Dam Safety

ILMA Conference

April 4, 2013

TODAY'S SPECIALS

APPETIZERS

- Course is discussion based, if you don't participate it will be lecture based. Bad idea
- Dennis is AWOL. Actually excused for his real job.
- Paul will be covering new material (Dennis's)
- Restrooms are past the moose, turn right.

PAUL MAUER, JR., P.E.

- Education
  - BSCE – Iowa State Univ.
  - MSCE – Univ. of Illinois
  - MBA – Univ. of Illinois

- Experience
  - IDNR-OWR
    - FP Implementation Engineer – 7 years
    - Dam Safety Engineer – 28+ years
    - Acting Division Manager – 2004-2008

DEFINITION - DAM

- Man made structure
- Intent to impound or divert water (fluid)
- (Levees are not dams in Illinois)
- Tanks are exempt

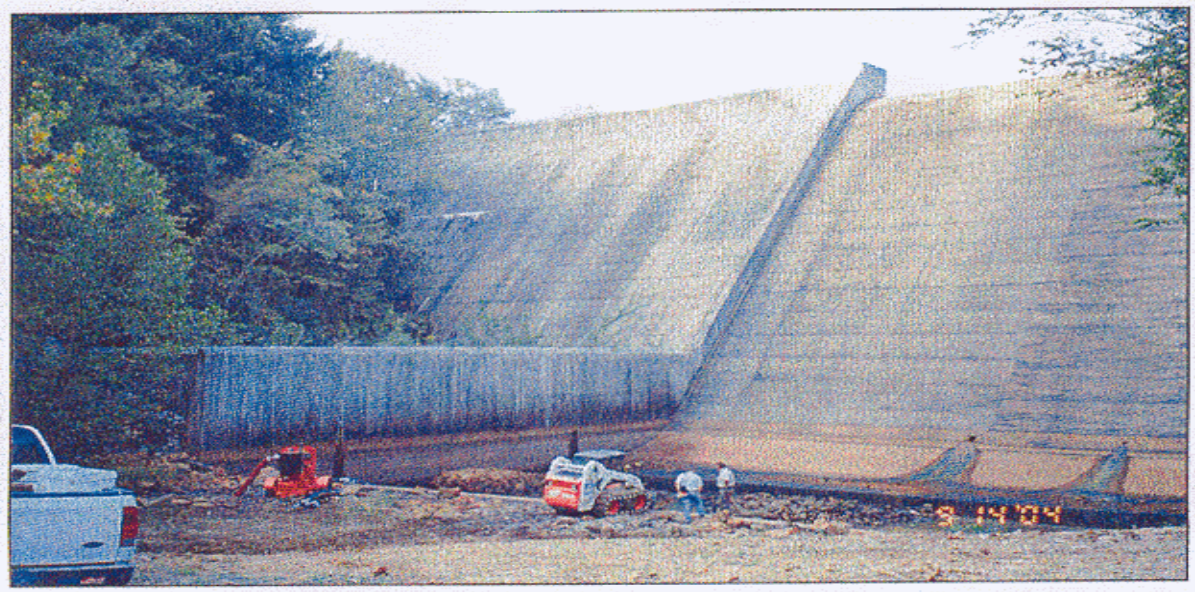


Photo 5. Dewatering, Inspection and Cleanout of Stilling Basin on September 14, 2004.

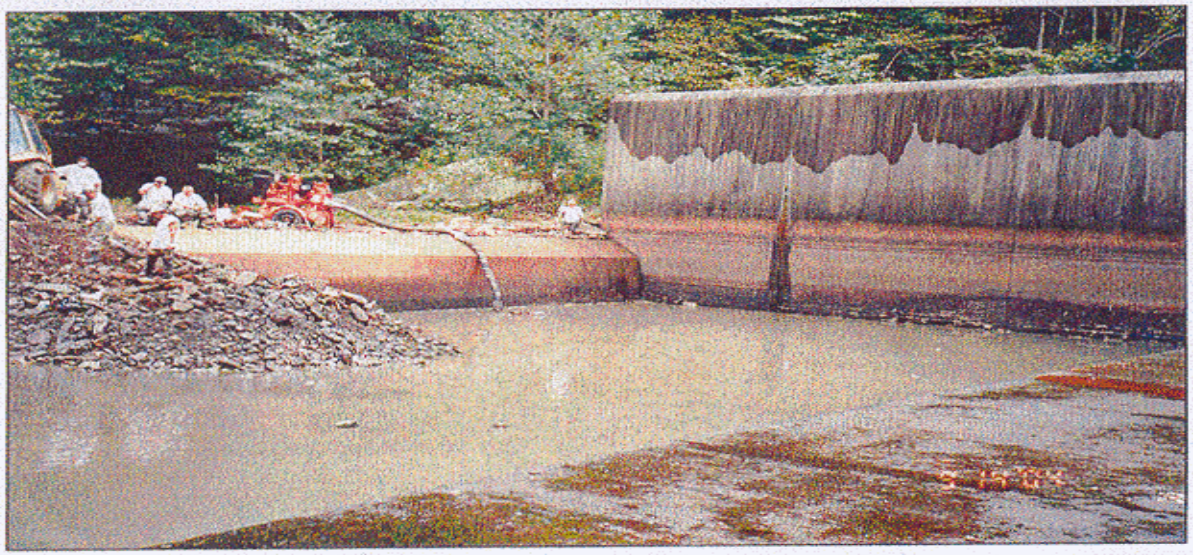


Photo 6. Stilling Basin Endsill

Crab Orchard National Wildlife Refuge
Crab Orchard Dam
September 28, 2005

Photo 29 - View of outlet works control structure, looking upstream. Photo was taken prior to exercising gates, with no leaks through the gates.

Photo 30 - Upstream view of outlet works control structure. Note reservoir staff gage mounted on wall.

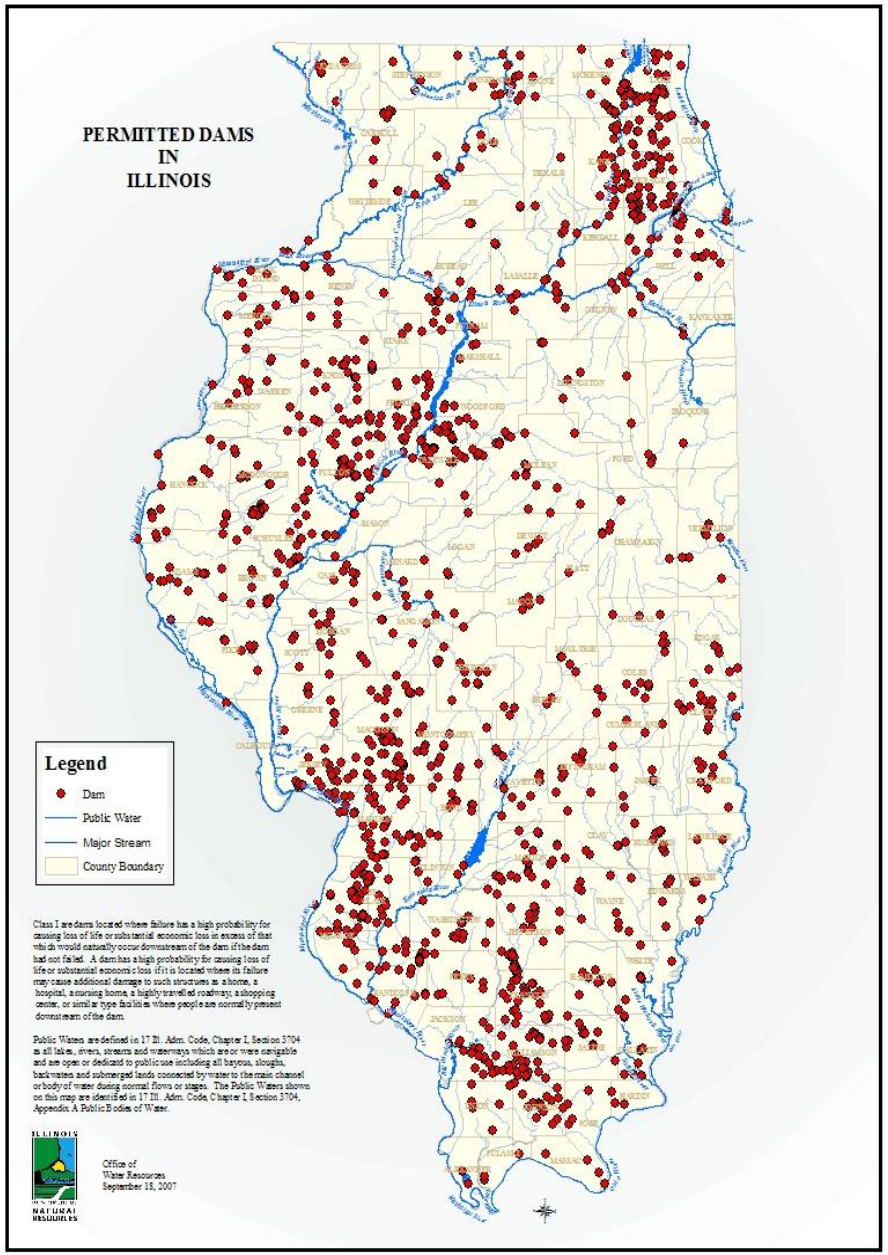

10/01/201


11/15/20

How Many Dams Are There?

- 4/3/2013 – 1761
  - Class I 223
  - Class II 298
  - Class III 1240

- Total
  - Estimates range from 5,000 to 10,000 to 90,000



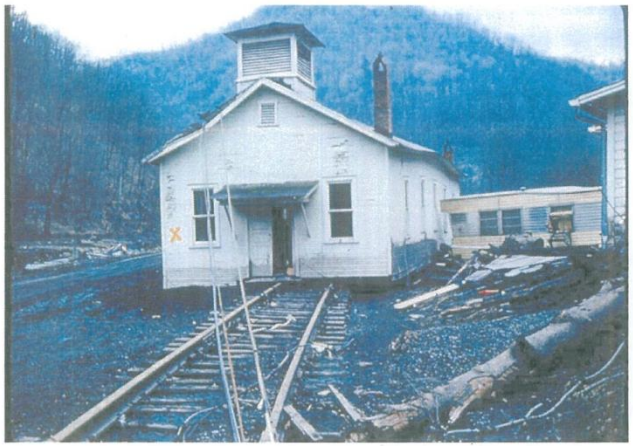
ILLINOIS DAMS

DAMS FAIL

- Tom Sauk - 2006
- Taccoa Falls/ Kelly Barnes– 1977
- Teton – 1976
- Buffalo Creek - 1972
- Baldwin Hills - 1964
- Johnstown – 1889

- (Only Teton is a first fill failure)

JOHNSTOWN, PA



Buffalo Creek

February 26, 1972

- 125 lives lost
- 1100 injured
- Destroyed over 500 homes
- Destroyed over 40 mobile homes
- 16 communities wiped out
- 4000 of 5000 inhabitants left homeless
- Roughly $50 million in damages
- No warnings until after the structure failed, but employees knew something was wrong
- Four false alarms in past
- No emergency action plan

ILLINOIS
DAM SAFETY

- Public Act 81-1062, Jan. 1, 1980
- Part 702 Rules, September 2, 1980
- Amended February 23, 1983

Program Publications

- Rules
- Guidelines
- Inspection Forms
- Guide Book
- Mining Coordination

Dam Safety Rules

- Statute – RL&S Act – 615 ILCS 23a
- Illinois Administrative Code – Part 3702
  - www.dnr.illinois.gov/waterresources
- Jurisdiction over ALL dams

- Definition
  - (man-made – impound)

DO I NEED A PERMIT?

HAZARD

- Class I – High probability of loss of one life
- Class II – Moderate probability
- Class III – Low probability
- Can be based on economic loss or environmental damage

Similar to the Corps classifications (H, S, L)

Permits

- New Construction
  - All Class I and Class II
    - Construction, Operation & Maintenance
  - Larger Class III
    - Height - Impounding Capacity (3702.20)
  - Small Class III in floodway
- Built Pre–9/2/1980 “Existing Dams”
  - All Class I and Class II
    - Permitted & in good condition
    - Operation & Maintenance
  - Modification of Larger Class III
    - Construction, Operation & Maintenance

Permits

- Removal
  - All dam removals require a permit
  - By policy
    - Only dams that required a construction or operation permit will require a removal permit

No Permits

- Maintenance
  - Mowing
  - Seeding
  - Painting
- Minor Repairs
  - Fence replacement
  - Concrete patching
- Minor Modifications

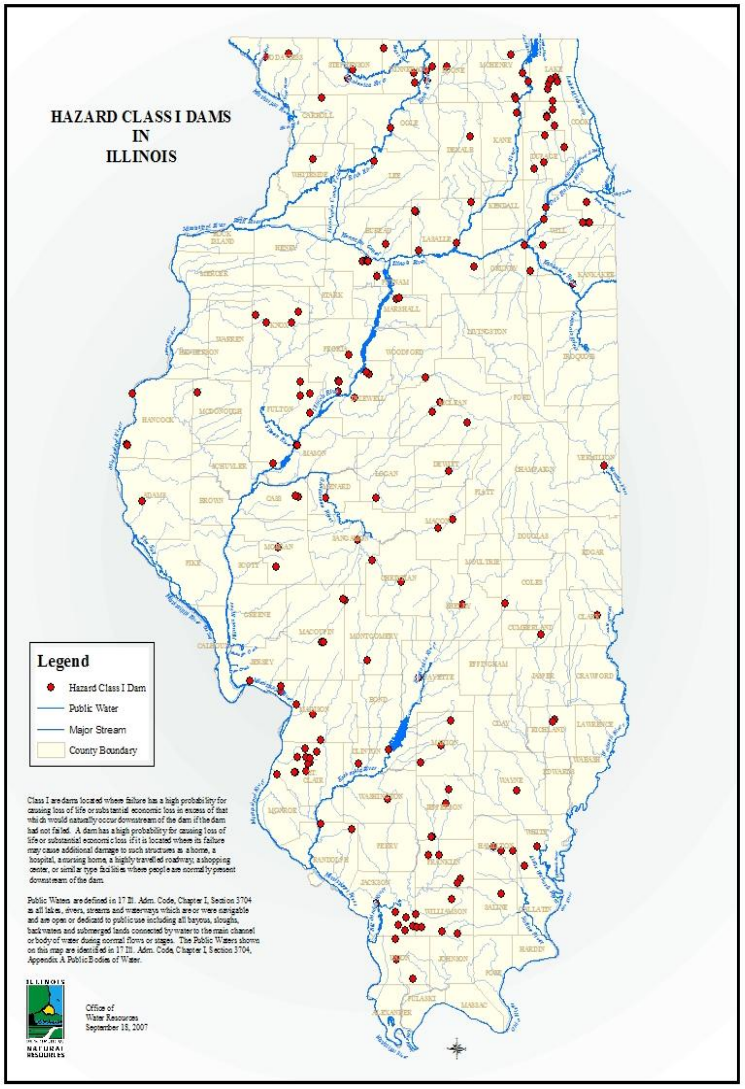
Proposed fee information

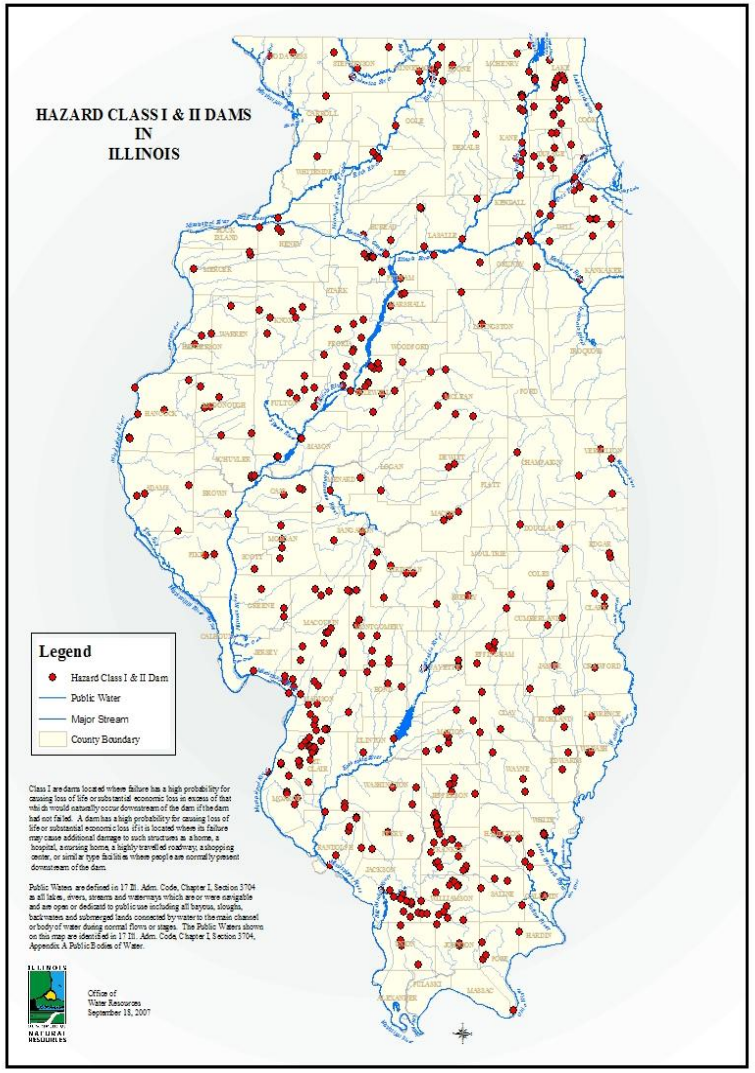
- PA 97-1136 Effective 1-1-2013
- Proposed Application Fee - $500
- Proposed total fee - $1500 to $4500
- Fee covers Owner’s ‘life of dam’

QUESTIONS

PAUL.MAUER@ILLINOIS.GOV

ILLINOIS DAMS





Permits

- GP 98-01
  - Developed to address waterfowl impoundments.
- GP 02-01
  - Developed to reduce workload
    - Places all responsibility (liability?) on engineer

Both GP's violate important sections of 3702

Expected to be rescinded with implementation of fees.

Seminar Goals

- Increase Efficiency – both yours and mine

- Review Permitting Process
- Review Basic Dam Engineering

- Answer your questions
  - Ask as we go – discussion not lecture
- Are you an ‘Engineer’? (3702.20)

FEDERAL RESPONSE

- 1973 – National Dam Inventory Funded
- 1978 – National Dam Safety Act Funded

BREAK

LIFE OF A DAM SAFETY PERMIT

- Step 1 Before the application

  – Preliminary Design Report
    - Establishes the provisional hazard classification to determine initial design performance standards

    - Provides a basis for early discussion of questions

LIFE OF A DAM SAFETY PERMIT

- Step 2
  - Application Package
    - The form and instructions (handout)
    - FEES
      - Public Act 97-1136
      - Draft Administrative Rules (handout)
      - Expected effective date – July 1, 2013
    - Plans & Specifications
    - Documentation

LIFE OF A DAM SAFETYPERMIT

- Documentation
  - What do I document? (everything)
    - Is ‘what’ you decided and ‘why’ you decided clear to the reviewer?
  - Where do I find the requirements? 3702.40
  - Is there a list? Yes 3702.60
    - 3702.40b)3 and 3702.40b)7 are not referenced

(Your opinion of engineering is valued)

LIFE OF A DAM SAFETY PERMIT

- Step 3
  - Review Process
    - Takes from 100 to 2,500+ days (3702.140)
    - Public Notice (3702.130)
    - May include a Public Hearing
  - Permit or Denial
    - Construction phase for 3 years, may be extended
    - O&M phase for the life of the dam
    - Permits cannot be transferred

PARTICIPANTS

LIFE OF A DAM SAFETY PERMIT

- Step 4
  - Construction is complete
    - Authorization to Fill for Class I and II
      - Requires
        - » Written request
        - » Pre-fill inspection by IDNR
    - Construction documentation
      - ‘As-Built’ plans and specifications
      - Post construction inspection

LIFE OF A DAM SAFETY PERMIT

- Step 5
  - Operation and Maintenance
    - Perpetual
    - Inspection by PE at specified intervals
    - Post-event inspections
    - Authorization for all modifications

LIFE OF A DAM SAFETY PERMIT

- Step 6
  - Removal (3702.50)
    - Requires permit authorizing removal and restoration
      - Controlled dewatering and structure removal
      - Restoration of structure site and reservoir

ENFORCEMENT

- Enforcement timeline – Not life threatening
  - Notice of deficiency
  - Reminder
  - Title impairment
  - Administrative hearing & order
  - Judicial enforcement

ENFORCEMENT

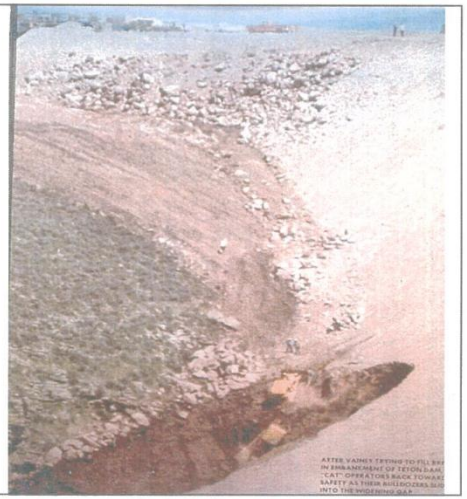
- Enforcement timeline – life threatening
  - Judicial Order
  - Modify or Remove Dam
  - All costs recovered from dam owner

TOM SAUK

- Most recent major midwest failure
- Failed in December
- Structural failure – nearly instantaneous
- If it failed in mid-summer there would have been up to 3000 people in the downstream floodplain.

TOM SAUK

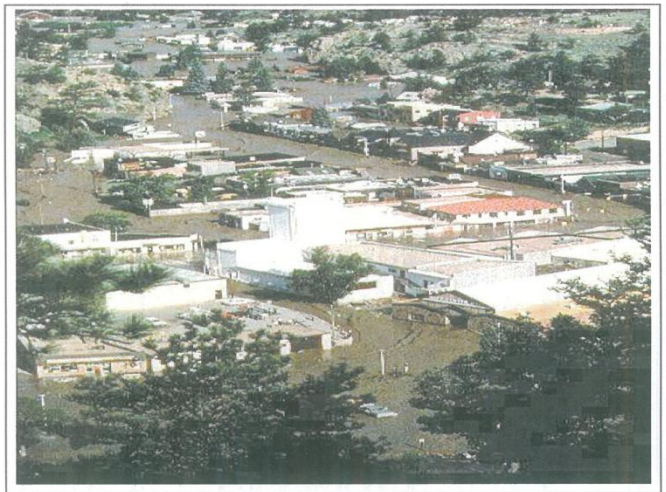
Dozers Lost



Teton Dam

June 5, 1976

- 11-14 lives lost
- 25,000 homeless
- 300 square miles inundated
- $400 million compensation
- Failed on initial filling
- Multiple errors of omission and commission
- Failure to learn from similar errors 11 years earlier
- Sent two bulldozers into the breach
- Warnings issued, and most of the impacted population successfully evacuated
- No emergency action plan



- Lawn Lake

Lawn Lake Dam

July 15, 1982

- High in Rockies overlooking resort community of Estes Park
- Dam was privately owned, but on National Park Service land
- Failed before 6:30 a.m. Flood wave destroyed lower Cascade Dam.
- Then flooded the camp ground
- Then roared through Estes Park
- Three deaths
- Over $31 million in property damage
- No emergency action plan by dam owner
- No contingency plan by National Park Service
- Warnings of failure to Park Service
- One ranger casually warned several, but not all, campers. No sense of urgency in warnings.
- Government liable to one deceased camper for $480,000

United States v. Coates, 612 F.Supp. 592 (C.D. Ill. 1985)

- "[T]he Government . . . also creates a duty for itself to develop orderly procedures for dealing with emergencies. It is imperative to have a plan in place because in such situations there is little time for reflection. Priorities should be established before an emergency arises; otherwise personnel are unprepared to deal with them."
- "Elementary lapses, obvious with the clarity of hindsight, could have been avoided through the development of orderly procedures for warning and evacuating people in the park in the event a crisis arose. There was a duty to plan. The Government failed to develop a plan, and the Court here finds that the failure to have a plan in place was a proximate cause of the death of Terry Coates."
- "The exercise of reasonable care mandated, at a minimum, the issuance of careful and complete warnings to all of the people who were camped in or otherwise using areas of the park which were downstream from Lawn Lake Dam."

JOHNSTOWN

- Pennsylvania – 1889
- 2209 dead
- 1 in 3 bodies never recovered
- 967 listed as ‘not known to be found”
- The first great disaster of the photography age
- First major disaster served by the American Red Cross, led by Clara Barton

Did we have lunch yet???

FAILURE
WHAT IF IT HAPPENS

It takes a lot to fail an engineered dam.

Dams are typically designed for 8-10 inches of rainfall. Today up to 35 inches.

A well maintained dam will typically handle 10-15 inches without failing, but with damage.

WHAT IF IT HAPPENS

- July 17-18,1996 - Northern Illinois – up to 16.92 inches recorded. To date we know of 8 dams that failed. No loss of life or personal injury.
- Mar 17-19, 2008 – Southern Illinois – up to 15.5 inches recorded. To date we know of NO dams that failed. One with major damage.
- June 2008 & Sept. 2008

WHAT IF IT HAPPENS

DAM SAFETY 102

- Requirements are performance based
  - Promotes creative solutions
- Performance standards are minimums
- Review may use different processes
  - Particularly true for software based designs

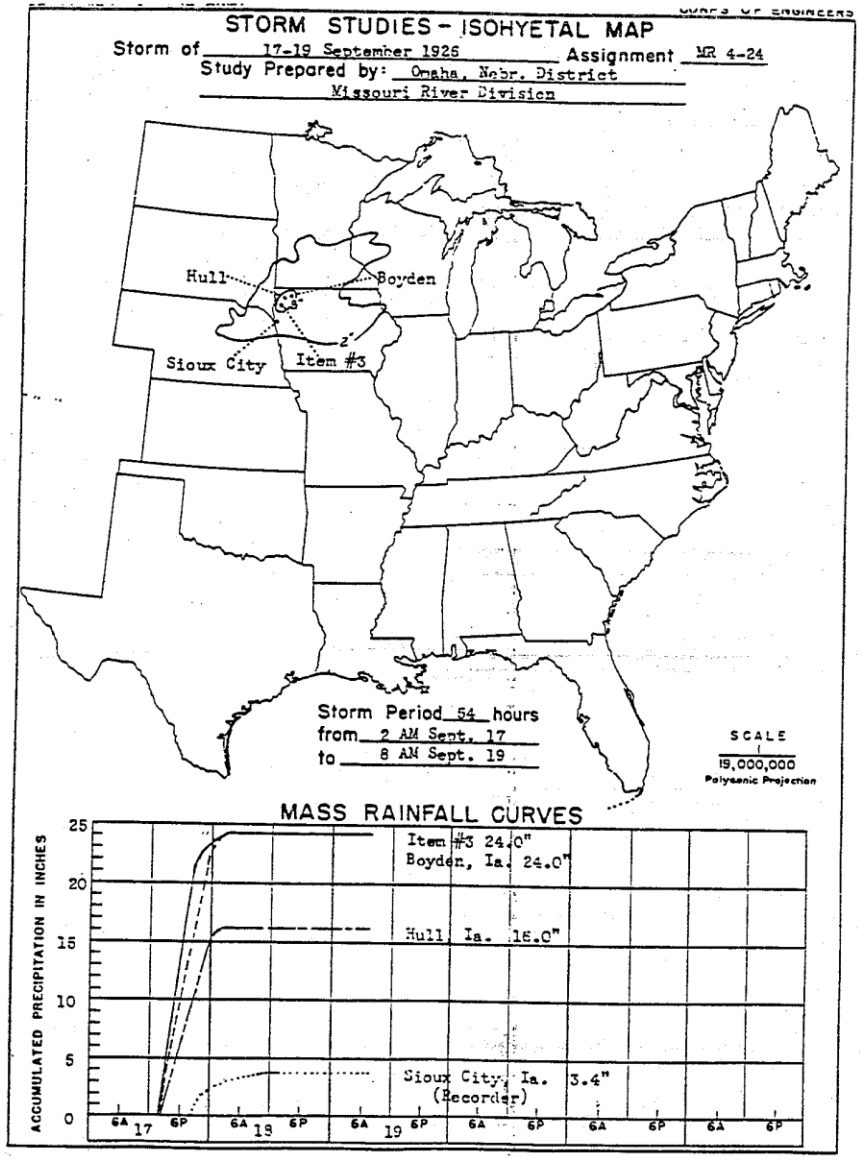
Spillway Design

- Rules
  - 3702.40b)2) page 14-15
  - Based on hazard and size
  - Risk based designs – Risk portofolios
    - Now standard for federal dam owners
    - Allowed only for modification of existing dams in IL

HYDROLOGY

- PMP
  - HMR 51-52
    - Usually 25” in 24 hours (NE) to 36” in 24 hours (S)
    - Realistic?

HMR Storm

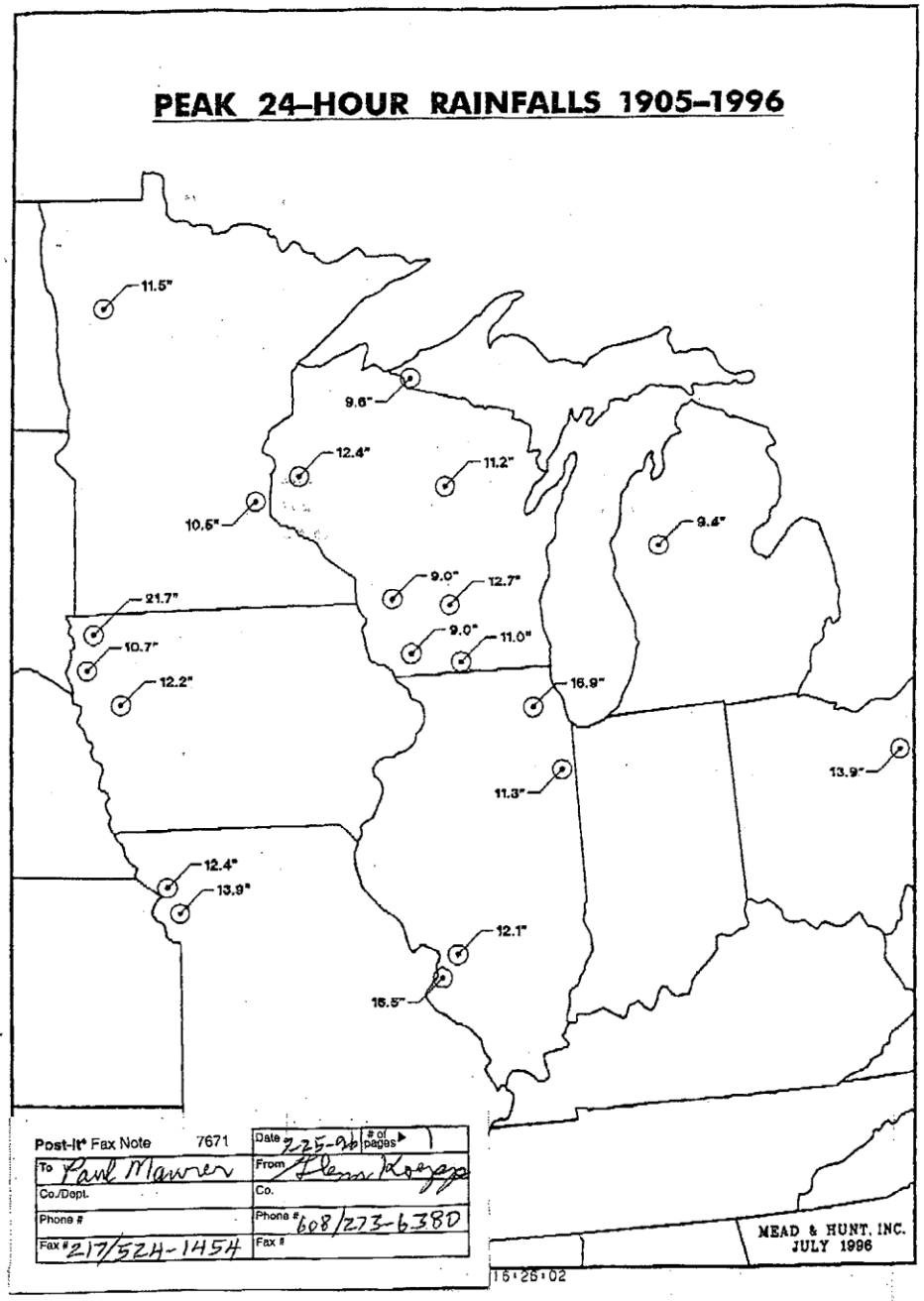

STORM STUDIES - ISOHYETAL MAP
Storm of 17-19 September 1926 Assignment MR 4-24
Study Prepared by: Omaha, Nebr. District
Missouri River Division
Hull
Boyden
Sioux City
Item #3
Storm Period 54 hours
from 2 AM Sept. 17
to 8 AM Sept. 19
SCALE
1:9,000,000
Polyconic Projection
MASS RAINFALL CURVES
ACCUMULATED PRECIPITATION IN INCHES
Item #3 24.0"
Boyden, Ia. 24.0"
Hull, Ia. 16.0"
Sioux City, Ia. 3.4"
(Recorder)
6A 17 6P 6A 18 6P 6A 19 6P 6A 6P 6A 6P 6A 6P

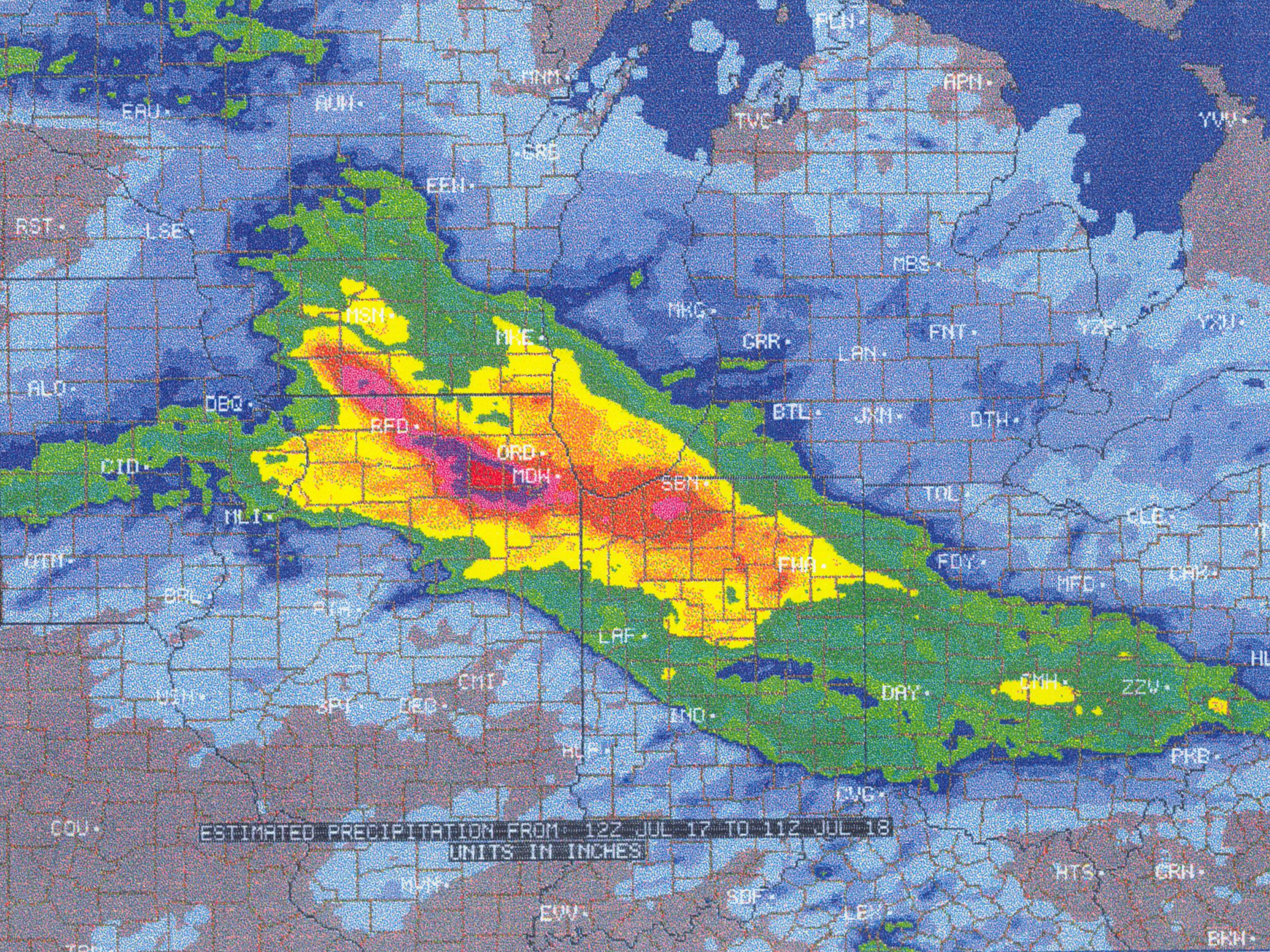
MidWest Rain Events

Add 13.7, 15.5, 15.2, 15.4 in Illinois since 2005

12.4 at Holt, Mo. Is a 40 minute event

10.7 at Hull, Ia. Is often referenced as a 6 hour event.




ESTIMATED PRECIPITATION FROM 12Z JUL 17 TO 11Z JUL 18
UNITS IN INCHES
MSN
MKE
RFD
ORD
MDW
SBN
FWA
DBQ
CID
MLI
LAF
IND
DAY
CMH
ZZV
GRR
LAN
BTL
JXN
DTW
TOL
FDY
CLE
MFD
FNT
MBS
MKG
TVC
APN
EAU
AUW
GRB
RST
LSE
ALO
BRL
CMI
CVG
PKB
HTS
CRW
EVV
SDF
LEX
COU
YVV

July 17&18,1996

- Record rainfall in Illinois
- 16.92 inches in 18 hours at Aurora
- 16.3 inches over 100 square miles
- 11.3 inches over 2000 square miles
- 8 dam failures, all low hazard dams
- 2 unique 5” in 1 hour storms at Lockport
- PMF at Aurora is 25-30 inches in 24 hours

HYDROLOGY

- PMF
  - HEC-HMS or HEC-RAS, FLODWAV, others
- GAGE STATISTICS
  - Principal spillways, Class III dams
- Non-hydrograph methods
  - USGS Regional Equations – STREAMSTATS
    - Class III dams
- Result is defined discharges for spillways

HYDRAULICS

- Spillway Types
  - Crest with Chute
  - Drop Inlet to Conduit
  - Hybrid – Labyrinth Weir – Tipping Weirs
  - Gates
  - Other
- Develop Rating Curve
  - Demonstrate required spillway capacities

HYDRAULICS

- Energy Dissipation
  - Impact Basins
    - Limited flow rates
    - Compact
  - Hydraulic Jump Basins
    - Unlimited flow rates
    - Space eaters
  - Plunge Pools
    - Low initial cost
    - Maintenance issues

HYDRAULICS

- Principal, Auxiliary, Emergency
  - Principal
    - never damaged – design for maximum flow
  - Emergency
    - Can be damaged, no loss of reservoir

HYDRAULICS

- Common Errors
  - Weir computations
    - Do you have a weir?
    - Do you support the computed flow?
    - Debris?
  - Drop Inlets
    - Weir vs. pipe flow
    - Cavitation/full flow (Do you need to vent?)
  - Antiseep Collars
    - Use ceased about 1985 (FEMA 484, Appendix A)

Drop Inlet

Is it a weir?

Coefficient?

Length?

Debris?

PICTURE 1 – DAM EMBANKMENT LOOKING EAST

PICTURE 2 – DAM EMBANKMENT LOOKING WEST

HYDRAULICS

- Common Errors
  - Pipe Systems
    - Minimize turbulence through embankment
    - A manhole in an embankment is for access to equipment / valves
  - Freeboard Computation (Min. dam height)
    - Design storm pool + wave runup + setup

HYDRAULICS

- Breach Analysis – Classification
  - Up to Full PMF
  - Continue downstream to 1.0’ incremental rise
- Breach Analysis – Design of I and II
  - Sunny day
  - Total spillway discharge storm event
  - Continue downstream to last identified hazard
  - Breach size/Breach time

BREAK

STRUCTURAL

- Geotechnical
  - Geology
    - NE – Glacial till – sand?
    - NW – fractured limestone bedrock?
    - Remainder – sand lenses & bedrock issues
  - Slope Stability
    - < 30’ – reasonable book values – translated test strengths
    - >30’ – Test values

STRUCTURAL

- Geotechnical
  - Filters & Drains
    - Must have grain size analysis
    - Geotextile filter fabric
      - FHWA Spec does not work
      - Proper AOS fabric can be expensive
      - Composite filter

STRUCTURAL

- Geotechnical
  - Slope Stability
    - End of Construction – $\Phi = 0$
    - Long term Steady State – c = 0 for embankment
    - Earthquake
      - Pseudo steady – FS > 1.0
      - Deformation analysis
      - Not required if peak acceleration < 0.1g
      - Latest NEH values slightly lower

STRUCTURAL

- Geotechnical
  - Embankment Protection
    - No erosion from flowing water
      - Upstream face
        - » Wave action
      - Downstream face
        - » Wave action?
        - » People action (animals?)
    - Protection from precipitation
      - Dense cover
      - Dormant season
      - No woody vegetation

STRUCTURAL

- Geotechnical
  - Riprap
    - Flexible System
    - Most designs undersize the stones
    - Rock quality is critical

    - ‘Grouted riprap’ is poorly designed concrete

STRUCTURAL

- Concrete Structures
  - ACI-318
  - Standardized structures – BuRec, COE, NRCS, etc.
  - Pipe
    - AWWA C300, C301, C302 or ASTM C361
    - Demonstrate equivalence
      - Internal Pressure
      - External Pressure
      - Watertight (ASTM typ. 10 min. vs 10 hr. or 10 days)
      - Expected life

STRUCTURAL

- Concrete
  - Roller Compacted Concrete (RCC)
    - Low cement content
    - Faster set time
    - Most advantageous in remote areas / high volume
    - Several PCI publications
- Steel
  - AISC, AASHTO, etc.
- Valves
  - Cycles in lifetime? Closure damage?

EMERGENCY ACTION PLAN

- Inundation Mapping
  - Required ?
  - Computer Modeling – when necessary
  - Mapping
    - Appropriate scale
    - Appropriate base
  - Information
    - Depth
    - Timing

EMERGENCY ACTION PLAN

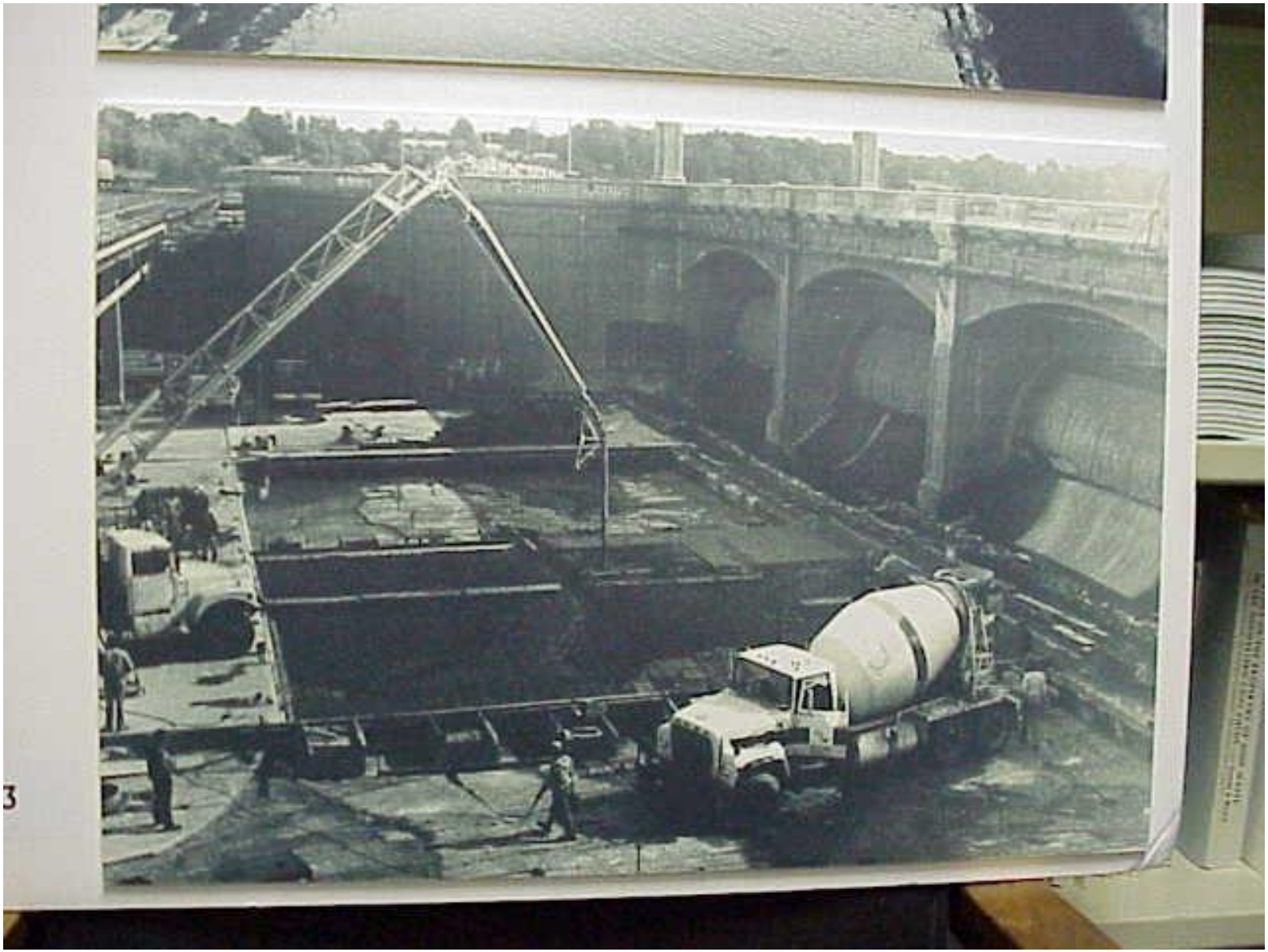
- Plan Development
  - EMI G274
    - Process based
  - On-line ‘forms’
    - NRCS (Oklahoma)
    - By Committee
    - Do not conform to Illinois Law
    - Consult with me before you start

DAM SAFETY
PROGRAM

Illinois Department of
Natural Resources
Office of Water Resources

Spaulding Dam

High flows
through spillway -
12/3/82



IF YOU NEED ME

- E-Mail
  - Paul.mauer@illinois.gov
  - Dnr.dwrm@illinois.gov
  - Damsafe@mtco.com
- Phone
  - Work - 217-782-4427 or 217-782-3863
  - Cell – (Don’t have one)
  - IEMA – 800-782-7860

QUESTIONS

Emergency Action Plans

- 171 of 192 Class I dams have a plan.
- 150 of 288 Class II dams have a plan.
- Quality of plans runs the gamut.

THE HAZARD

- Dynamic Flooding
- A wet tornado
- A flash flood of D-9’s