.0 mm limestone coarse aggregate	532
19.0 to 37.5 mm limestone coarse aggregate	534
37.5 to 75 mm limestone coarse aggregate	1363
Batch water	158
Water-Reducing Admixture	7.5 fl oz
Air-Entraining Admixture	2.8 fl oz

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Resultant Strengths

Unconfined Compressive Strength, MPa (psi)

1-day	3-Day	7-day	28-day	90-day
3.1(450)	6.3 (910)	13.6 (1970)	27.8 (4030)	34.4 (4990)
2.7 (390)	5.8 (840)	12.9 (1870)	26.3 (3820)	31.4 (4550)
2.9 (420)	6.1 (880)	13.3 (1920)	27.1 (3930)	32.9 (4770)

Site After Phase I Foundation Complete September 2000

Concrete Plant

Concrete Batch Plant

Aggregates

Materials Handling

Aggregate Re-Screen Deck

SCM Secondary Storage

Mass Concrete - Field Adjustments

Concrete Handling

Concrete Handling

Concrete Placement with Conveyor

Concrete travel path from batch plant to point of placement.

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Mass Concrete Placement
Ogee Section 5-2 25 April 2001

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Vibrating Crew
Ogee Section 5-2

Site Overview 13 June 2001

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15 September 2003

Upstream View
15 April 2002

Site Overview

In Service

Table Rock Auxiliary Spillway

29 June 2005

Questions