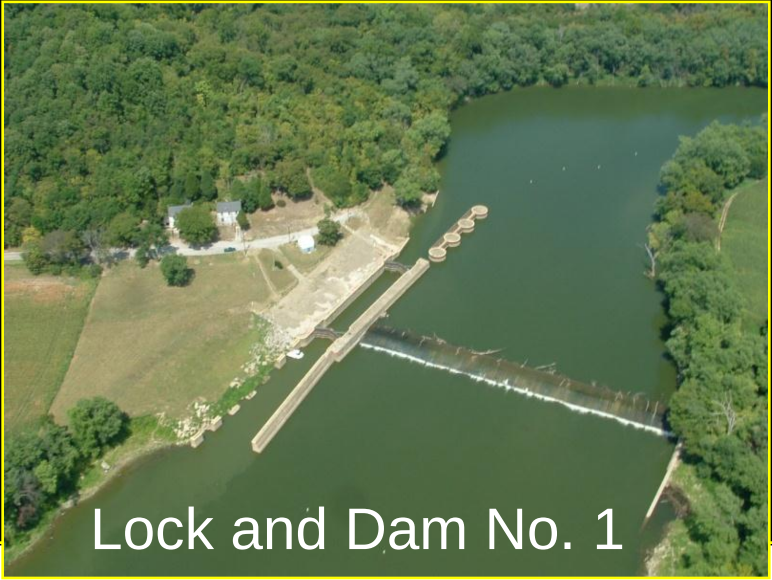
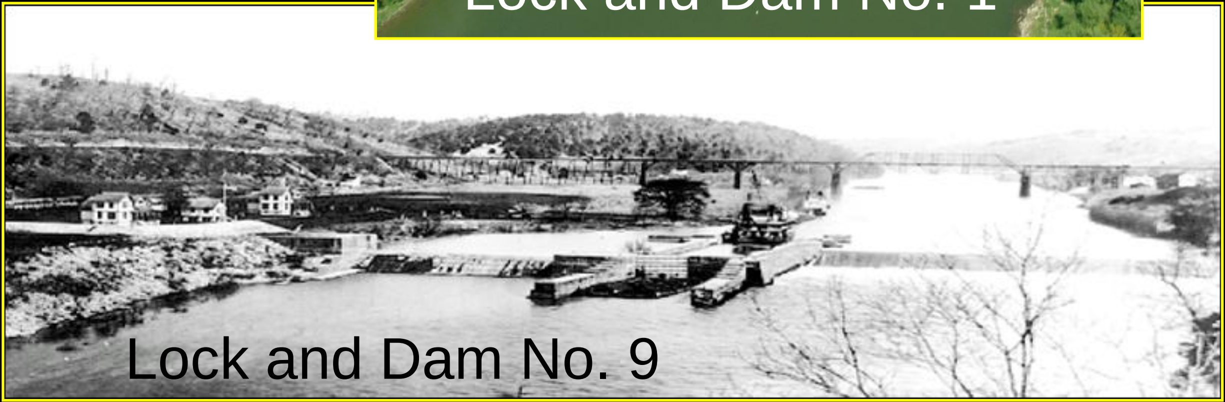
Kentucky River Lock and Dam Projects





Daniel A. Gilbert, PE
April 29, 2011
KSPE Annual Conv.

One Team. Infinite Solutions.

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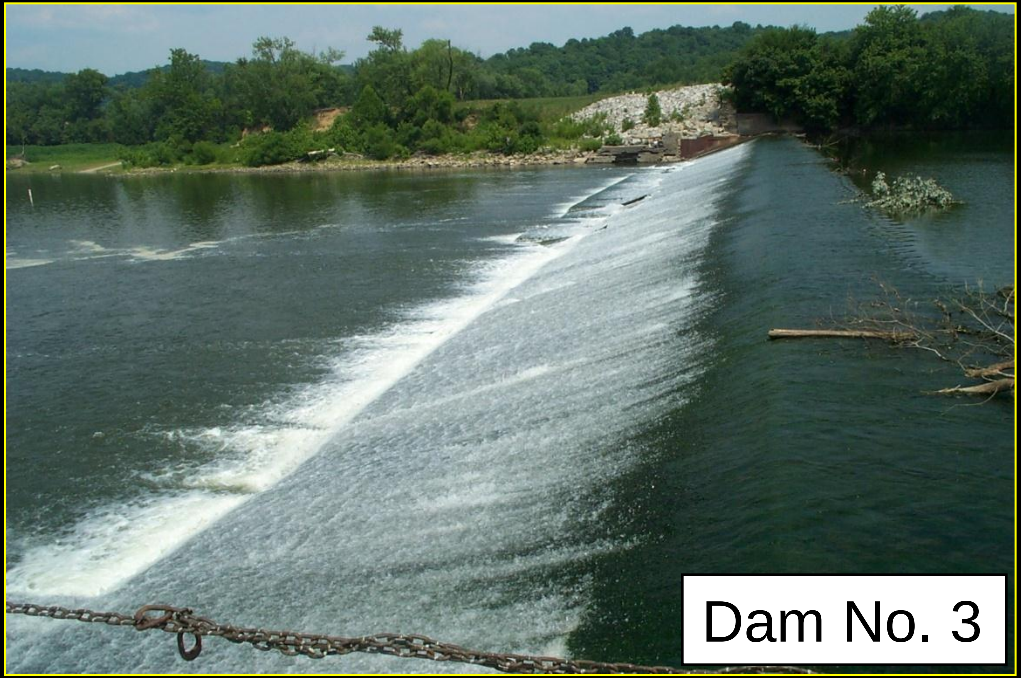
Presentation Overview

- General Information
- History
- Existing Conditions
- Recent Projects
- Why Cell Dams?
- Dam Construction
- Lessons Learned



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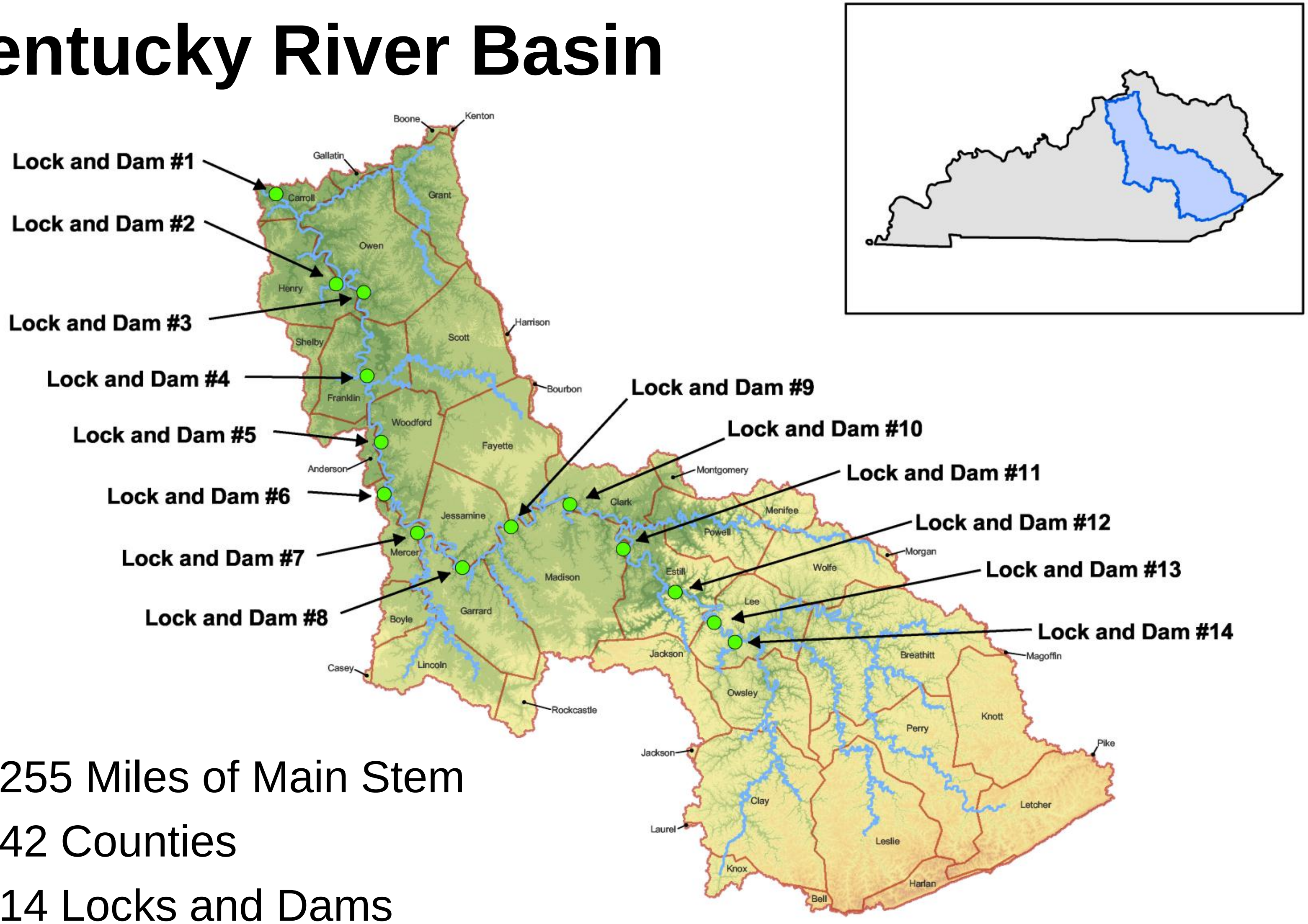
Kentucky River Basin



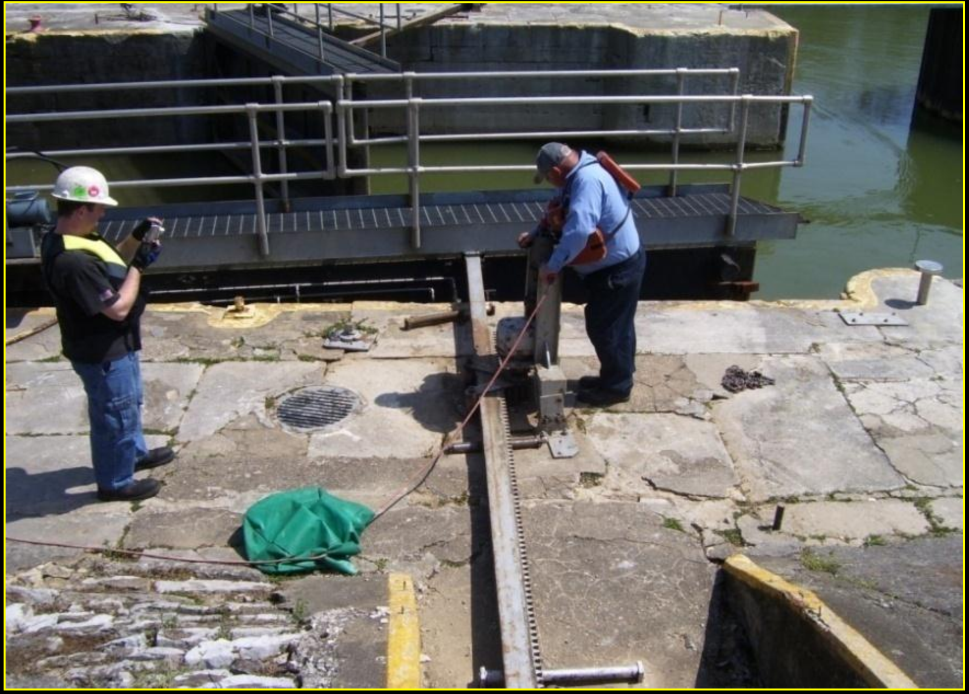
- 255 Miles of Main Stem
- 42 Counties
- 14 Locks and Dams

Navigation

- Locks 1 – 3 – Restricted Use
- Lock 4 – Seasonal Operation
- Locks 5–9 and 11-14 – Cutoff Walls

Ownership and Operation

- KRA Established in 1986
- Lock and Dams 1-4
  - USACE Owned
  - KRA Leased and Maintained
- Lock and Dams 5-14
  - KRA Owned and Maintained



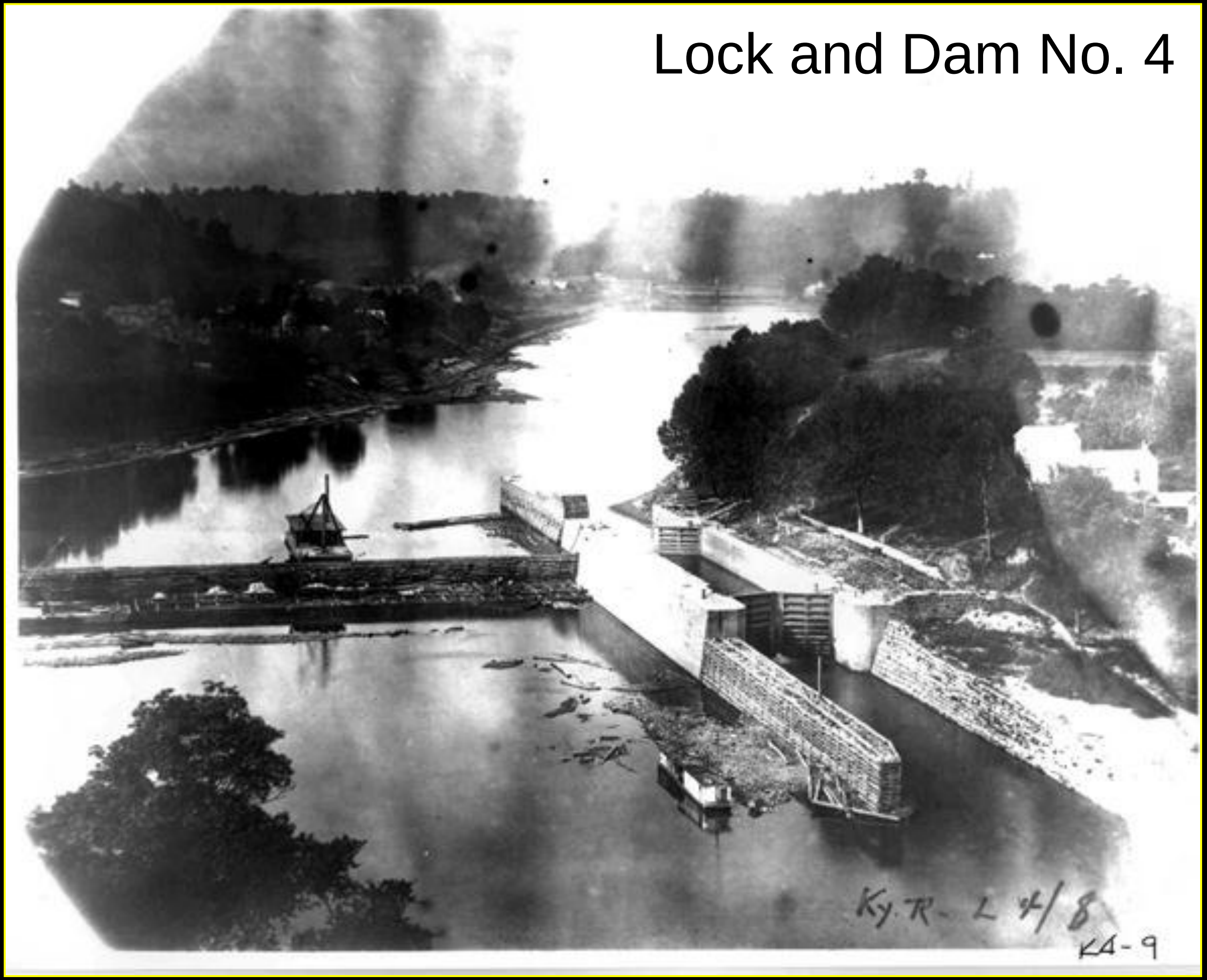
Kentucky River Users

- Tier I
  - Over 780,000 Households
  - 2¢ per 1,000 Gallons
  - Fund KRA Base Operations

- Tier II
  - 11 Municipal Water Suppliers
  - 9 Business Entities
  - 6¢ per 1,000 Gallons
  - Fund Capital Projects

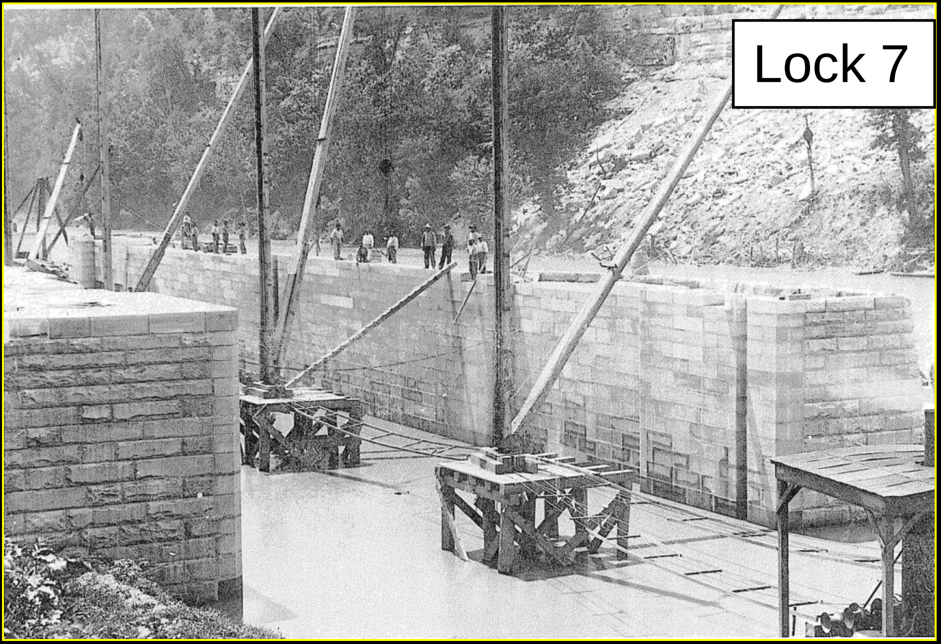
Kentucky River Lock and Dam History

- Original Construction 1836 to 1917
- 19th Century Commerce



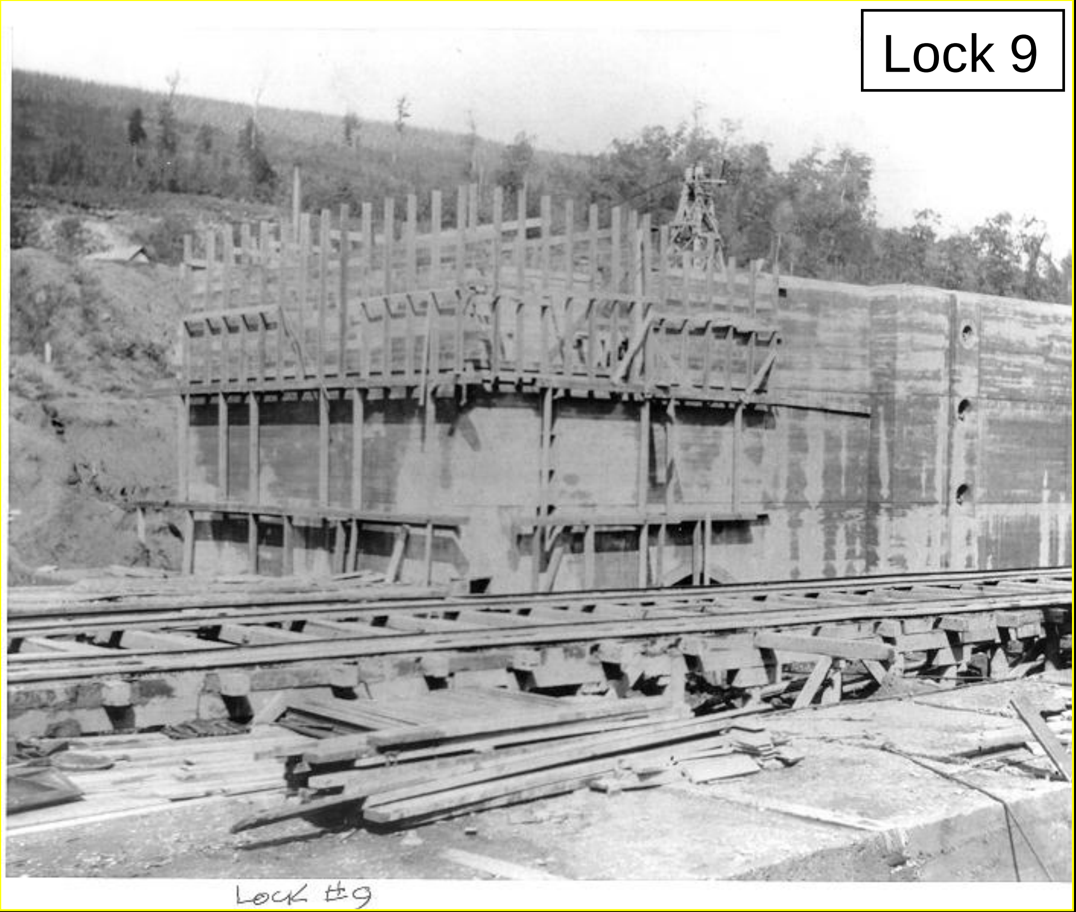
Lock Wall Construction

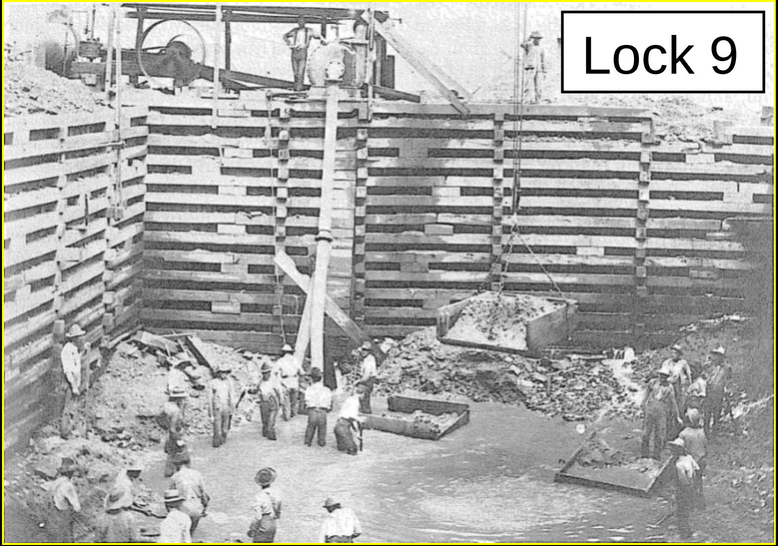
- Locks 1 - 8
  - Masonry Construction



Lock Wall Construction

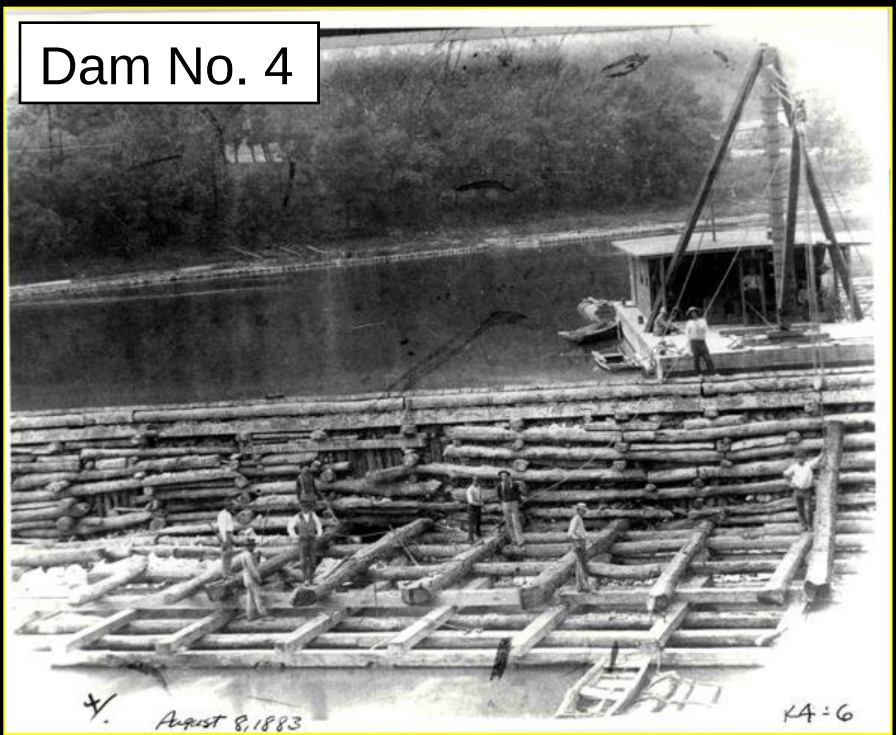
- Locks 9 – 14
  - Concrete Construction



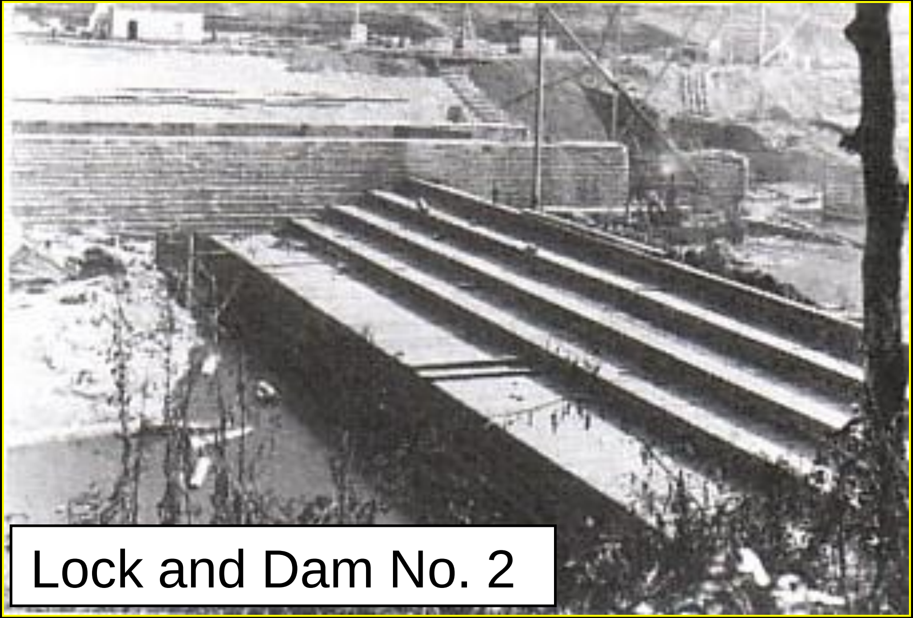


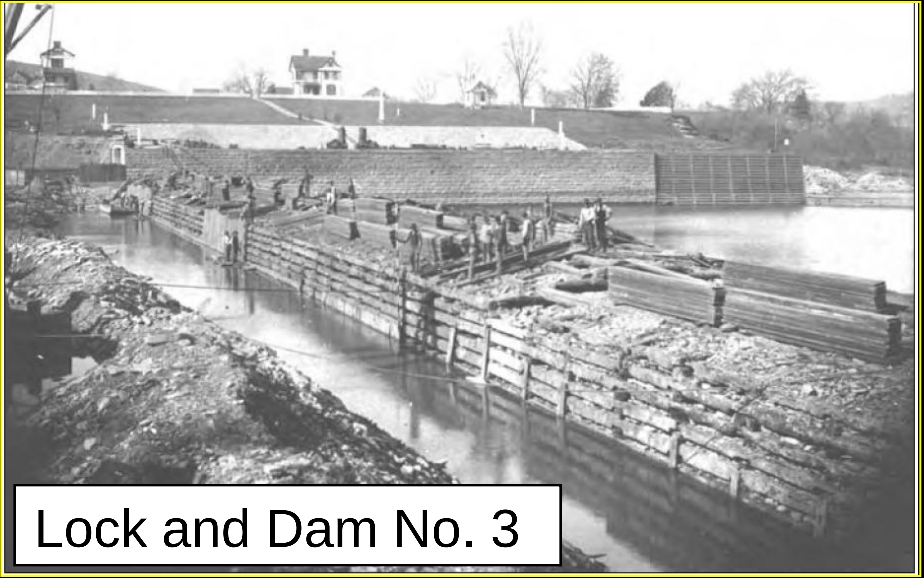
Dam Construction

- Dams 1 - 8
  - Rock-filled Timber Crib



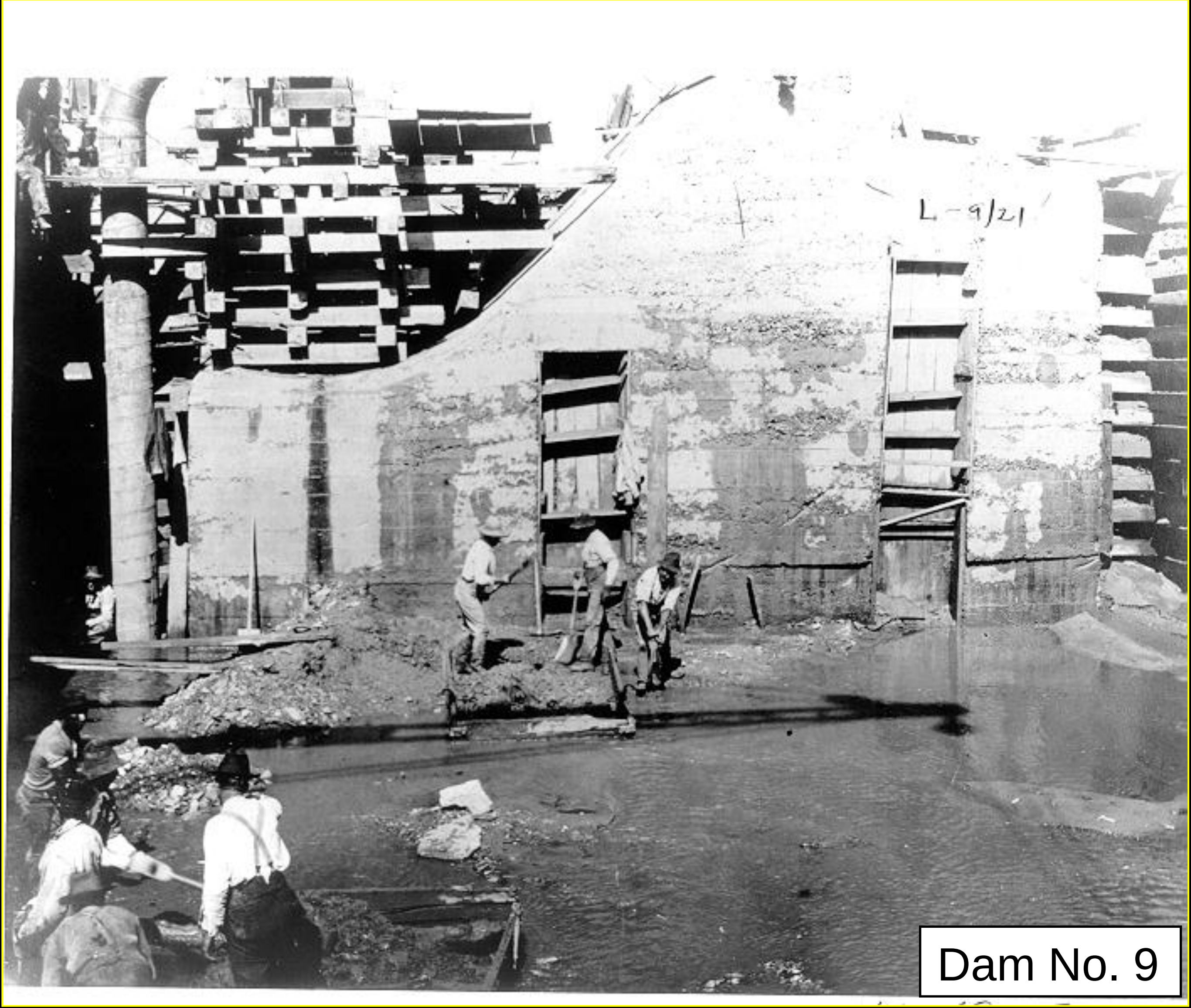
Dam No. 4


Lock and Dam No. 2


Lock and Dam No. 3

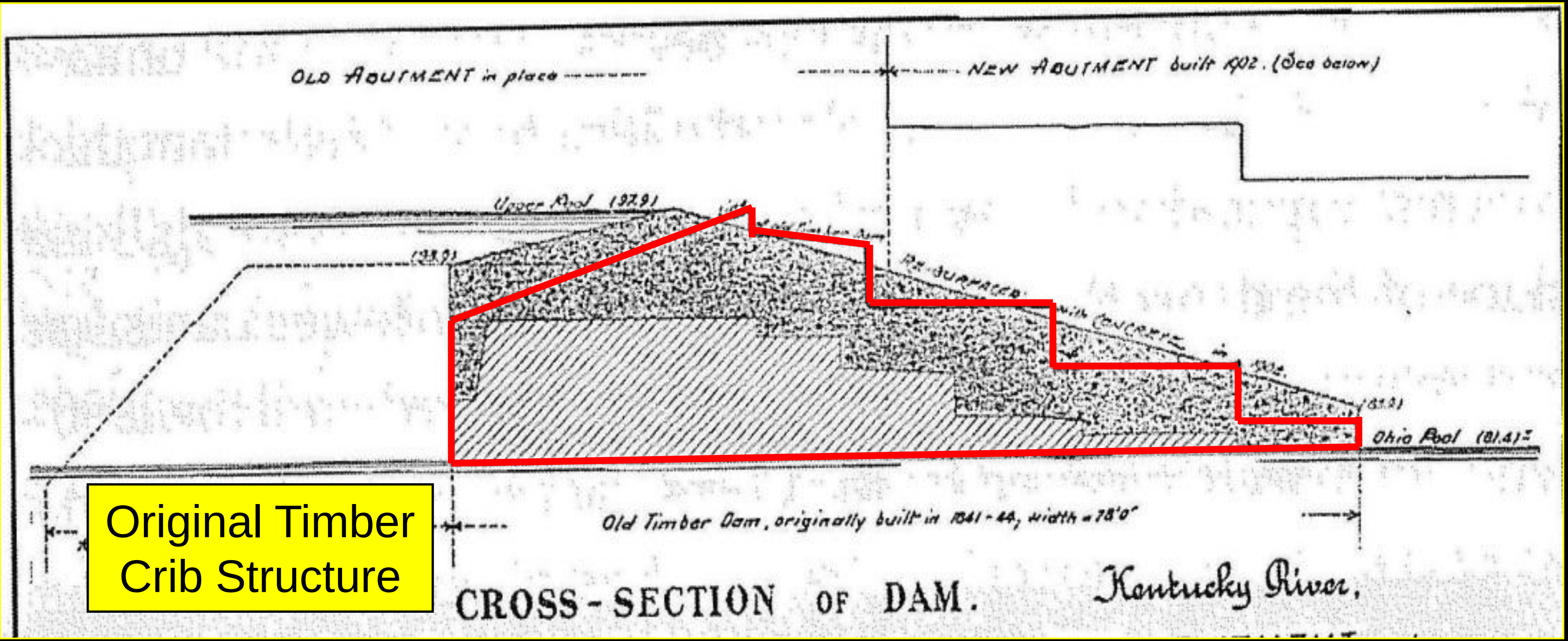
Dam Construction

- Dams 9 – 14
  - Concrete Construction



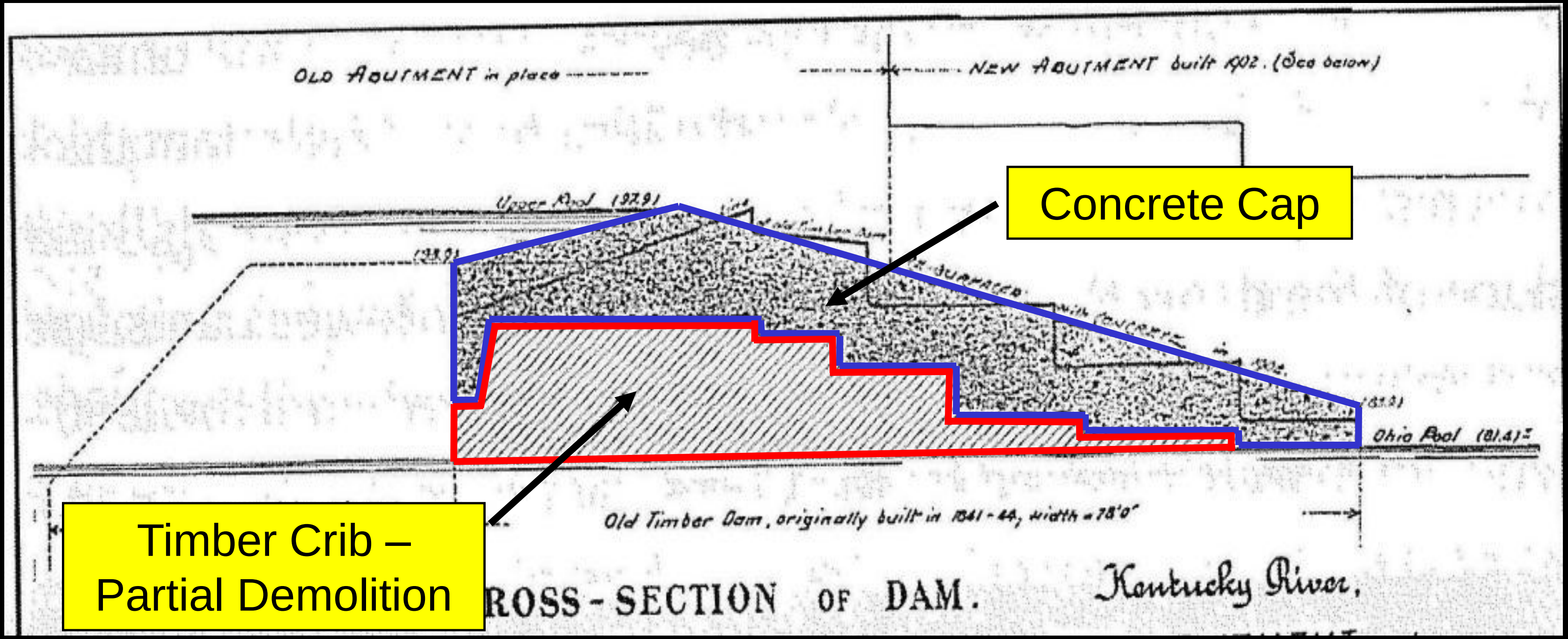
Typical Dam Repairs

- Concrete Capping



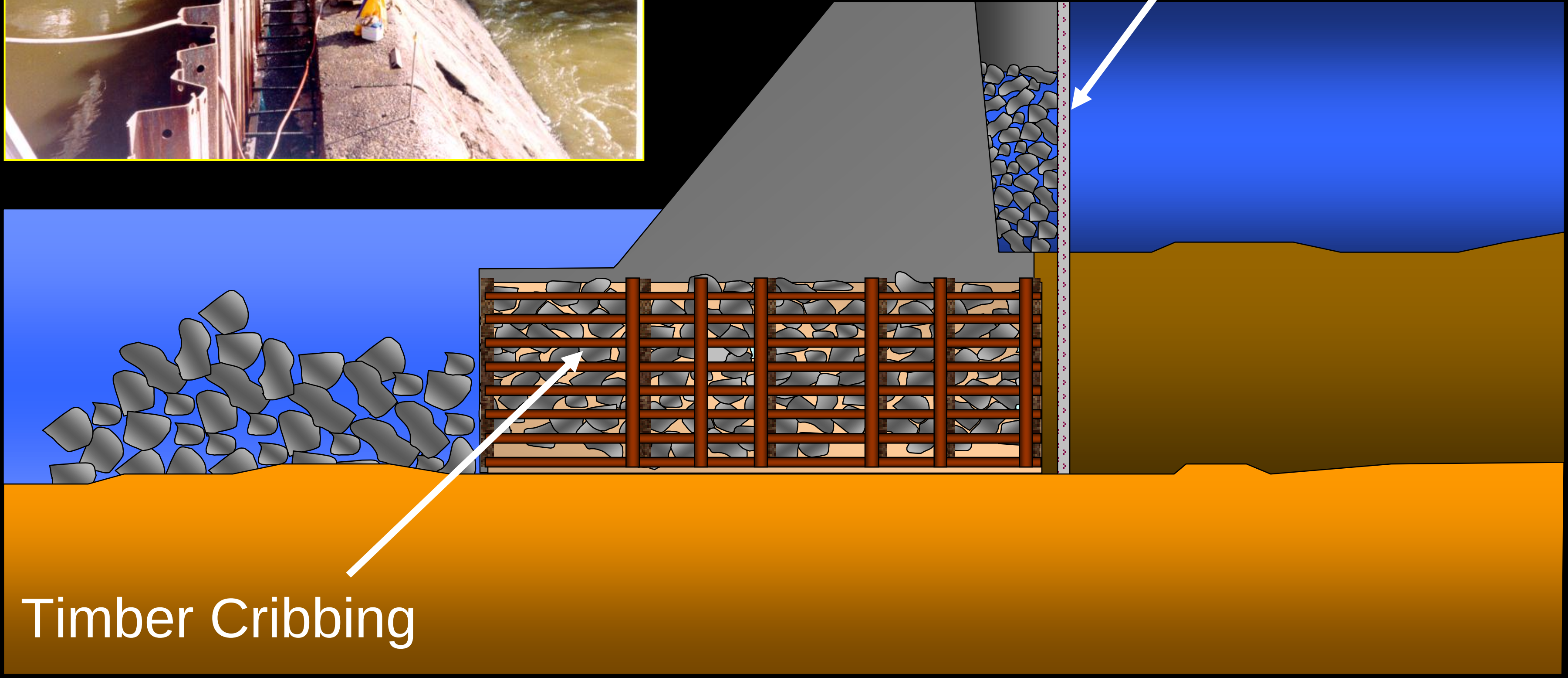
Typical Dam Repairs

- Concrete Capping



Typical Dam Repairs

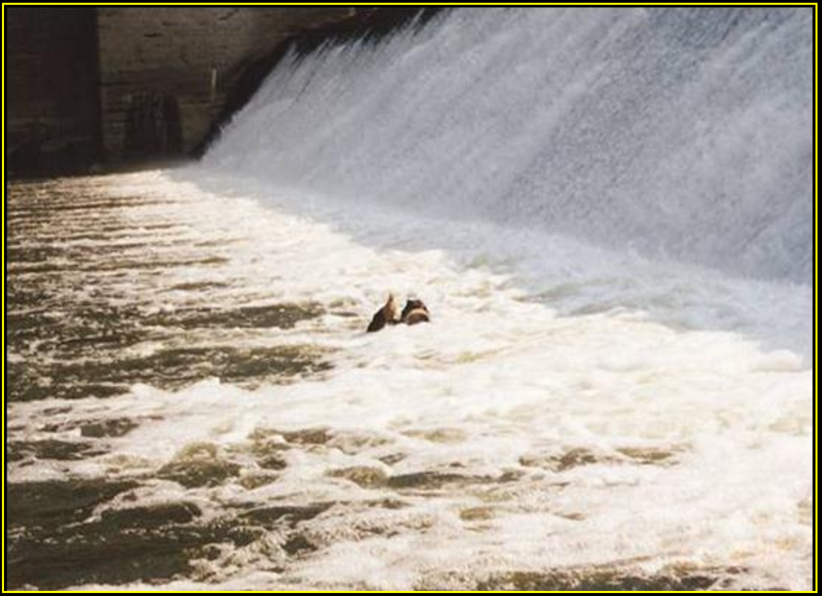
- Sheet Pile Facing



Cutoff Walls

Existing Conditions

- 2007 Assessment of Lock and Dams
- Identify Deficiencies
  - Above and Below Water Inspections
  - Historical Review
- Prioritize Repairs
  - Risk-based Analysis
- Conceptual Designs



Assessment Findings

- Deficiencies Observed at each Facility
- Facilities Have Outlived Design Service Life
- Highest Priority Elements
  - Far Abutments
  - Dams
  - Upper Lock Gates
  - Downstream Training Walls
- No Imminent Failures Indicated by Observations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Final Report
Assessment Study for Kentucky River
Dam Nos. 1-8 and 11-14
Various Counties, Kentucky

Prepared for:
Kentucky River Authority
Frankfort, Kentucky

October 16, 2008

Typical Deficiencies

- Lack of Derrick Stone
- Downstream Toe Undermining
- Timber Crib Section Loss
- Missing Apron Sections
- Signs of Instability in Walls
- Concrete in Poor Condition
- Deteriorating Sheet Piling
- Deteriorating Lock Gates

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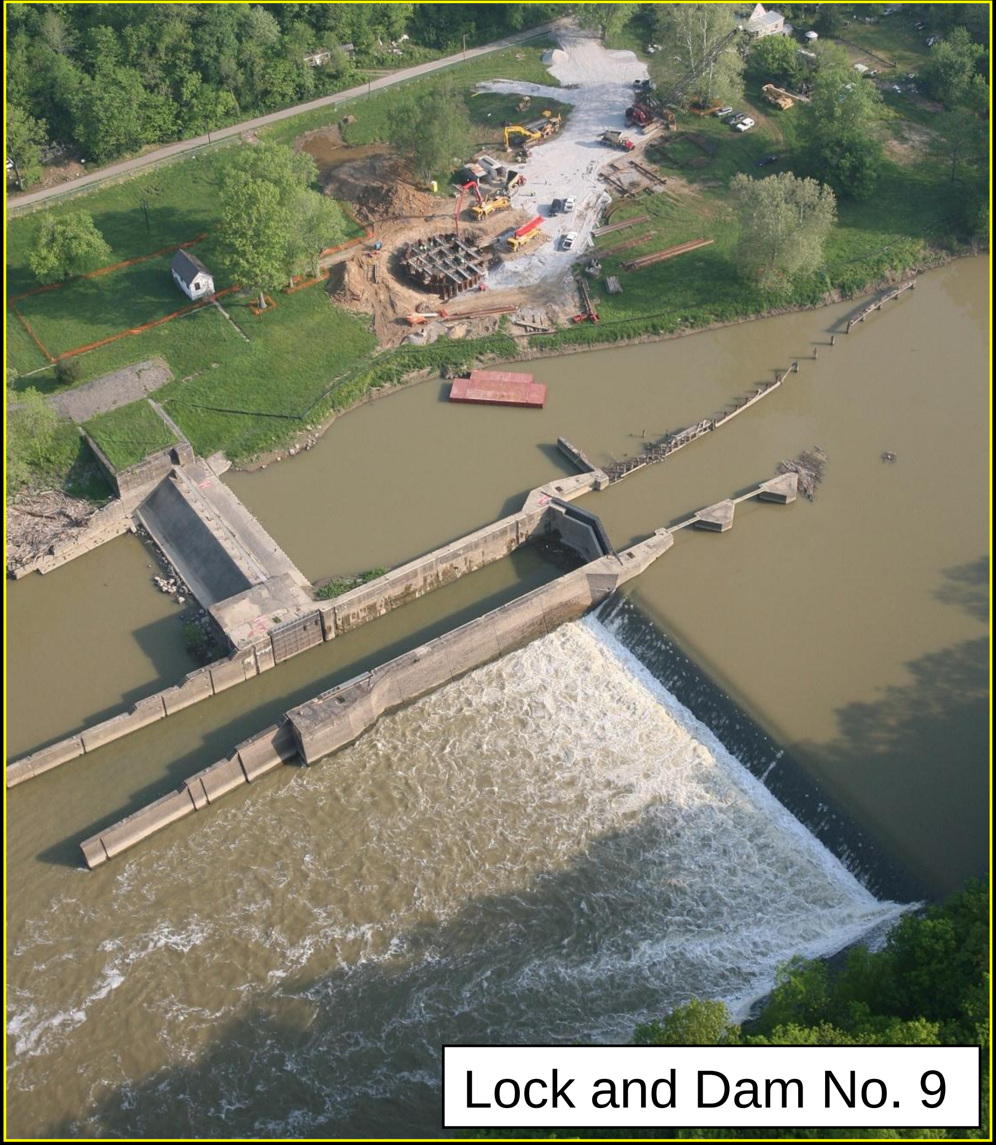
Recent Lock and Dam Projects

- Lock and Dam No. 9
  - $14.7M
  - 2007 – 2010
- Lock and Dam No. 3
  - $13.8M
  - 2009 - 2011



Lock and Dam No. 9

Key People

Owner (Finance and Admin. Cabinet)

Contractors

LD9

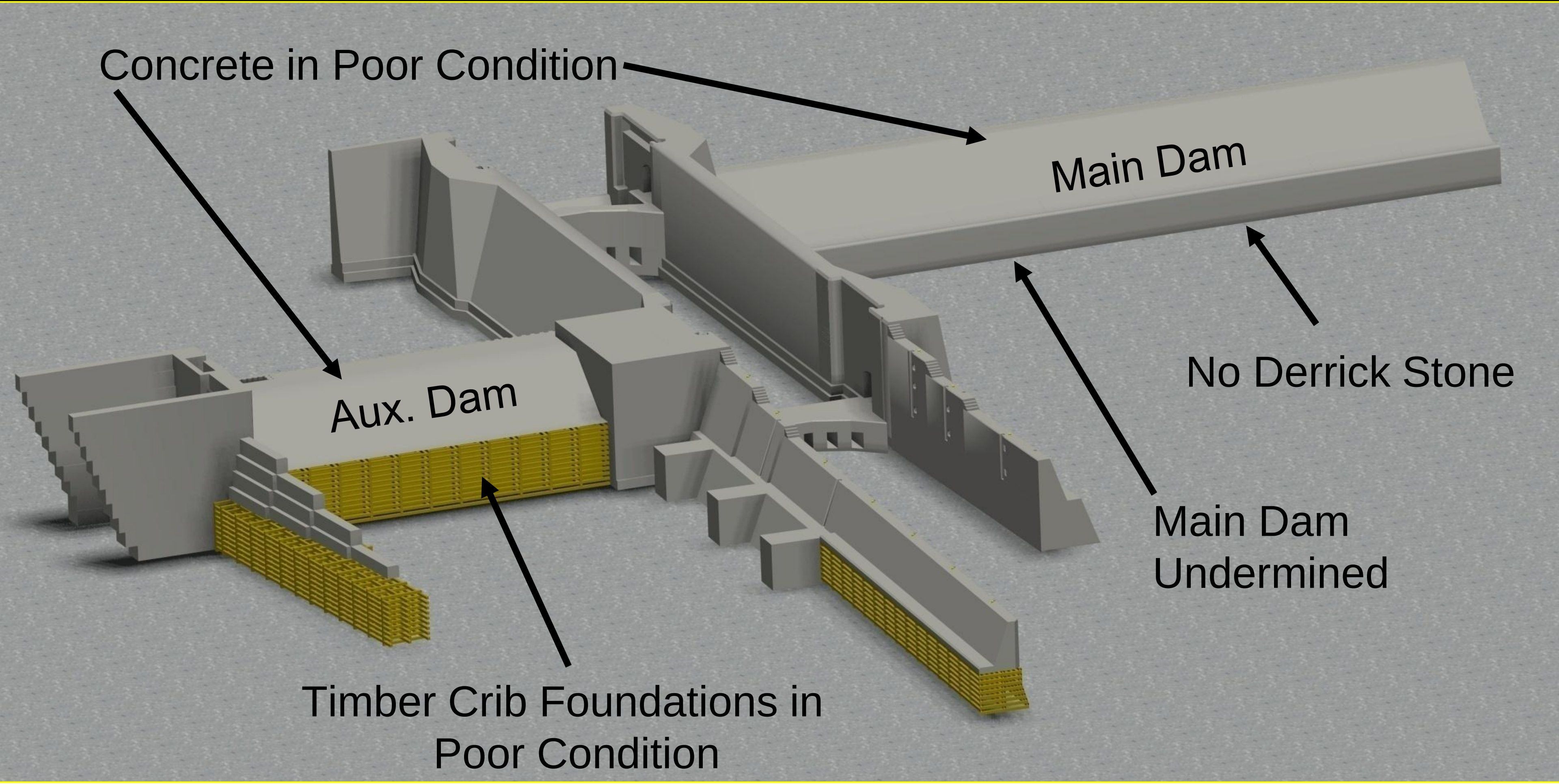
LD3

Using Agency

Engineer

LD9 - Existing Conditions

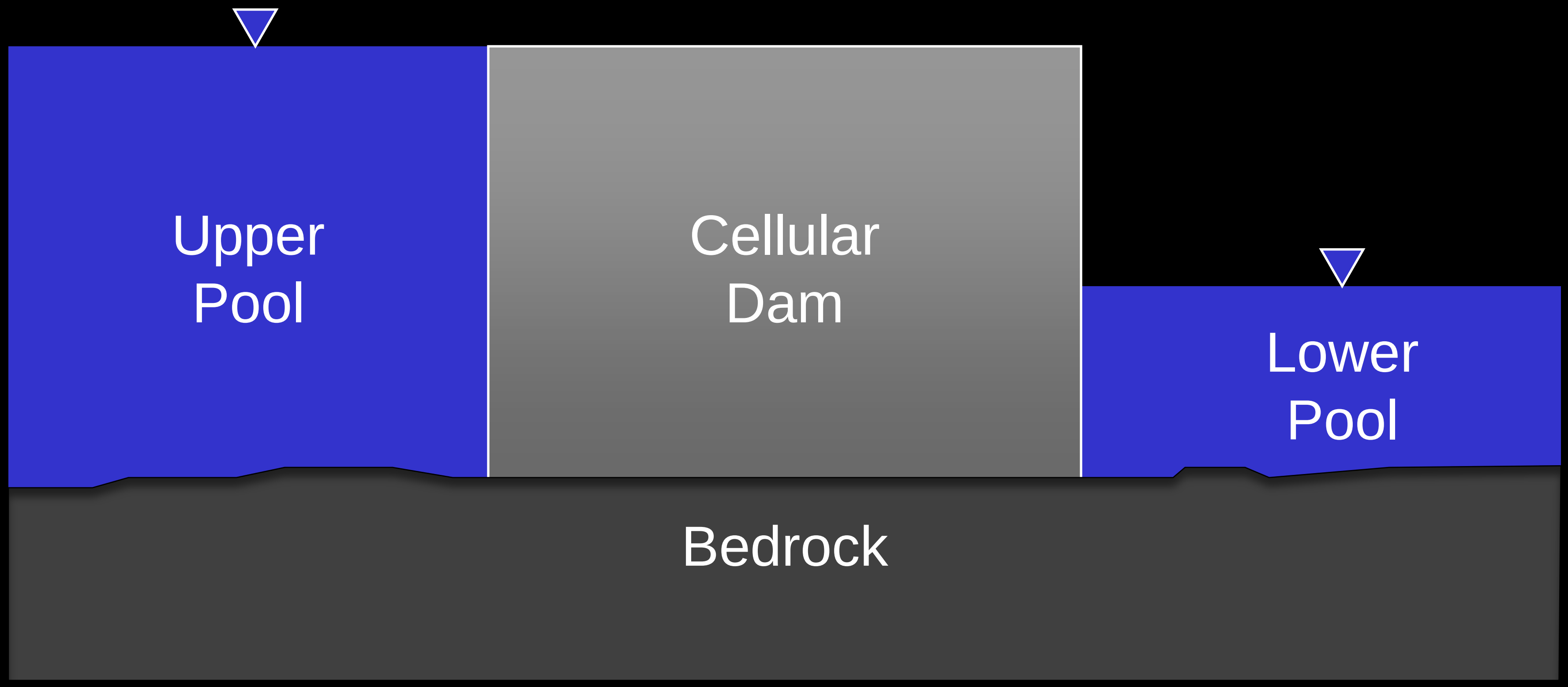
- Structures do not meet Current Stability Criteria
- Long Term Prognosis is Poor



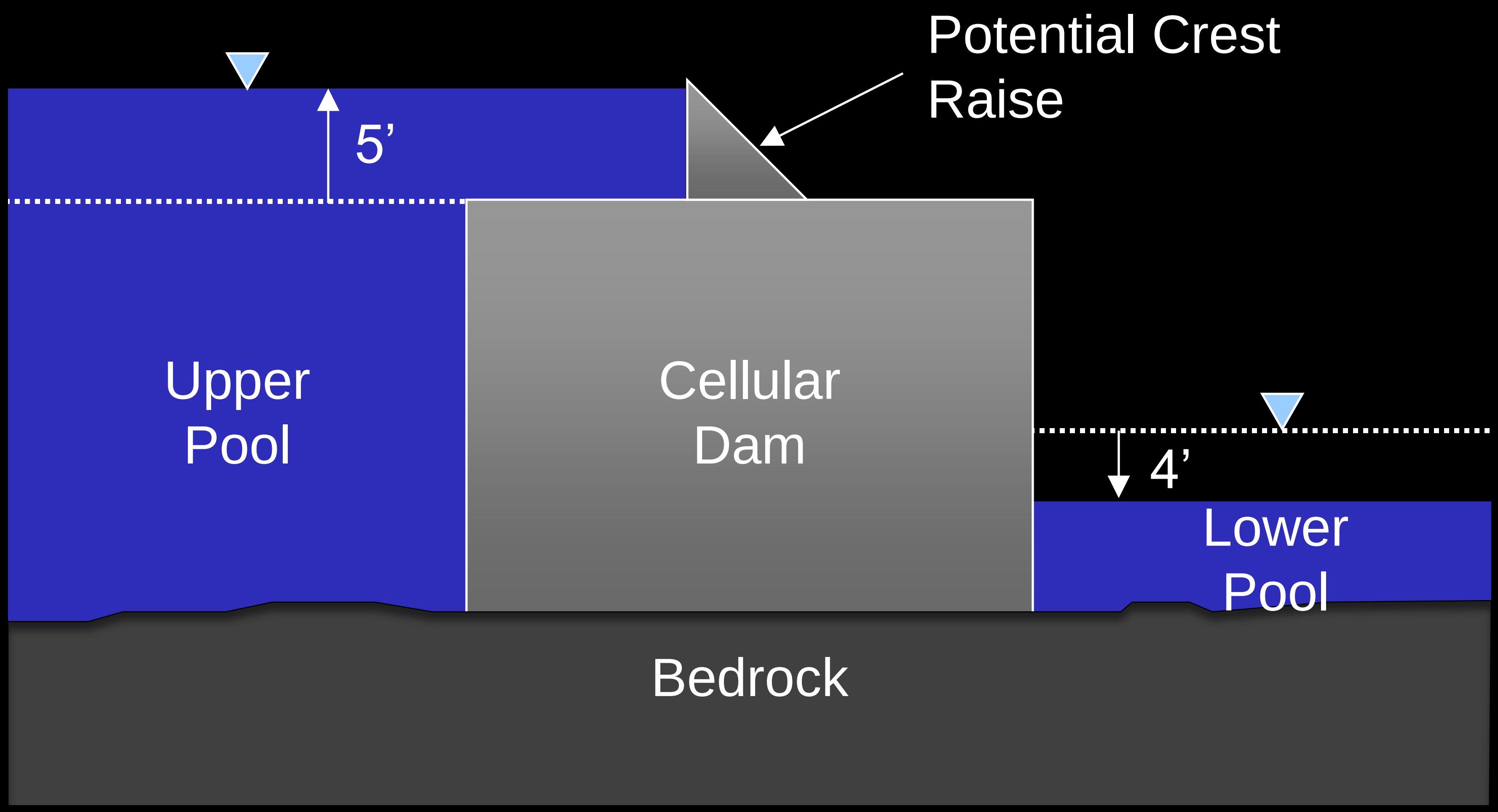
LD9 – Project Design Goals

- Meet Current Design Criteria
- 50 Year Design Life
- Preserve Lock Walls
- Preserve Hydraulic Signature
- Accommodate Future Crest Raise
- Accommodate Pool 8 Mining
- Include Water Conveyance System (WCS)

Crest Raise, Pool Mining, and WCS

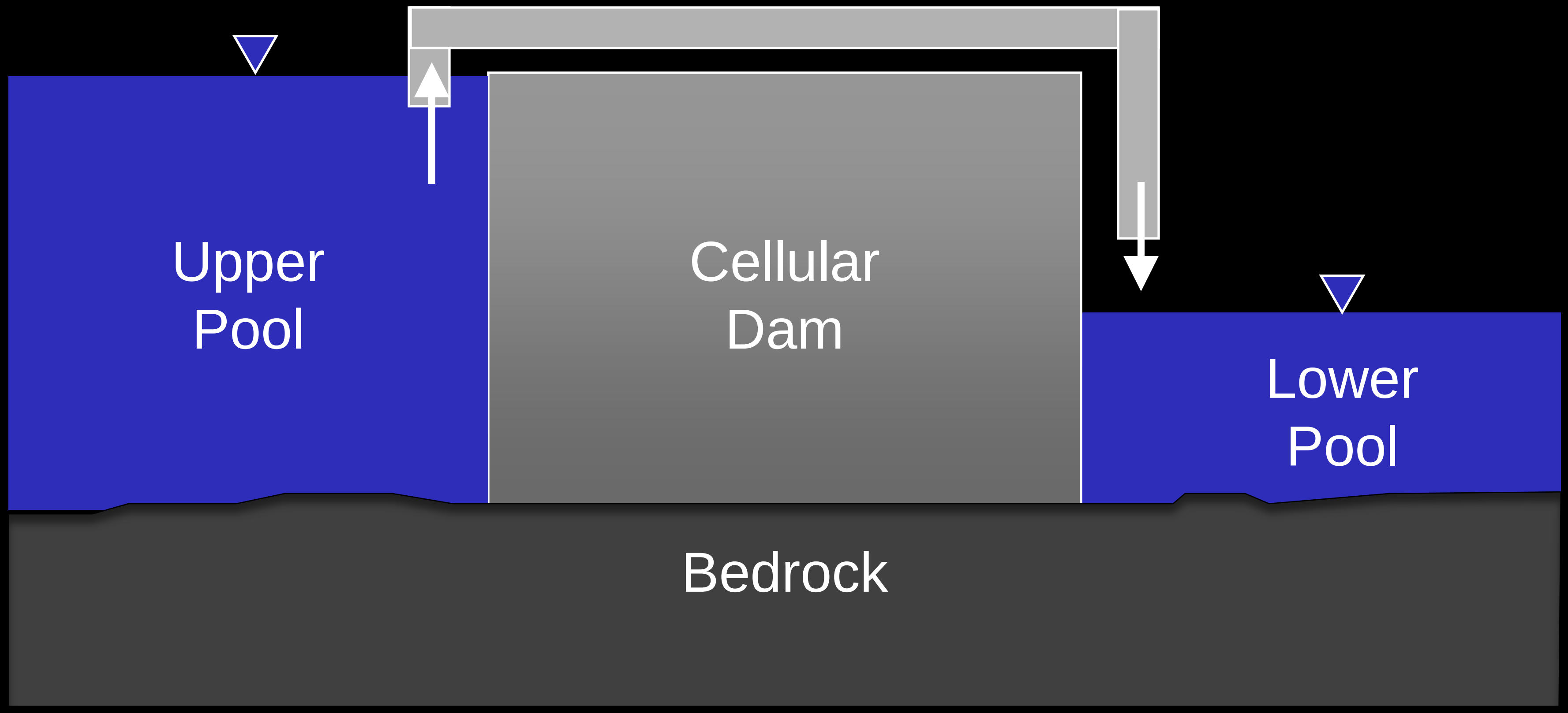


Crest Raise, Pool Mining, and WCS



Crest Raise, Pool Mining, and WCS

Siphon Pipes over Dam - 3 pipes
@ approx. 23 cfs (max) each



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LD9 Pre-Construction Conditions

Photo from GRW Aerial Surveys (2001)

LD9 – Construction Plan

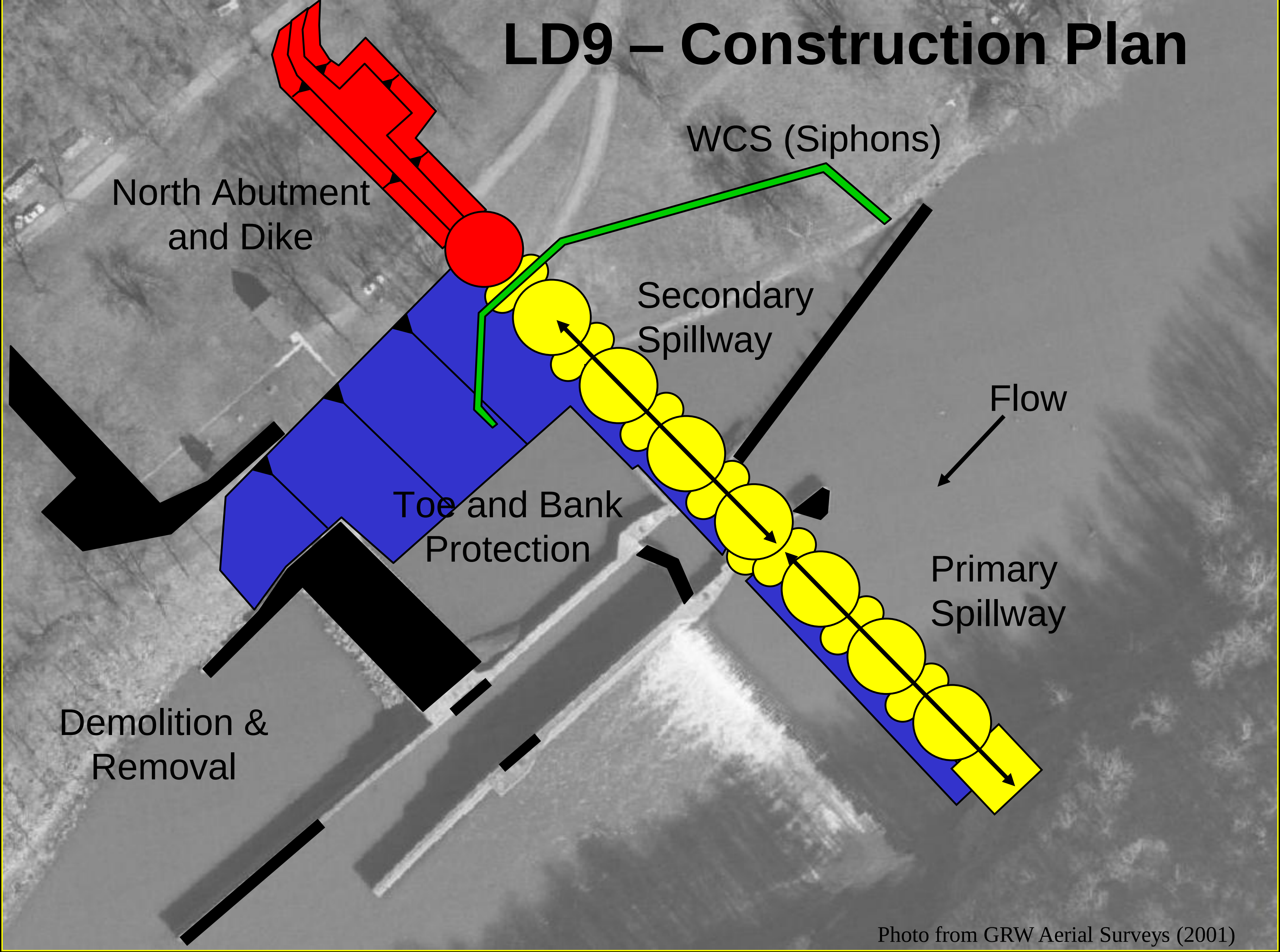

Photo from GRW Aerial Surveys (2001)

LD9 – Completed Construction

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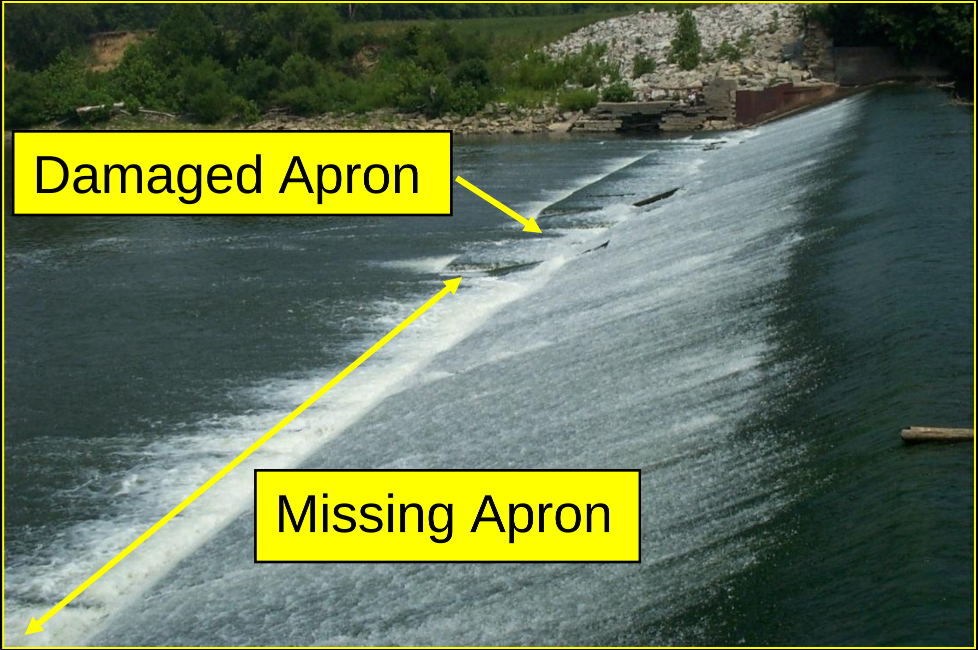
LD3 - Existing Conditions

- Absence of Derrick Stone
- Downstream Undermining of Spillway
- Missing or Damaged Sections of Apron
- Partial Collapse of Stone Abutment
- Concrete in Poor Condition
- Structures do not meet Current Stability Criteria
- Long Term Prognosis is Poor

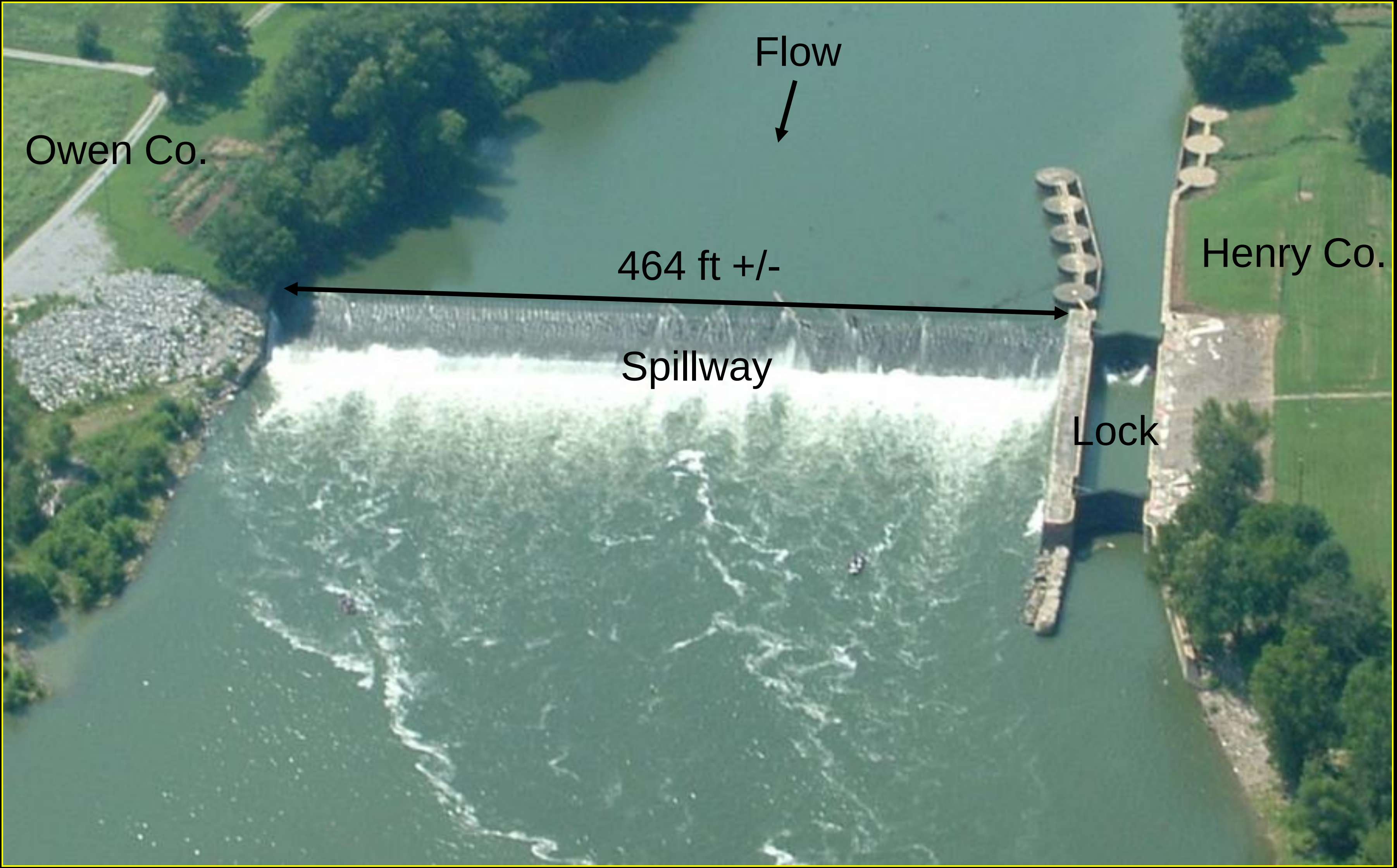


LD3 – Project Design Goals

- Meet Current Design Criteria
- 50 Year Design Life
- Preserve Lock for Operation
- Preserve Hydraulic Signature
- Accommodate Future Crest Raise

- Rehabilitate Lock Nos. 3 & 4 (Design)

LD3 – Pre-Construction Conditions



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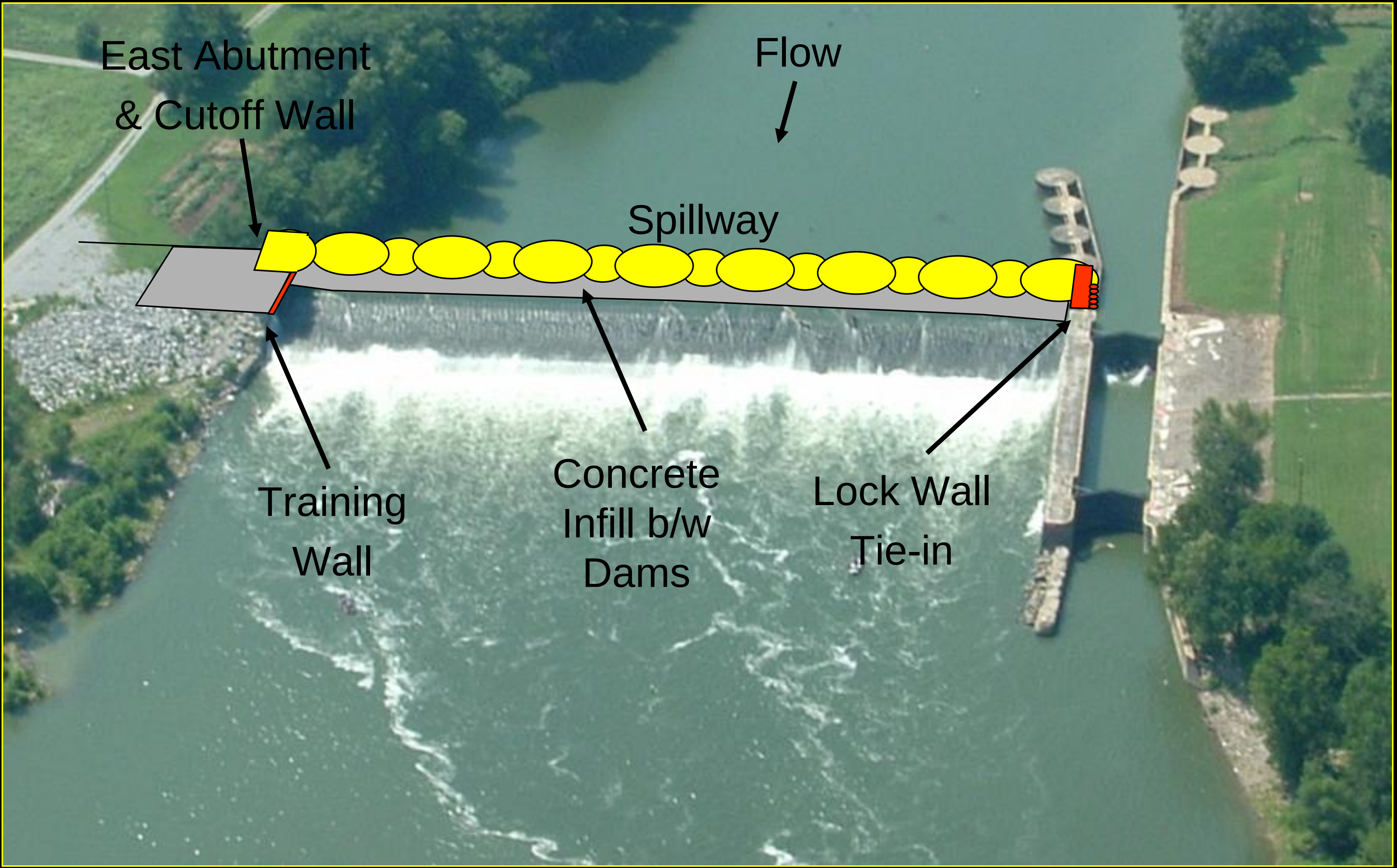
LD3 – Construction Plan



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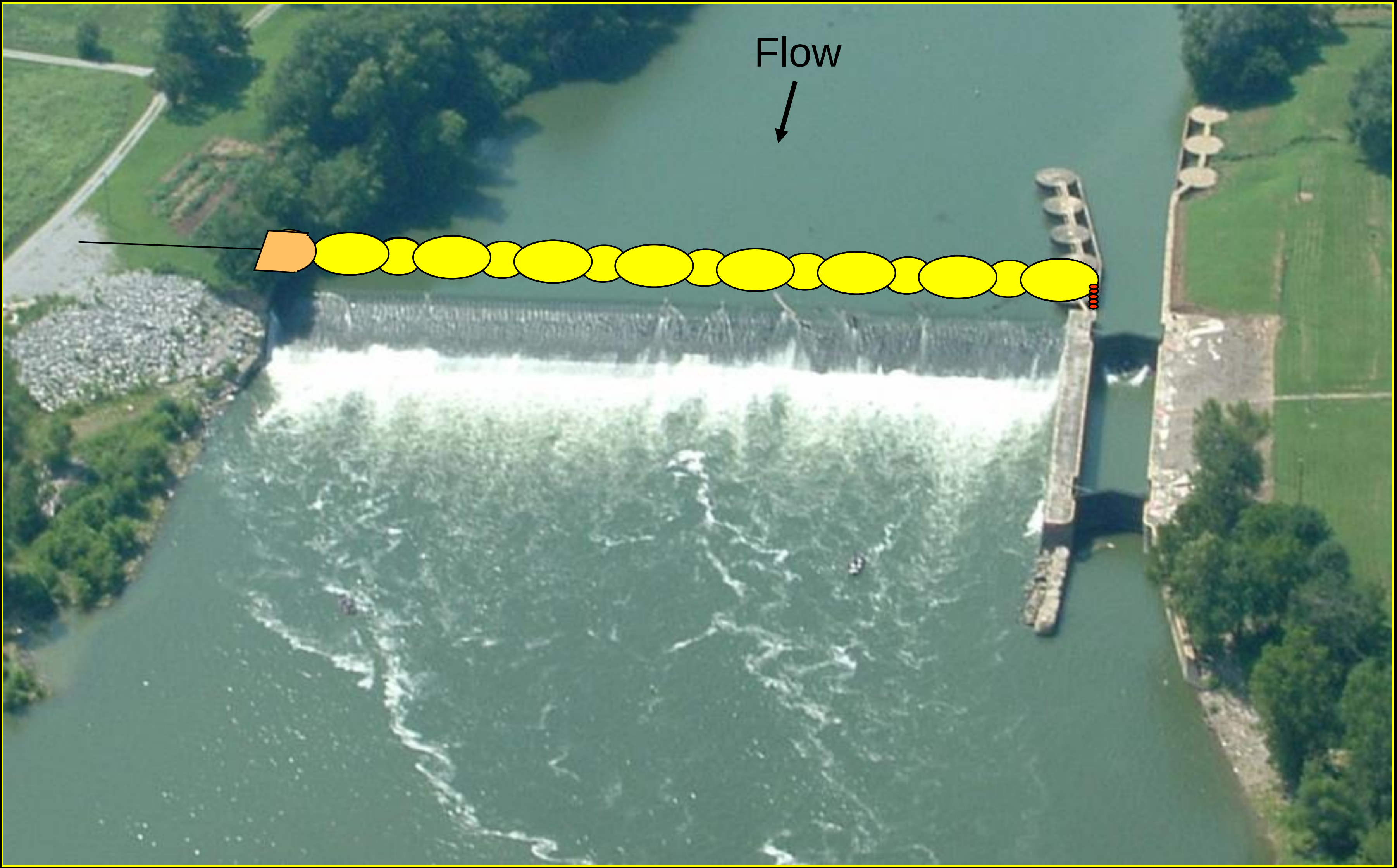
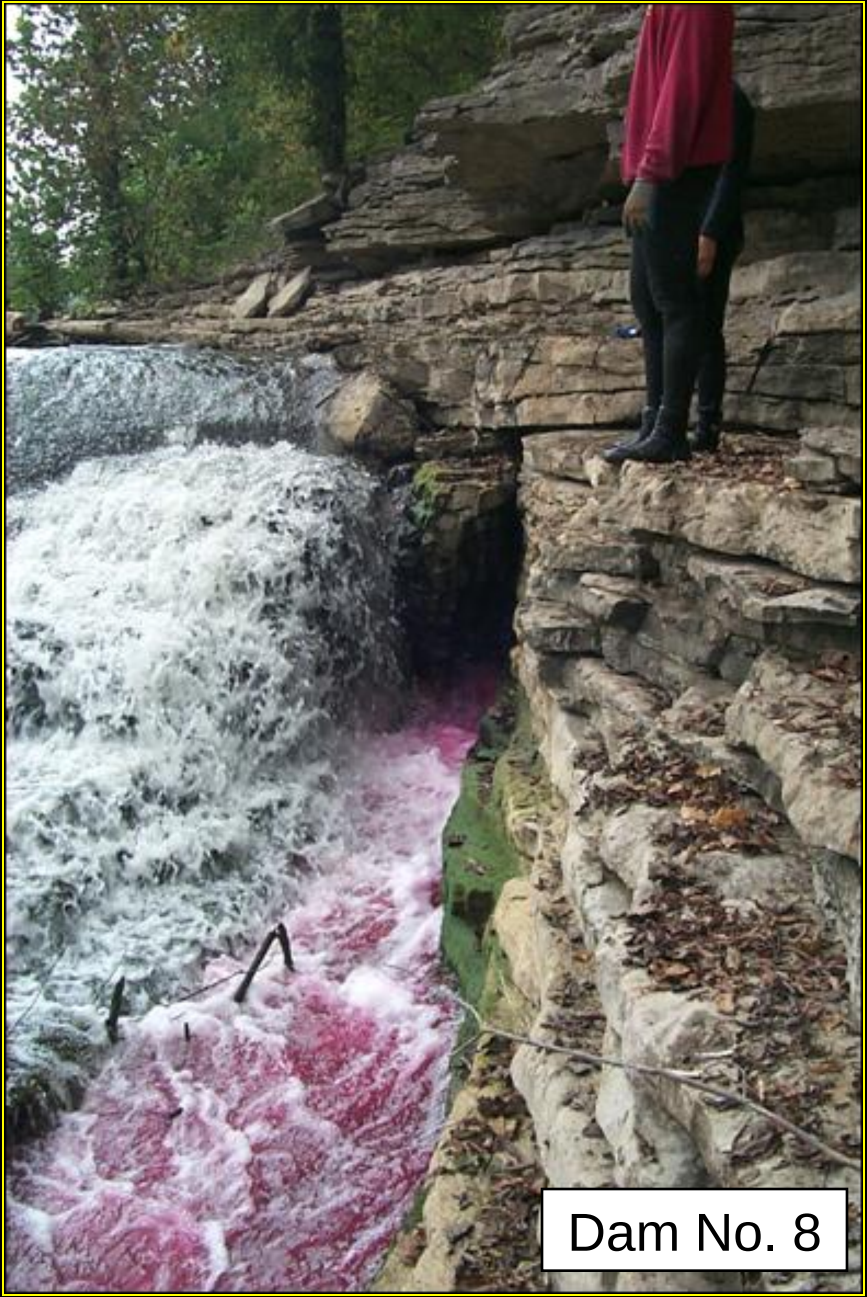
LD3 – Current Construction Progress



Upcoming Projects

- Dam No. 8
  - 2011 - 2014

- Lock Nos. 1-4
  - 2012



Why Cell Dams?

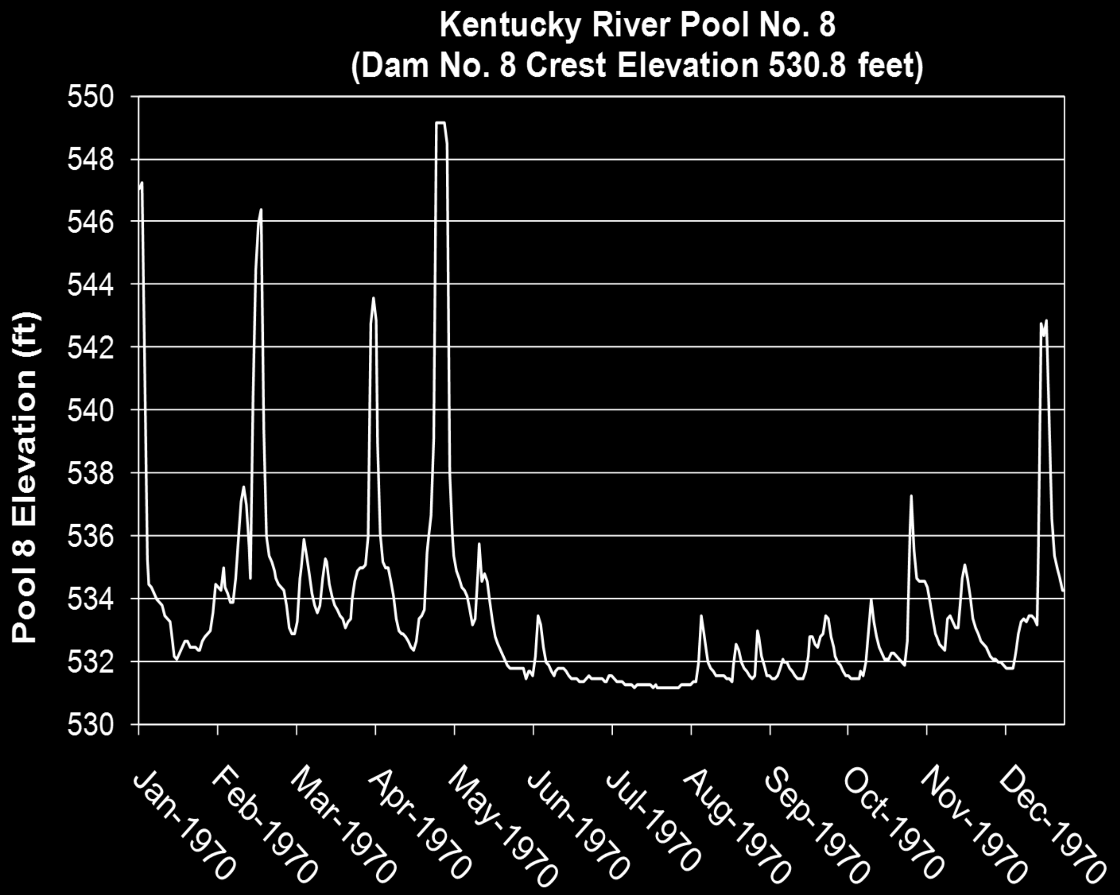
- Similar to Cofferdams and Mooring Cells ("In-the-Wet")
- Filled with Concrete
- Simple, Flexible Construction
- Commonly Used on Run of the River Dams

Green River

Muskingum River

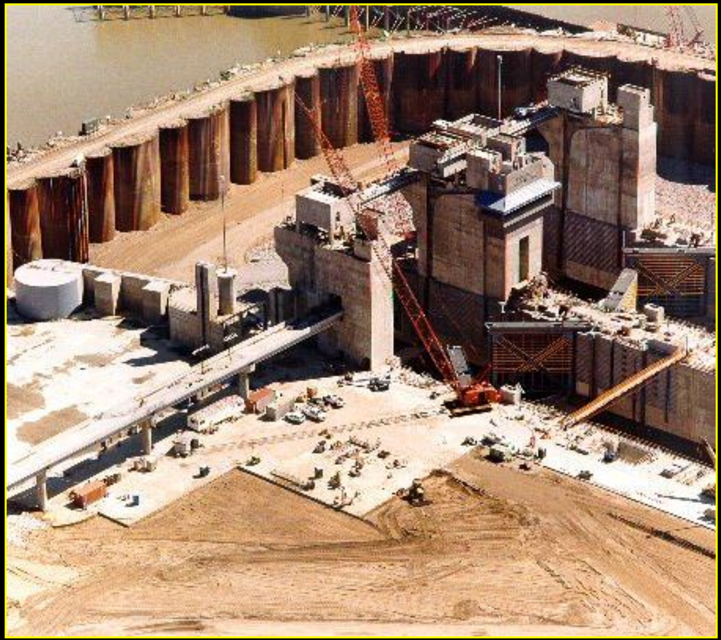
Why Cell Dams?

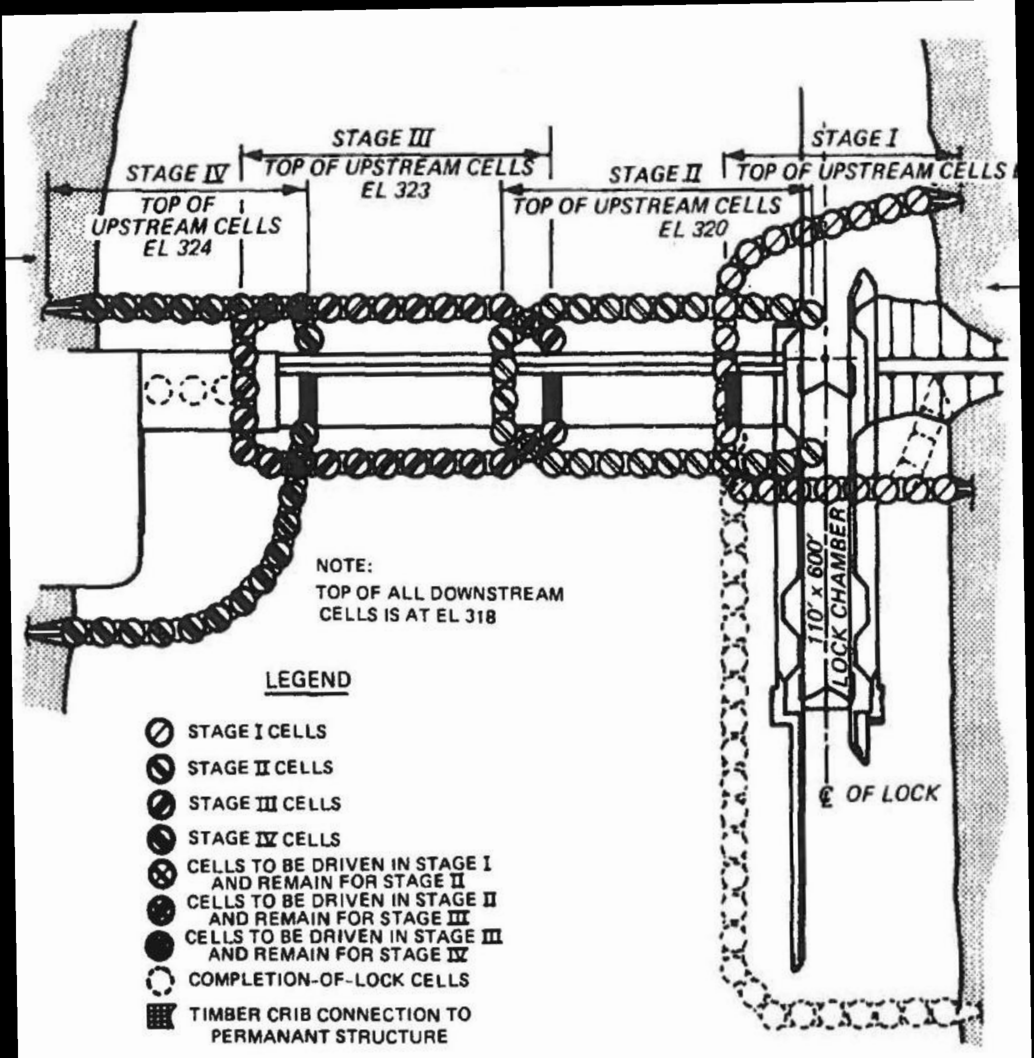
- River Volatility
  - Pool can quickly rise and fall 5 to 10 feet several times per year.
  - Contractor Risk Driver
  - Strong Consideration in Approach Evaluation
  - Affects Effective Height of Cofferdams



Why Cell Dams?

- Cofferdams
  - Staged Construction
  - In-depth Analysis
  - Effective Height
  - Maintain Dewatered Condition





Example Staged Cofferdam Scheme

Volatility of the Kentucky River - Example

- At Lock and Dam 9, typically 0-2 feet of water going over the dam.
- May 2, 2010, 8AM = 5.6 ft over the dam
- May 2, 8PM = 24.6 ft over the dam
- May 3, 8AM = River crested at 31 ft over the dam

Contractor staging area is about 22 feet above crest of LD9

Contractor staging area is about 22 feet above crest of LD9

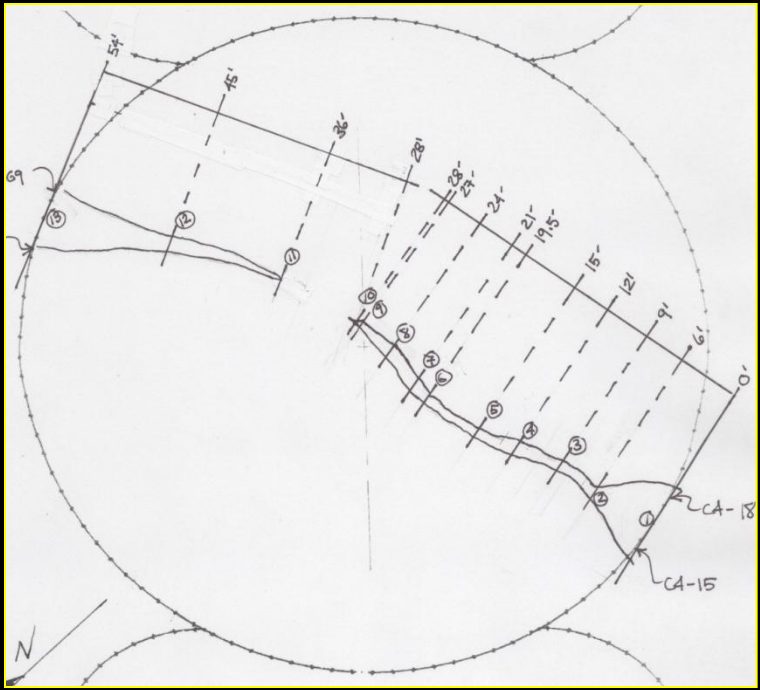
River crested about 31 feet above crest of LD9

Why Cell Dams?

- Dewatering
  - Difficulties with Karst Geology
    - Feasible?
    - Undetermined prior to Construction
    - May Need Grouting Program
  - Increased Risks to Contractor
  - Increased Risks to Owner
  - Increased Costs

- In-the-Wet Approach Avoids Need to Dewater

Dewatering at LD9



Foundation Cell Inspection for LD9

Why Cell Dams?

Advantages

- Reduced construction footprint
- Reduced environmental impacts
- Cost and schedule savings
- Reduced risks to contractor
- Reduced risks to owner
- Accommodate irregular rocklines
- Reduced karst geology risks
- Suitable for volatile rivers

Disadvantages

- Underwater diver work
- More difficult quality assurance
- Dam geometry not optimized
- Underwater concrete placement

Dam Construction

- Concrete-filled Cellular Sheet Pile Structures w/ Connecting Arc Cells

- Pre-Dredge
- Set Template
- Drive Sheet Piling
- Cell Cleanout
- Concrete
- REPEAT

Lock and Dam No. 9

Sheet Pile Template

Sheet Piling Installation

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Cell Cleanout - Dredging

A Bit of History

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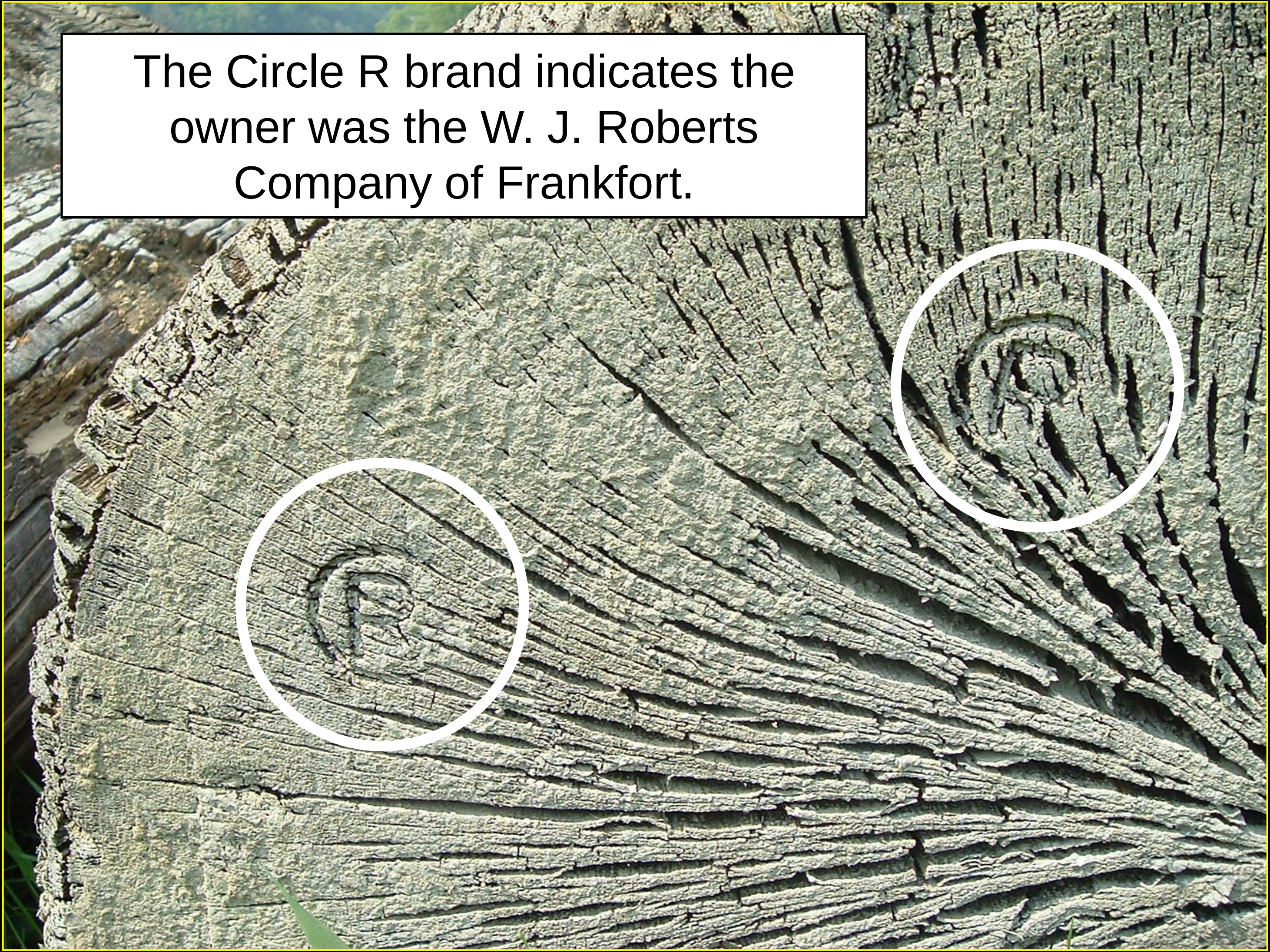
A Bit of History

The Circle R brand indicates the owner was the W. J. Roberts Company of Frankfort.



Cell Cleanout - Airlifting

Cell Cleanout - Diver Work

Contractor Risks – High Water Events


May 1, 2010

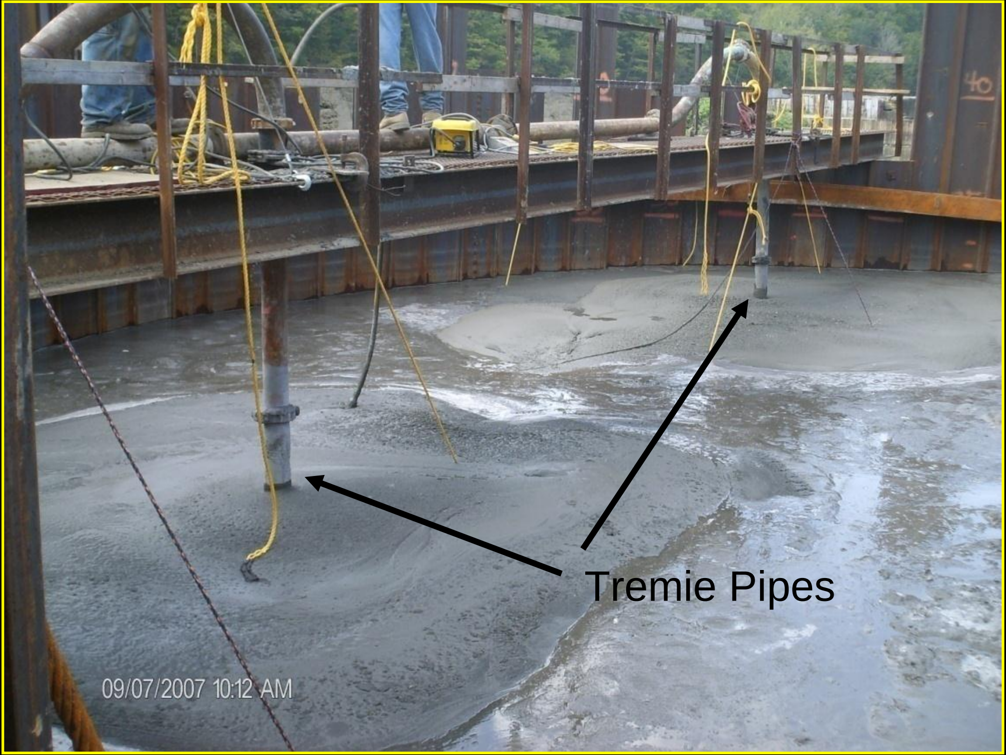

May 12, 2010


May 15, 2010

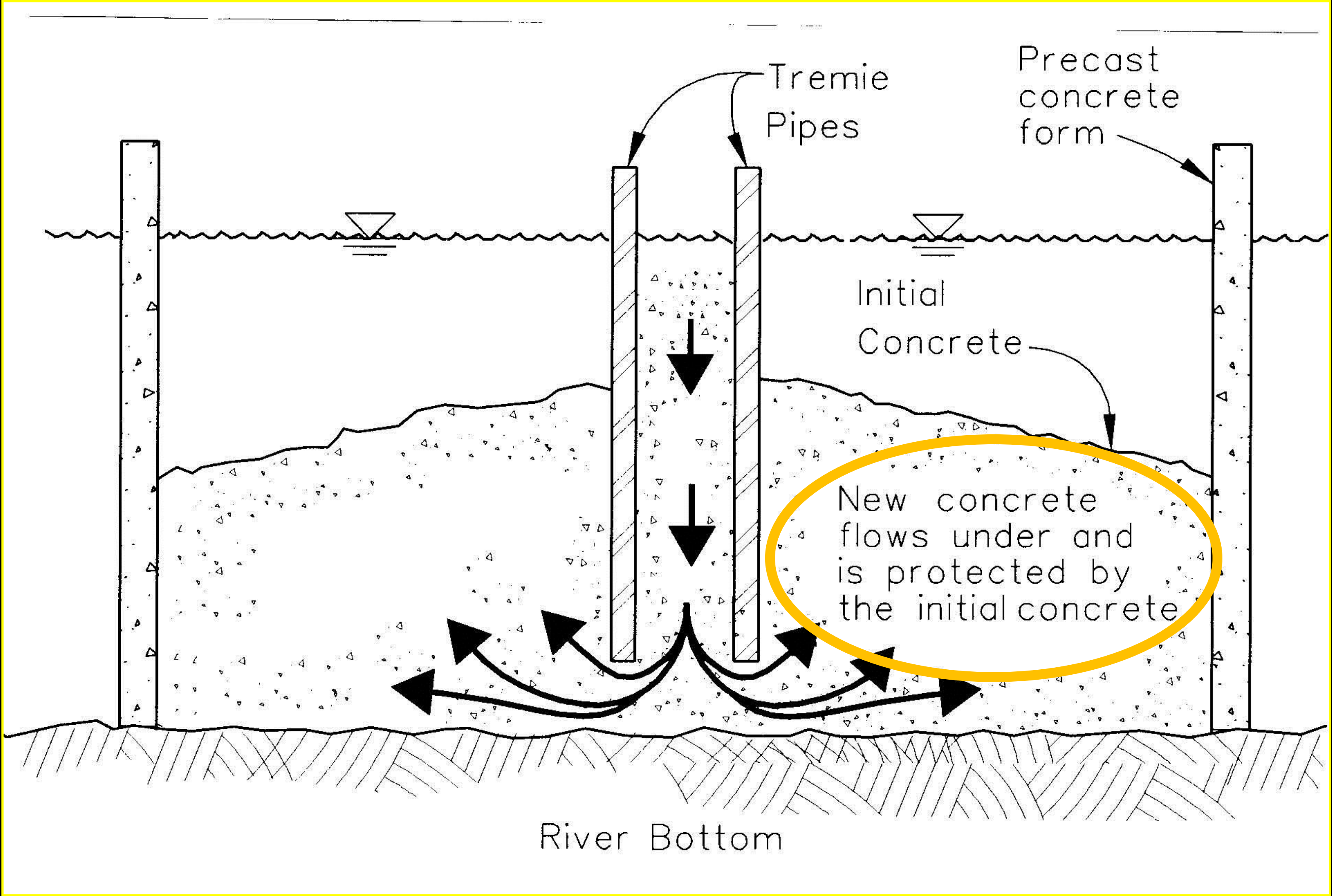
Cell Infill Placement – "In-the-Wet"

Gravity Method

Pump Method

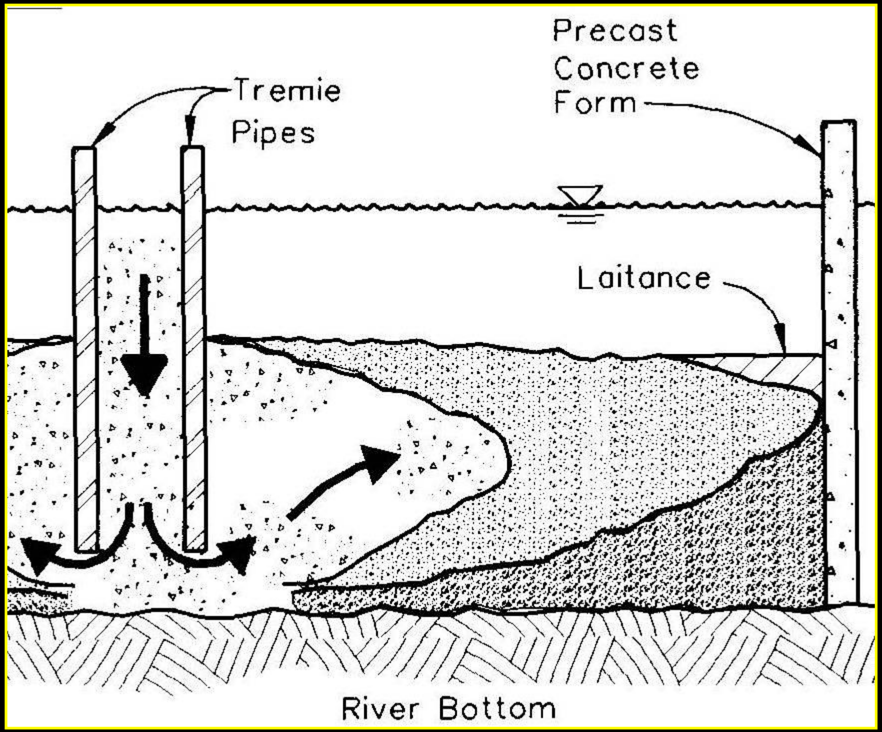


Tremie Concrete Placement

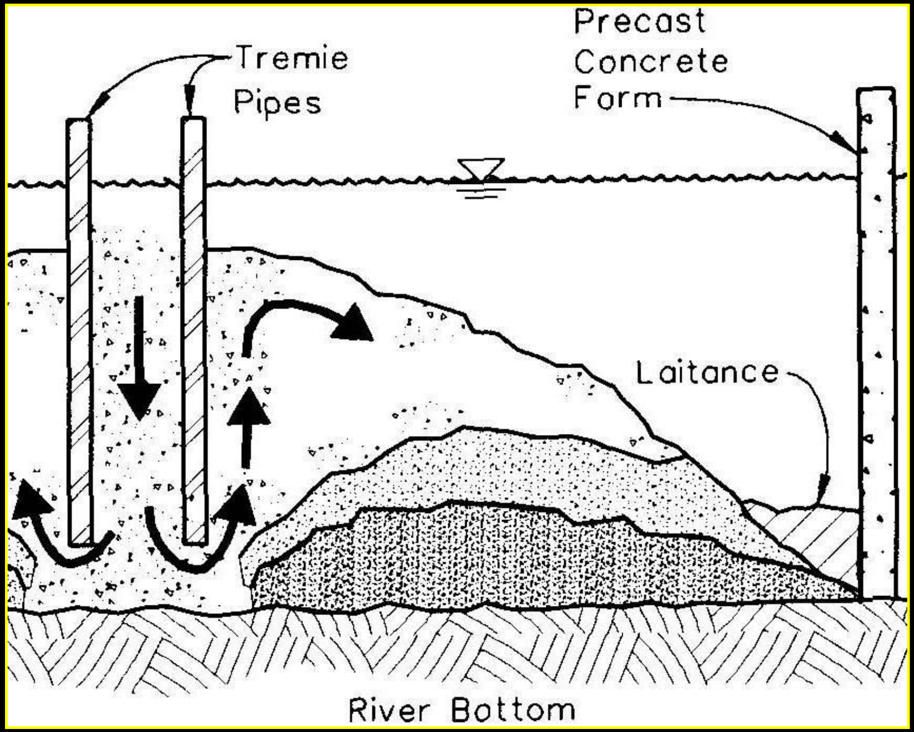


Tremie Concrete Placement

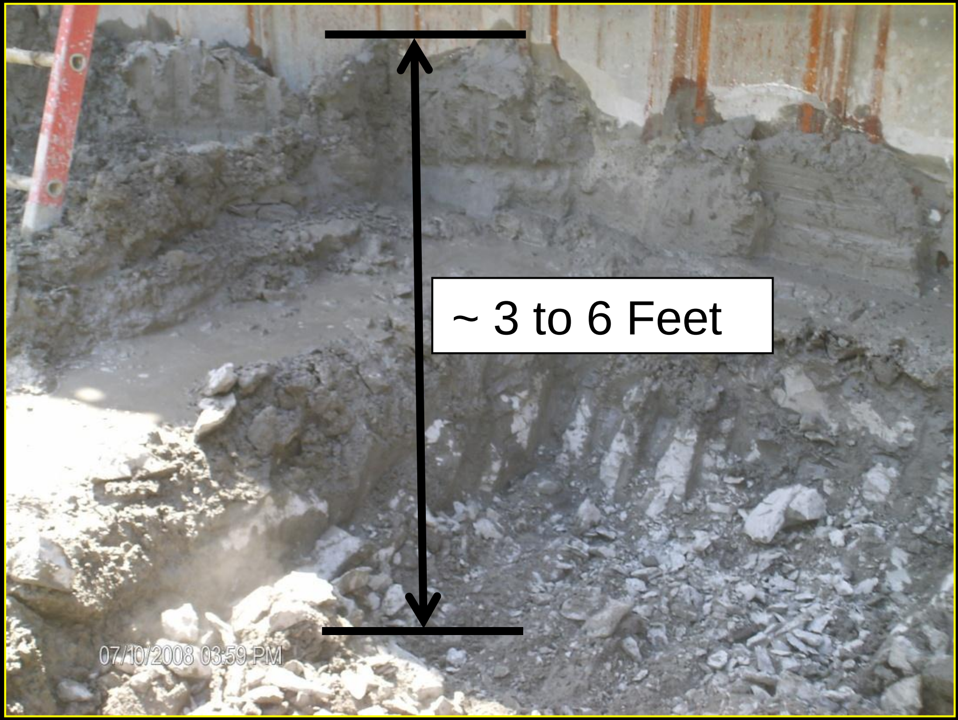
- Bulging Flow Pattern



- Layered Flow Pattern



Concrete Laitance



Underwater Concreting

Couple of Things to Consider……

- Concrete Mix & Admixtures
- Placement Plan
  - Gravity Method
  - Pump Method
- Rate of Rise
- Retardation Time
- Tremie Layout/Sequencing
- QA/QC
- Demonstration Placement

Requires Detailed Concreting Plans!


Dam No. 3

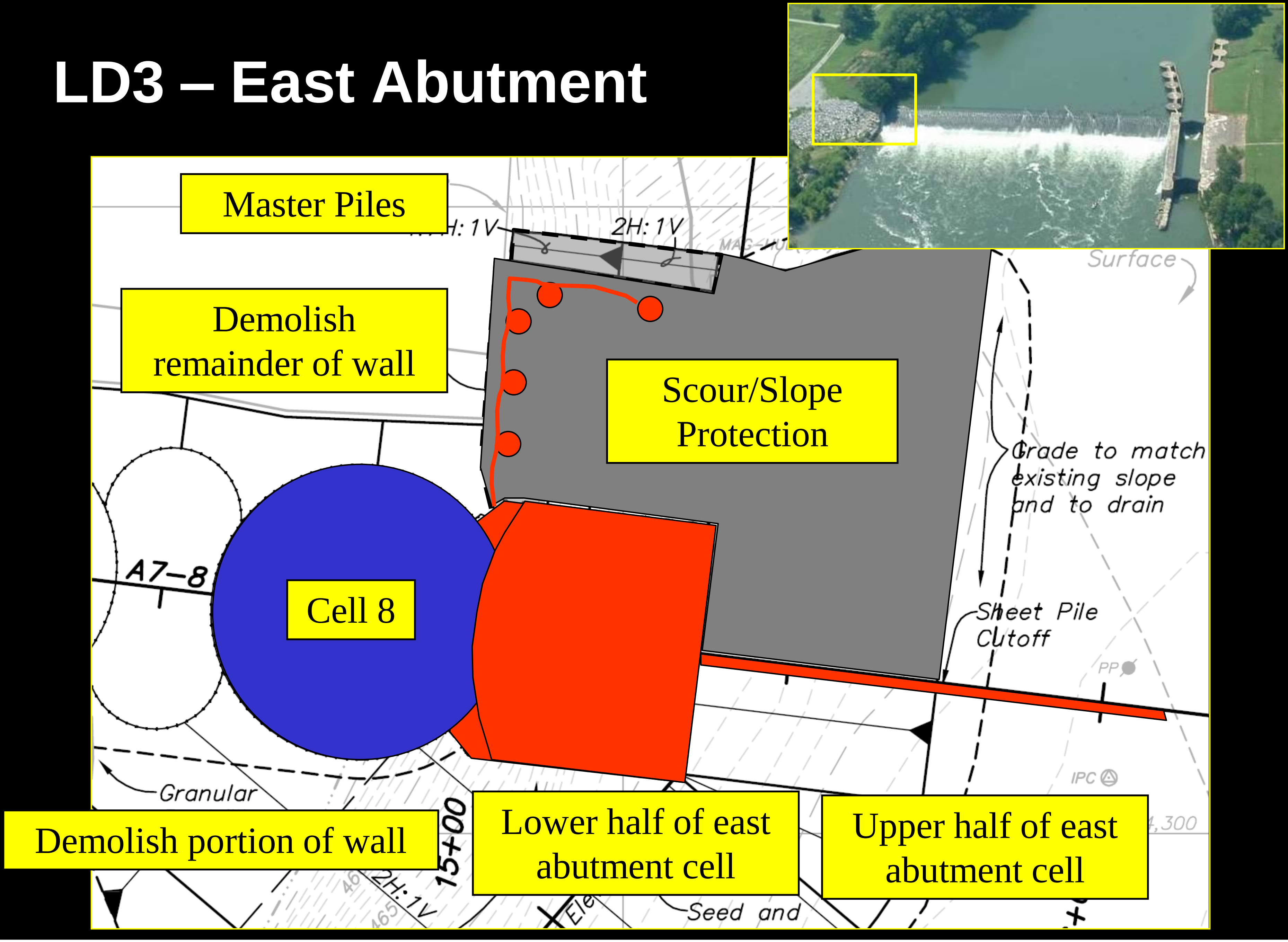
Cap Concrete Placement

Abutments/Tie-ins

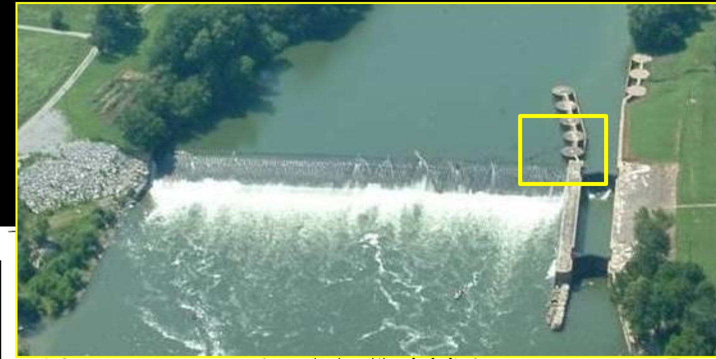
“The hard parts”

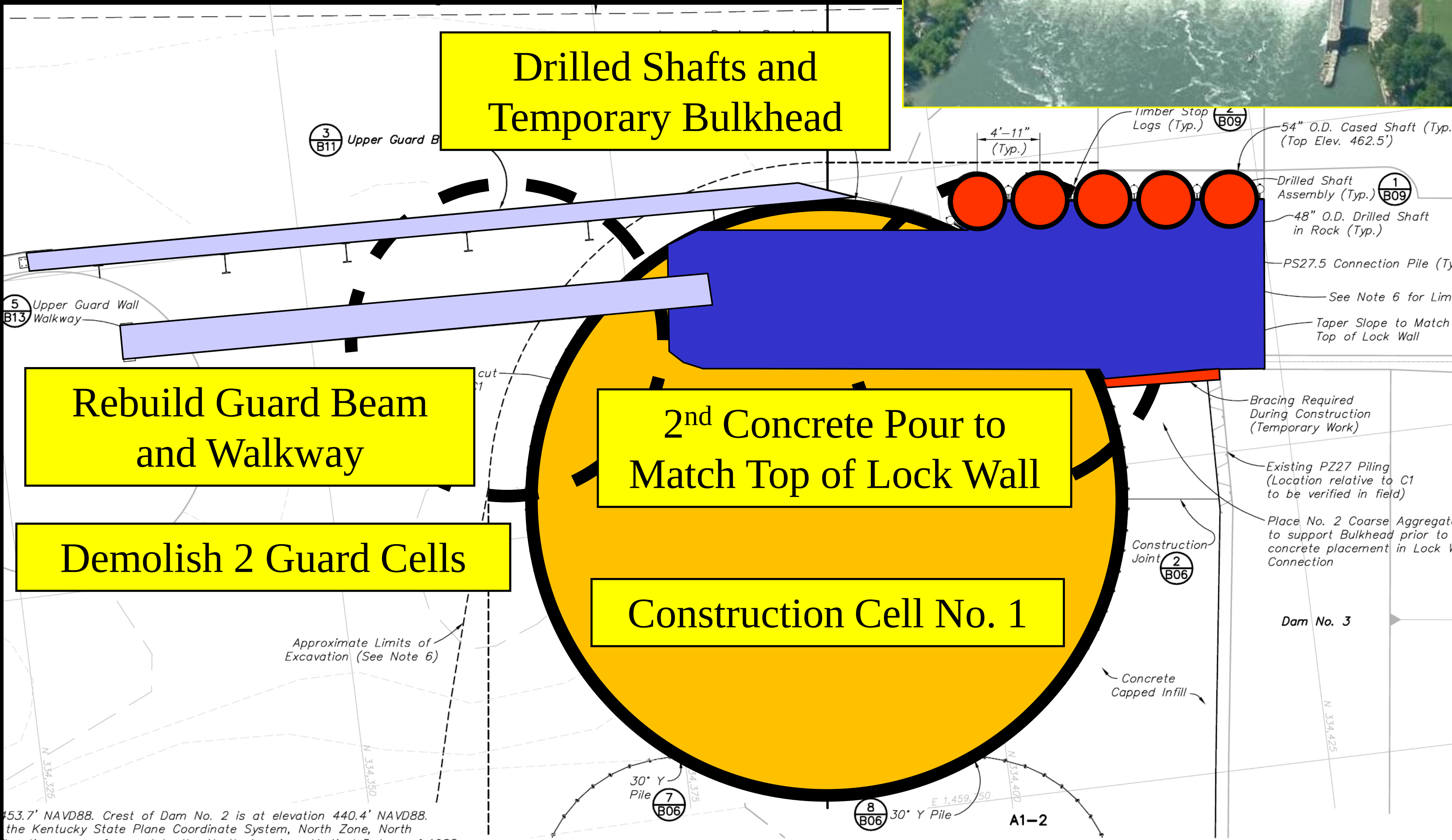
- External Soil Loads
- Account for Scour
- Geometric Constraints / Interaction with other Structures
- Risk of Flanking (During Construction and Long Term)
- Seepage & Piping (Around or Through)
- Pareto Principal (80-20 Rule) in Effect During Design

LD3 – East Abutment



LD3 – Lock Wall Tie-in





Lessons Learned

- Construction Delays
  - How Are They Evaluated/Regulated?
    - River Elevations
    - Set Workdays
  - Realistic Construction Schedules
    - Take into Account Historical Hydrographs
- Damages from Elevated River Conditions
- Rockline Adjustments
- Unit Prices for Potential Additional Work Items

Lessons Learned

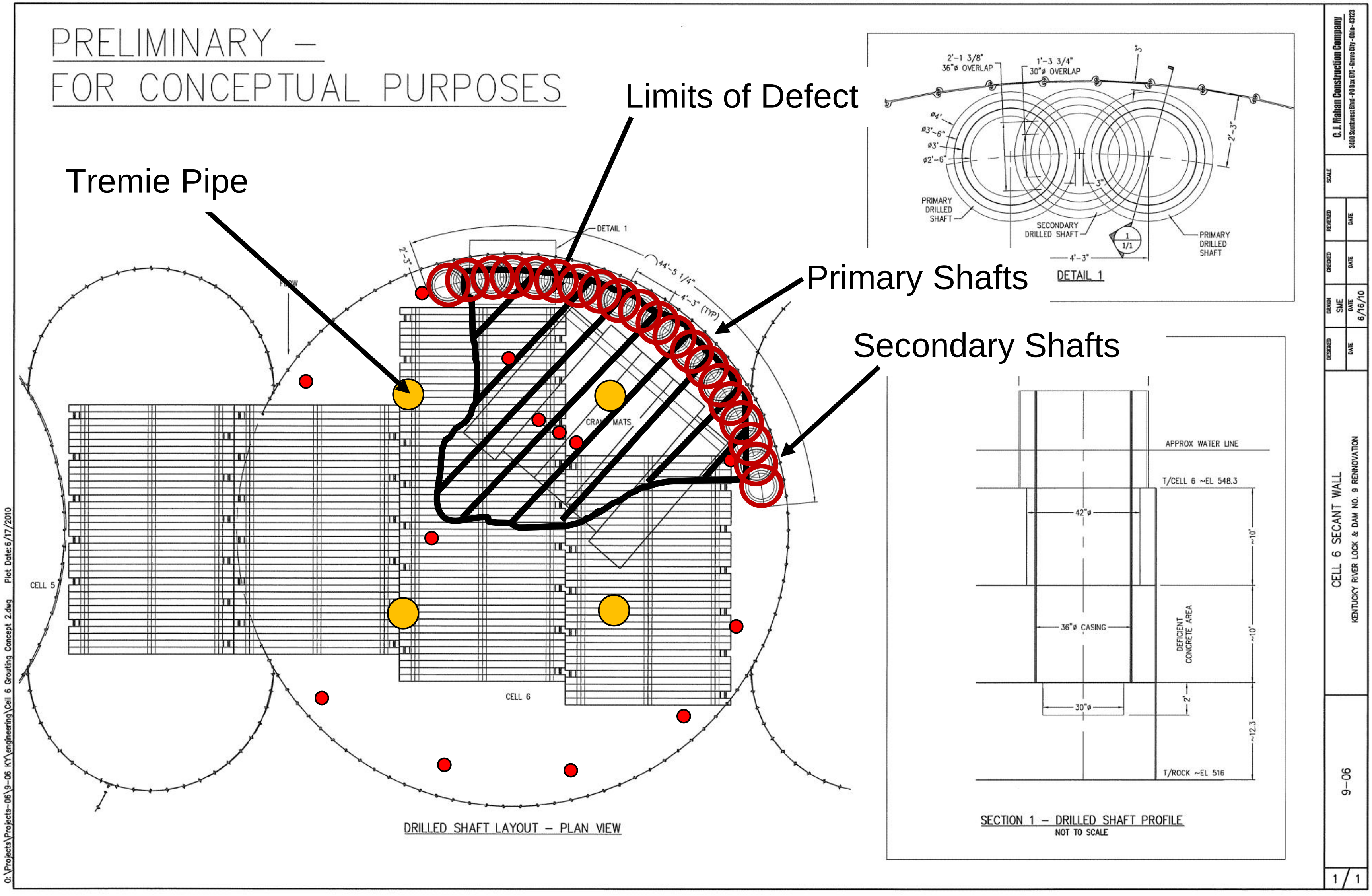
- Detailed Submittal Process
  - PE Stamp for All Calculations
  - Assures Contractor has Specific Approach
  - Engineer/Owner Opportunity to Review

- Construction Sequence/Restrictions
  - Protect Pool
  - Spell Out Very Clearly

Lessons Learned

- Concreting
  - Demonstration Placements
    - Concrete Retardation Durations
    - “Work Out the Bugs”
  - Prepare Contract Documents for Gravity and Direct Pumping Concrete Placement Methods
  - QA/QC Measures
    - Confirmation Coring
    - Good Documentation
    - Investigate if Questions Exist

Lessons Learned



Lessons Learned

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Lessons Learned

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Questions?

- References
  - Leiand R. Johnson, “The Falls City Engineers”, 1984
  - “Assessment of Underwater Concrete Technologies for In-the-Wet Construction of Navigation Structures”, USACE, 1999.
  - KRA Website
    - http://finance.ky.gov/ourcabinet/attachedagencies/kra.htm
  - “Assessment Study for KY River Dam Nos. 1-8 and 10-14”, Stantec, 2007.
  - Technical Report INP-SL-1, USACE, September 1999.