The Flood Damage Mitigation Works of the Miami Conservancy District, Ohio, 1922 -

Stephen J. (Steve) Burges

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University of Washington

CEE 500 Seminar – April 13, 2023

Topics

Brief Professional History

Rain generated Super Floods

Flood Damage Mitigation:
Miami Conservancy District, Ohio

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Brief Professional History

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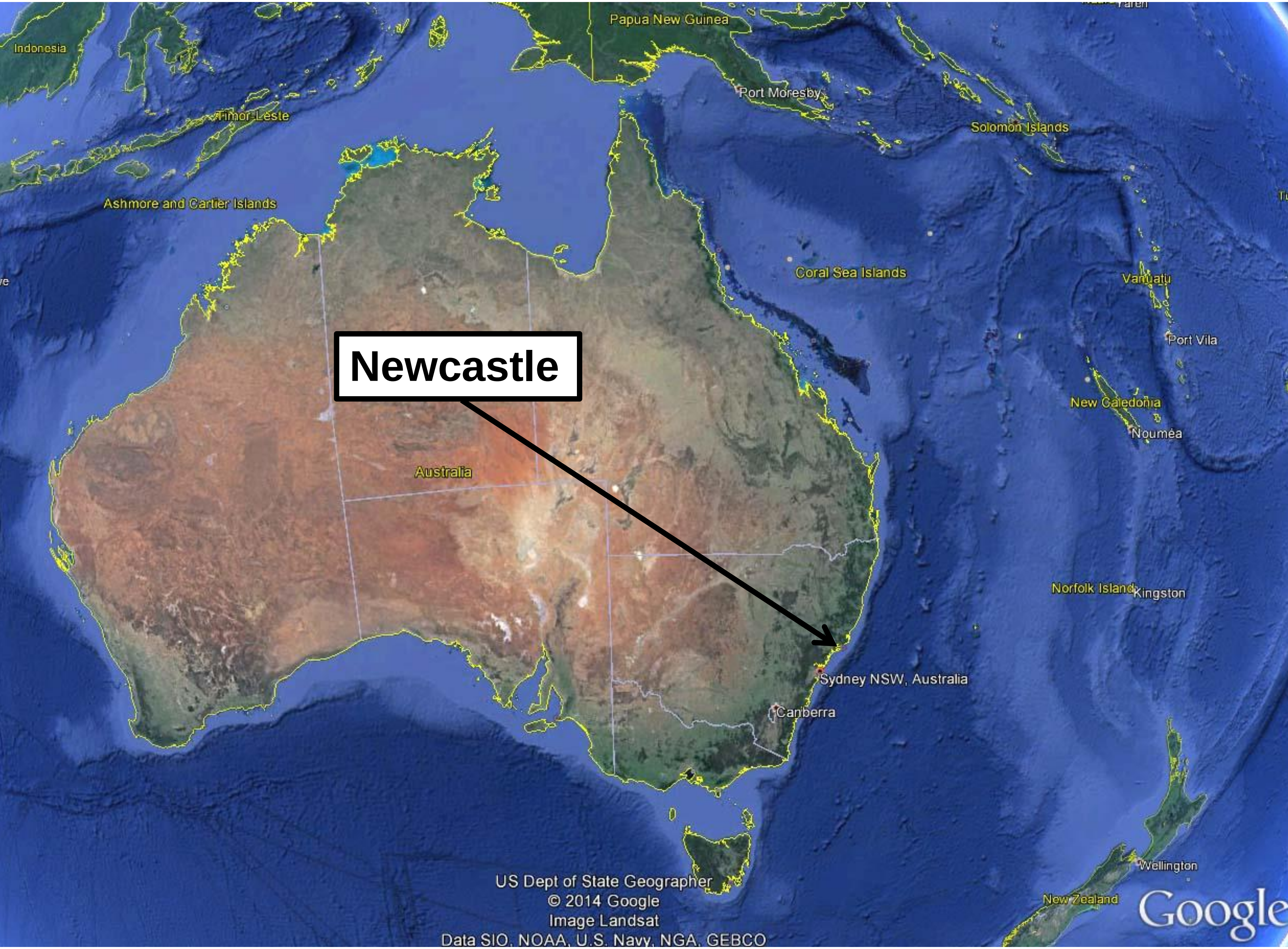
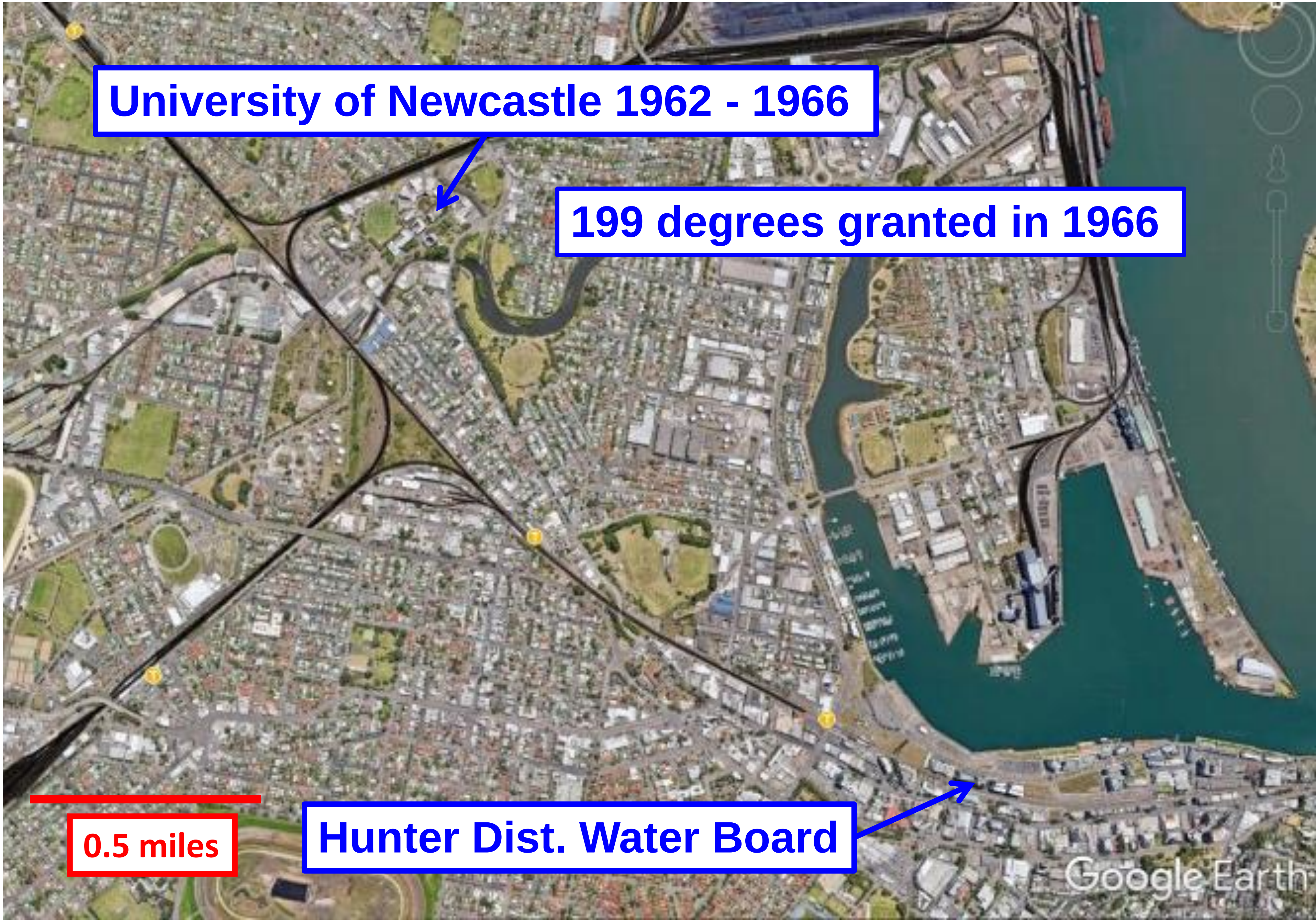
My early professional years – Newcastle Australia:


Newcastle
Indonesia
Papua New Guinea
Timor-Leste
Port Moresby
Solomon Islands
Ashmore and Cartier Islands
Coral Sea Islands
Vanuatu
Port Vila
New Caledonia
Nouméa
Australia
Norfolk Island
Kingston
Sydney NSW, Australia
Canberra
Wellington
New Zealand
US Dept of State Geographer
© 2014 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google


University of Newcastle 1962 - 1966
199 degrees granted in 1966
0.5 miles
Hunter Dist. Water Board
Google Earth

Summer internships – trainee civil engineer, Hunter District Water Board 1963 - 1966:

Member of construction crews – sewers, water supply, treatment plants, pumping stations.

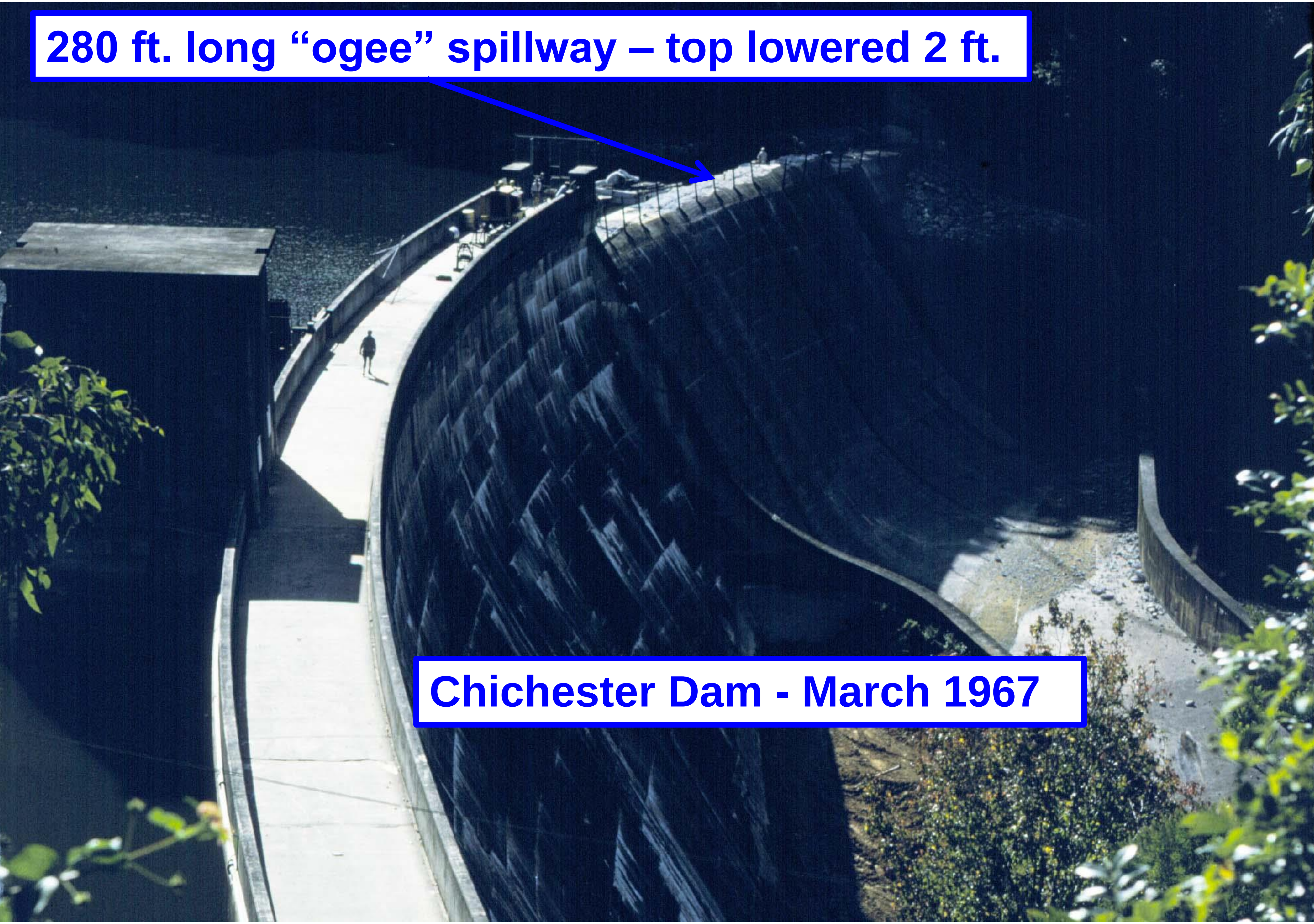
I gained huge respect for workers who do hard physical work.

Engineers must not waste any worker’s time!

Construction Engineer - November 1966 - August 1967

Hunter District Water Board – (now, Hunter Water)

Site Engineer - Lowering the Spillway at Chichester Dam for Enhanced Dam Safety


280 ft. long “ogee” spillway – top lowered 2 ft.
Chichester Dam - March 1967

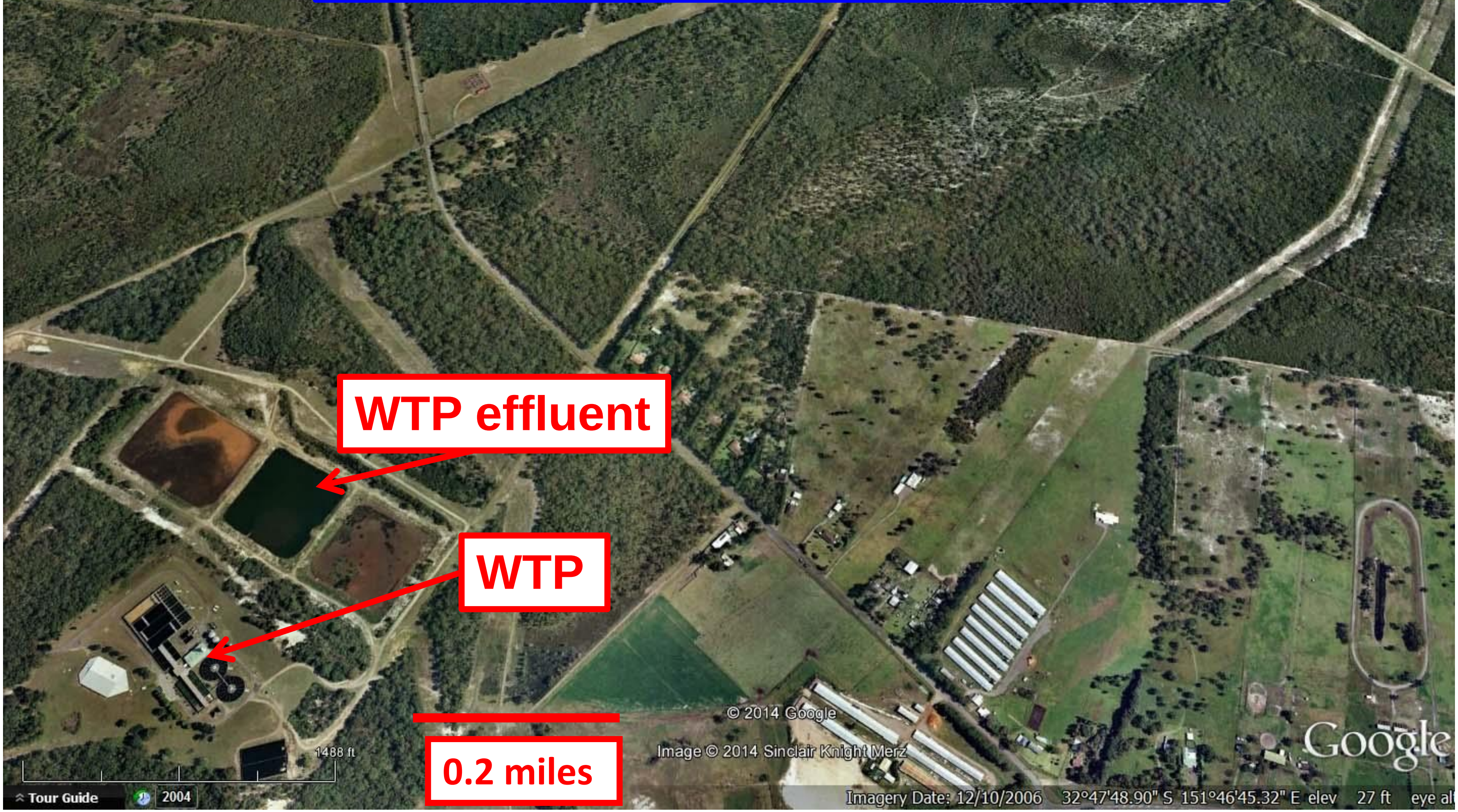
Construction Engineer - November 1966 - August 1967

Hunter District Water Board – (now, Hunter Water)

Site Engineer - Lowering the Spillway at Chichester Dam for Enhanced Dam Safety

Site Engineer - Earthworks for expansion of the Tomago Potable Water Treatment Plant

Site – pre-construction: tree covered; thin organic soil over deep sand




Remove trees; excavate hill "cut"–
use as "fill" for pond walls;
backfill and compact sand for WTP
"fill"
section
high ground outside boundary
10 ft. deep "cut" -
5 scrapers; 5 cat DH8s
0.1 miles
Image © 2014 Sinclair Knight Merz
875 ft
Google earth
Imagery Date: 12/10/2006 32°48'38.96" S 151°45'38.09" E elev 57 ft eye alt 4016 ft

Site engineer, 1967

Stanford University, Civil Engineering

September 1967 – June 1968 – M.S.

June 1968 – August 1970 – Ph.D.

University of Washington – Civil Engineering

Assistant Professor 1970; Associate Professor 1975; Professor 1979

PE License, February 1980

Professor Emeritus – June 2010

Details (CV): https://www.ce.washington.edu/people/faculty/burgess

Topics

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Flood Damage Mitigation:
Miami Conservancy District, Ohio

Why super floods are important

They differ substantially from lesser floods,

are infrequent,

annual exceedance probability, $p < 10^{-2}$,

and cause greatest societal disruption and damage

Super flood – Essential Information

Domain

Meteorological context – storm sequence

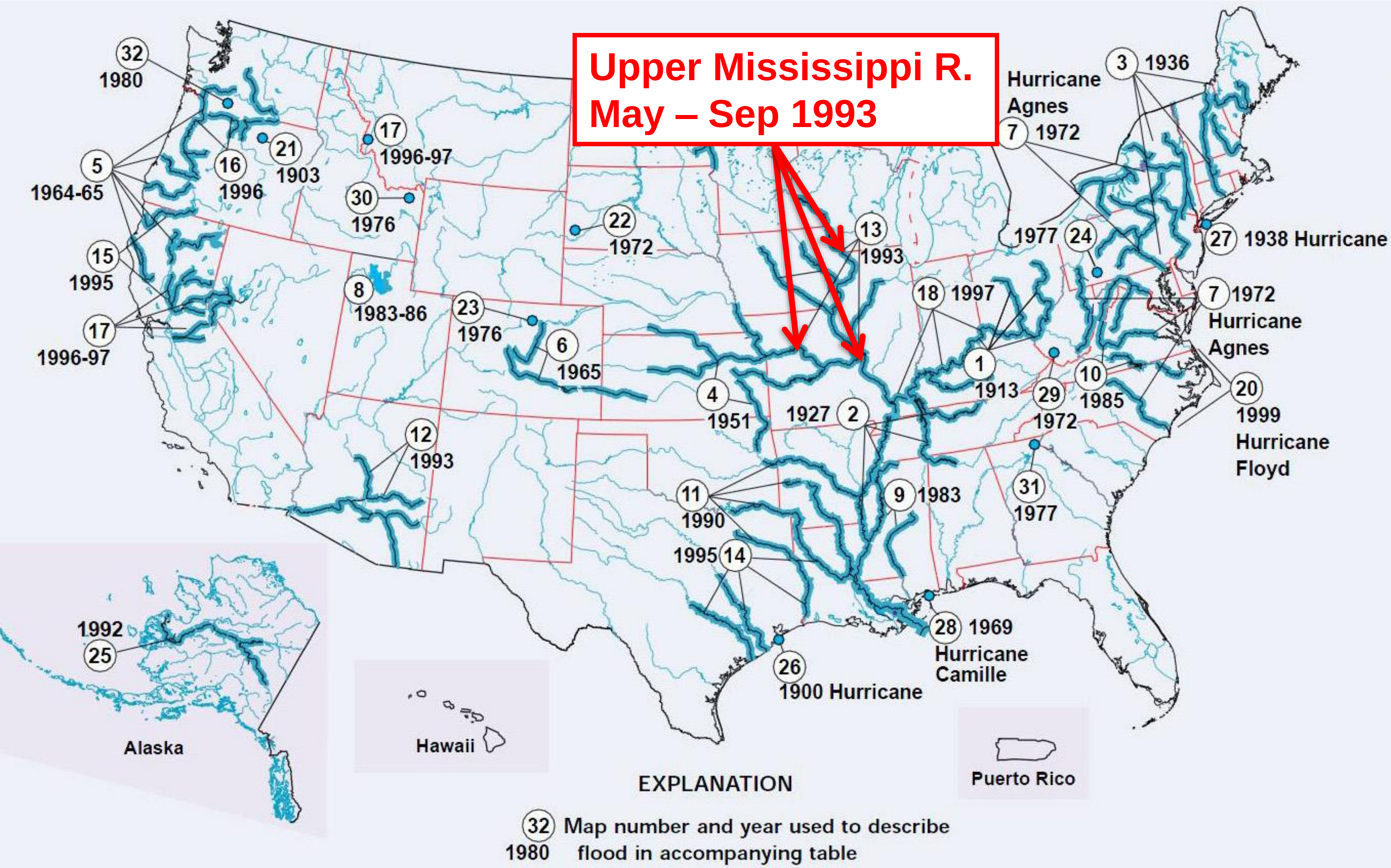
Inundation details

Complete flood hydrograph – multiple locations

Super flood features - example

Great Flood of the Upper Mississippi River, May to September,1993

Extensive documentation and satellite images



Significant Floods in the United States During the 20th Century - USGS Measures a Century of Floods
USGS Fact Sheet 024–00 March 2000 - Charles A. Perry

Super flood: May - Sep 1993 - Missouri River

Aerial view of the Missouri River flooding on July 30, 1993, in the vicinity of Cedar City and Jefferson City Memorial Airport immediately north of Jefferson City, Missouri, looking south (photograph from the Missouri Highway and Transportation Department).

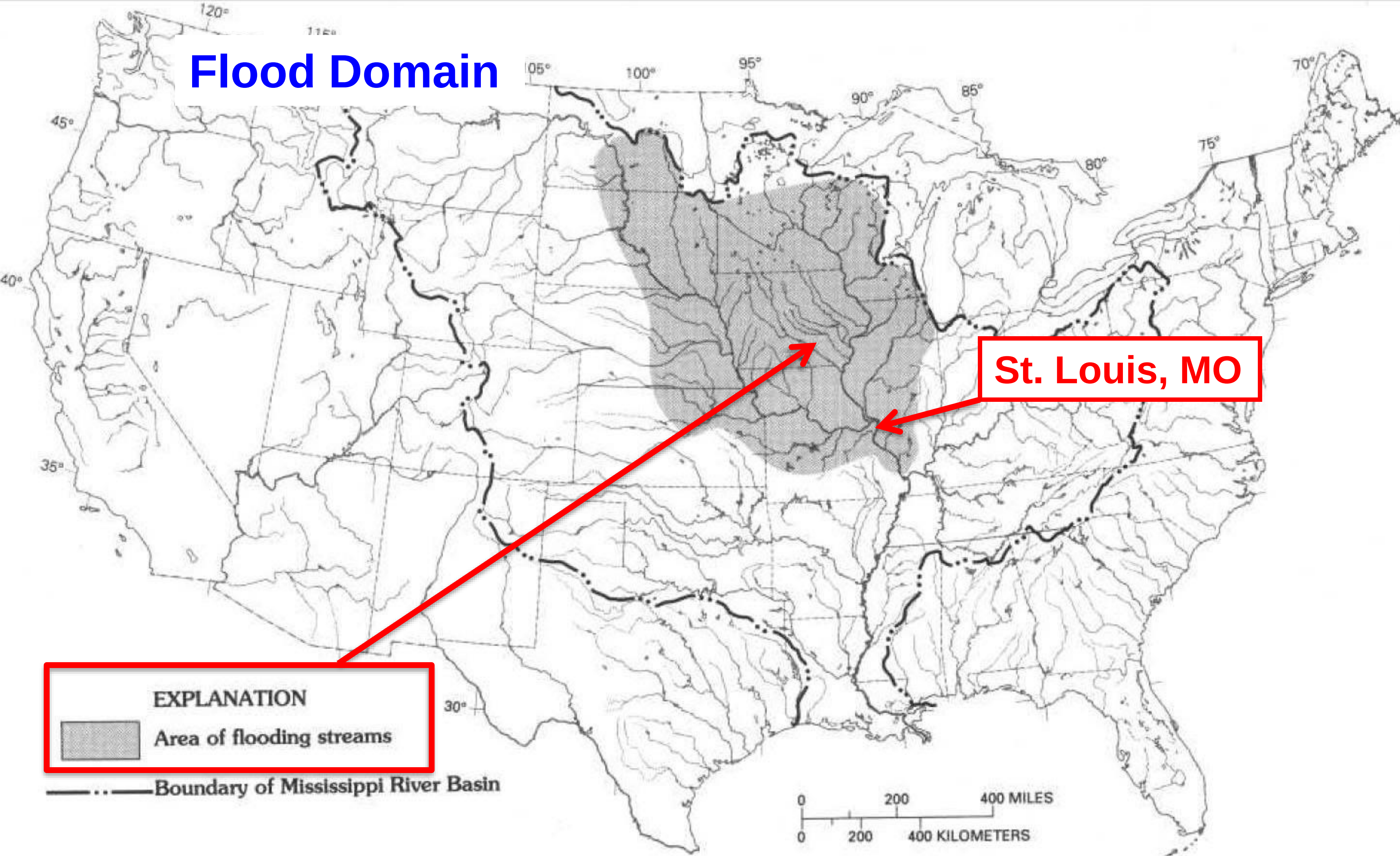


Fig 1. Flood Discharges in the Upper Mississippi River Basin—1993: U.S. Geological Survey Circular 1120-A

Meteorology

Storm sequence

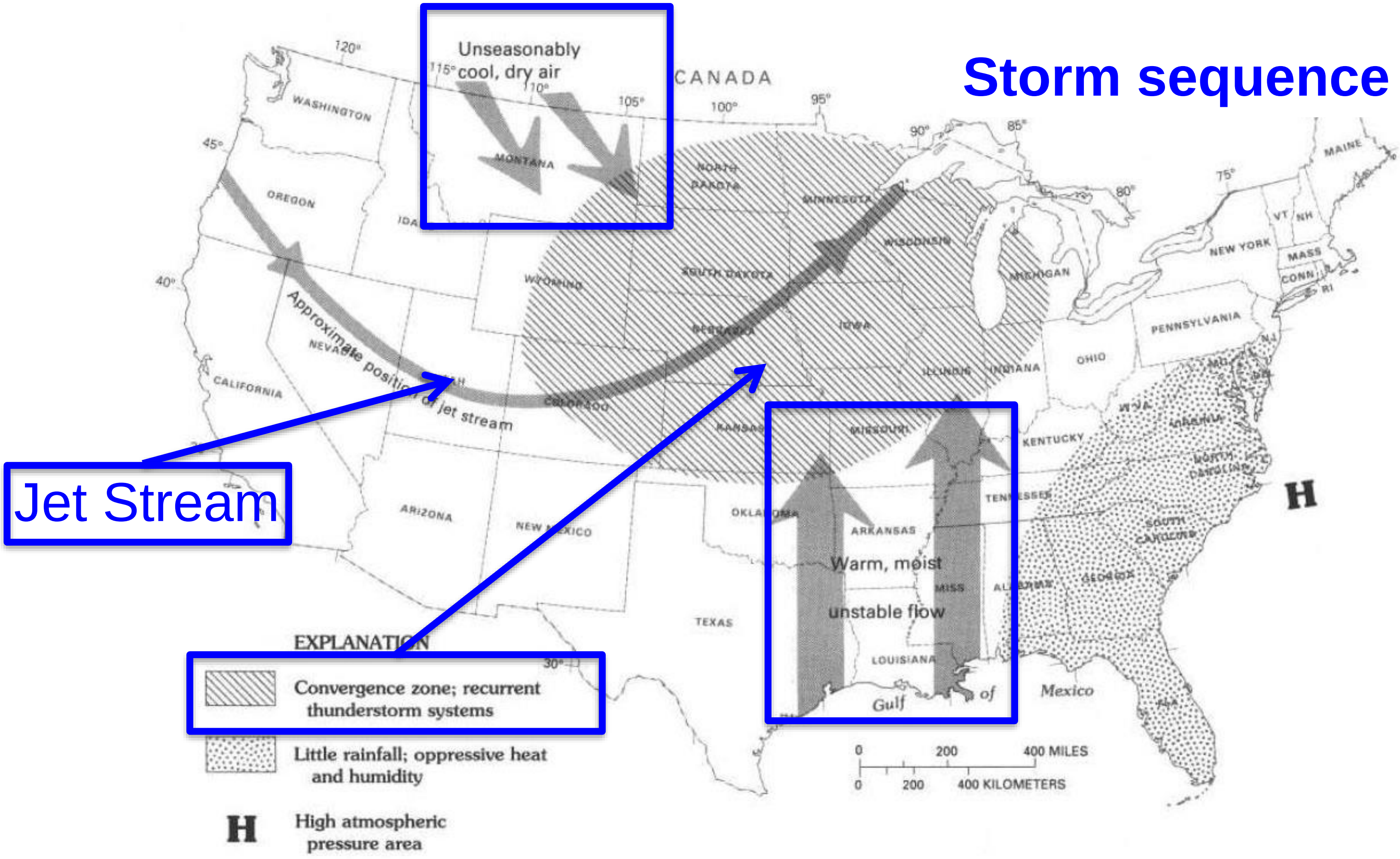


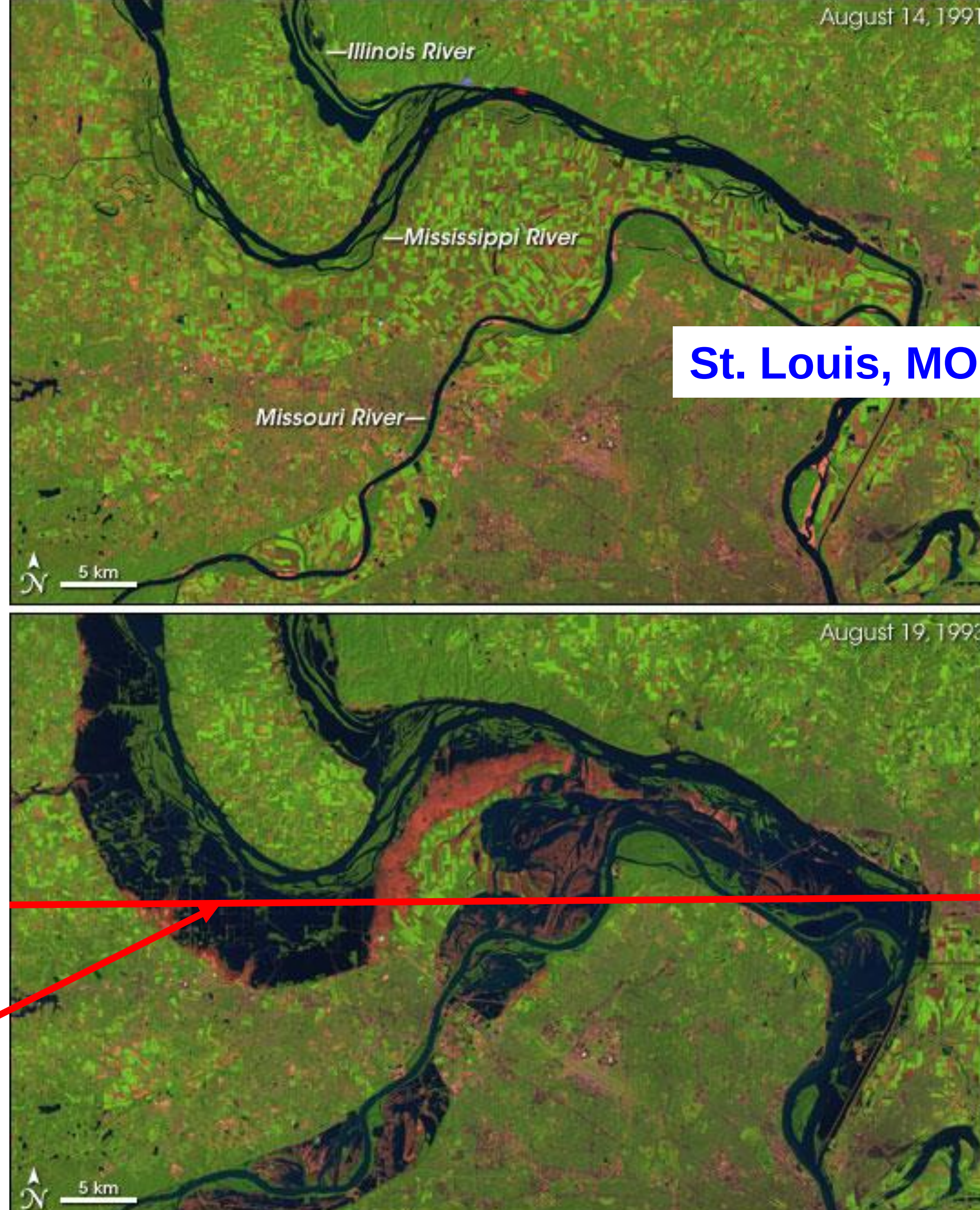
Figure 2. Dominant weather patterns over the United States for June through July 1993 (from National Weather Service, 1993).

Precipitation in the Upper Mississippi River Basin—January 1 through July 31, 1993: U.S. Geological Survey Circular 1120-B

Resulting flooding extent near St. Louis, MO

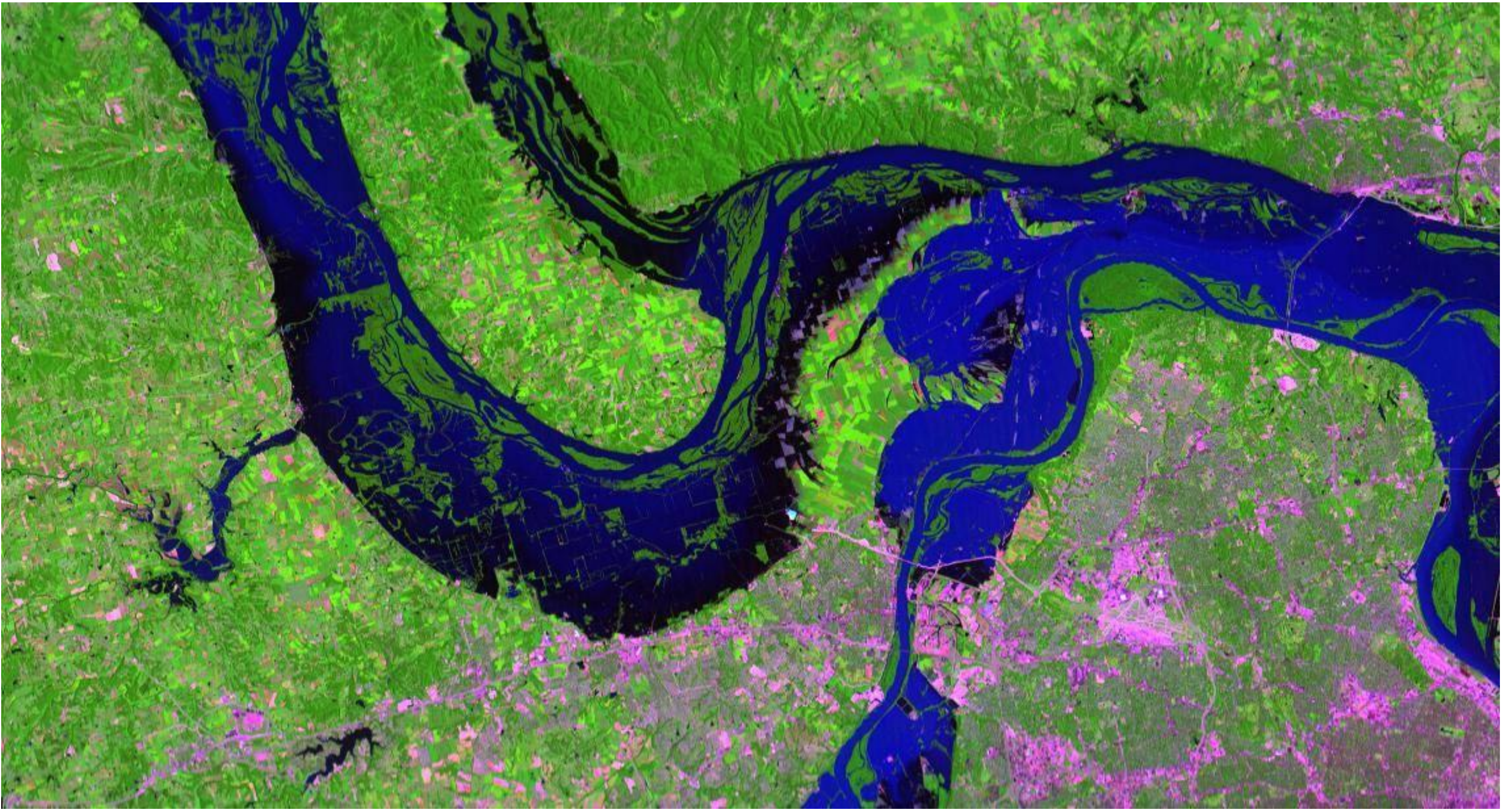
Image August 14, 1991, no flood

Image August 19, 1993, extensive flooding



65 km

NASA



Higher resolution St. Louis, MO

NASA

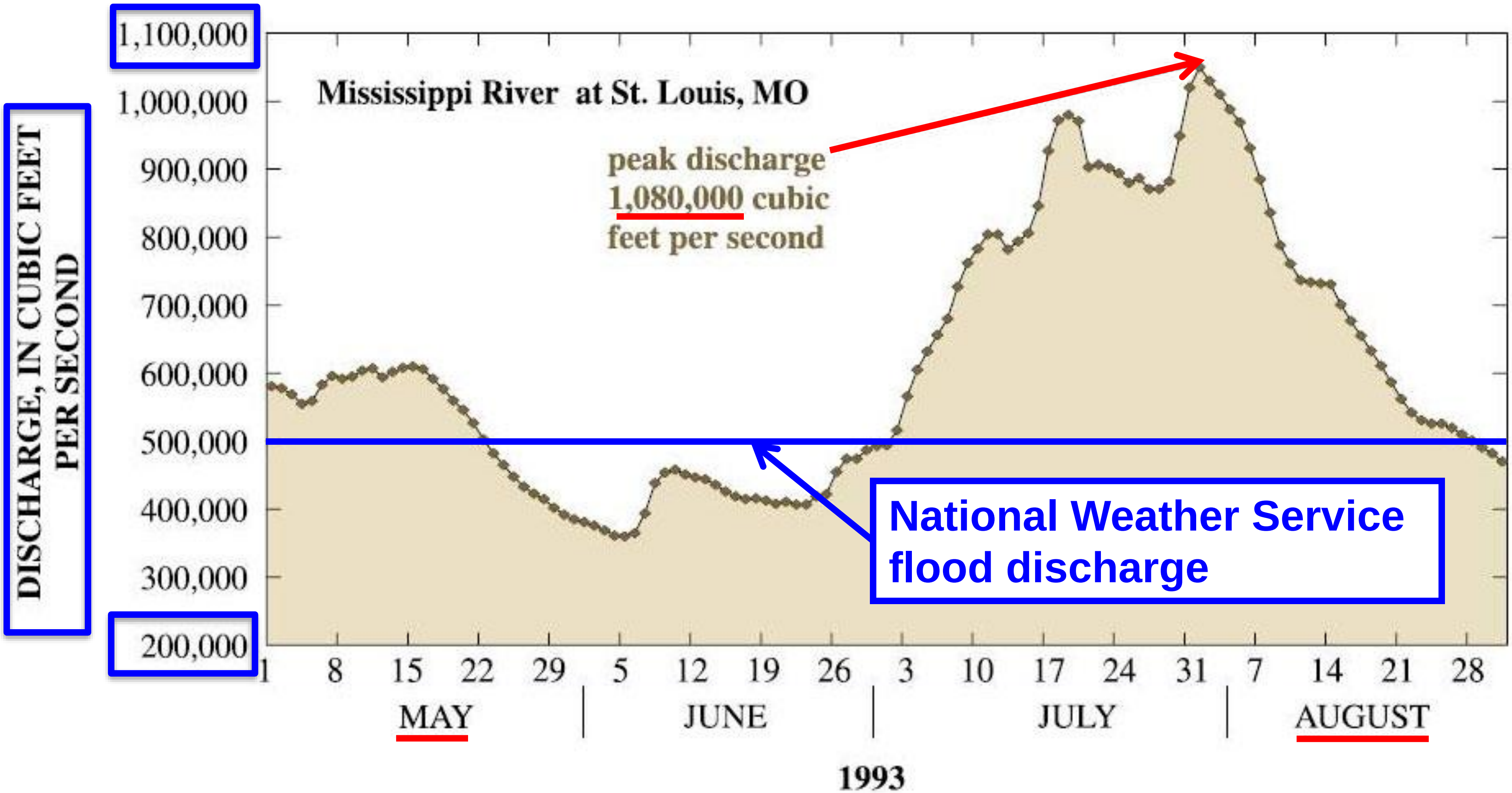


Figure 3. Hydrograph of Mississippi River at St. Louis, Missouri, from May to August 1993.

The Great Flood of 1993 on the Upper Mississippi River—10 Years Later, Gary P. Johnson, Robert R. Holmes, Jr., and Loyd A. Waite, USGS Fact Sheet 2004-3024, May 2004

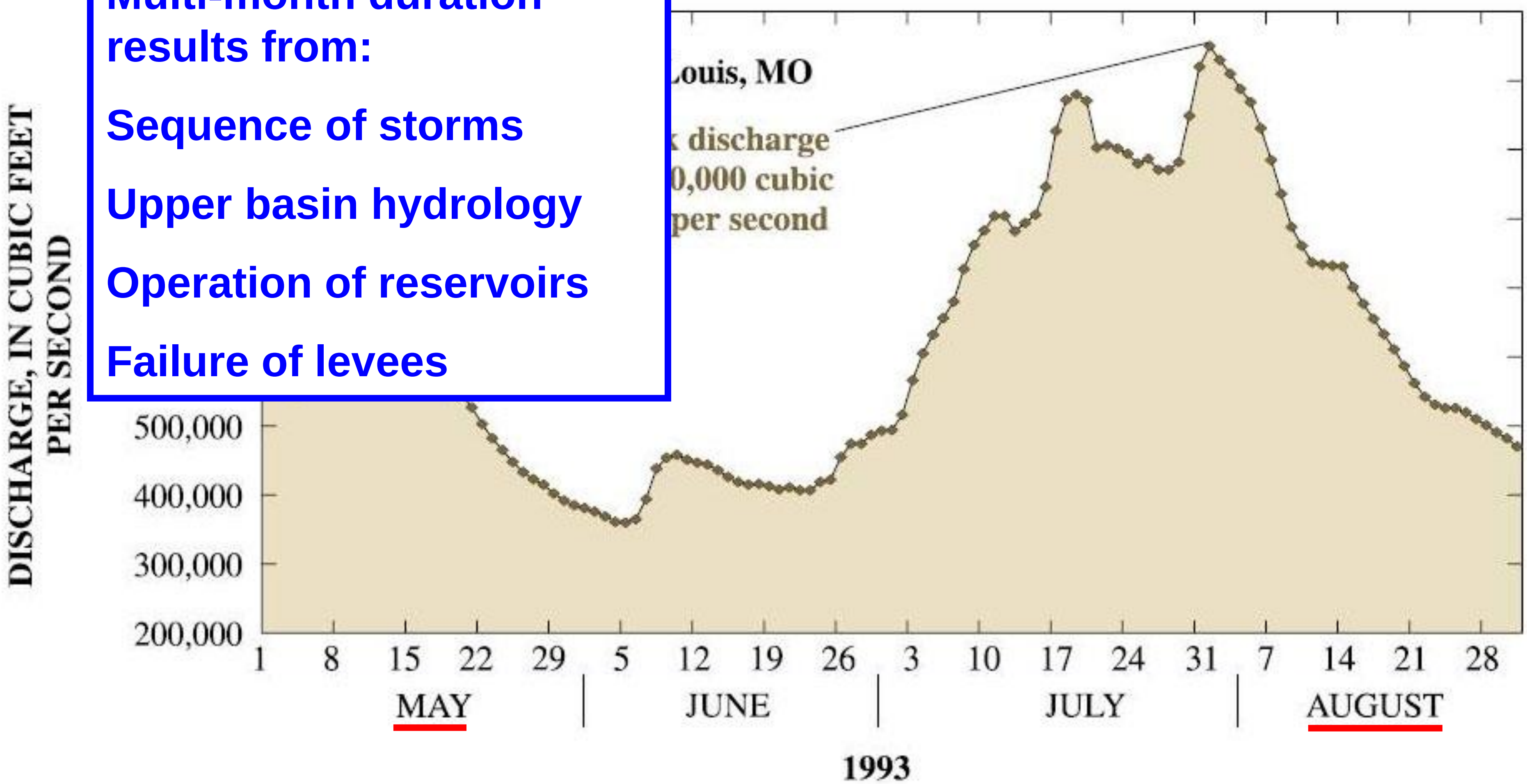
Multi-month duration results from:

Sequence of storms

Upper basin hydrology

Operation of reservoirs

Failure of levees



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How should we design for flood damage mitigation?

This has been known for a long time.

FLOODS

BY WILLIAM G. HOYT

AND WALTER B. LANGBEIN

Essential reading!

PRINCETON, NEW JERSEY

PRINCETON UNIVERSITY PRESS · 1955 469 pp

Floods and ongoing national flood risk –

from pages 9-11,

Hoyt and Langbein, "Floods", Princeton Univ. Press,1955

…. meteorologic and hydrologic conditions will combine to produce super floods of unprecedented magnitude.

We have every reason to believe that in most rivers past floods may not be an accurate measure of ultimate flood potentialities.

It is this super flood with which we are always most concerned. …

Flood Damage Mitigation

Floods are an act of God; flood damages result from acts of men.

House Document 465, 89th Congress, 2d Session

A Unified National Program for Managing Flood Losses, August 1966

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Miami Conservancy District, Ohio

Example of flood protection works at the

river basin scale

to address

life-cycle societal resilience

against

rain caused "super floods"

How did I learn about The Miami Conservancy District, Ohio?

Serendipity – subtle guidance by Professor Ray K. Linsley, doctoral adviser, precious mentor, and friend.

Ray K. Linsley, NAE, 1/13/1917 - 11/6/1990

Ray Linsley asked me in 1976 to write a paper on Water Resources Systems Planning 1776-1976 for the bicentennial. He suggested that I might find the works of "The Miami Conservancy District" informative. (See Burges 1979 – next slide)

Thus began my 47 years historical interest in this work and the work of Arthur E. Morgan.

I revisit it frequently for inspiration.

JOURNAL OF
THE WATER RESOURCES
PLANNING AND
MANAGEMENT DIVISION

Water Resource Systems Planning in U.S.A.: 1776–1976[a]

By Stephen J. Burges,[1] M. ASCE

Introduction

The term "systems analysis" means different things to different people. Therefore the end product of a well-done systems analysis or design is often seen as being the result of using "applied common sense." Systems analysis is a formalization of the process followed in identifying and examining a given problem, developing a set of alternative solutions, and selecting and implementing the best solution. This process necessitates clear definitions of criteria by which an alternative can be judged as the best. While it is not clear when the terminology of systems analysis was first introduced into water resources planning, the systems philosophy was articulated at least as early as 1915 (37); the modern terminology (objectives, criteria, alternatives, optimization, etc.) became widely used following publication of the classic book by Maass, et al. (29) in 1962.

Arthur E. Morgan
Chief Engineer,
Miami Conservancy
District

What is Systems Engineering?

The systems approach (engineering and planning) requires formal identification of objectives, criteria (by which alternative solutions may be evaluated), and constraints.

These activities can be difficult to perform.

If improperly identified objectives are examined, the resulting system will fail to respond to the real problem that initiated the planning effort.

The generation of alternatives depends upon technological, human, and resource limitations;

alternative solutions to a problem are a function of time and place and societal structure.

Implementation of the preferred alternative is one of the most difficult planning activities when conflicts necessitate modifications to the community preferred alternative.

“Satisficing”, or satisfactory solutions, (proposed by future Nobel Laureate, Herbert A. Simon in 1947 - https://en.wikipedia.org/wiki/Satisficing) rather than optimal solutions result.

Good system plans will be robust to changing demands or uses.

U.S. Legislation for Flood Damage Mitigation

U.S. Flood Damage Mitigation and Dam Safety Legislation:

Extensive Federal Legislation over a century

Summarized in Tables C.1 and C.2 from:

Dam and Levee Safety and Community Resilience – a Vision for Future Practice, NRC 2012

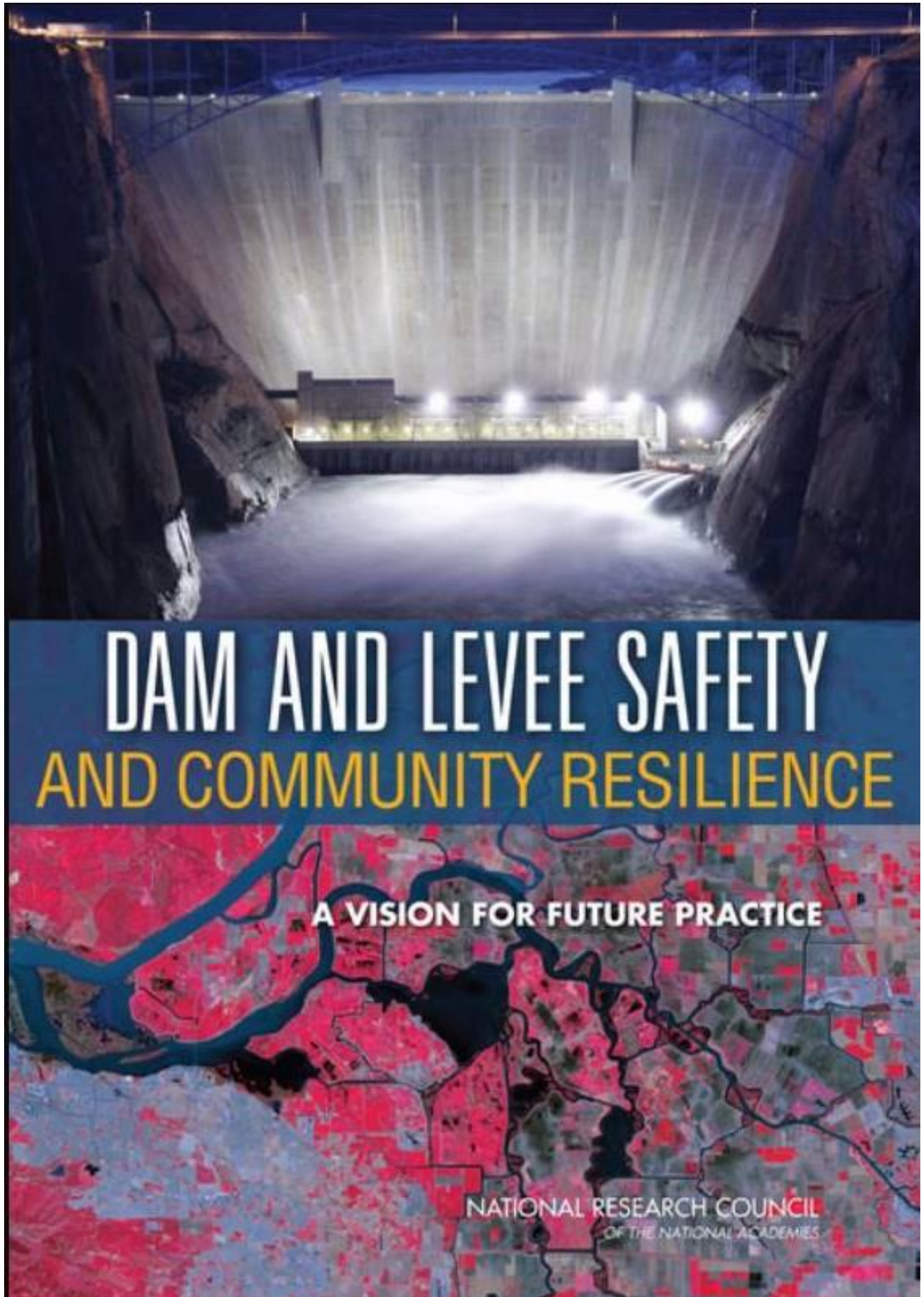
DAM AND LEVEE SAFETY
AND COMMUNITY RESILIENCE
A VISION FOR FUTURE PRACTICE
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Table C.1 – Dam Safety

TABLE C.1 Principal Laws and Policies Shaping Dam Safety Governance

Date	Law or Mandate	Relevance	Policy and Programs Enabled
1917	Flood Control Act	First major flood legislation	Dealt primarily with levees on the Mississippi and Sacramento Rivers
1928	Flood Control Act Expanded	Extended 1917 act to include control mechanisms	Policy extended to include floodways, spillways, and channels; provided foundation for dam safety legislation
1972	33 USC 467: National Dam Safety Act	Authorized national inspection of dams	U.S. Army Corps of Engineers tasked with inventorying and inspecting dams
1977	Department of Energy Organization Act	Established Department of Energy and Federal Energy Regulatory Commission (FERC) from Federal Power Commission	FERC licenses and inspects nonfederal hydroelectric projects
1979	Executive Order 12148	Created Federal Emergency Management Agency (FEMA); required federal agencies to implement federal guidelines for dam safety	Guidelines for dam safety management
1986	Water Resources Development Act	Authorized National Dam Safety Program under secretary of the Army	Established National Dam Safety Review Board, National Inventory of Dams, and state assistance
1996	Water Resources Development Act, Pub. L. 104-303, § 215, National Dam Safety Program Act	Reauthorized National Dam Safety Program under FEMA	Granted assistance to states for research and training; expanded National Dam Safety Review Board
2002	PL 107-310: Dam Safety and Security Act	Reauthorized National Dam Safety Program and added national-security considerations	Failed to provide funding for repair and rehabilitation
2006	PL 109-460 National Dam Safety Program Act	Reauthorized National Dam Safety Program	

Dam and Levee Safety and Community Resilience – a Vision for Future Practice, NRC 2012

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1986	Water Resources Development Act	Authorized National Dam Safety Program under secretary of the Army	Established National Dam Safety Review Board, National Inventory of Dams, and state assistance

Federal – local cost sharing legislated

Table C.2 – Levee Safety

TABLE C.2 Principal Laws and Policies Shaping Levee Safety Governance

Date	Law	Relevance	Policy and Programs Enabled
1917	Flood Control Act	First major flood legislation—Mississippi and Sacramento Rivers	Dealt primarily with levees
1928	Flood Control Act Expanded	Extended 1917 act to include control mechanism	Extended policy to include floodways, spillways, and channels
1936	Flood Control Act	Declared flood control a federal interest and vested authority in U.S. Army Corps of Engineers (USACE)	Levees along main stem of Mississippi become federal
1955	Pub. L. 84-99: Flood Control and Coastal Emergencies Act	Directed USACE to provide emergency repair or rehabilitation of federally authorized flood control works	
1968	National Flood Insurance Act	Authorized National Flood Insurance Program	Levees became part of the equation for flood insurance
1994	National Flood Insurance Reform Act	Prevented loans from federal agencies and programs for property in specific flood hazard areas	Placed some accountability in insurance program
2005	Pub. L. 109-148: National Levee Data Base Authority	Authorized national levee inventory and database	Interagency Levee Policy Review Committee established by Federal Emergency Management Agency (FEMA); USACE initiated levee inventory
2007	Pub. L. 110-114: WRDA, National Levee Safety Program Act	Established National Levee Safety Program (oversight by FEMA) and National Committee on Levee Safety (NCLS, chaired by USACE)	Mandated that NCLS develop a National Levee Safety Policy

Dam and Levee Safety and Community Resilience – a Vision for Future Practice, NRC 2012

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US population 103 Mi.

US population 166 Mi.

Reflects evolving issues of societal structure and needs

The Miami Conservancy District

by

ARTHUR E. MORGAN

Former Chief Engineer, Miami Conservancy District; Former Chairman, Tennessee Valley Authority; Former President, Antioch College, Yellow Springs, Ohio; Former Vice-President, American Society of Civil Engineers; President, Community Service, Inc., Yellow Springs, Ohio; President, Dayton-Morgan Engineering Company, Yellow Springs, Ohio

Rare 25-years post project effectiveness assessment

First Edition

Excellent social-political-economic flood engineering

McGRAW-HILL BOOK COMPANY, INC.

New York Toronto London

1951 **504 pp**

The flood protection works of the Miami Conservancy District, have been in place since 1922.

Built following disastrous flooding in March 1913 in the Dayton, Ohio region - 360 bodies were recovered; hundreds disappeared.

An estimated 20,000 homes were destroyed in Ohio, mainly in the Great Miami River Valley.

Hamilton and Dayton suffered the greatest damage.

Approximately 10 square miles of Dayton were inundated.

Excellent example of integrated flood damage disaster prevention and systems and life cycle engineering.

The Morgan Engineering Company (headed by Arthur E. Morgan) was asked on May 5, 1913, to examine the entire problem.

From a "Systems Engineering Approach" the charge of the local Citizens' Flood Prevention Committee was a rare single objective:

"The valley has suffered a calamity that must not be allowed to occur again. Find a way out."

What and where are the flood works of the Miami Conservancy District?

Dayton, OH
Calgary
Vancouver
Seattle
Mount Rainier 14,410 ft
Portland
Regina
Winnipeg
Helena
Bismarck
Boise
Thunder Bay
Duluth
Minneapolis
Ottawa
Montréal
Moncton
Halifax
Augusta
Concord
Boston
Syracuse
Toronto
Milwaukee
Toledo
Chicago
Philadelphia
NORTH AMERICA
GREAT BASIN
Reno
Francisco
Salt Lake City
Cheyenne
Sioux Falls
Omaha
Des Moines
Indianapolis
Columbus
Cincinnati
Washington, D.C.
Virginia Beach
Denver
Kansas City
St. Louis
Louisville
Colorado
Arkansas
St. George
Las Vegas
Wichita
Nashville
Charlotte
Santa Fe
Memphis
Huntsville
Atlanta
Los Angeles
San Diego
Phoenix
GREAT PLAINS
Oklahoma City
Little Rock
Dallas
Montgomery
Savannah
Jacksonville
Jackson
Baton Rouge
Mobile
Tallahassee
Austin
San Antonio
Houston
New Orleans
Tampa
Hermosillo
Chihuahua
Ciudad Obregón
Monclova
Torreón
Monterrey
Gulf of Mexico
Miami
Nassau
ATLANTIC OCEAN
Havana
Santa Clara
Las Tunas
Pinar del Río
Guantánamo
Santo Domingo
Culiacán
Linares
Ciudad Victoria
Tropic of Cancer
Mazatlán
Aguascalientes
Mérida
Tepic
Guadalajara
Mexico City
Puebla
Campeche
Chetumal
Kingston
Caribbean Sea
120° 115° 110° 105° 100° 95° 90° 85° 80° 75°
0 mi 200 400 600 800 1000
Map Style: Comprehensive
About this Map


Muncie
White
Anderson
Hoosier Hill
1257 ft
Troy
OShaughnessy Reservoir
Westerville
Port Columbus International Airport
Columbus
James M Cox Dayton International Airport
Springfield
Richmond
Huber Heights
Fairborn
Great Miami R.
Dayton
Beavercreek
Xenia
Dumpling Hill
Scioto
Whitewater
Kettering
Centerville
Caesar
Creek Lake
Deer Creek Lak
Middletown
HOPEWELL CULTURE
NATIONAL
HISTORICAL PARK
Hamilton
Fairfield
Chillicothe
Columbus
Great Miami
Farrell
Hill
Norwood
Delhi
Cincinnati
incinnati - Northern Kentucky International Airport
Ohio River
Portsmouth
85° 30'
85°
84° 30'
84°
83° 30'
83°
39
0 mi
10
20
30
40
50
Map Style:
Comprehensive
About this Map

MCD
MIAMI CONSERVANCY DISTRICT

Great Miami River Watershed

Miami Conservancy District

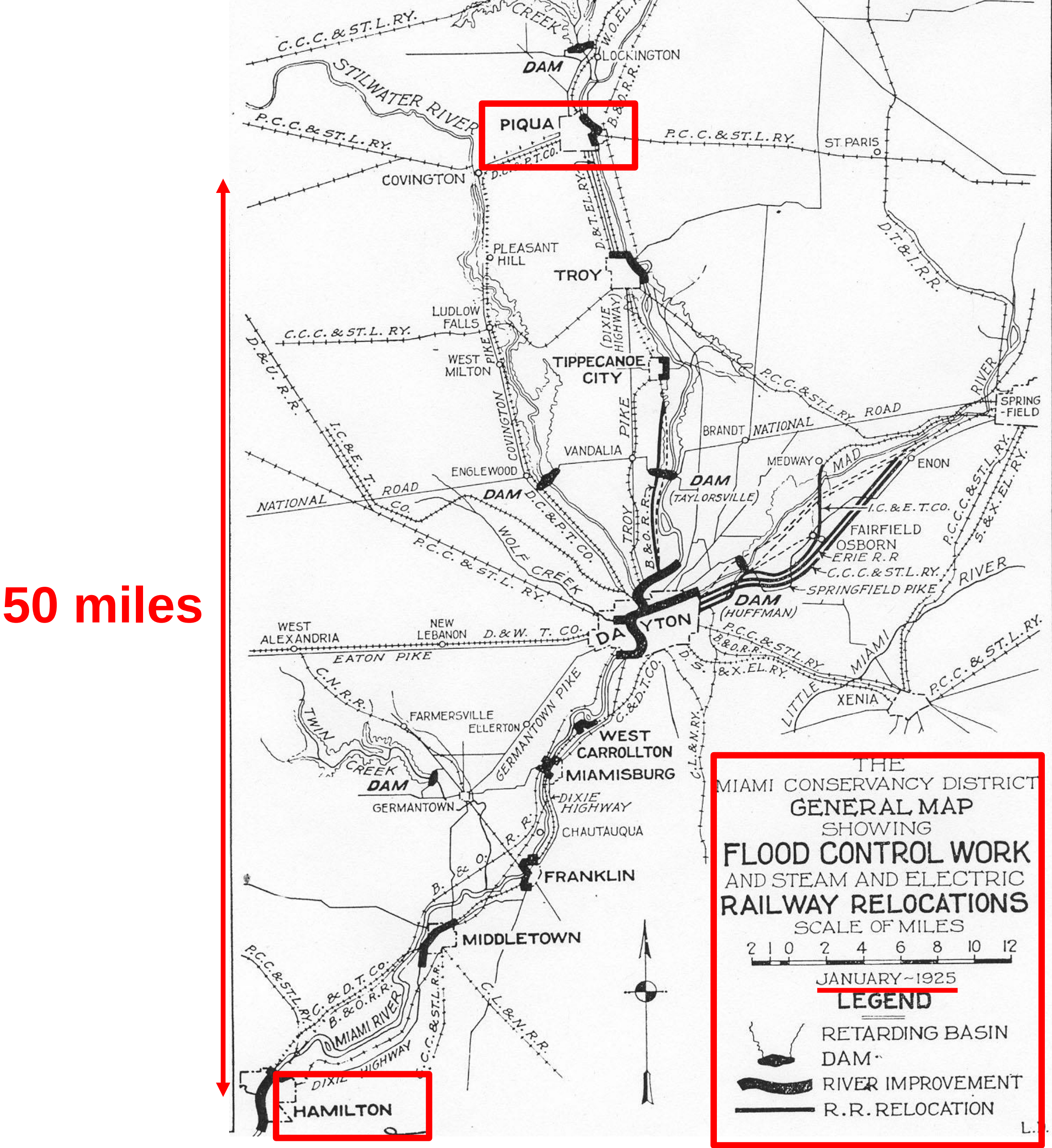
15 Counties

https://www.mcdwater.org/wp-content/uploads/2017/04/Great-Miami-River-Watershed.png

Miami Conservancy District – established 1914

Encompasses entire catchment - 4,000 sq. miles, 15 counties

Model for governance and public infrastructure funding that provides ongoing financing for operations and maintenance, and replacement


50 miles
THE
MIAMI CONSERVANCY DISTRICT
GENERAL MAP
SHOWING
FLOOD CONTROL WORK
AND STEAM AND ELECTRIC
RAILWAY RELOCATIONS
SCALE OF MILES
2 1 0 2 4 6 8 10 12
JANUARY~1925
LEGEND
RETARDING BASIN
DAM
RIVER IMPROVEMENT
R.R. RELOCATION
PIQUA
LOCKINGTON
DAM
STILWATER RIVER
COVINGTON
ST. PARIS
PLEASANT HILL
TROY
LUDLOW FALLS
WEST MILTON
TIPPECANOE CITY
BRANDT
VANDALIA
ENGLEWOOD
DAM
DAM (TAYLORSVILLE)
MEDWAY
ENON
SPRING-FIELD
FAIRFIELD
OSBORN
DAM (HUFFMAN)
DAYTON
WEST ALEXANDRIA
NEW LEBANON
XENIA
FARMERSVILLE
ELLERTON
WEST CARROLLTON
MIAMISBURG
DAM
GERMANTOWN
CHAUTAUQUA
FRANKLIN
MIDDLETOWN
HAMILTON
MIAMI RIVER
DIXIE HIGHWAY
NATIONAL ROAD
EATON PIKE
SPRINGFIELD PIKE

Integrated river basin solution

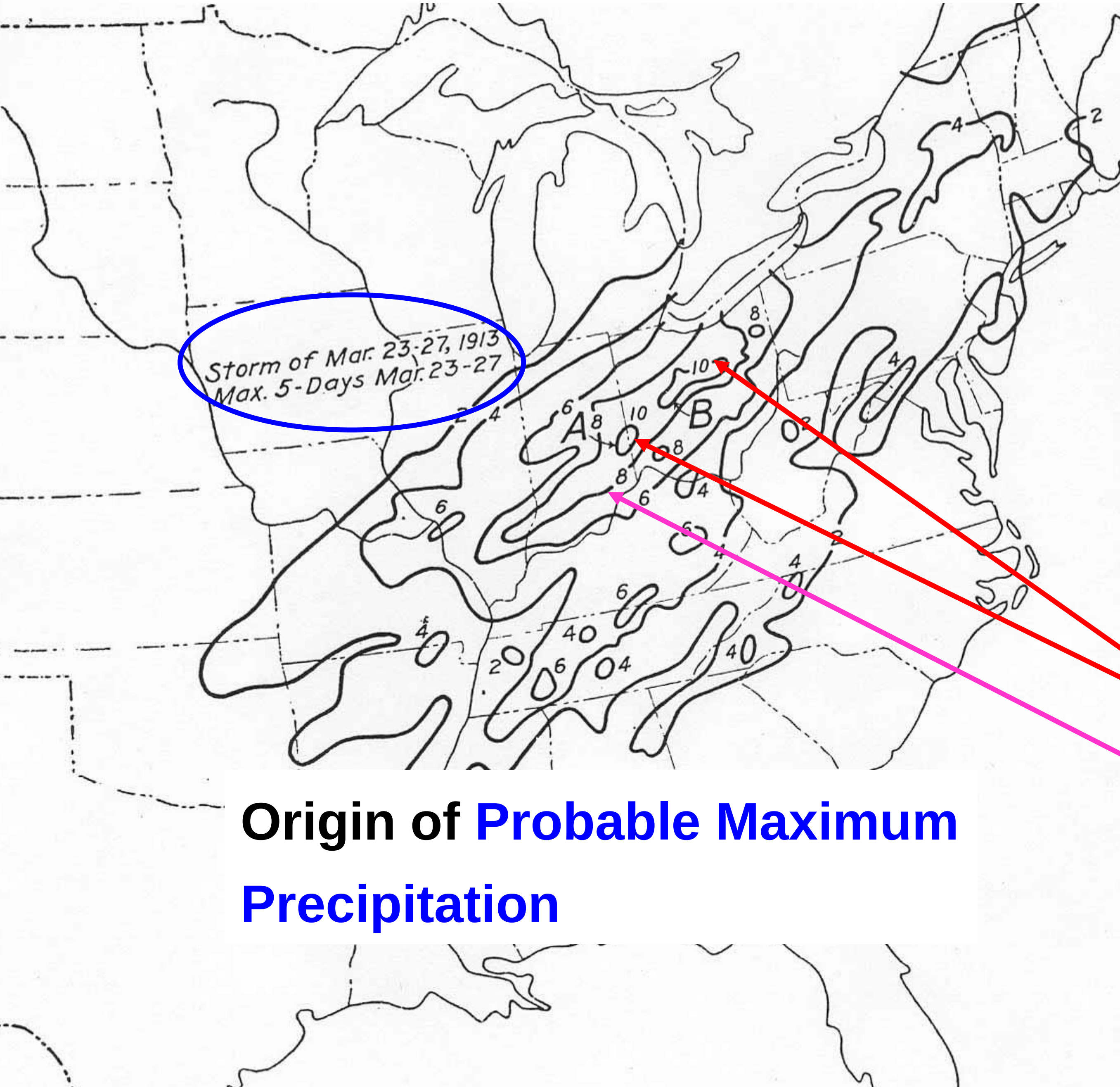
Three dams on major tributaries are critical components

Pioneering work on reconstructing flood producing rain and assessing future possible major storms

Extensive scientific and engineering hydro-meteorological investigation and international data gathering and assessment.

Documented in Technical Reports Part V, 1917.

Reconstructed cumulative daily rainfall



254 mm

203 mm

Rain fell on saturated ground – approximately 90% runoff

Origin of Probable Maximum Precipitation

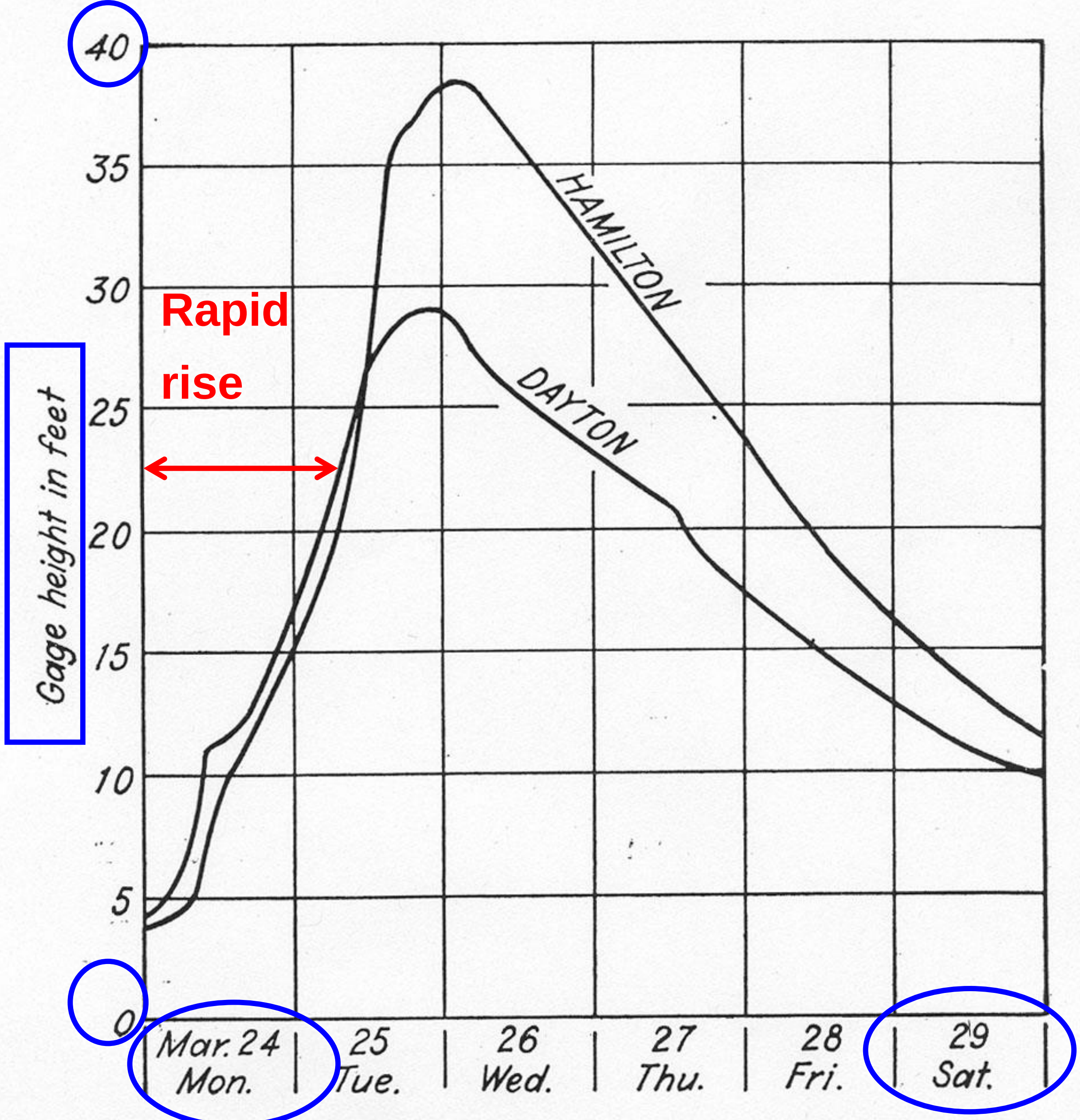


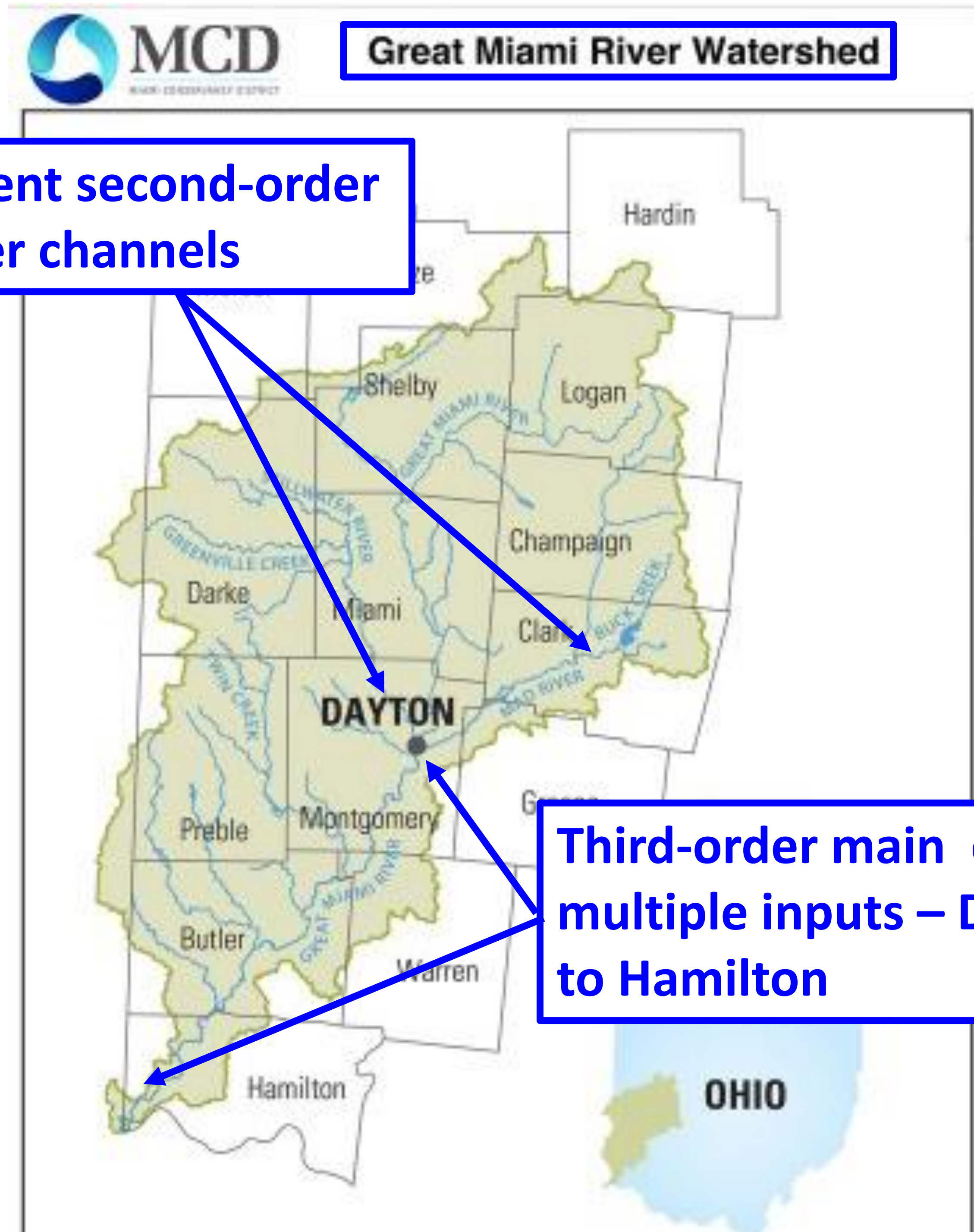
Diagram showing the rise and fall of the Miami River at Dayton and at Hamilton during the flood of March, 1913.

What dominated the hydrograph shape?

Storm orientation – alignment with catchment

The channel system is a highly efficient drainage concentrator

Efficient second-order feeder channels

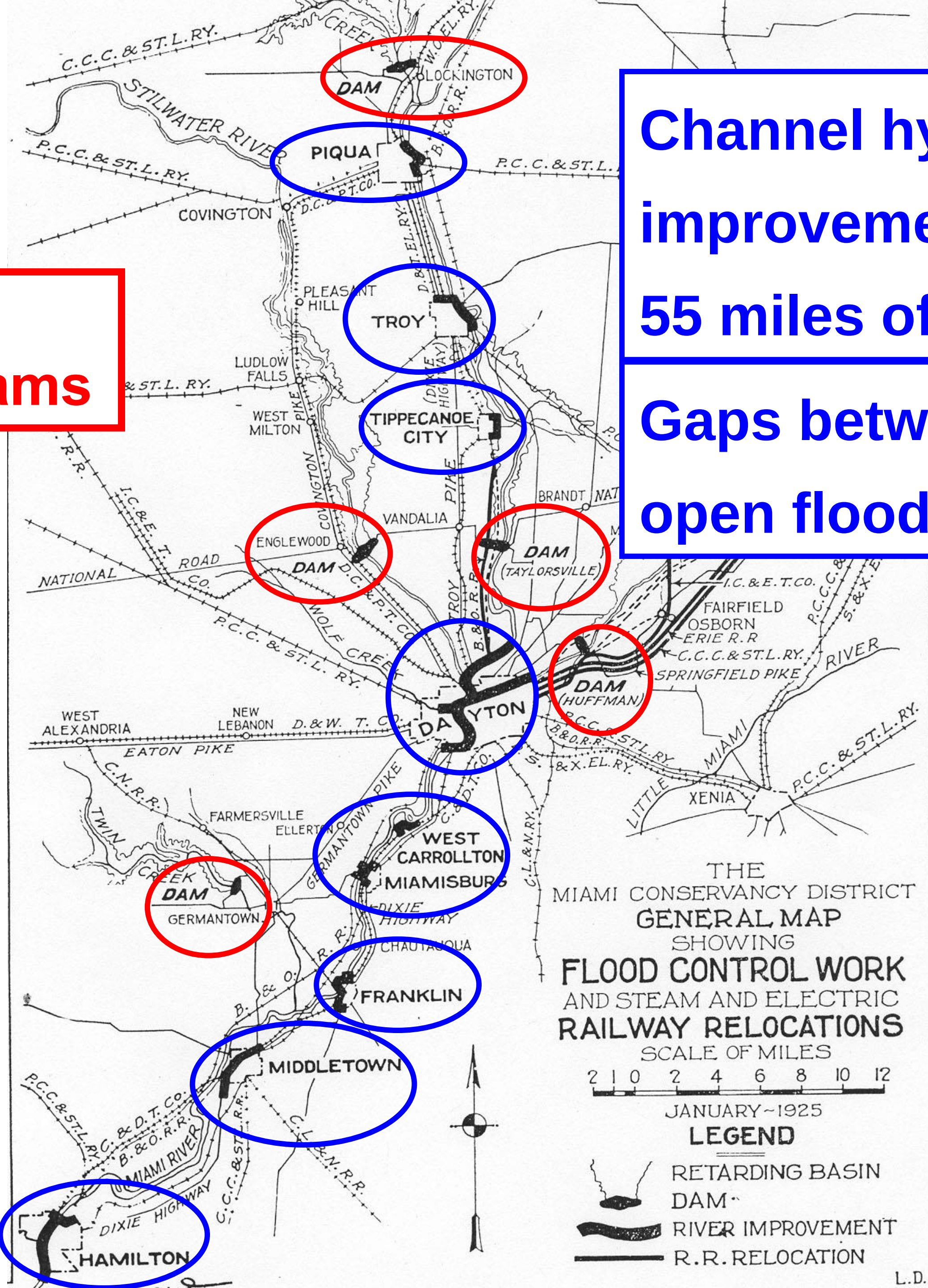


Third-order main channel; multiple inputs – Dayton to Hamilton

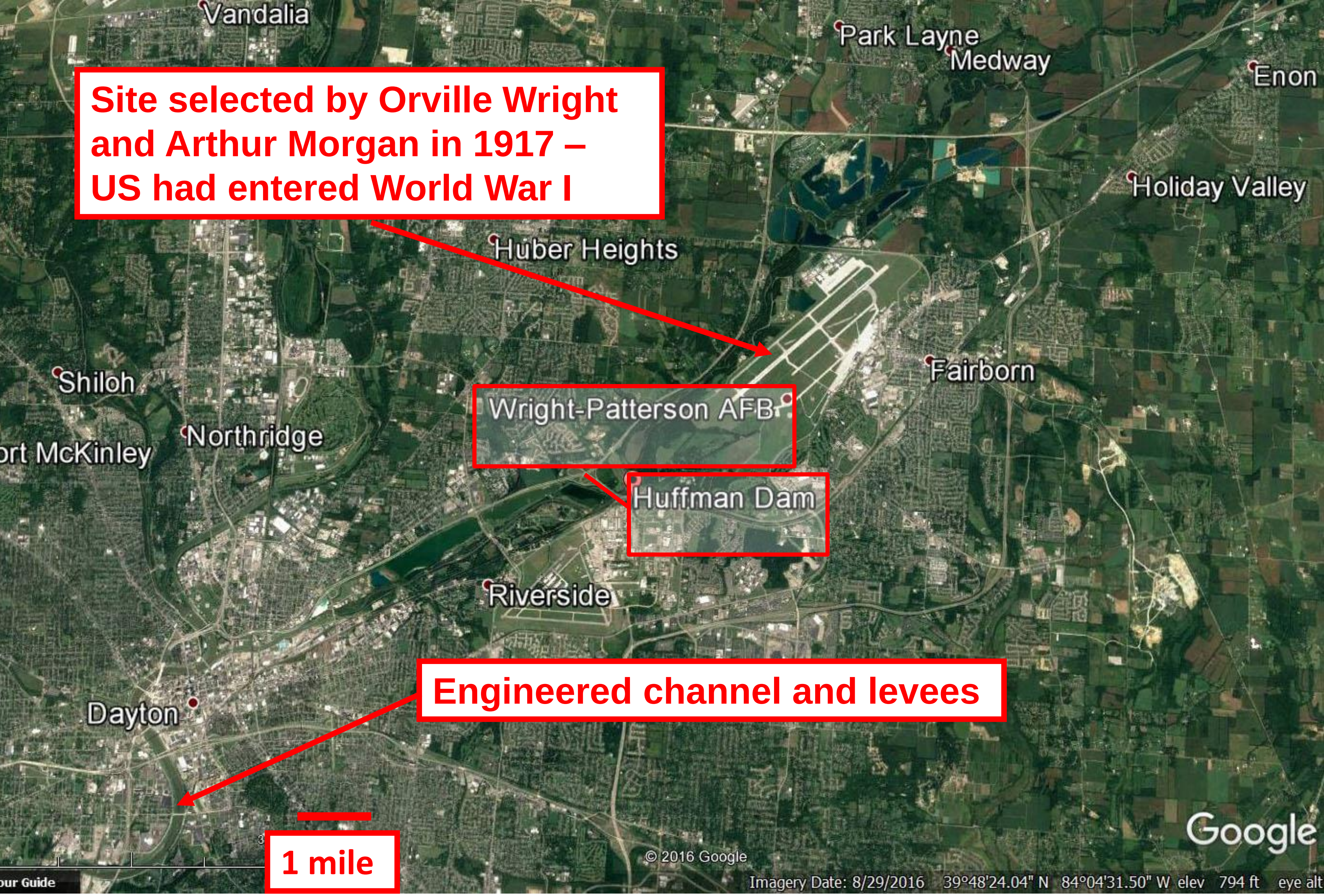
5 major "dry" dams

Channel hydraulic improvements including 55 miles of levees

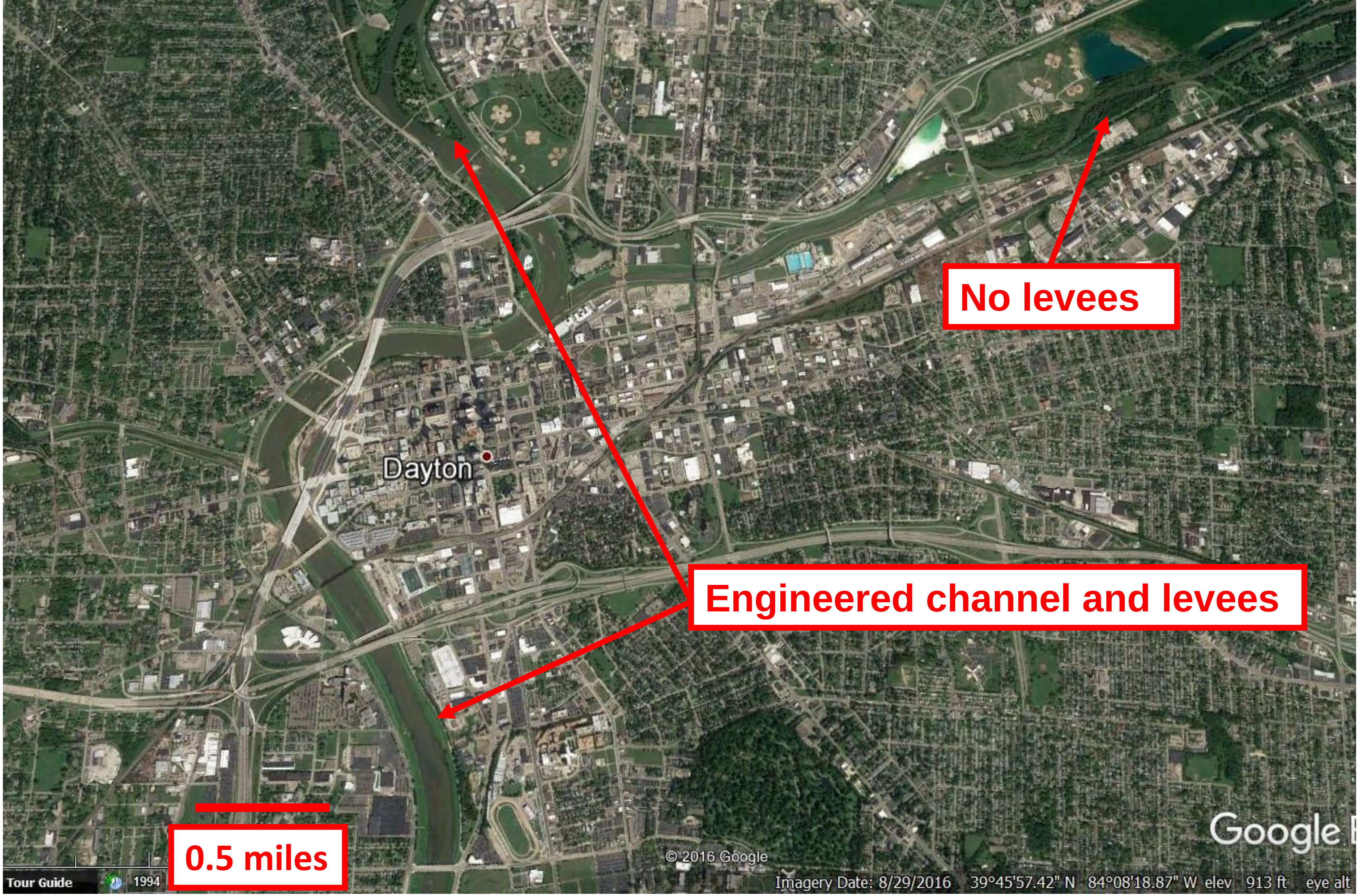
Gaps between levees are open flood plains



Examples of levees and channel armoring



Dayton region – major levees and channel widening



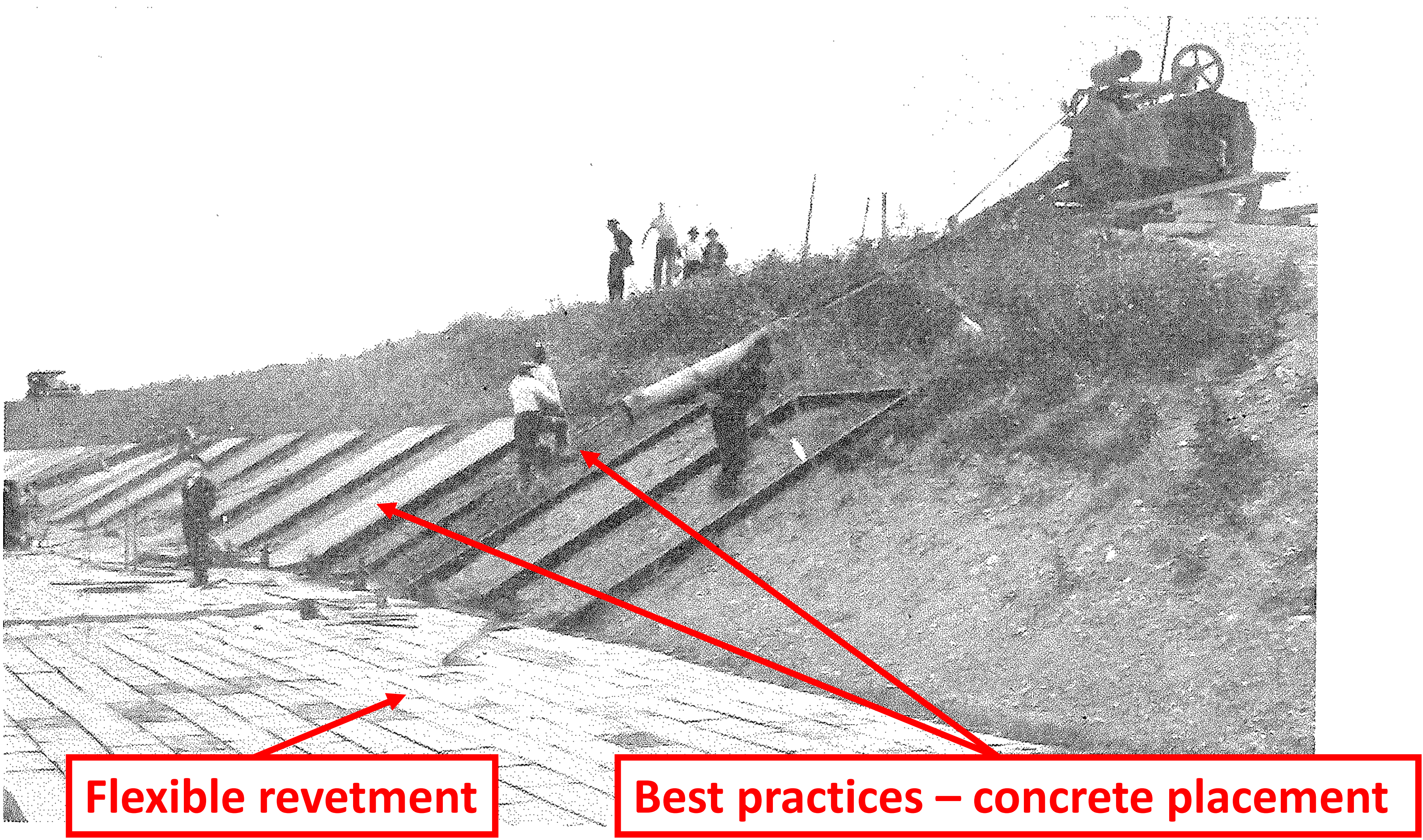
Dayton – major levees and channel widening

Levee and hydraulically efficient channel liner near Dayton – original materials - photograph (Steve Burges)

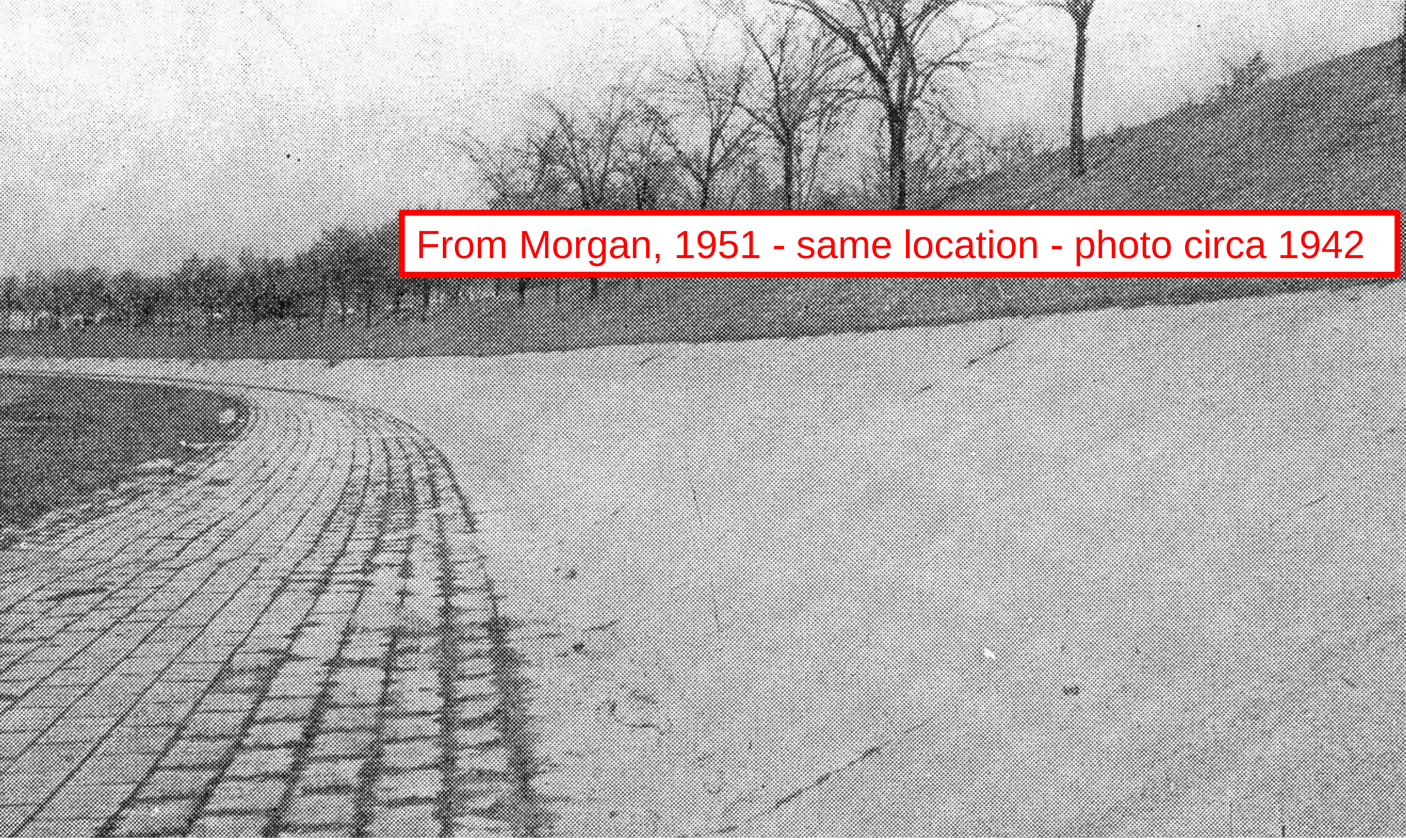
May 1984

Figure 71 Dayton Feature - Laying blocks for flexible revetment. Looking upstream of Great Miami River. McKinley Park sewer outlet in slope

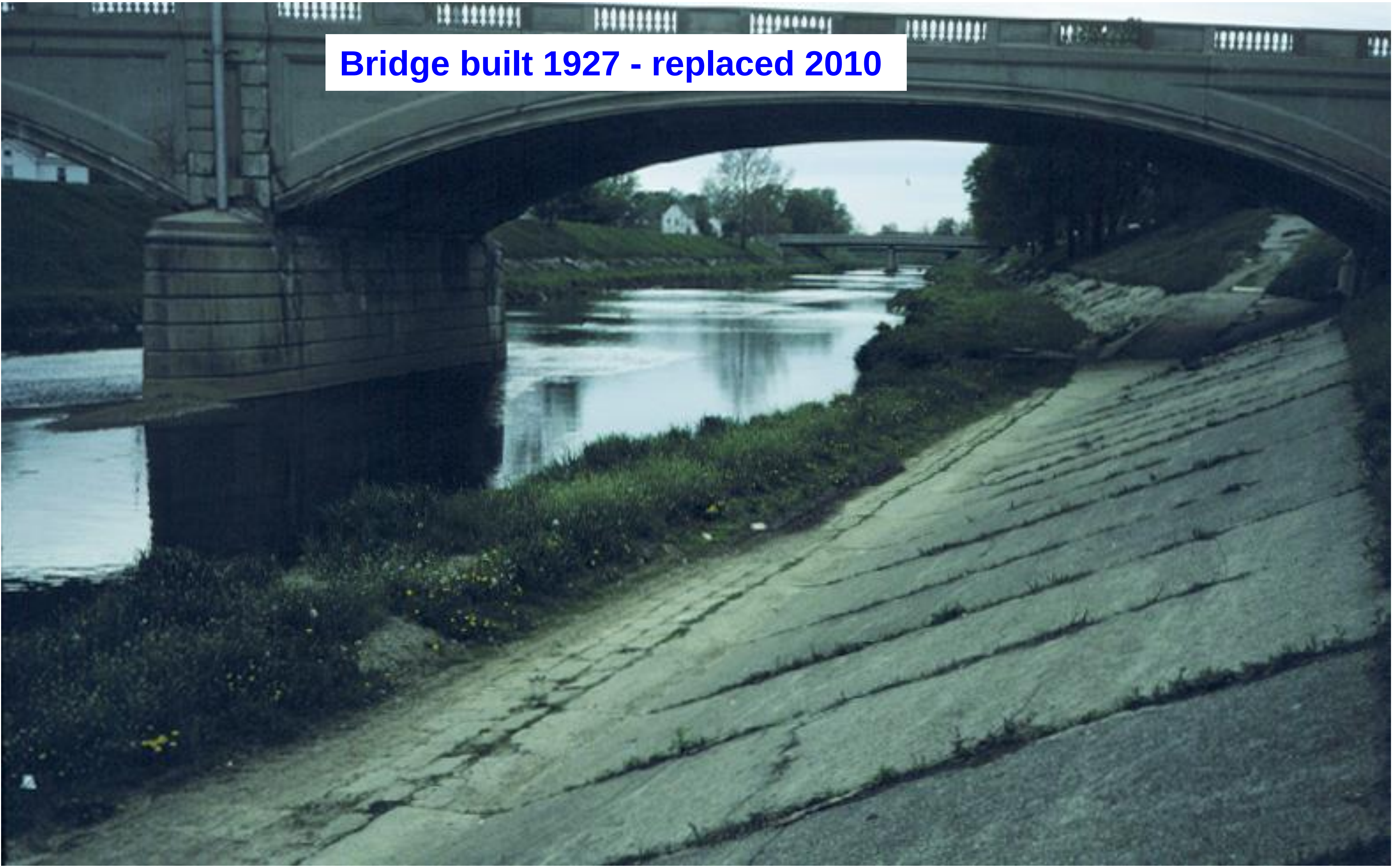

Modern equivalent
Geotextile
http://www.cfmwi.com/images/petraflex.jpg



Construction of revetment in 1920.



From Morgan, 1951 - same location - photo circa 1942



Wolf Creek - tributary to Great Miami River at Dayton – Bridges and revetment

May 1984

Great Miami River near Dayton – Scale of Levee

May 1984

Great Miami River near Dayton - Levee section – Recreation paths

May 1984

Significance of first use of "dry dams" in the U.S. – effectively large detention reservoirs.

How did dry dams become part of the system-wide flood damage mitigation design?

This resulted from application of "Conclusive Engineering Analysis" as explained in material from pages 284 – 286 of "The Miami Conservancy District", A. E. Morgan, 1951.

A general principle was adopted for approaching the solution of the engineering problems of the Miami flood-control project which I have termed "conclusive engineering analysis."

The principle in essence is that, to whatever extent the importance of the work justifies, every possibility for solution of the problem, whether promising or not, should be explored, with effort to become aware of unrealized and unexpected ways of approach;

and that each such possibility be explored to a point where, in comparison with other methods of solution, it either is proved to be inferior or finally emerges as the best possible solution.

In the search for solutions to the Miami River flood problem, the different ways of approach were assigned to different engineers or groups of engineers.

At that time, I had little or no expectation of finding a solution by means of dams and retarding basins.

One reason why the possibilities of dams and retarding basins on the Miami Conservancy project were not sooner appreciated was that at that time few topographic maps of the possible basin sites had been published …

it would not have been supposed that here, in populous Ohio, would exist some of the finest and least obstructed sites in the country.

While the process of conclusive engineering analysis had its most spectacular result in developing the possibility of retarding basins, it was applied in practice throughout the job, and with many interesting results.

One of the most distinctive of these was the development of the hydraulic-jump design for dissipating energy at the dam outlets.

Years later, while spending an evening with Thomas A. Edison at his home, I asked him this point-blank question: "Do you have any general method for solving a problem?"

He said he did and outlined substantially the process I have described but with greater elaboration.

In some cases, he said, he would have as many as forty possible answers to a problem before he would begin the process of comparison and elimination.

Rarely, he said, did his final solution have "any noticeable similarity to my first inspiration or 'hunch.' "

Was there existing proof of the effectiveness of the use of "retarding basins" for flood damage mitigation?

Yes. The Pinay Dam on the Loire River in France.

Waters that were retained for short duration behind the Pinay Dam deposited rich sediments that enhanced the productivity of the inundated land.

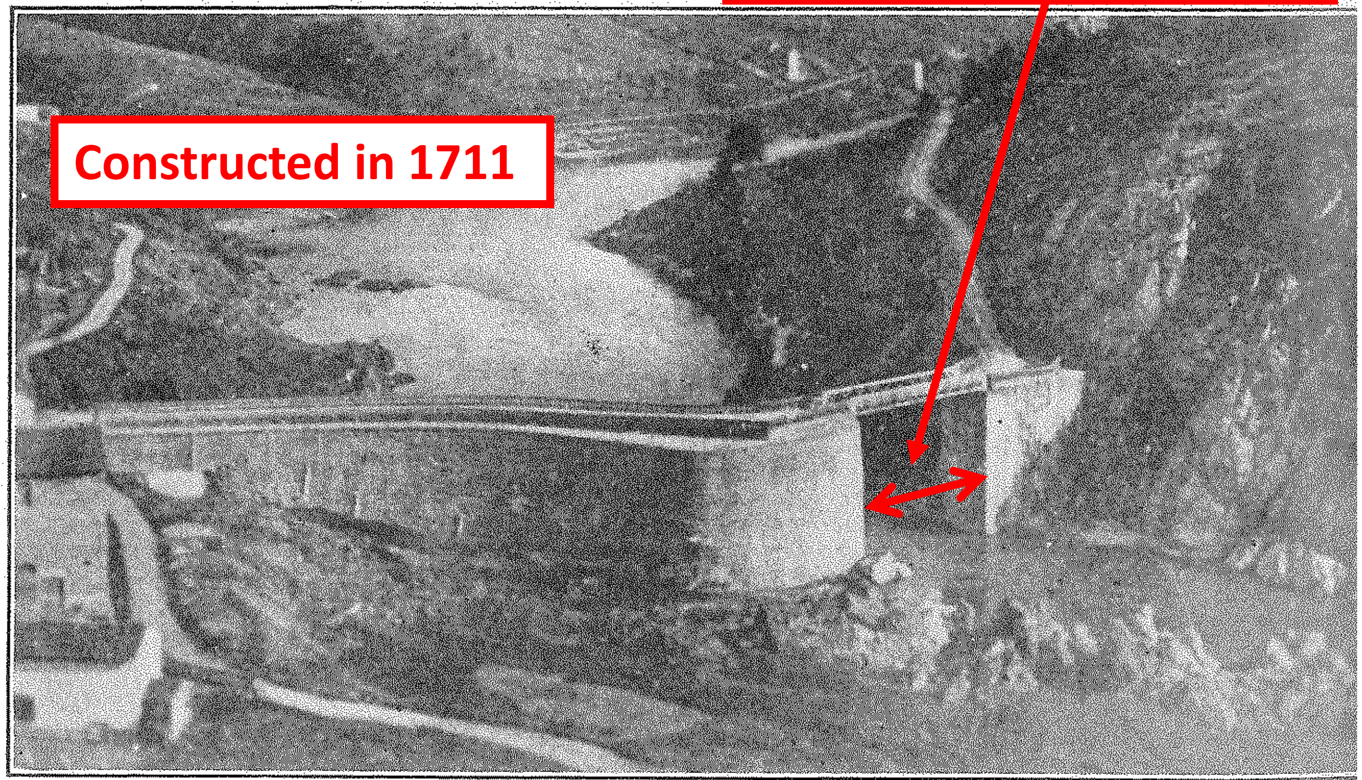
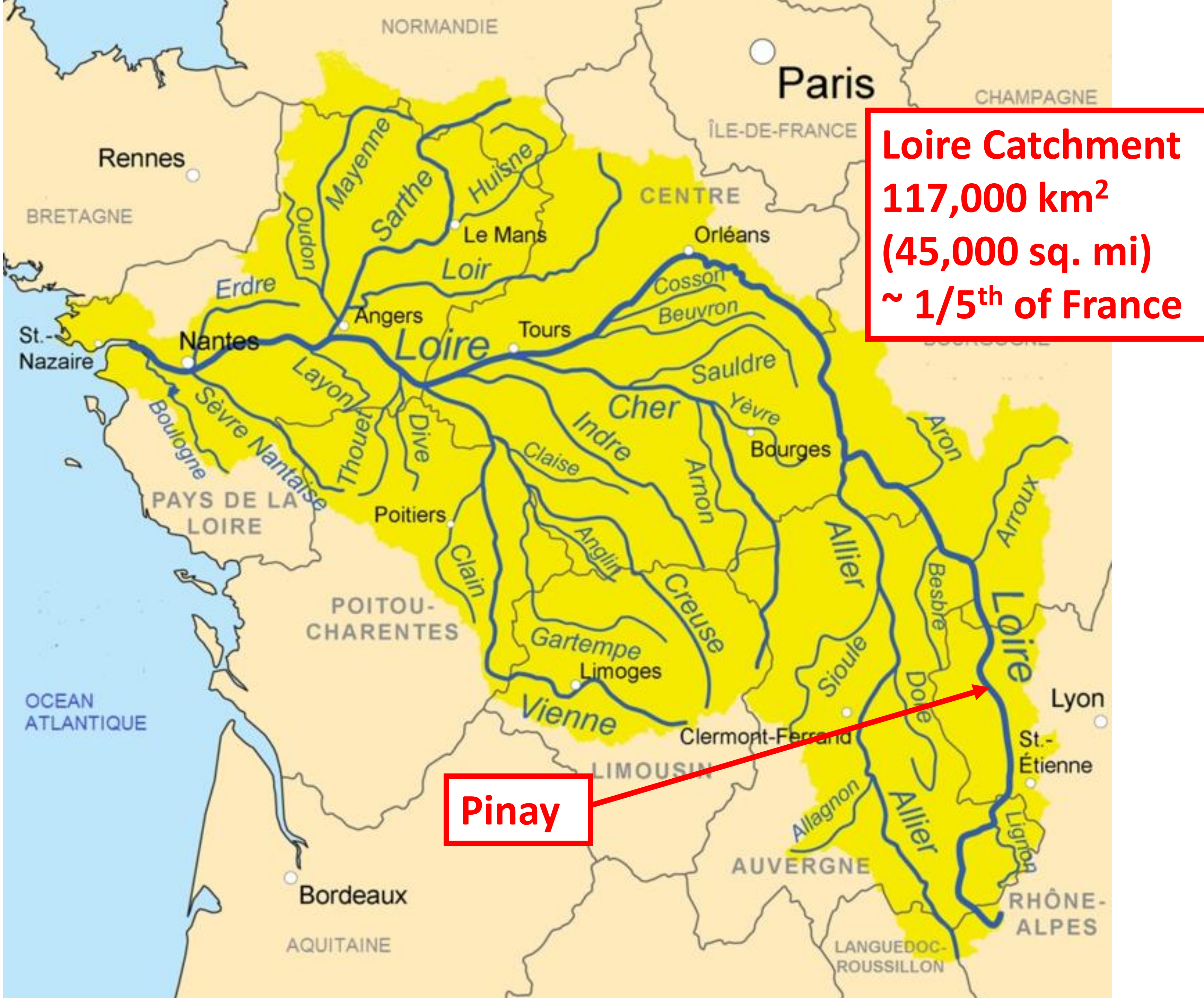
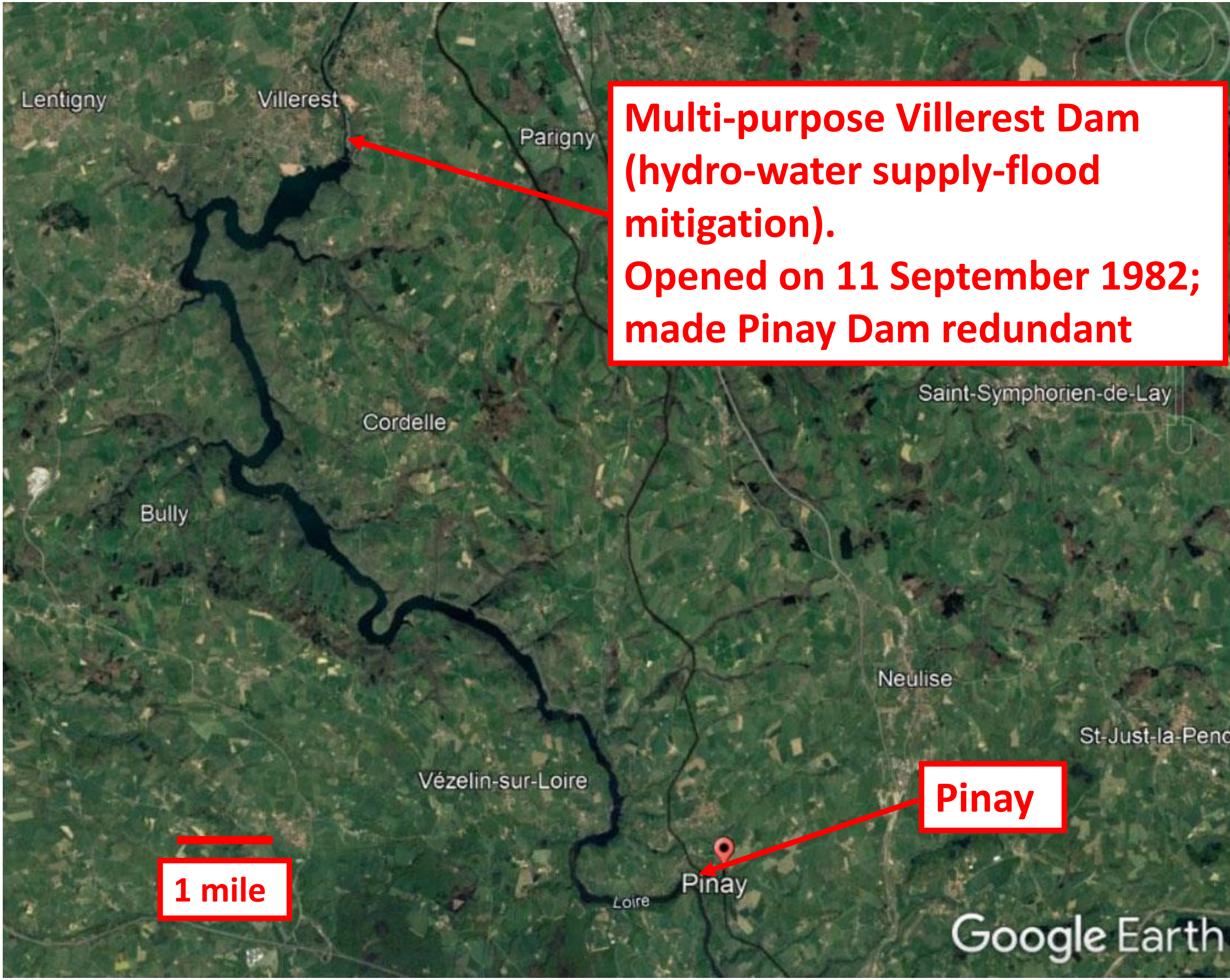


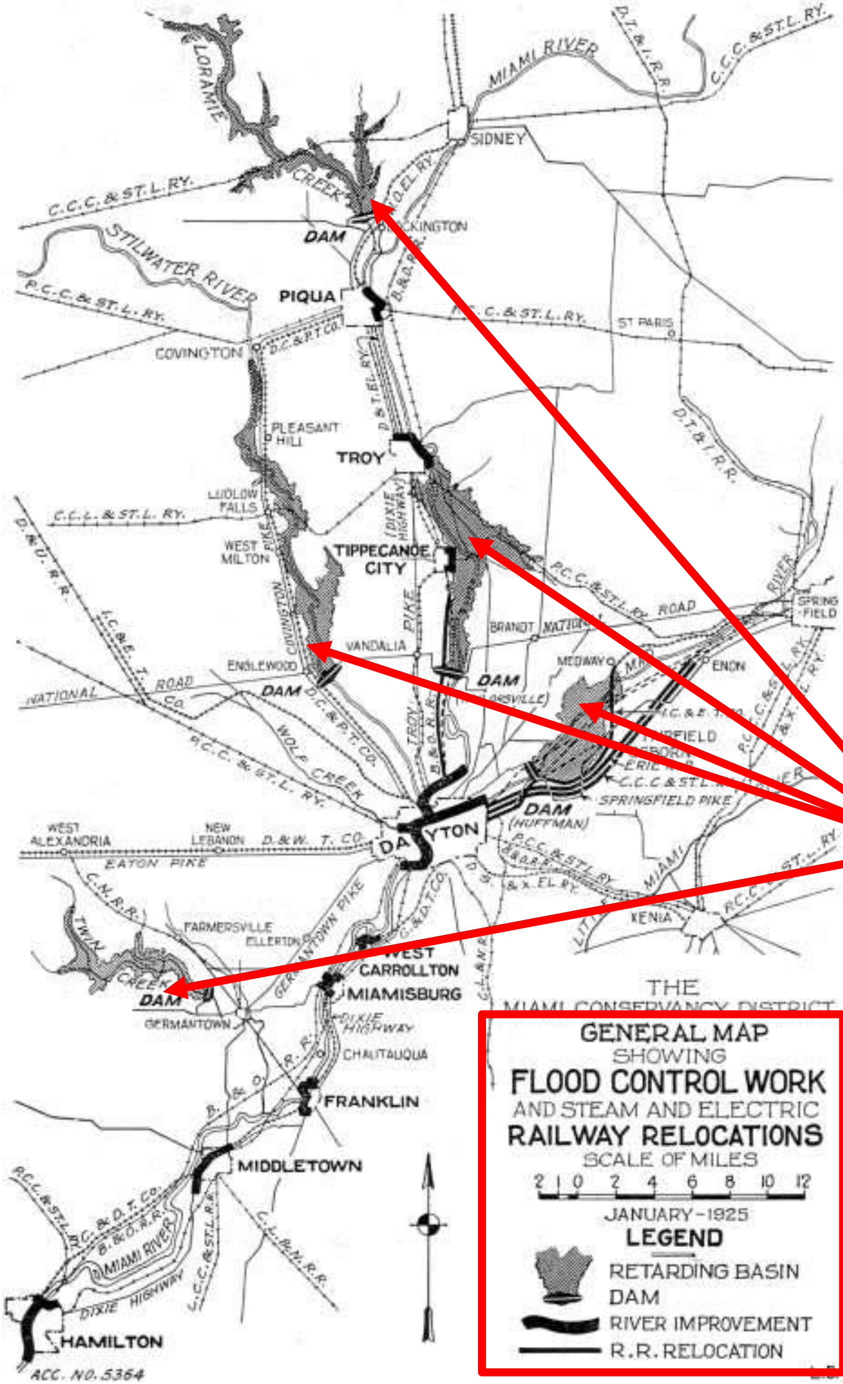
FIG. 20-4. The Pinay Dam on the Loire River in southern France. (*Courtesy of Arthur Morgan.*)


Loire Catchment
117,000 km²
(45,000 sq. mi)
~ 1/5th of France
Pinay
NORMANDIE
Paris
CHAMPAGNE
ÎLE-DE-FRANCE
Rennes
BRETAGNE
CENTRE
Mayenne
Sarthe
Huisne
Oudon
Le Mans
Loir
Orléans
Erdre
Cosson
Beuvron
Angers
St.-Nazaire
Nantes
Loire
Tours
Sauldre
Layon
Cher
Yèvre
Boulogne
Sèvre Nantaise
Thouet
Dive
Indre
Claise
Arnon
Bourges
Aron
PAYS DE LA LOIRE
Poitiers
Anglin
Allier
Arroux
Clain
Creuse
Besbre
POITOU-CHARENTES
Gartempe
Limoges
Sioule
Dore
Loire
Lyon
OCEAN ATLANTIQUE
Vienne
Clermont-Ferrand
St.-Étienne
LIMOUSIN
Allagnon
Allier
Lignon
AUVERGNE
RHÔNE-ALPES
Bordeaux
AQUITAINE
LANGUEDOC-ROUSSILLON


Lentigny
Villerest
Parigny
Multi-purpose Villerest Dam (hydro-water supply-flood mitigation).
Opened on 11 September 1982; made Pinay Dam redundant
Saint-Symphorien-de-Lay
Cordelle
Bully
Neulise
St-Just-la-Pendu
Vézelin-sur-Loire
Pinay
1 mile
Loire
Pinay
Google Earth

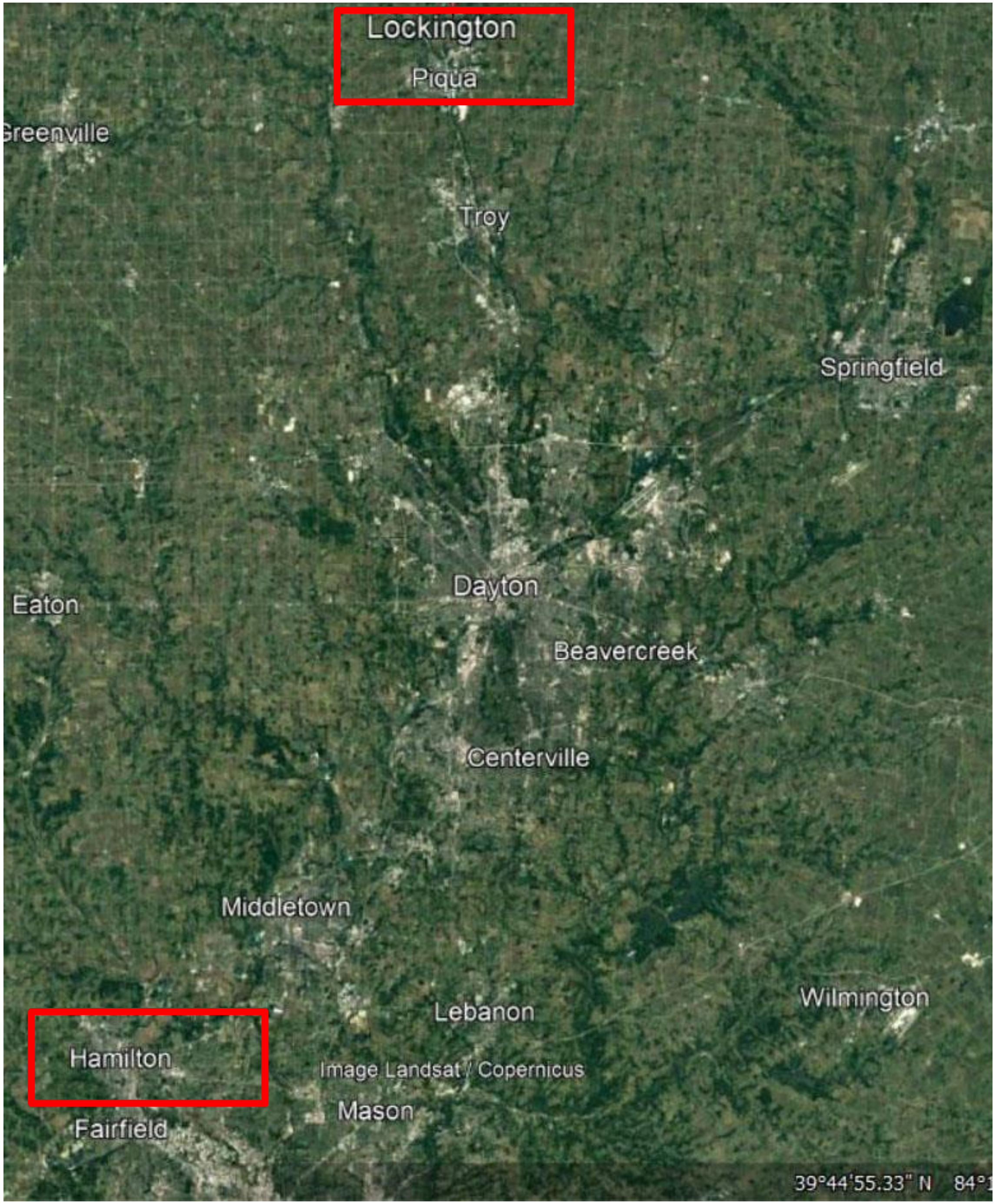

Approximate location of Pinay "retarding basin" – Operated from 1711 to 1984
0.05 miles
Google Earth
Imagery Date: 4/26/2018 45°52'09.22" N 4°07'40.46" E elev 1053 ft eye alt 2157 ft

Features of the five “dry dams” and their locations



Inundation extent when dams operated for the design flood

Map prepared 1925



Google Earth Image of Region

All five earth dams were constructed by the "hydraulic fill method" using materials dredged up river.

This was done before the development, by Karl von Terzaghi and others, of "soil mechanics" now called "geotechnical engineering".

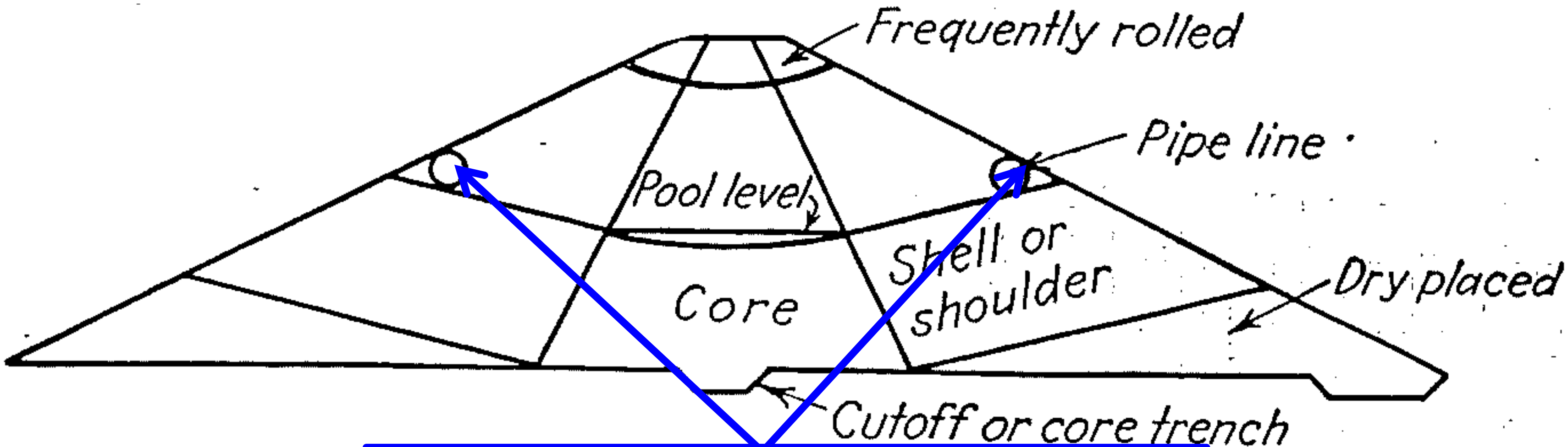


Fig. 9.—Hydraulic-fill construction.

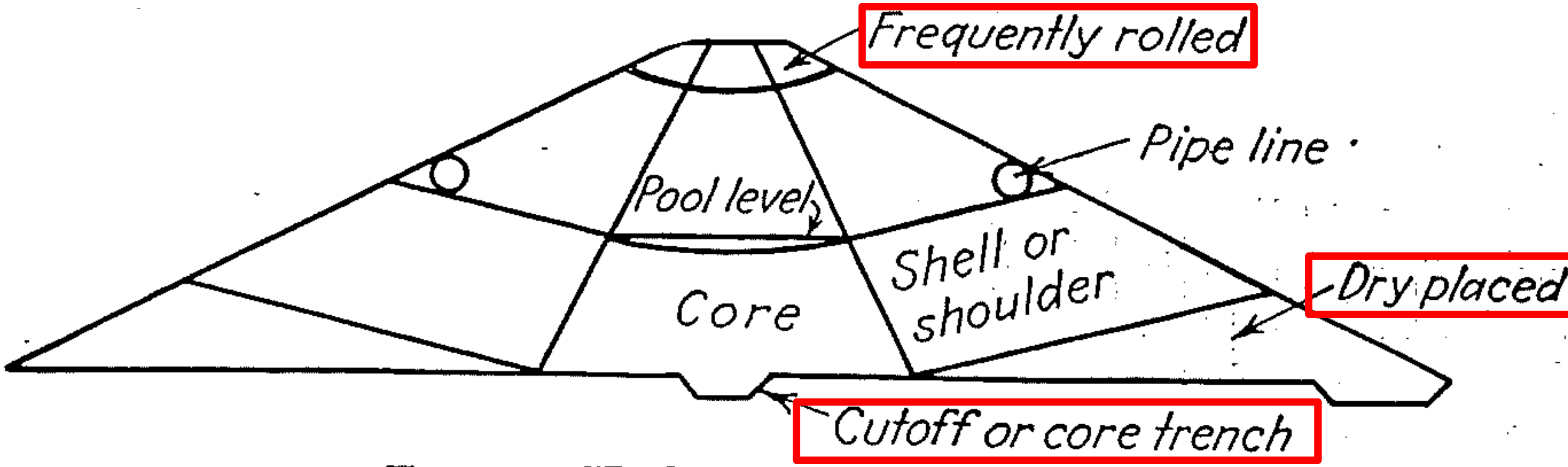
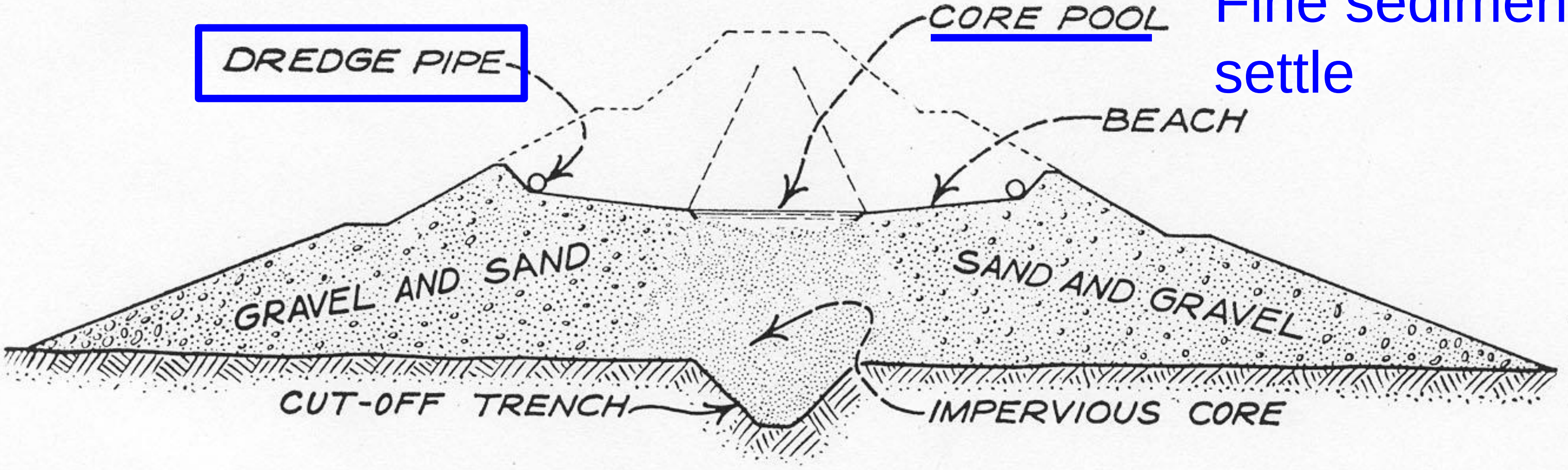


FIG. 9.—Hydraulic-fill construction.



Fine sediments settle

The hydraulic-fill process.

Note – upper part lacks impervious core – added in dam safety upgrades starting 1999 at Englewood Dam

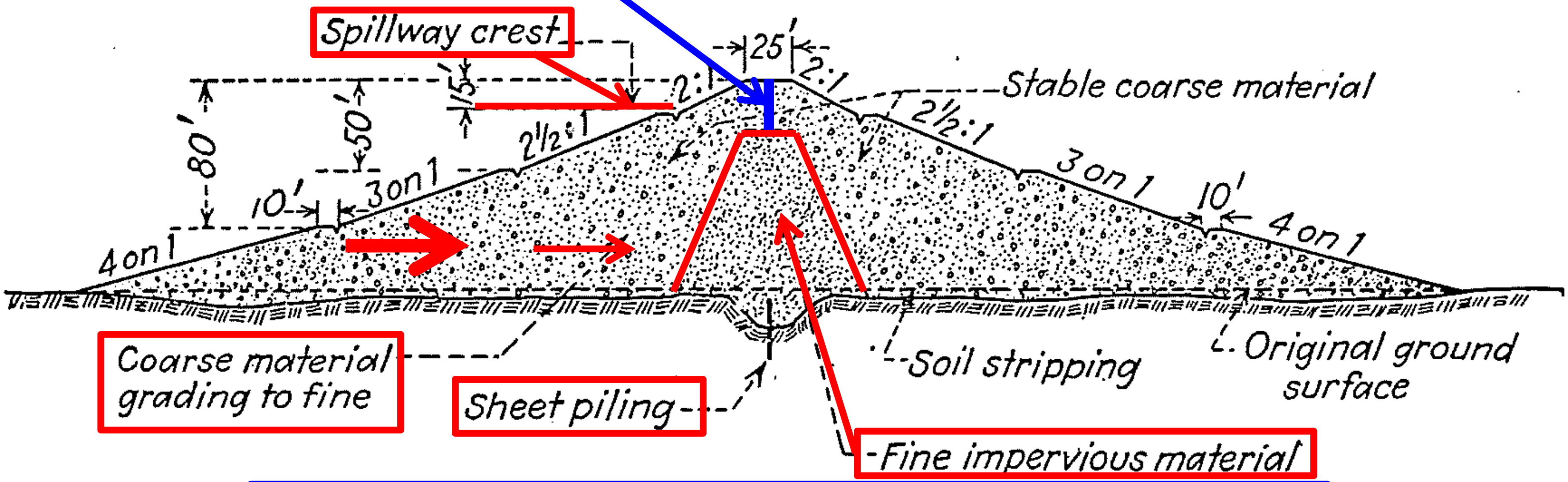
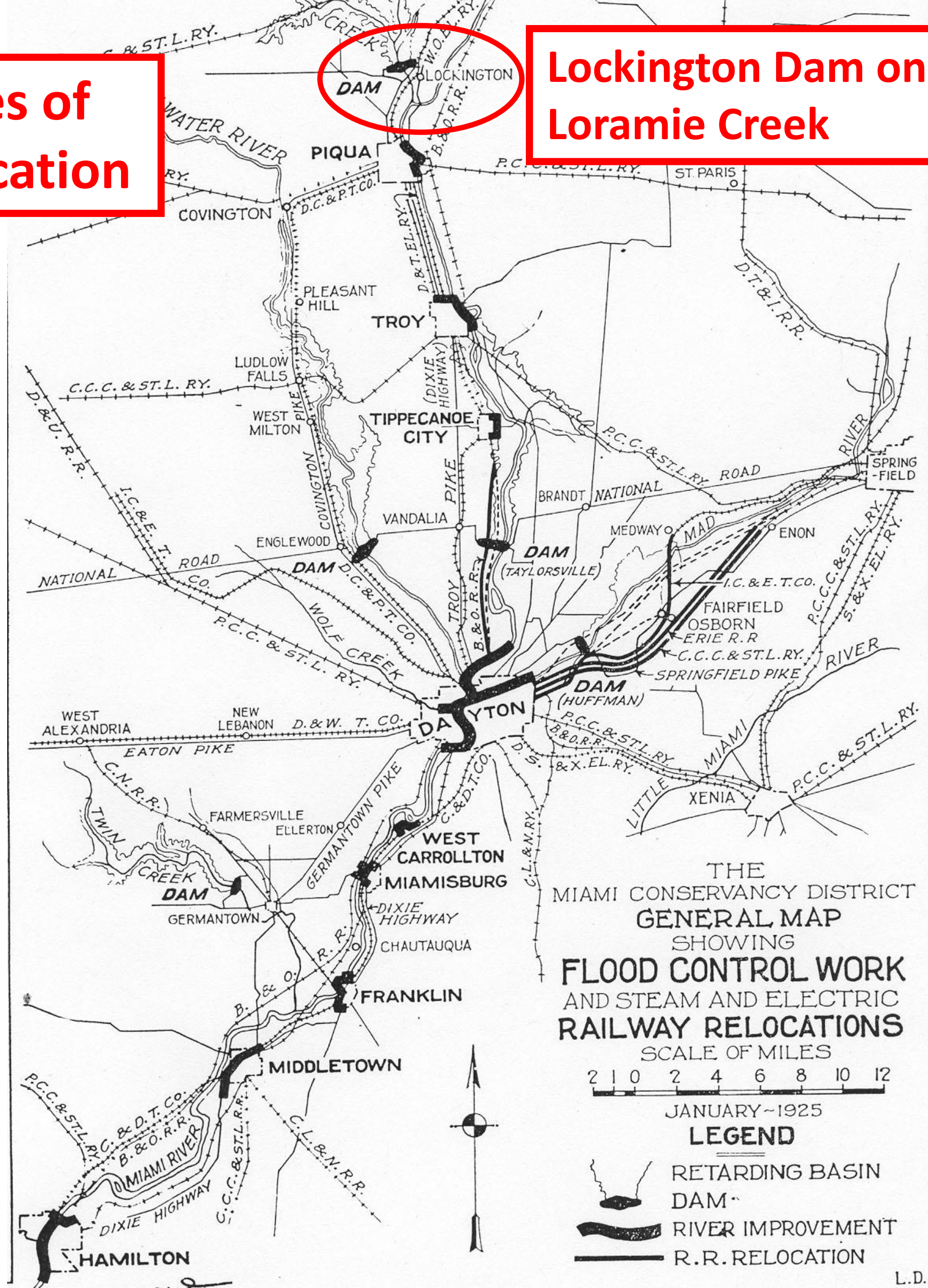
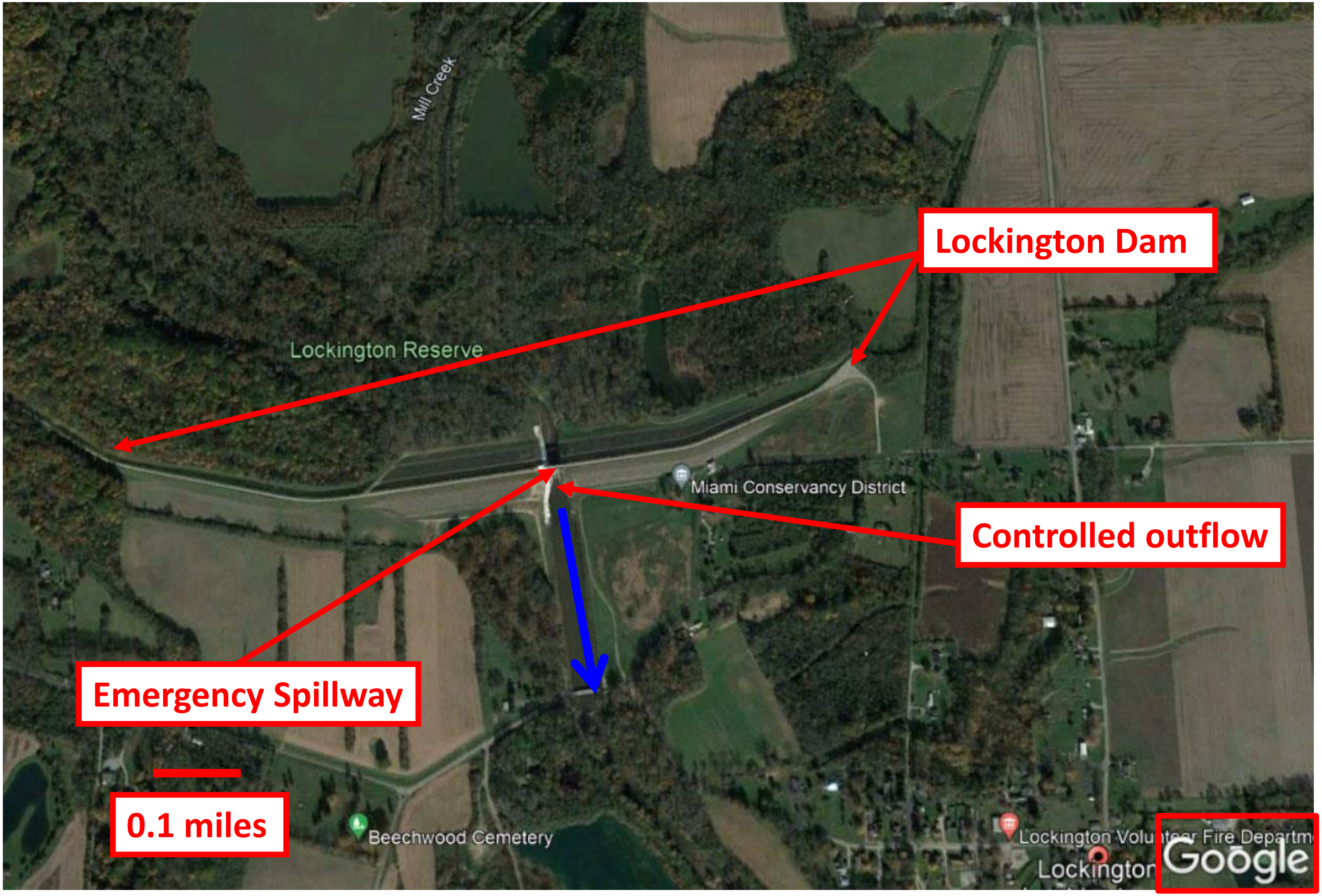


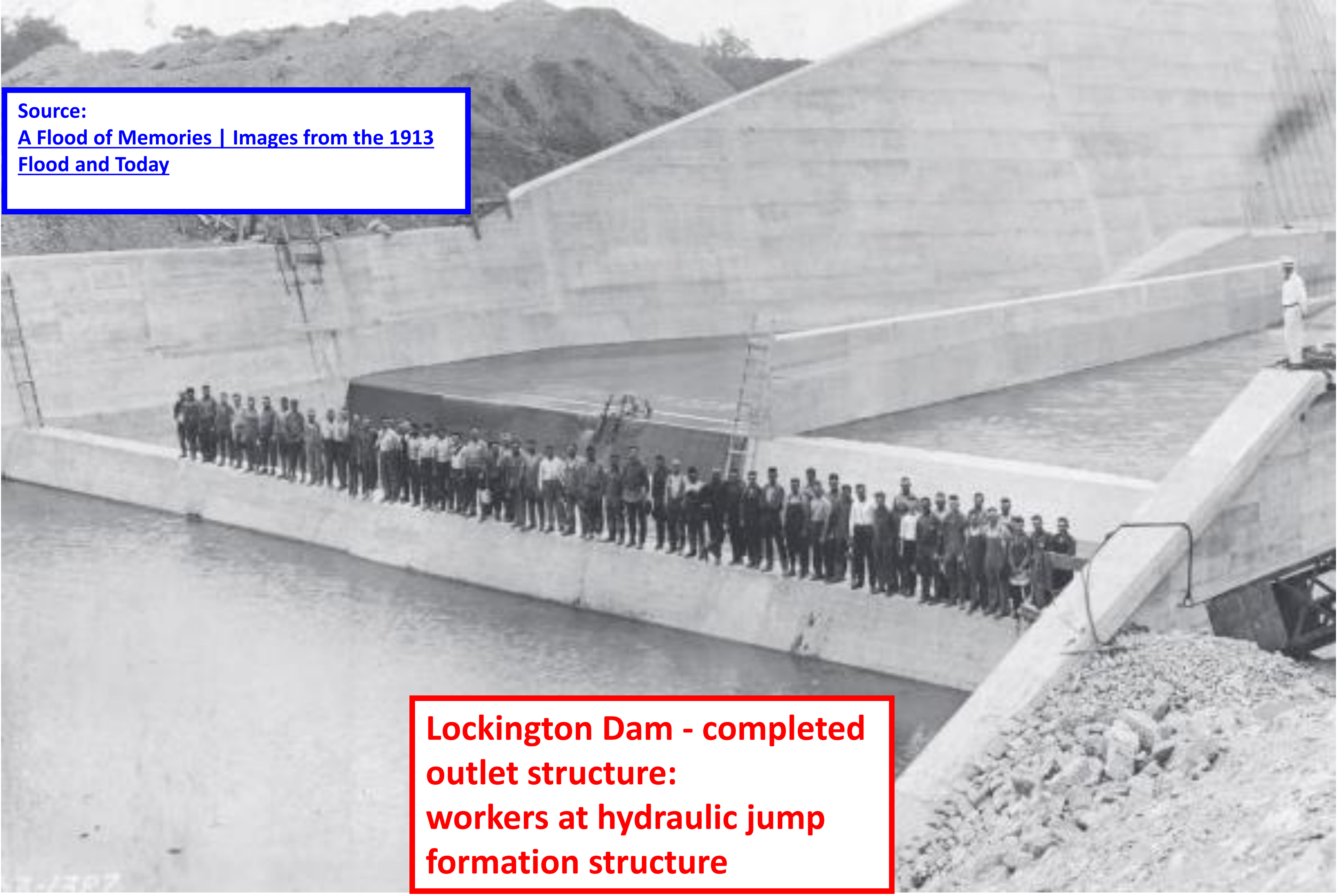
Fig. 20.—Germantown Dam, Miami Conservancy District.

Google images of "dry" dam location

Lockington Dam on Loramie Creek




Mill Creek
Lockington Reserve
Lockington Dam
Miami Conservancy District
Controlled outflow
Emergency Spillway
0.1 miles
Beechwood Cemetery
Google

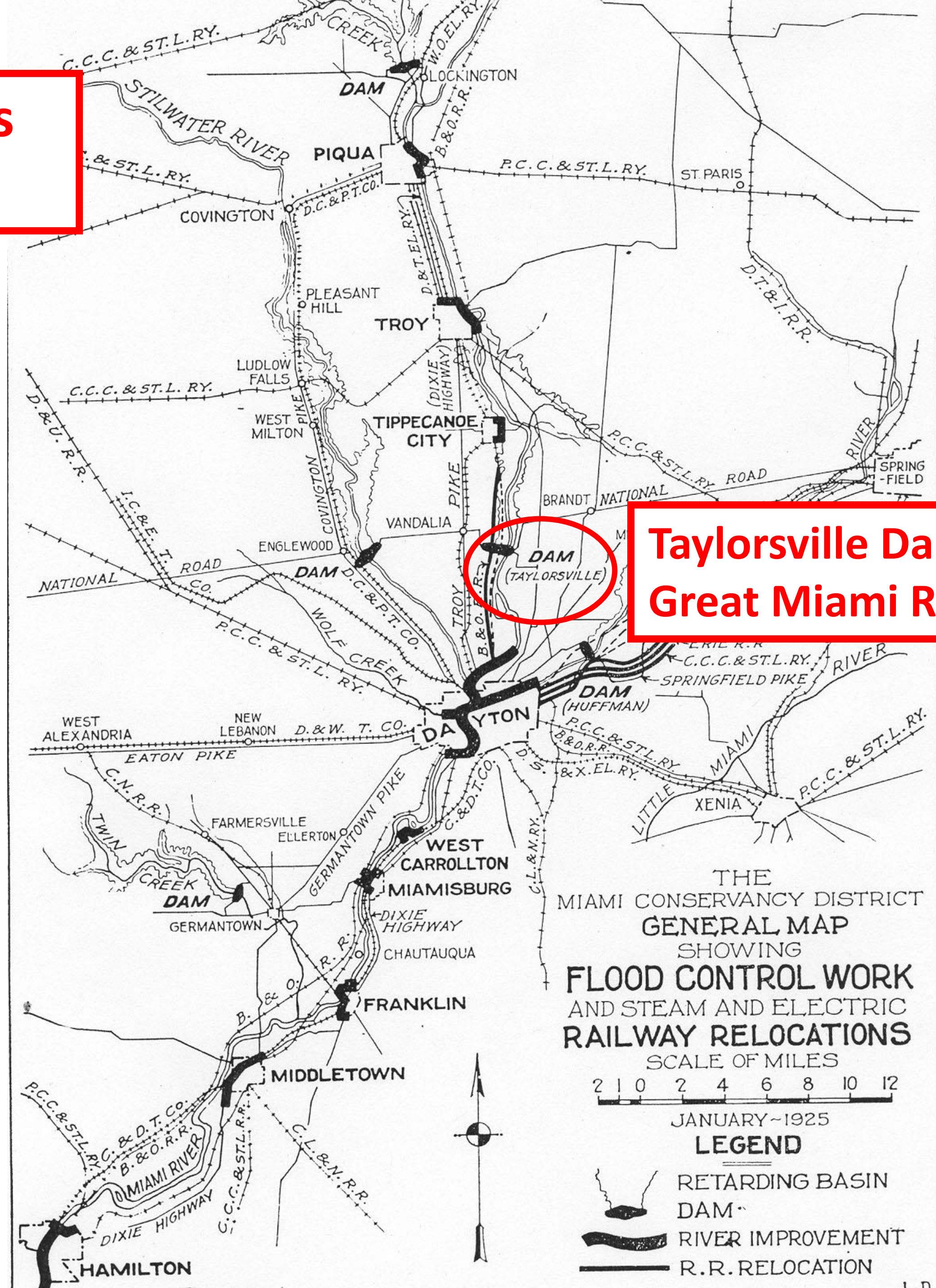


Source:
[A Flood of Memories | Images from the 1913 Flood and Today]

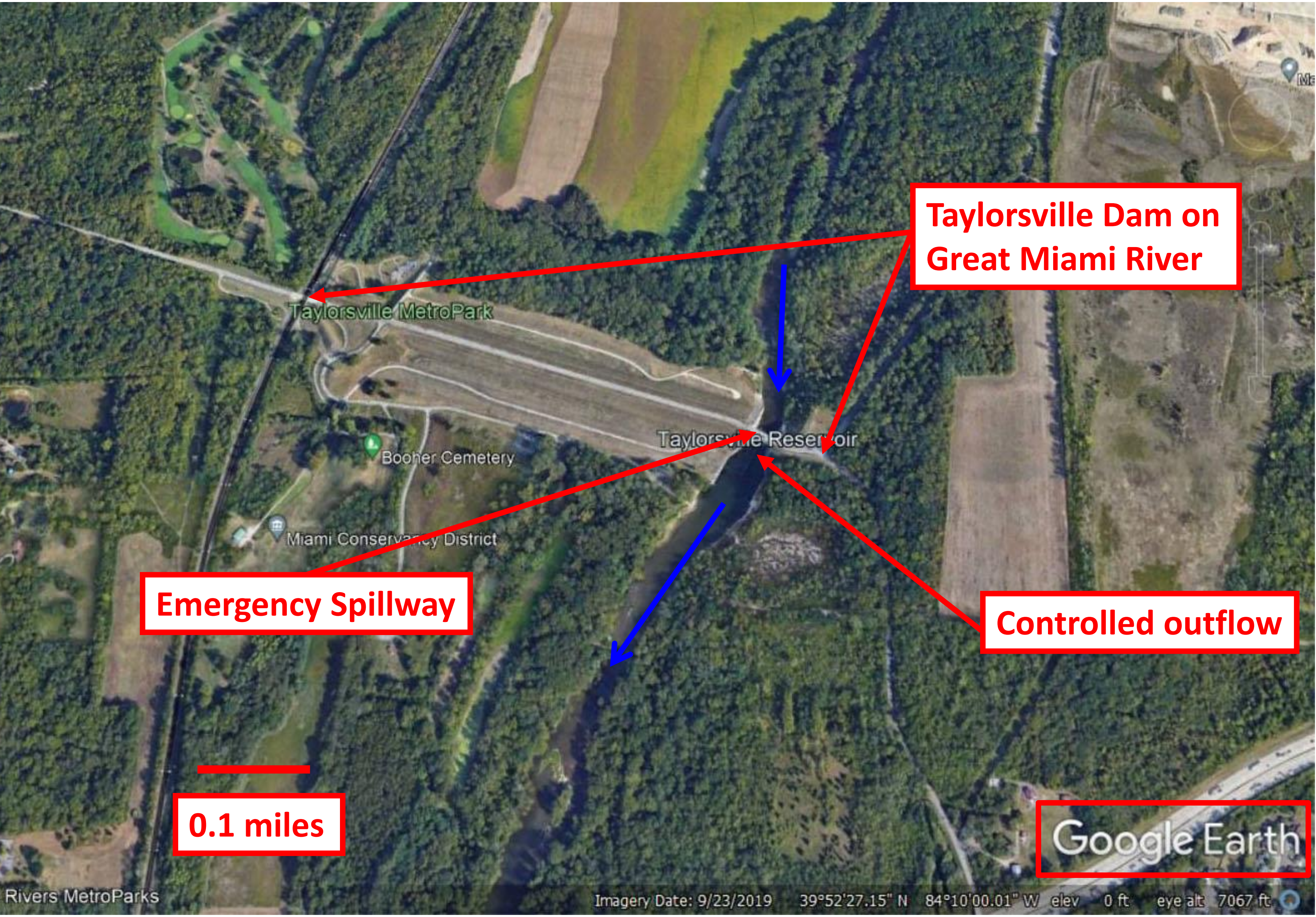
Lockington Dam - completed outlet structure:
workers at hydraulic jump formation structure

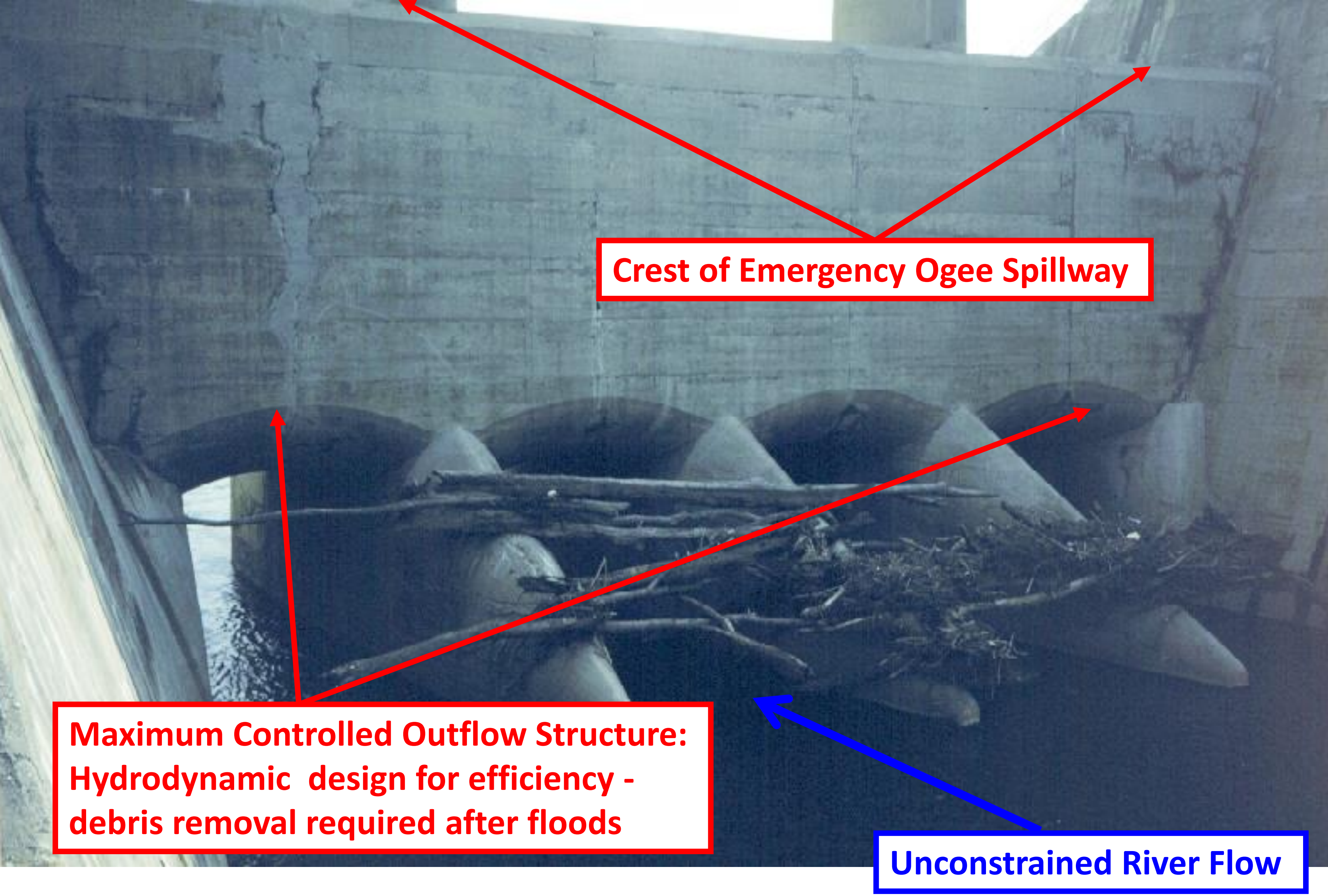
Lockington Region – Farmland

Google images of “dry” dams

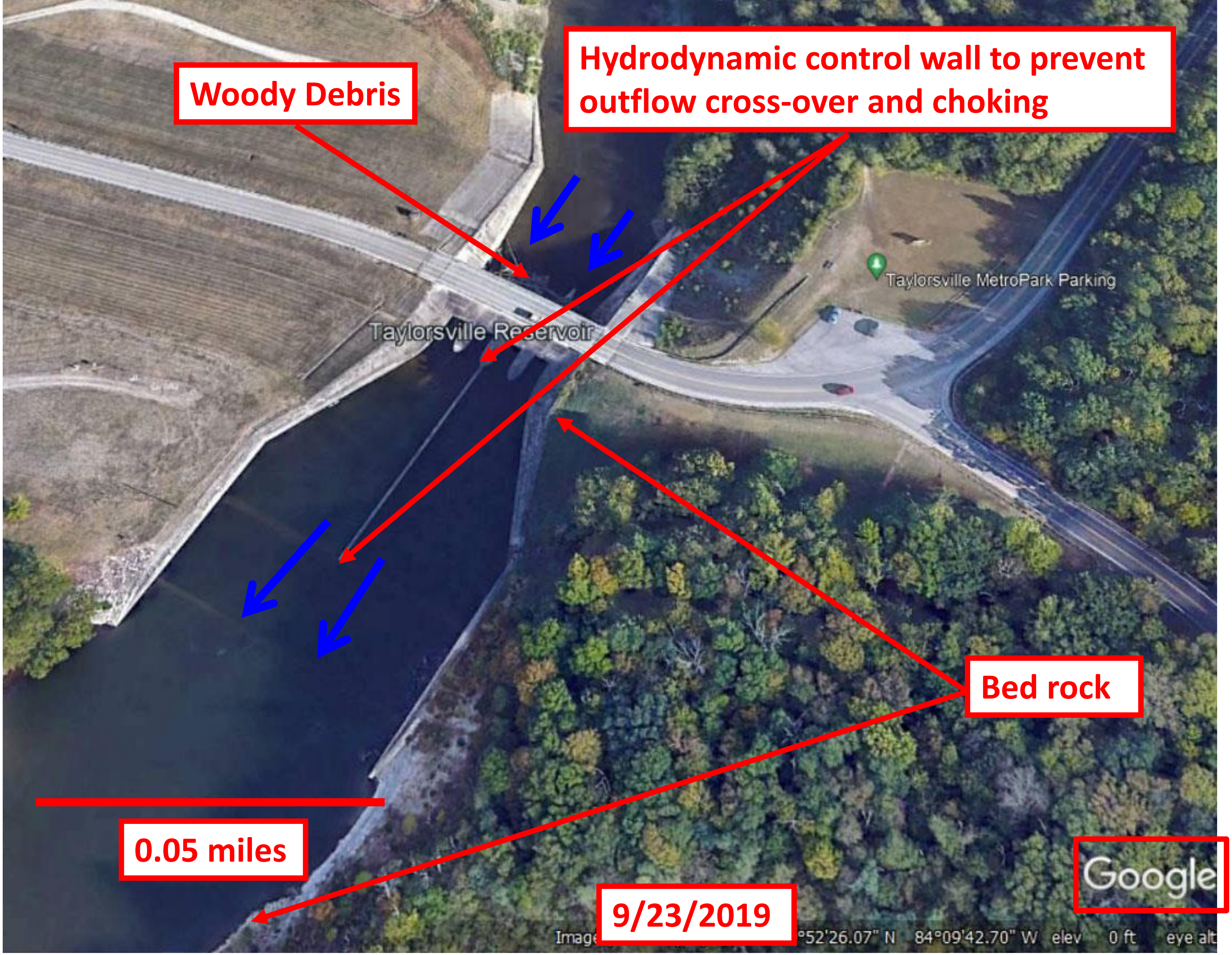


Taylorsville Dam on Great Miami River

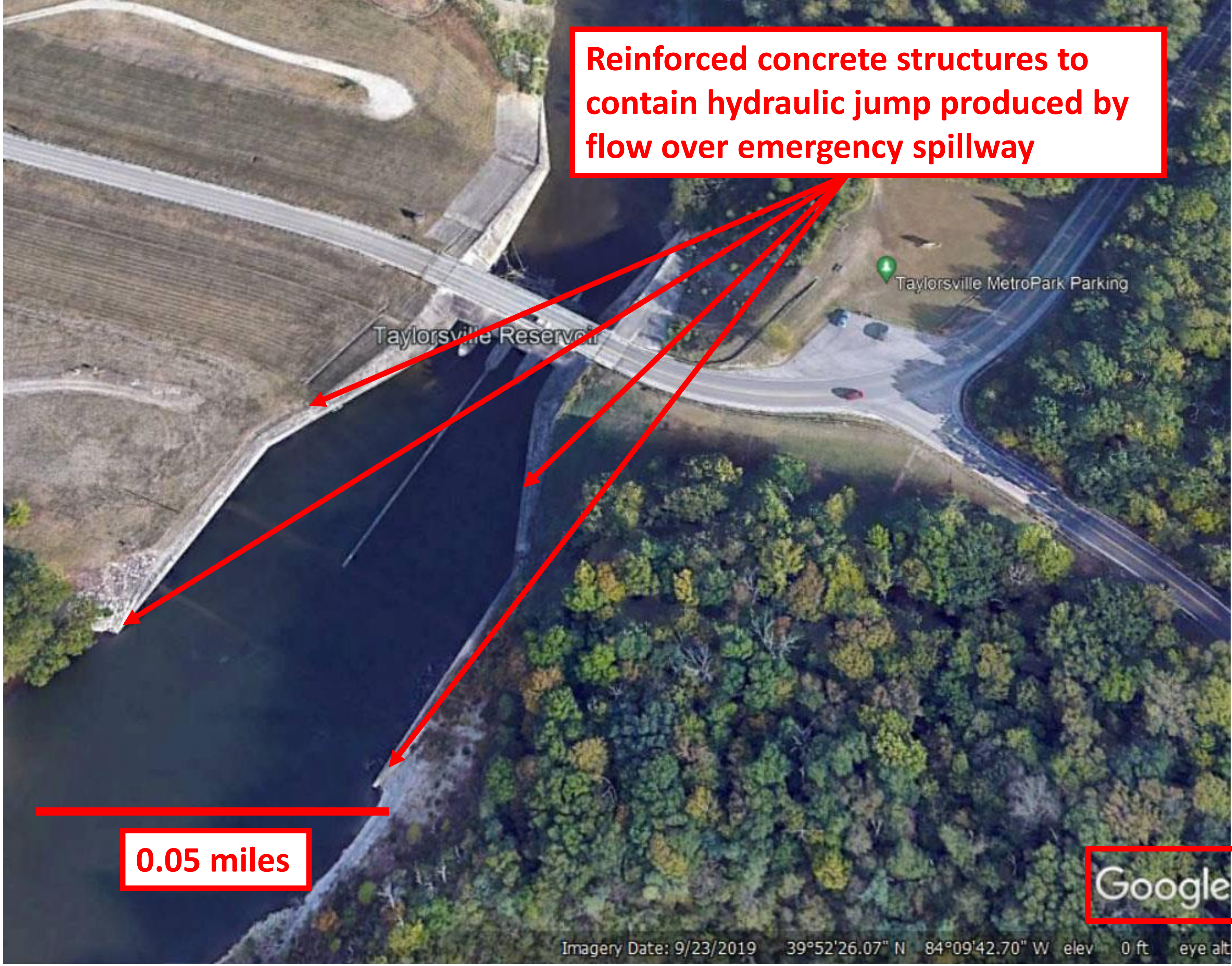

Taylorsville Dam on
Great Miami River
Taylorsville MetroPark
Taylorsville Reservoir
Booher Cemetery
Miami Conservancy District
Emergency Spillway
Controlled outflow
0.1 miles
Google Earth
Rivers MetroParks
Imagery Date: 9/23/2019 39°52'27.15" N 84°10'00.01" W elev 0 ft eye alt 7067 ft


Crest of Emergency Ogee Spillway
Maximum Controlled Outflow Structure:
Hydrodynamic design for efficiency -
debris removal required after floods
Unconstrained River Flow

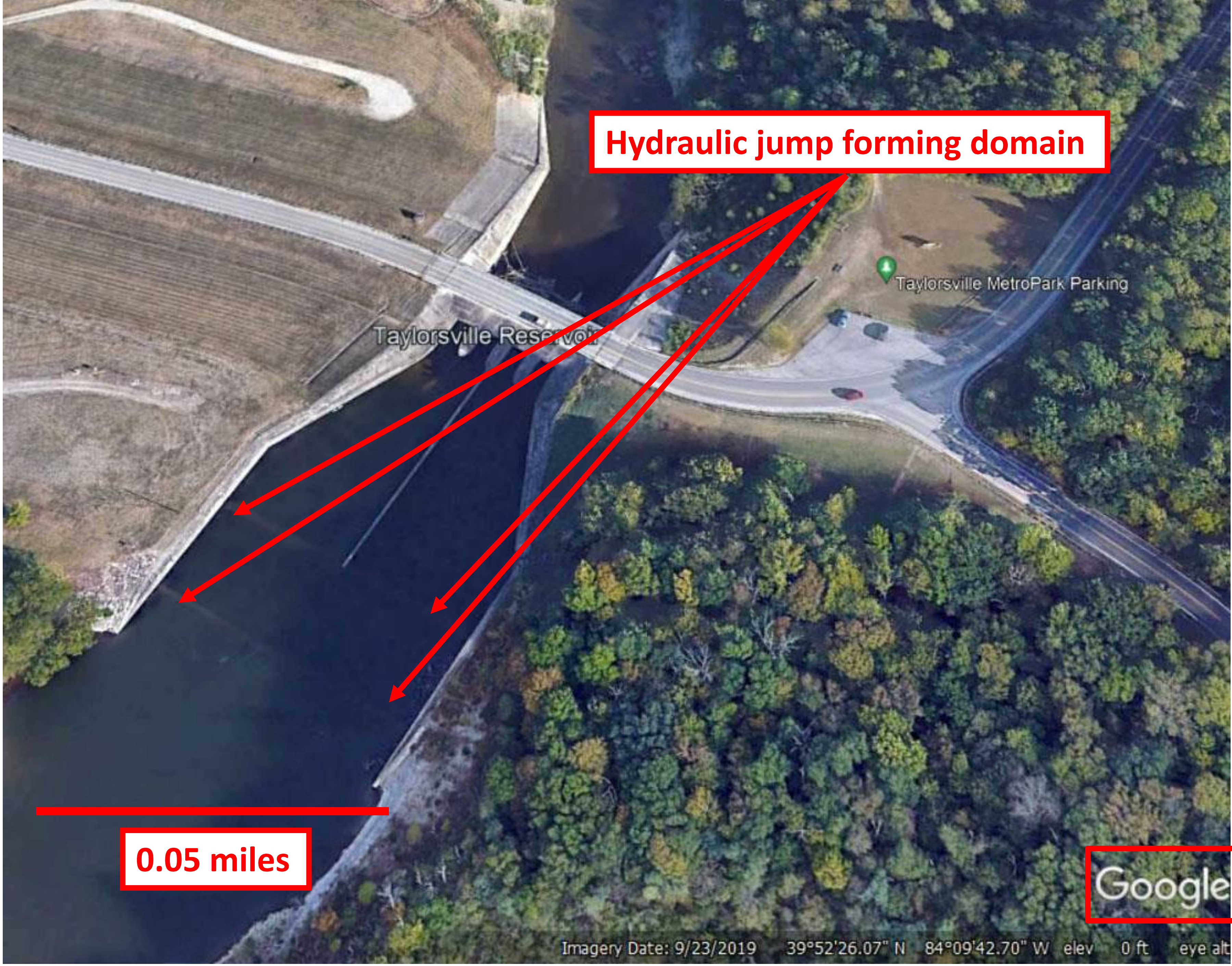
May 1984

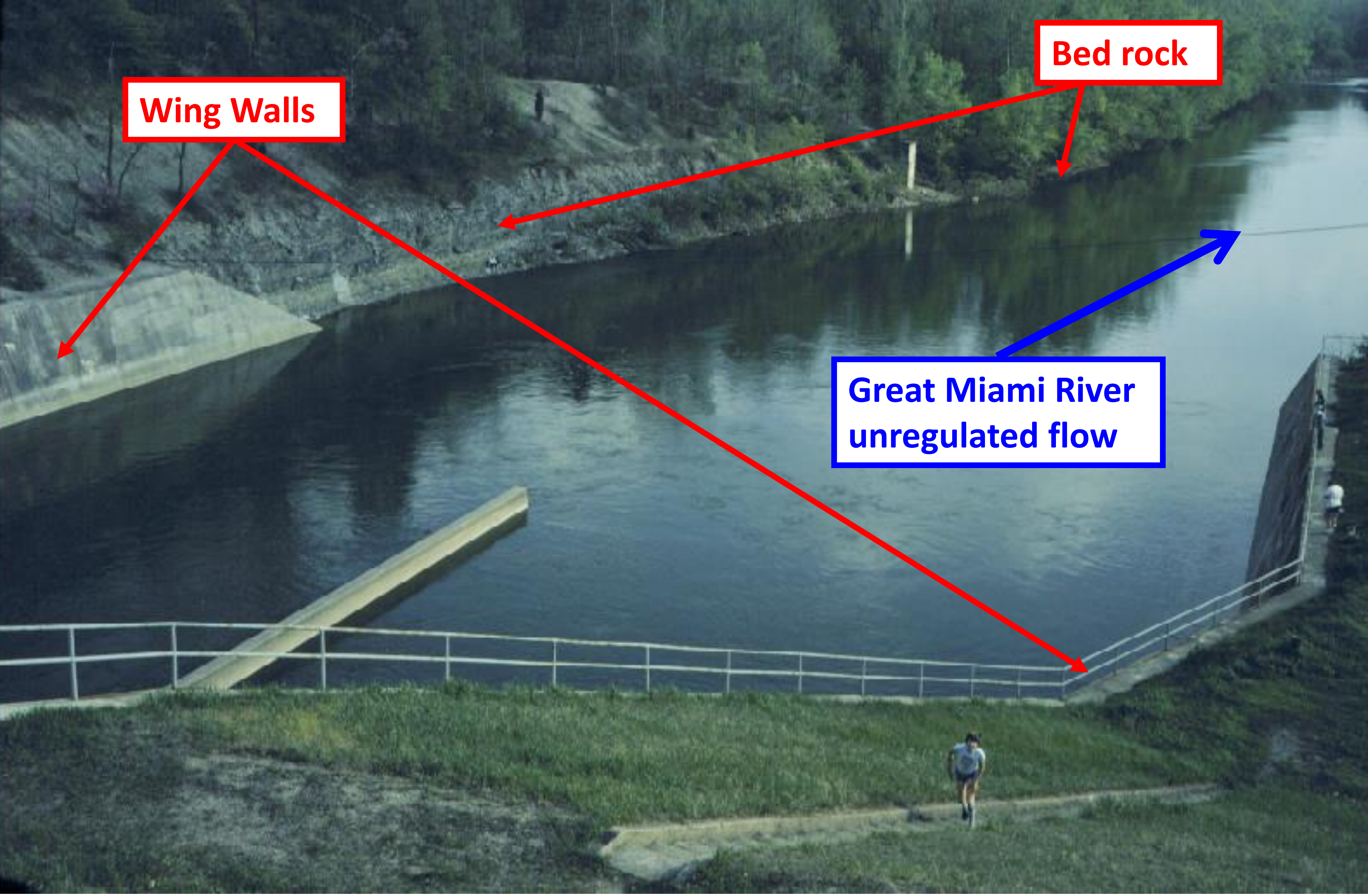


Hydrodynamic control wall to prevent outflow cross-over and choking
Woody Debris
Taylorsville MetroPark Parking
Taylorsville Reservoir
Bed rock
0.05 miles
9/23/2019
Google
°52'26.07" N 84°09'42.70" W elev 0 ft eye alt



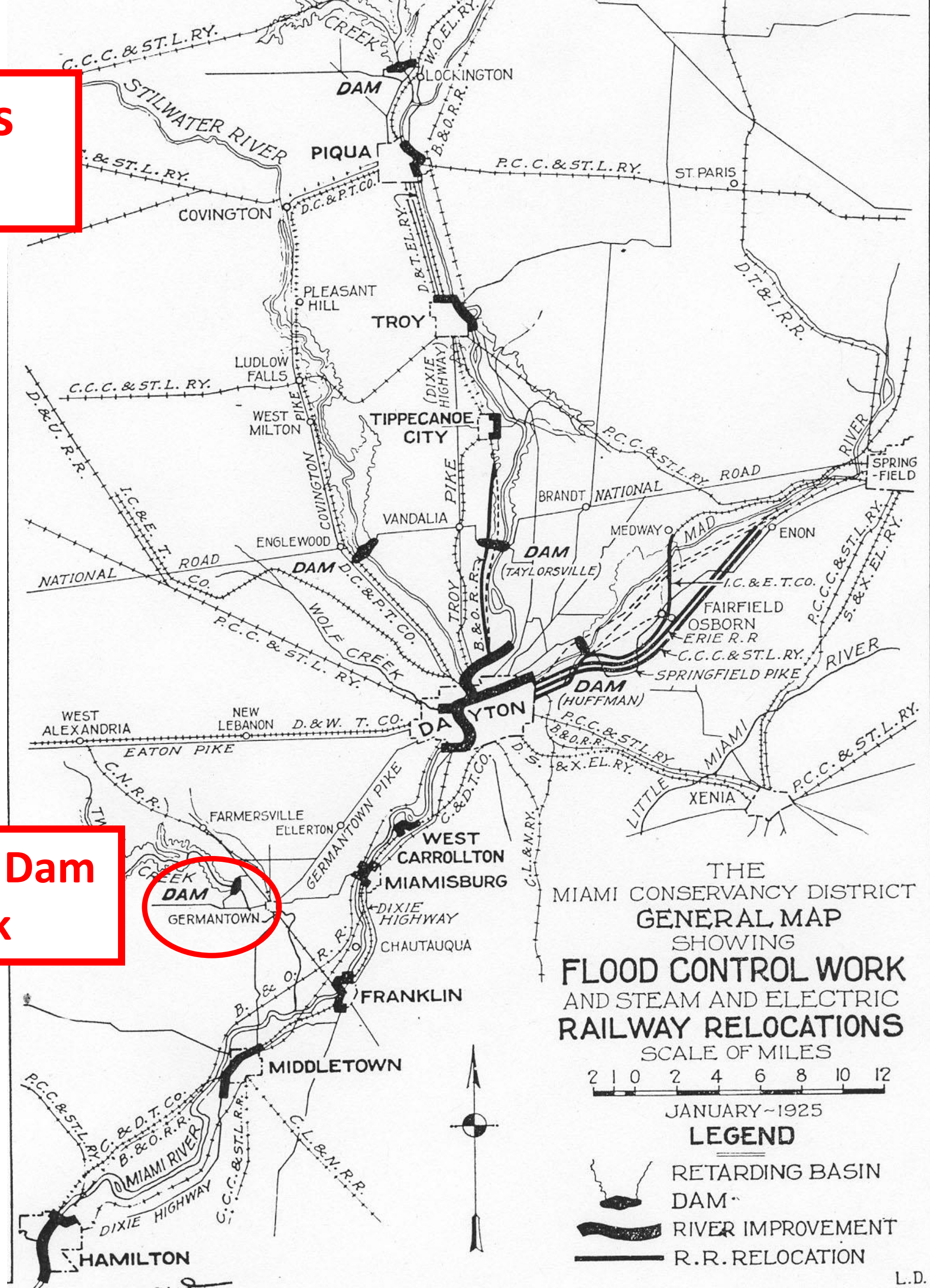
Reinforced concrete structures to contain hydraulic jump produced by flow over emergency spillway
Taylorsville Reservoir
Taylorsville MetroPark Parking
0.05 miles
Google
Imagery Date: 9/23/2019 39°52'26.07" N 84°09'42.70" W elev 0 ft eye alt


Hydraulic jump forming domain
Taylorsville MetroPark Parking
Taylorsville Reservoir
0.05 miles
Google
Imagery Date: 9/23/2019 39°52'26.07" N 84°09'42.70" W elev 0 ft eye alt

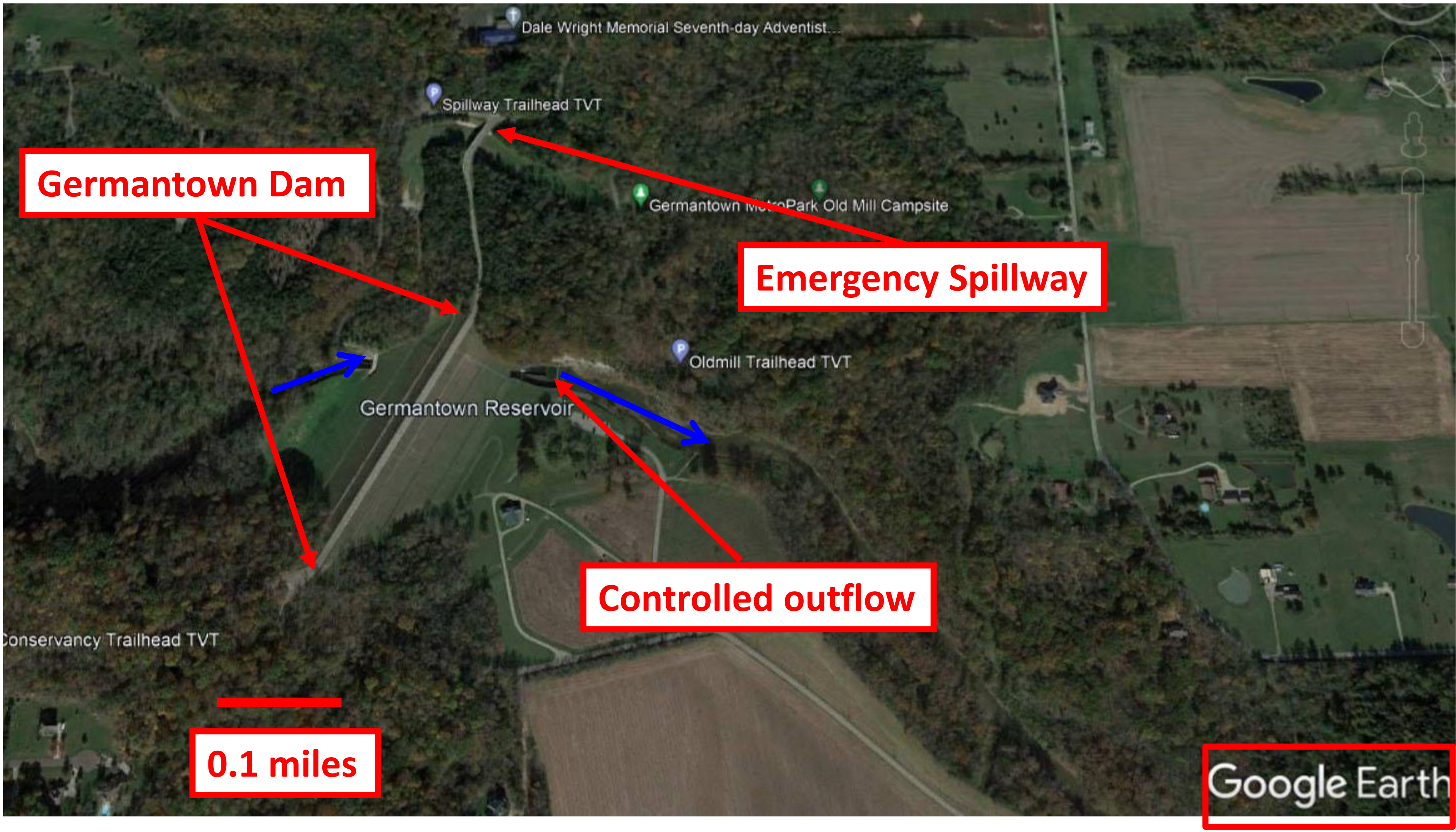


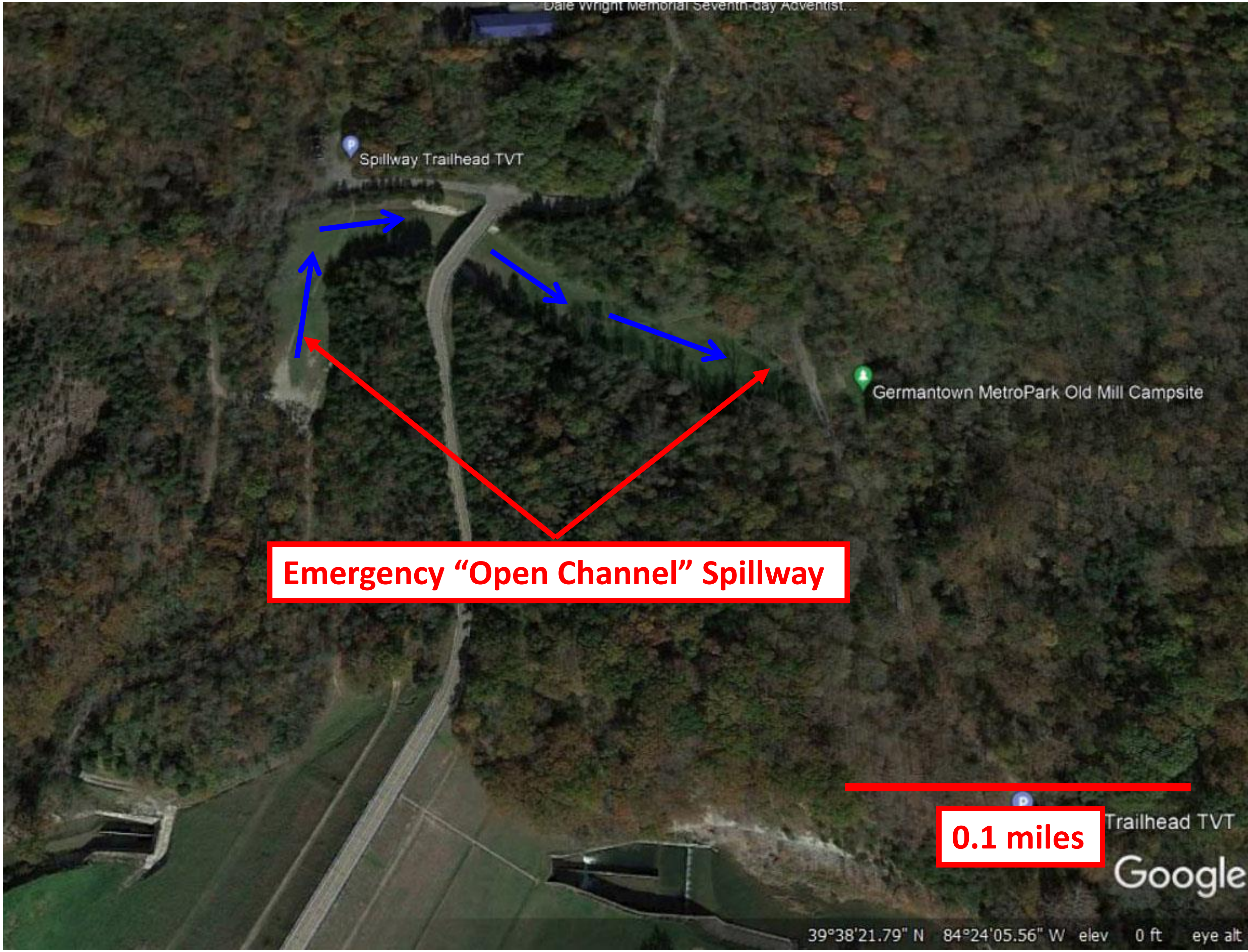
May 1984

Google images of “dry” dams

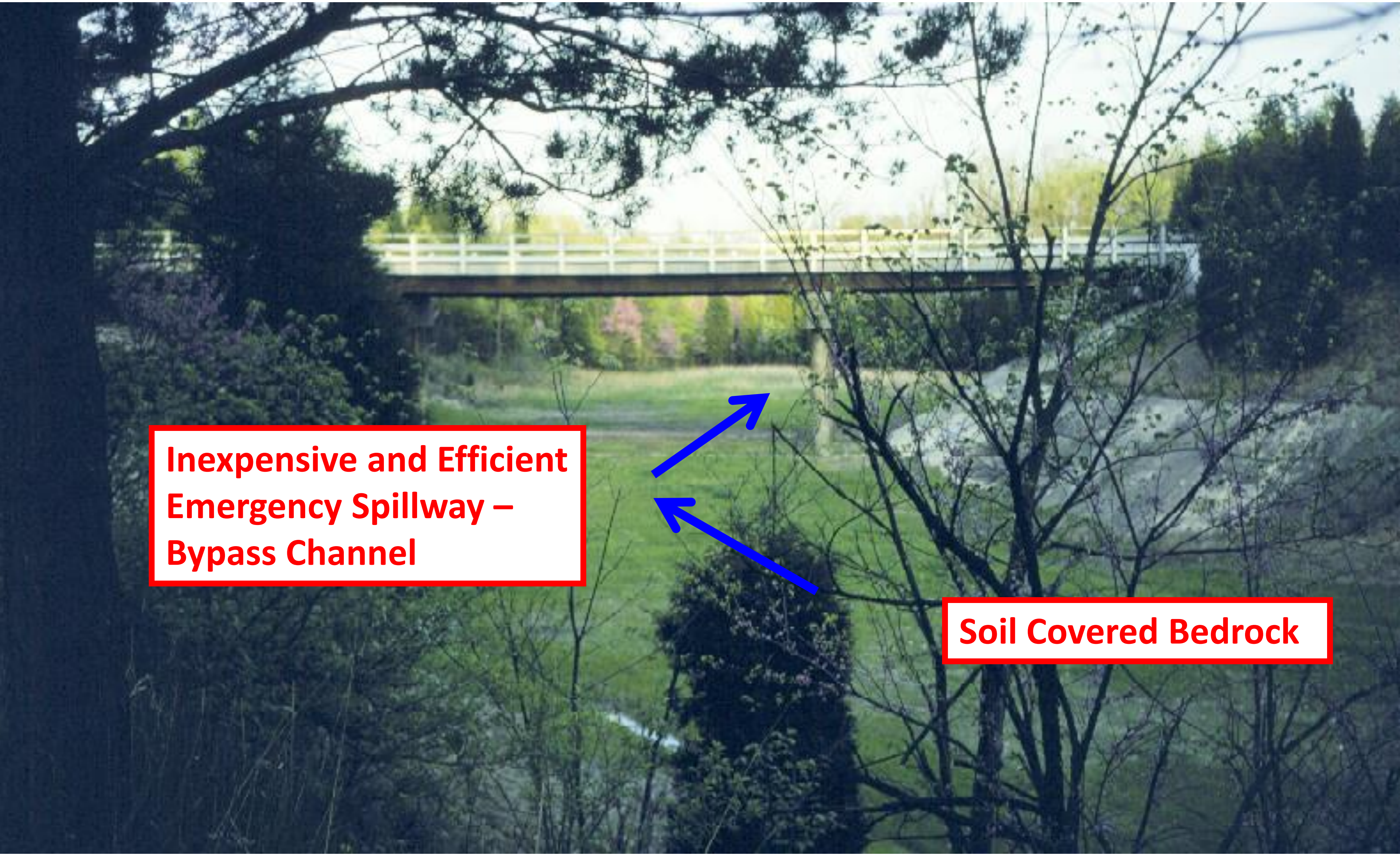


Germantown Dam on Twin Creek

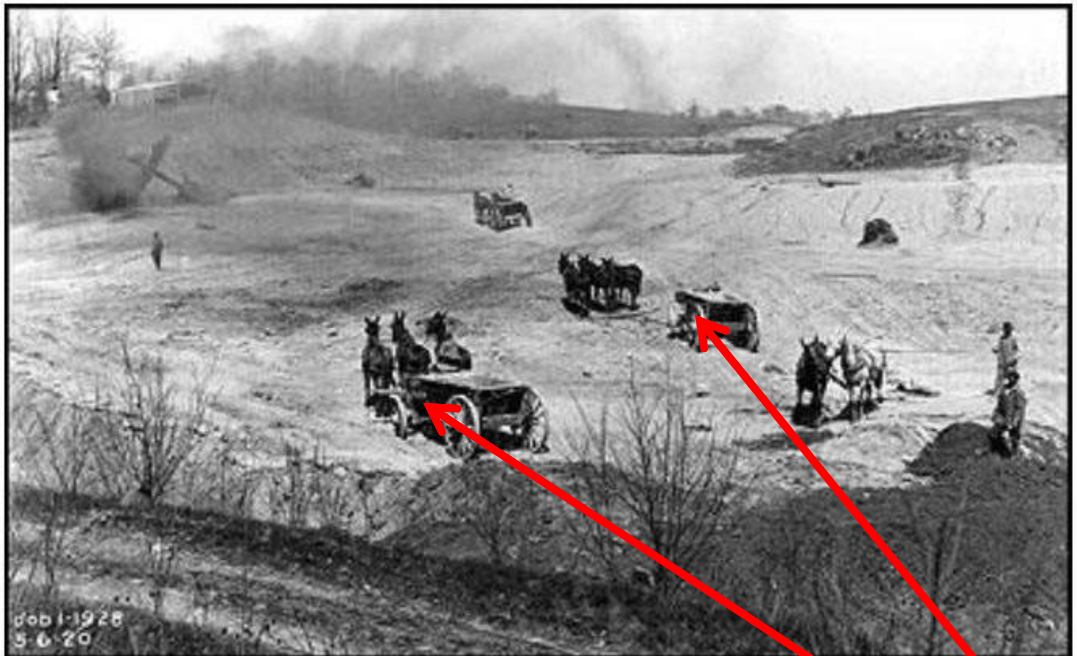

Dale Wright Memorial Seventh-day Adventist...
Spillway Trailhead TVT
Germantown Dam
Emergency Spillway
Oldmill Trailhead TVT
Germantown Reservoir
Controlled outflow
Conservancy Trailhead TVT
0.1 miles
Google Earth

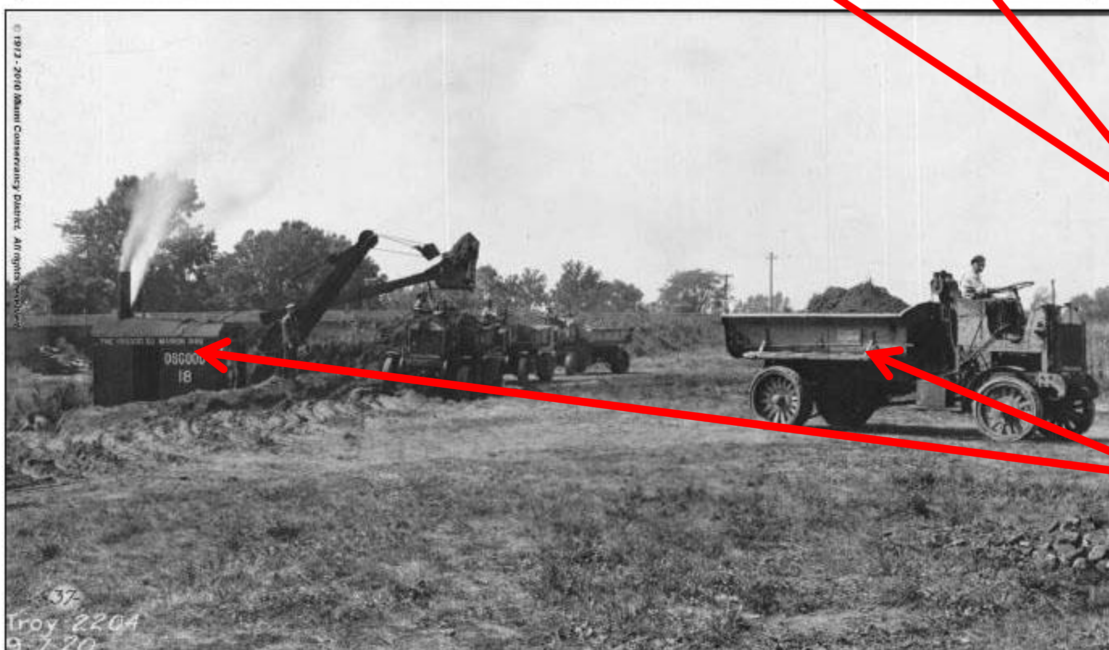


Dale Wright Memorial Seventh-day Adventist...
Spillway Trailhead TVT
Germantown MetroPark Old Mill Campsite
Emergency "Open Channel" Spillway
0.1 miles
Trailhead TVT
Google
39°38'21.79" N 84°24'05.56" W elev 0 ft eye alt


Inexpensive and Efficient Emergency Spillway – Bypass Channel
Soil Covered Bedrock

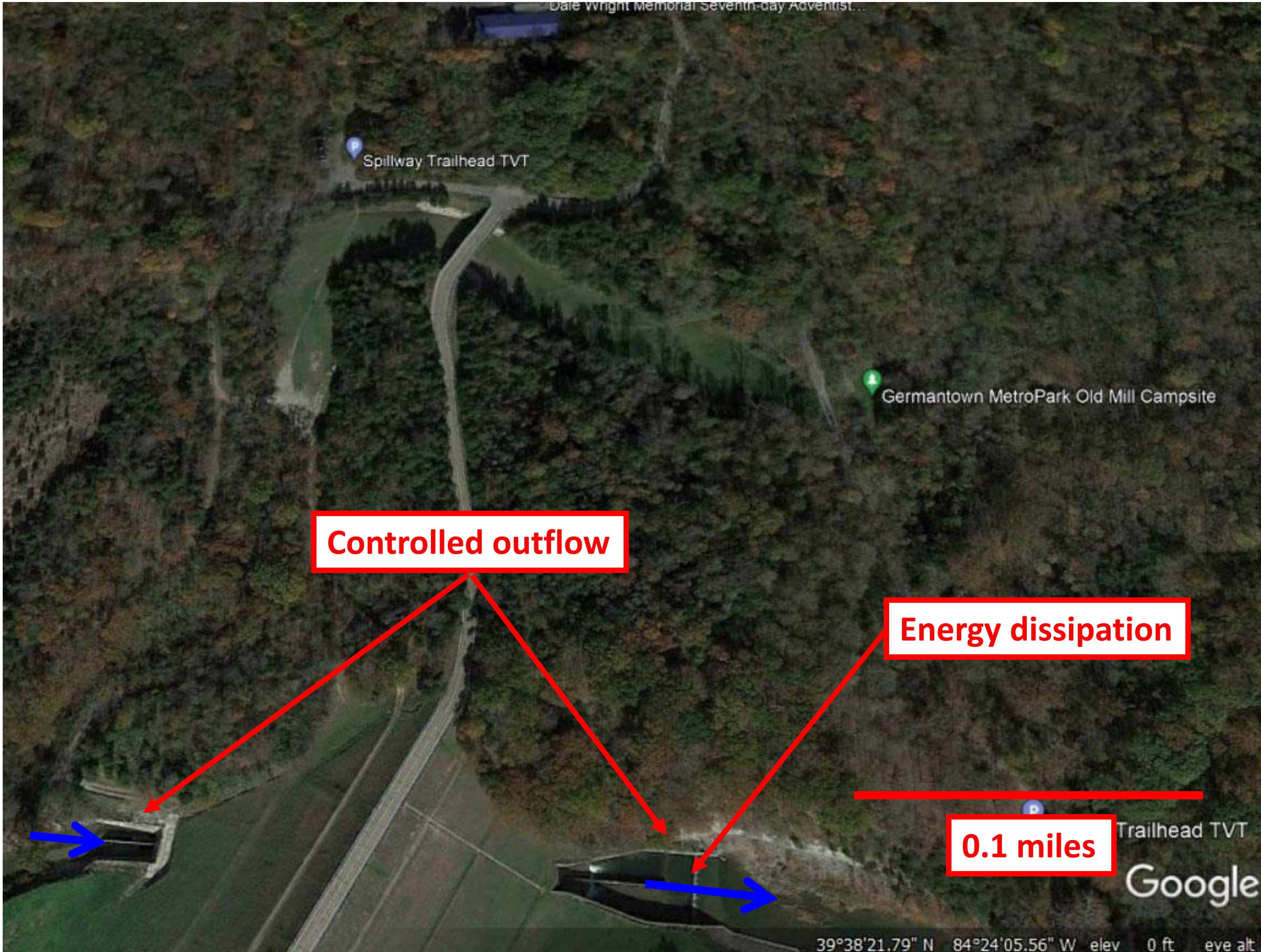
May 1984

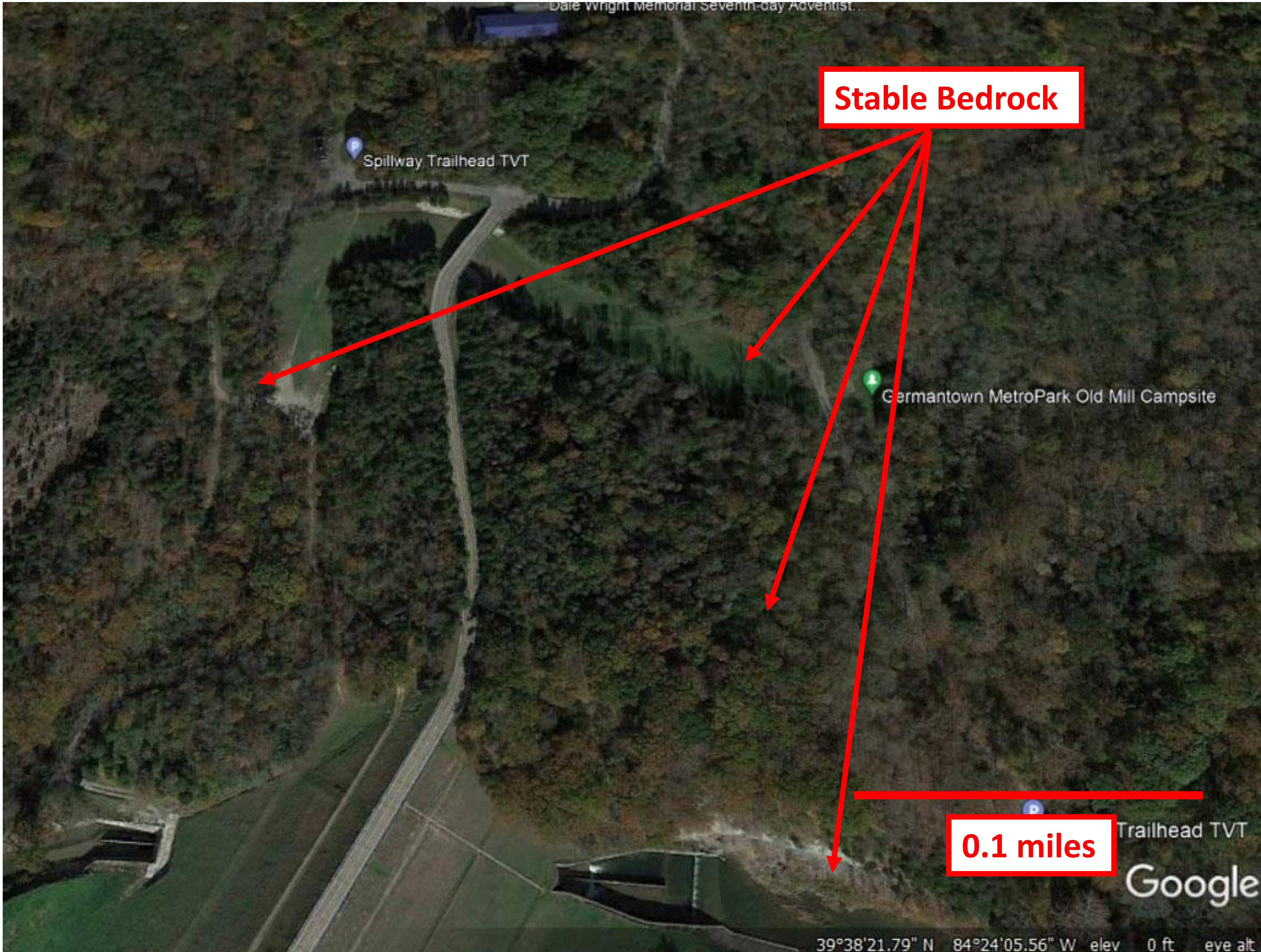




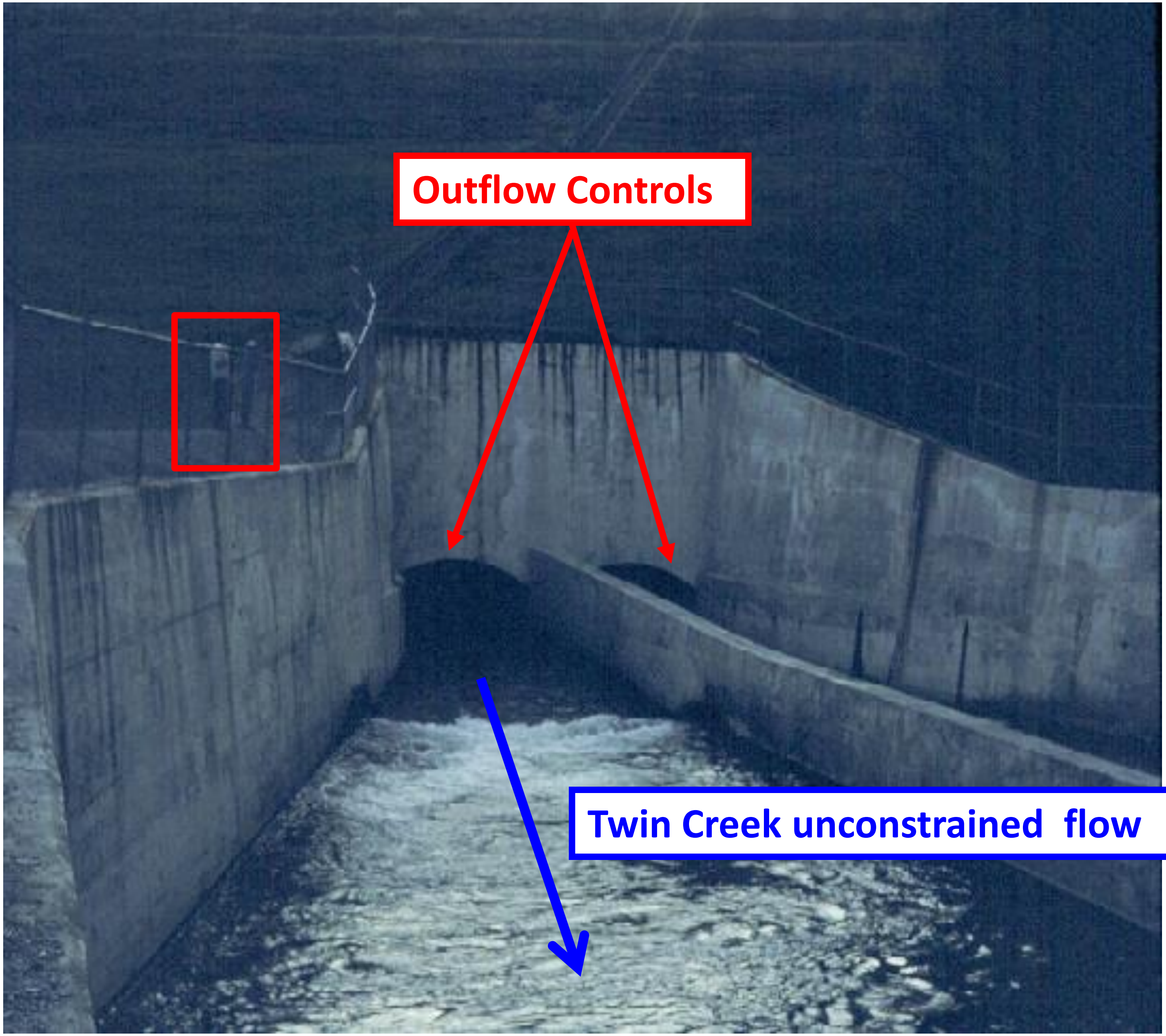
- The Miami Conservancy Project witnessed the transition from beasts of burden to mechanized transport for common earthmoving.
- The upper view shows work on the spillway for the Germantown Dam in early May 1920, using Fresno scrappers and hopper dumping wagons.
- Lower image - Shovels loading dump trucks on Great Miami River levees in Troy, Ohio

Slide courtesy of Professor J. David Rogers, Missouri University of Science & Technology


Dale Wright Memorial Seventh-day Adventist...
Spillway Trailhead TVT
Germantown MetroPark Old Mill Campsite
Controlled outflow
Energy dissipation
0.1 miles
Trailhead TVT
Google
39°38'21.79" N 84°24'05.56" W elev 0 ft eye alt

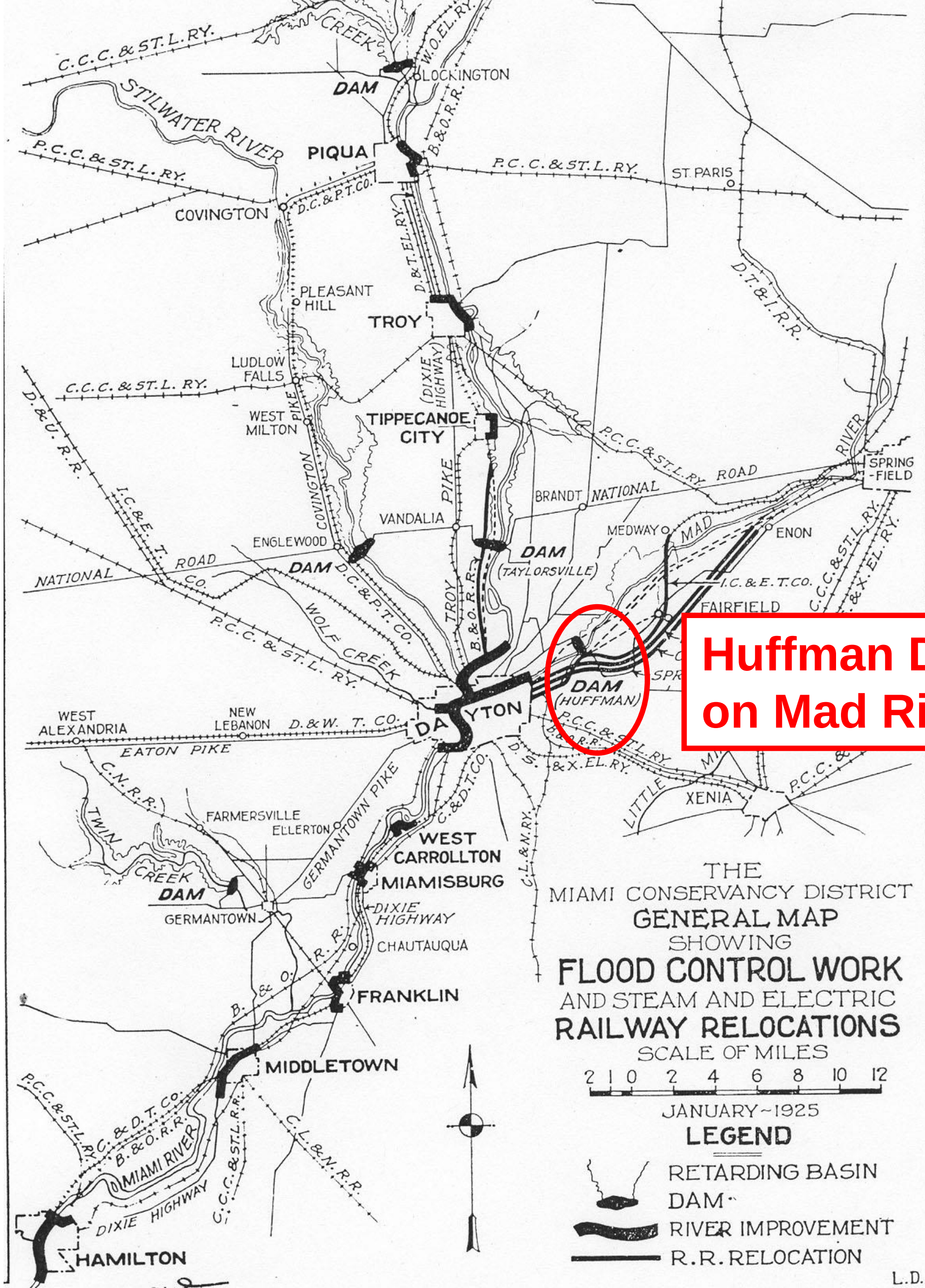


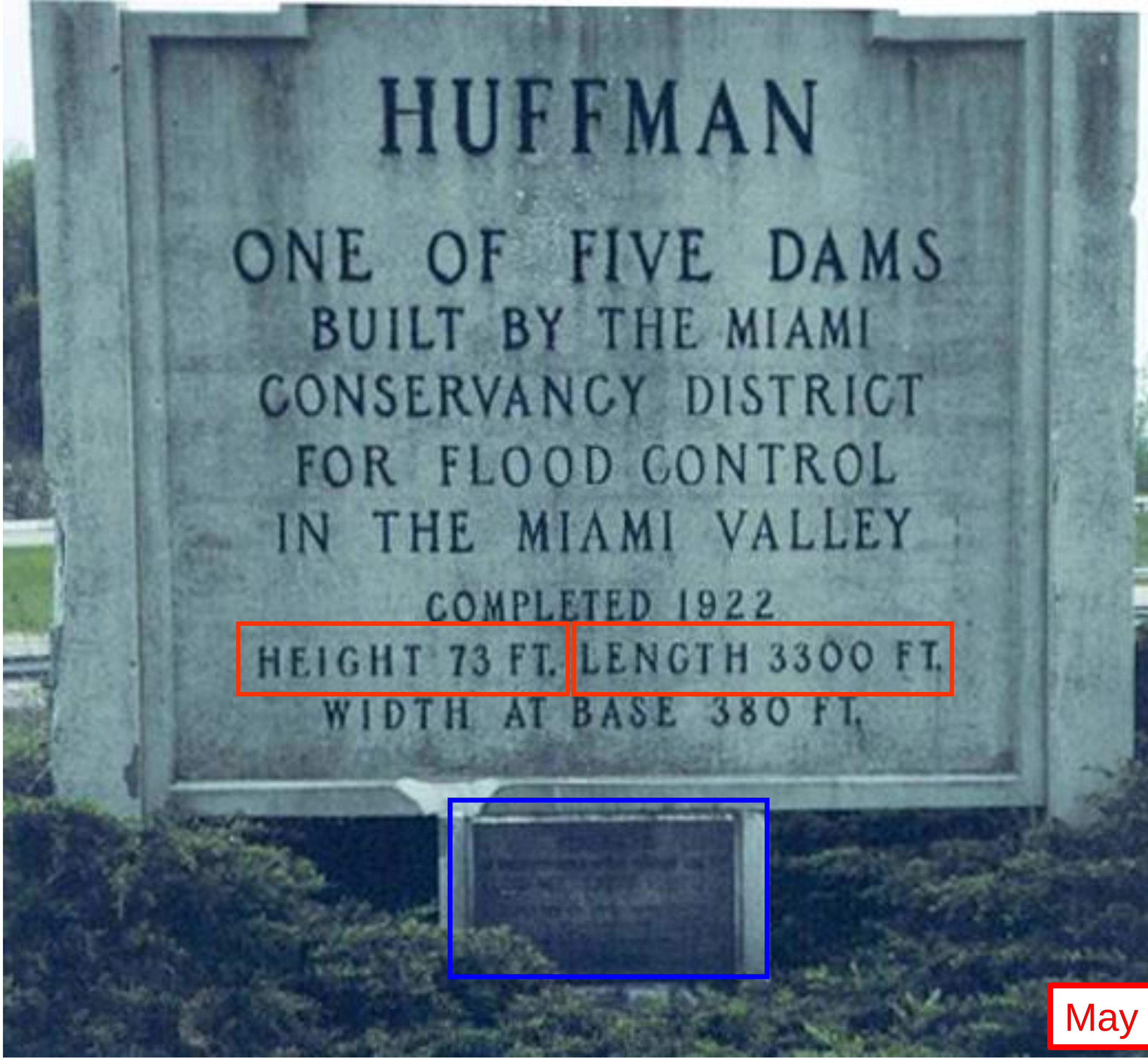
Dale Wright Memorial Seventh-day Adventist...
Stable Bedrock
Spillway Trailhead TVT
Germantown MetroPark Old Mill Campsite
0.1 miles
Trailhead TVT
Google
39°38'21.79" N 84°24'05.56" W elev 0 ft eye alt



May 1984

Huffman Dam on Mad River




HUFFMAN
ONE OF FIVE DAMS
BUILT BY THE MIAMI
CONSERVANCY DISTRICT
FOR FLOOD CONTROL
IN THE MIAMI VALLEY
COMPLETED 1922
HEIGHT 73 FT. LENGTH 3300 FT.
WIDTH AT BASE 380 FT.

May 1984

THE DAMS

OF THE MIAMI CONSERVANCY DISTRICT ARE FOR

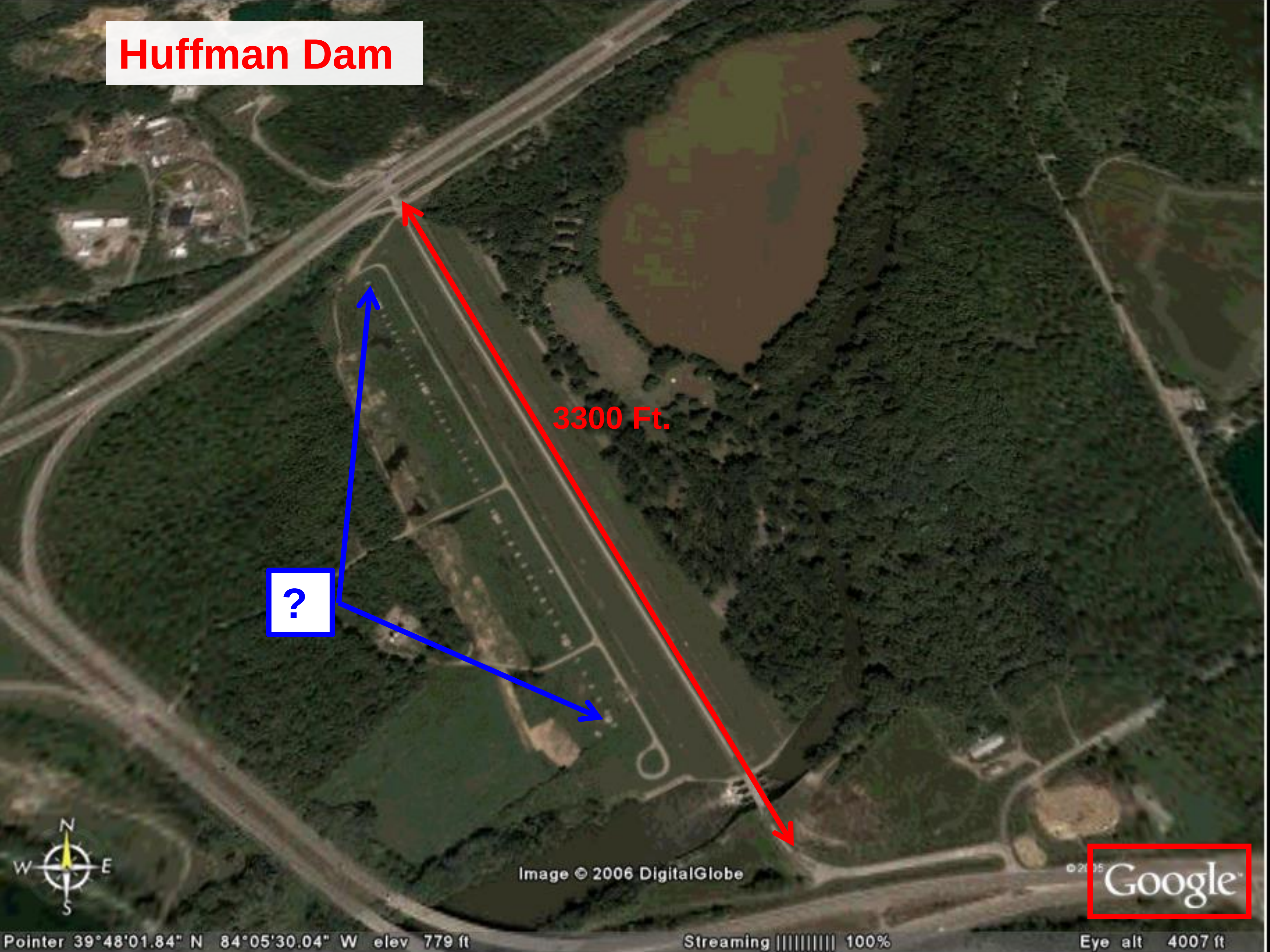
FLOOD PREVENTION PURPOSES

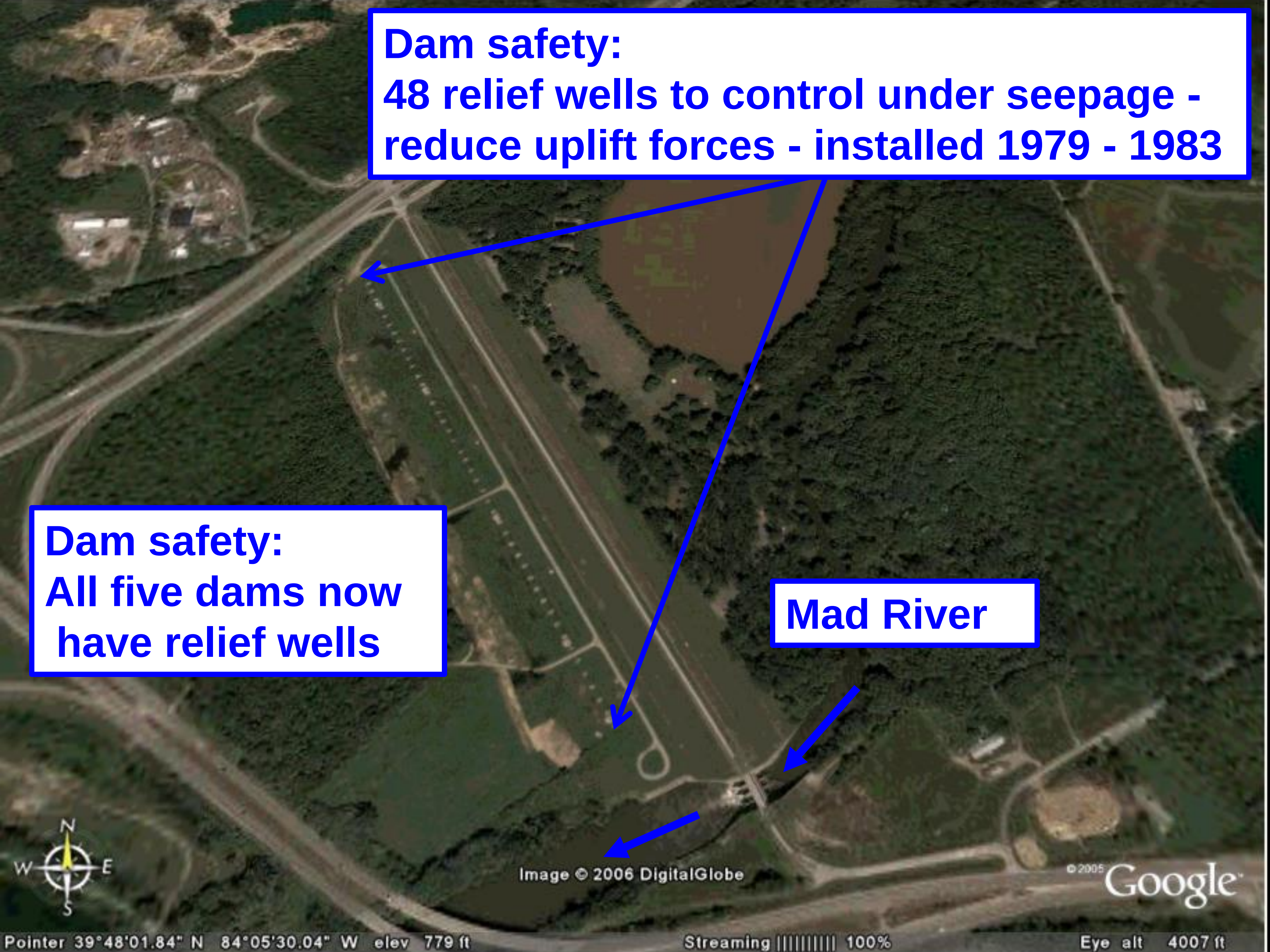
THEIR USE FOR POWER DEVELOPMENT

OR FOR STORAGE

WOULD BE A MENACE

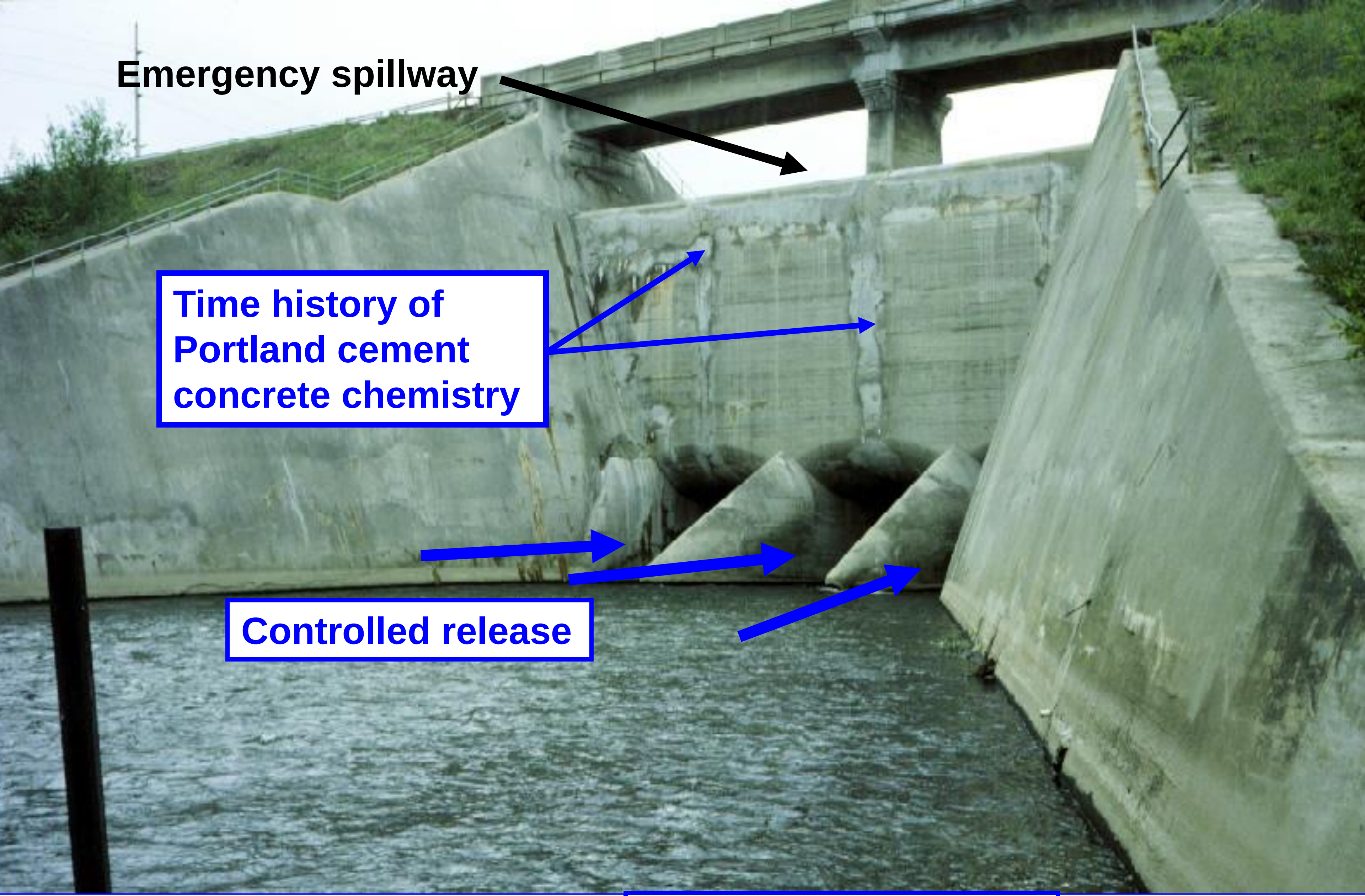
TO THE CITIES BELOW


Huffman Dam
3300 Ft.
?
N
W
E
S
Image © 2006 DigitalGlobe
Google
Pointer 39°48'01.84" N 84°05'30.04" W elev 779 ft
Streaming |||||||||| 100%
Eye alt 4007 ft


Dam safety:
48 relief wells to control under seepage - reduce uplift forces - installed 1979 - 1983
Dam safety:
All five dams now have relief wells
Mad River
Image © 2006 DigitalGlobe
©2005 Google
Pointer 39°48'01.84" N 84°05'30.04" W elev 779 ft
Streaming |||||||||| 100%
Eye alt 4007 ft

Unconstrained Mad River flow – Huffman Dam Outlet works

May 1984

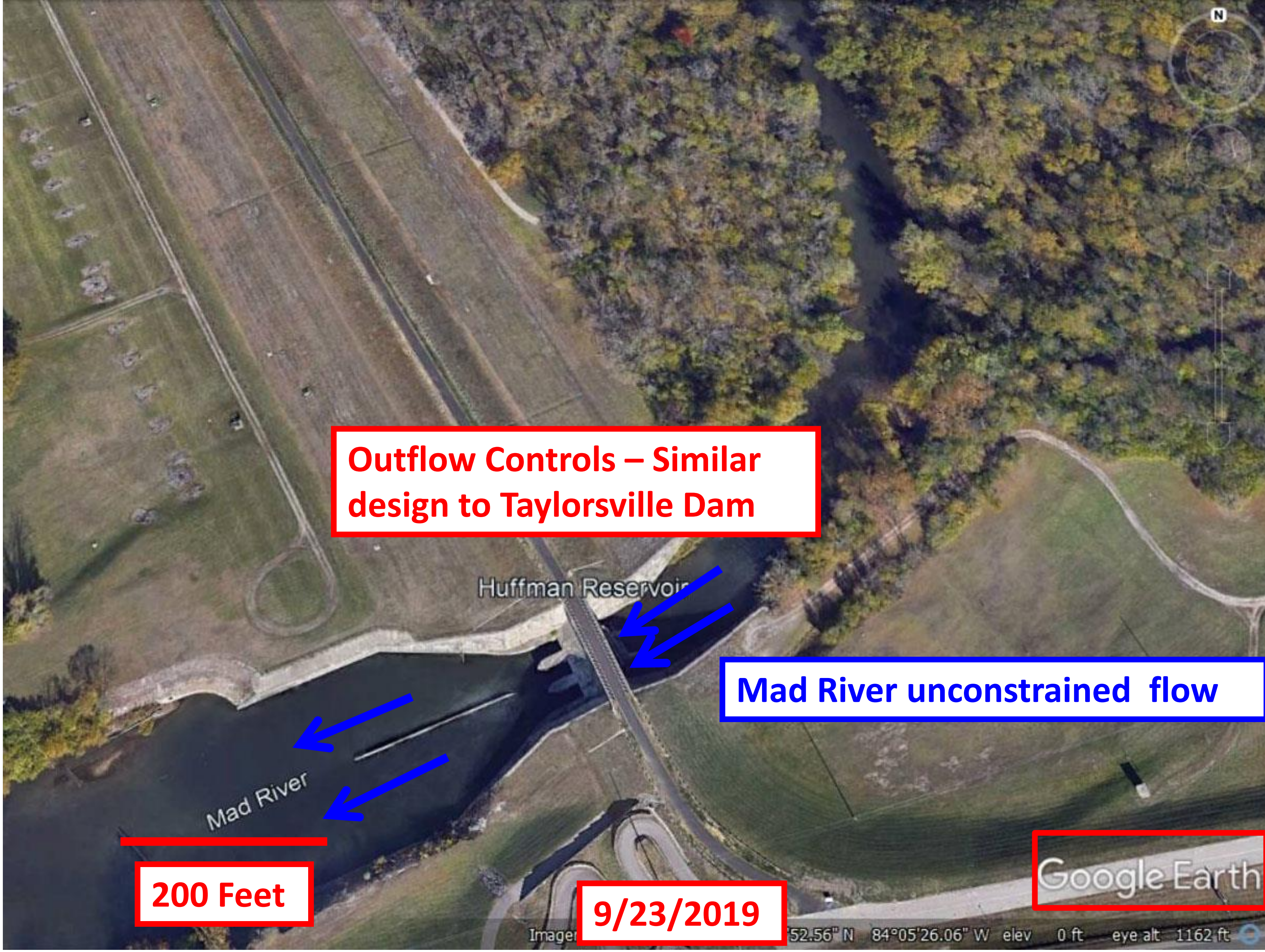


Huffman Dam Outlet works – Hydrodynamic Design

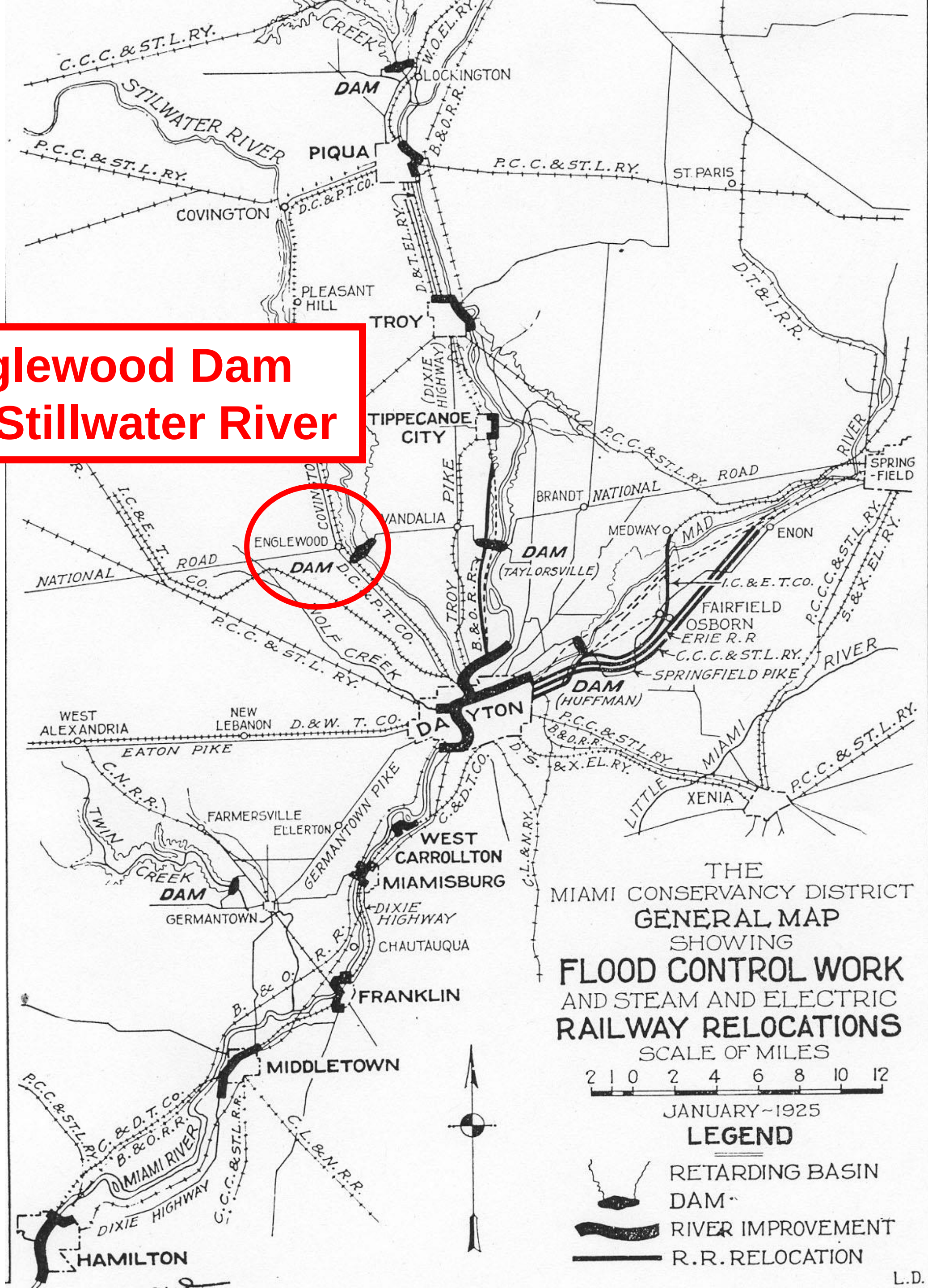
May 1984

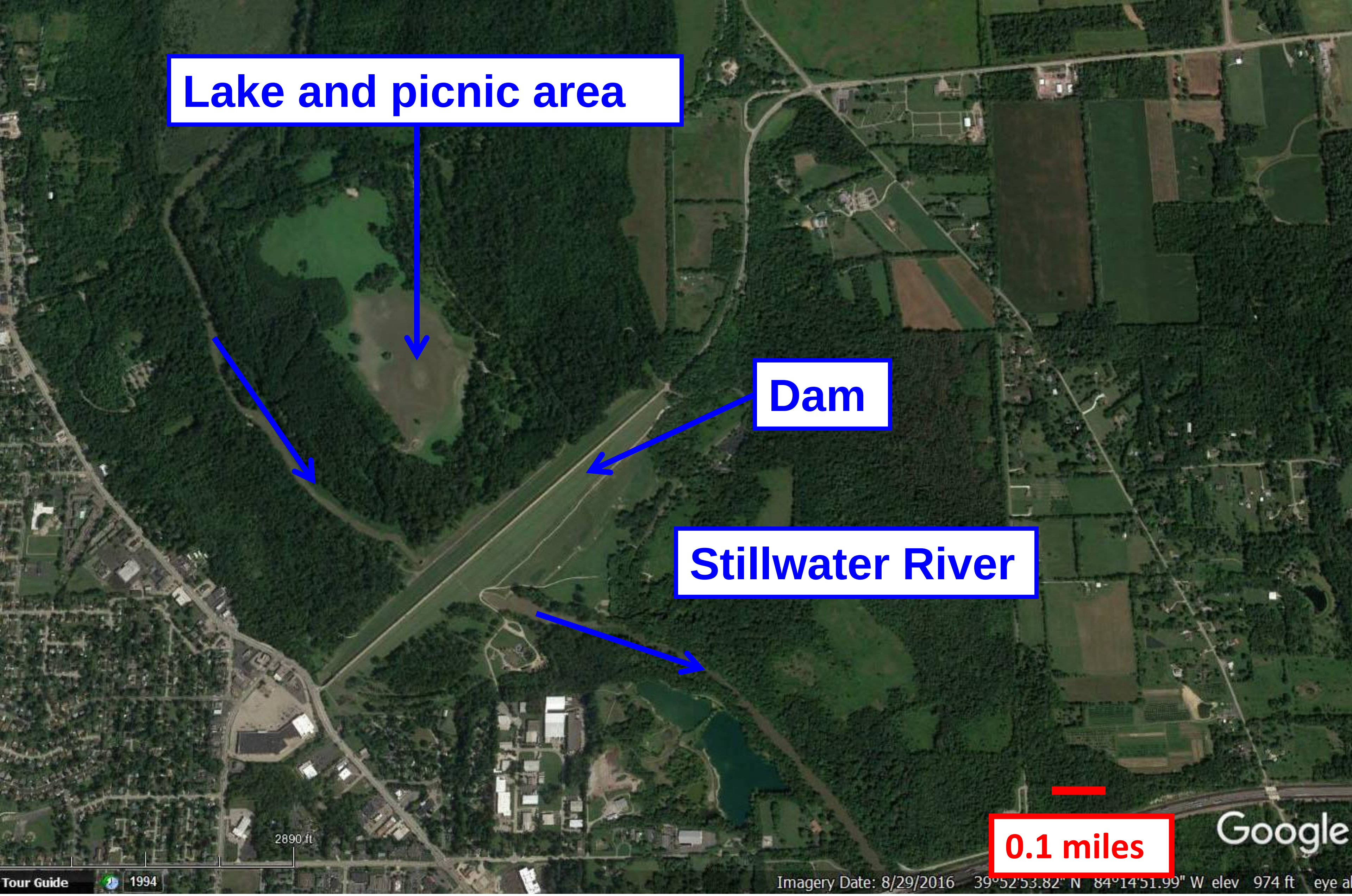
Hydraulically efficient divided outlet flow

May 1984

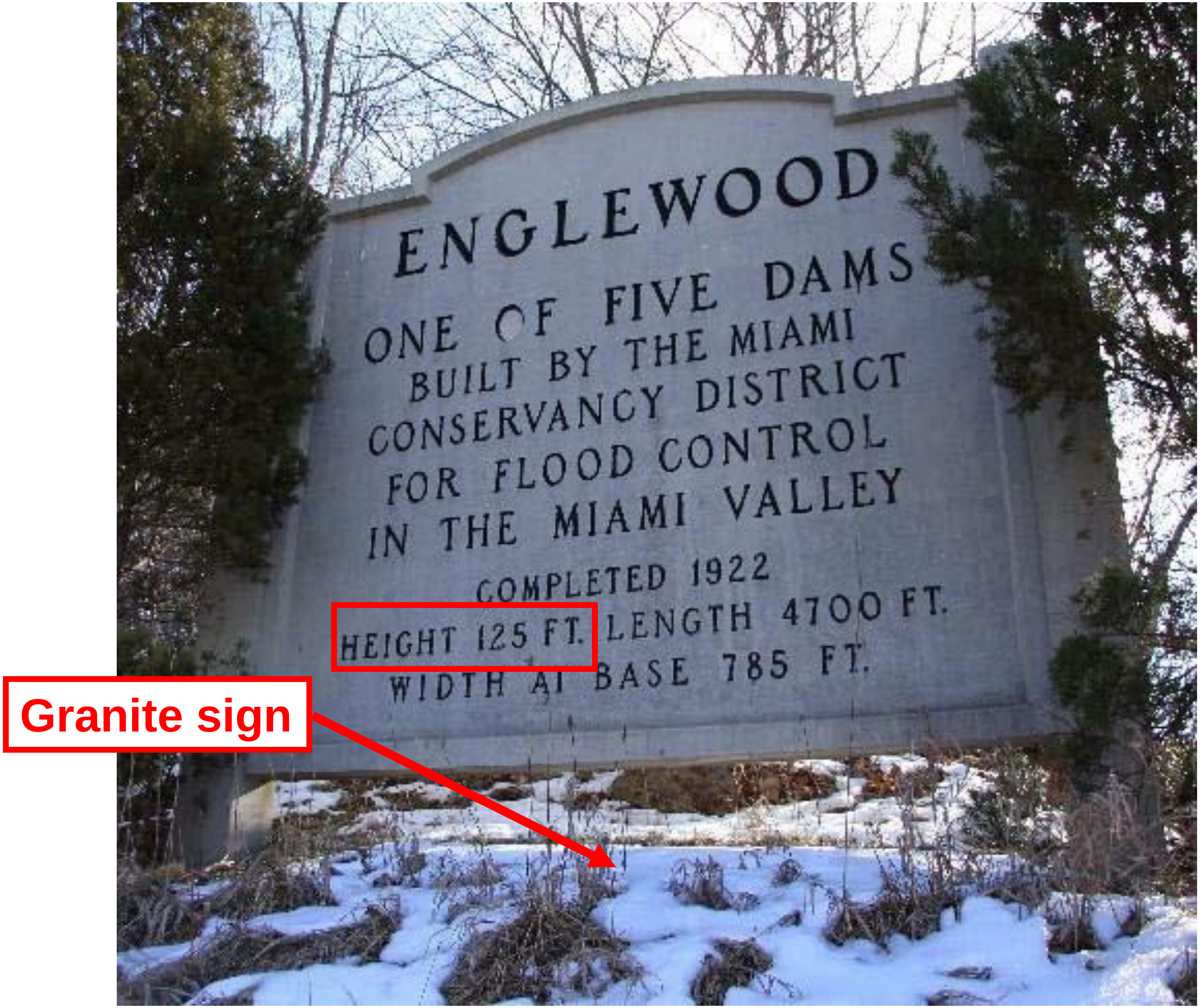

Outflow Controls – Similar design to Taylorsville Dam
Huffman Reservoir
Mad River unconstrained flow
Mad River
200 Feet
9/23/2019
Google Earth
84°05'26.06" W elev 0 ft eye alt 1162 ft

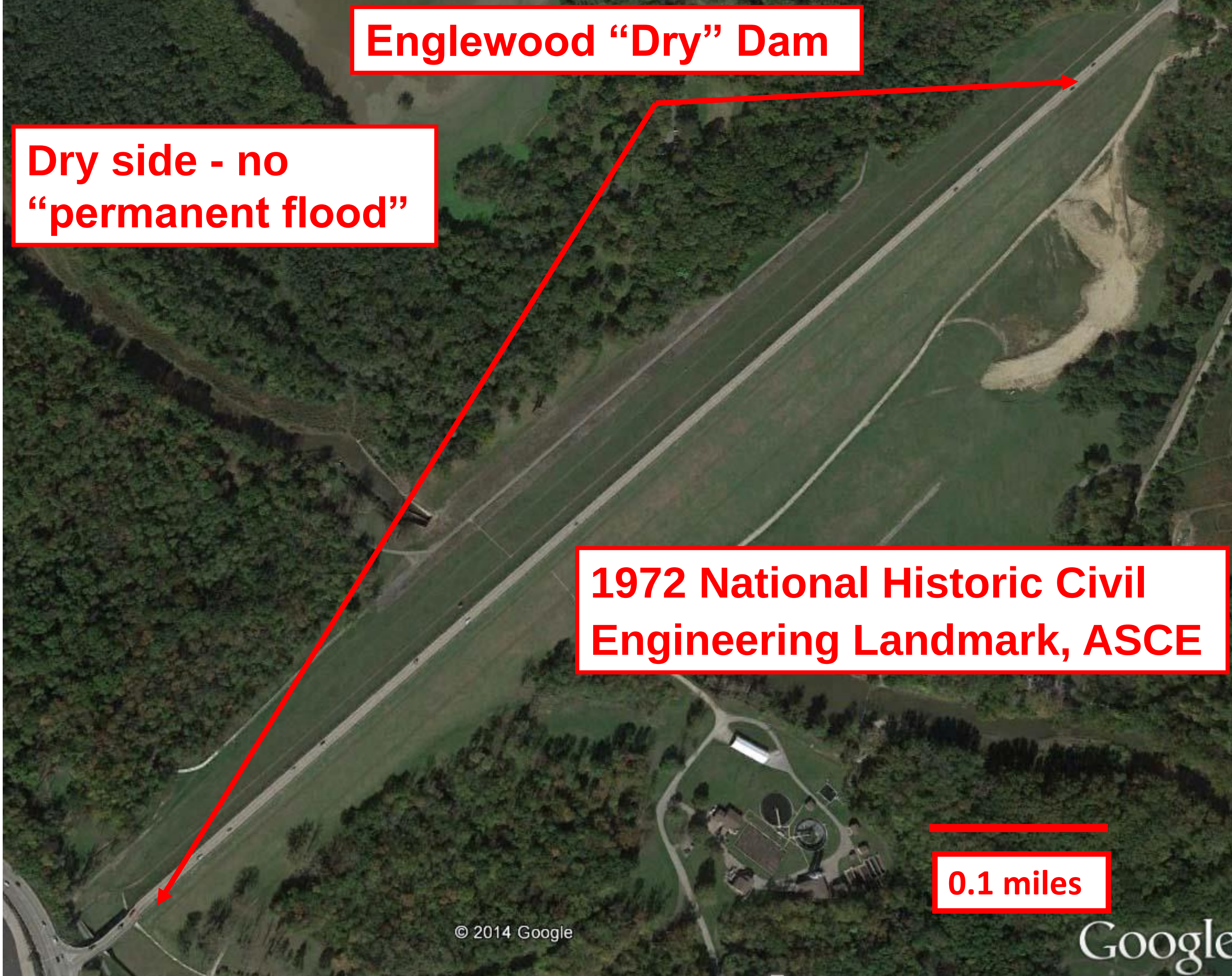
Englewood Dam on Stillwater River

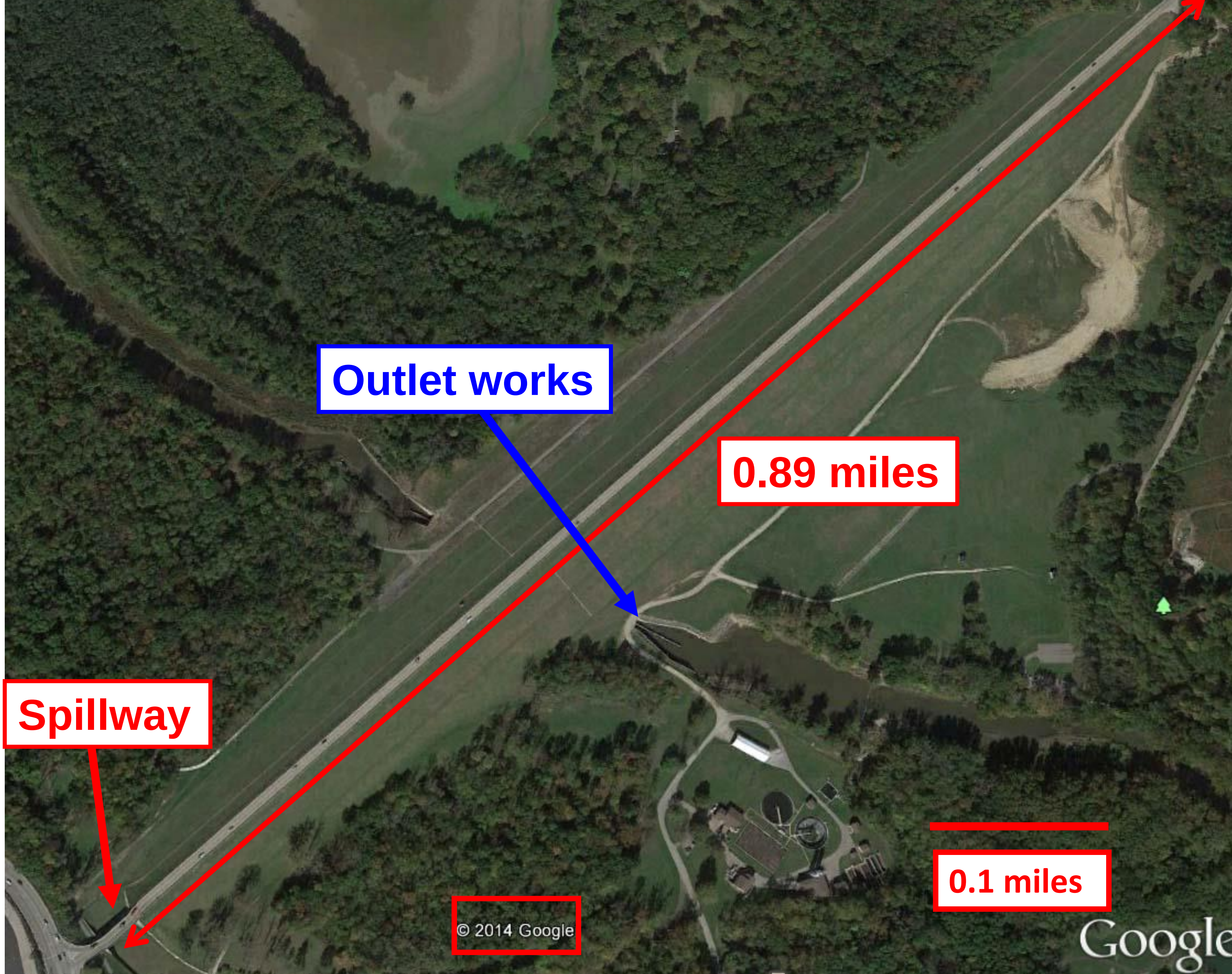


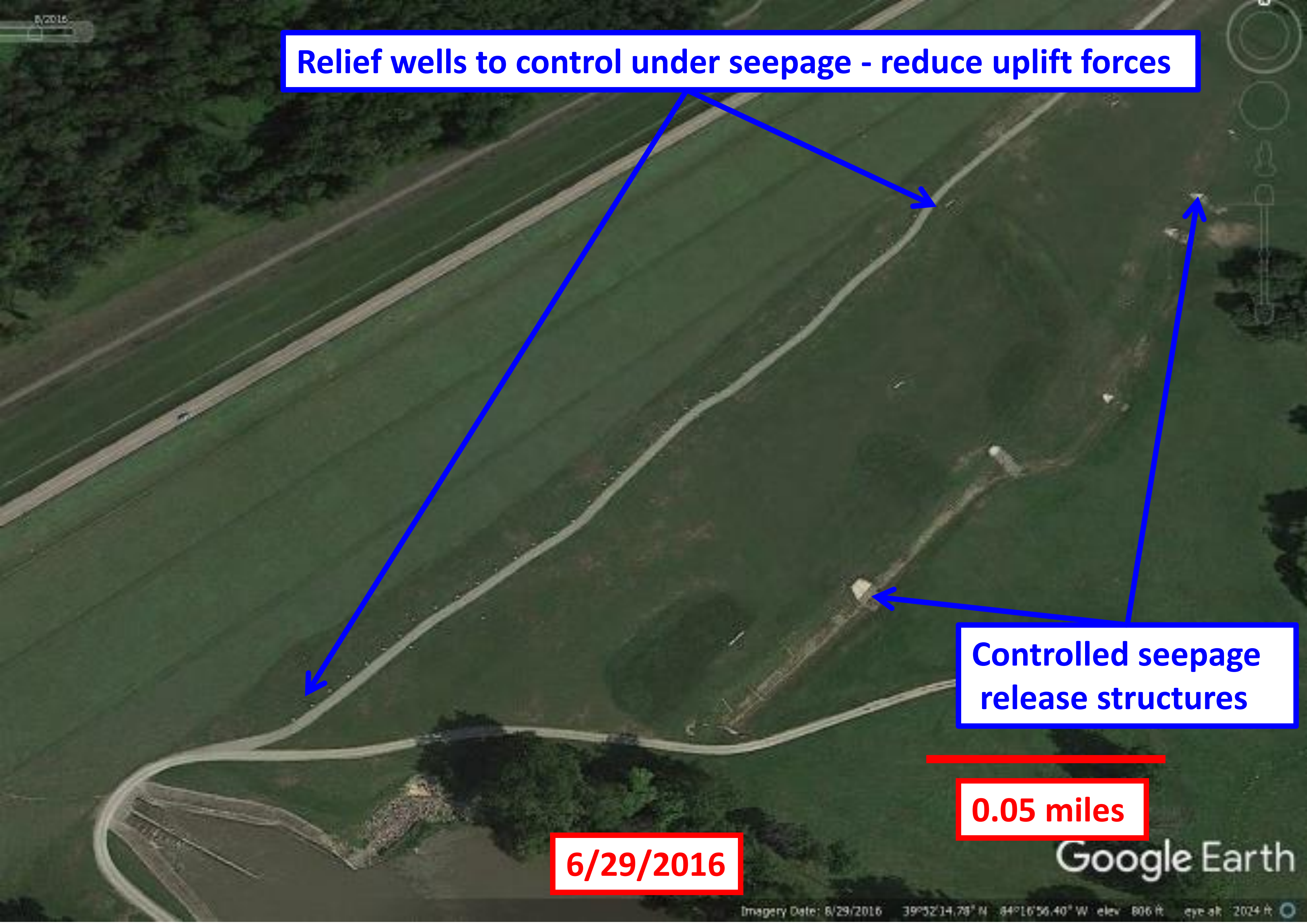


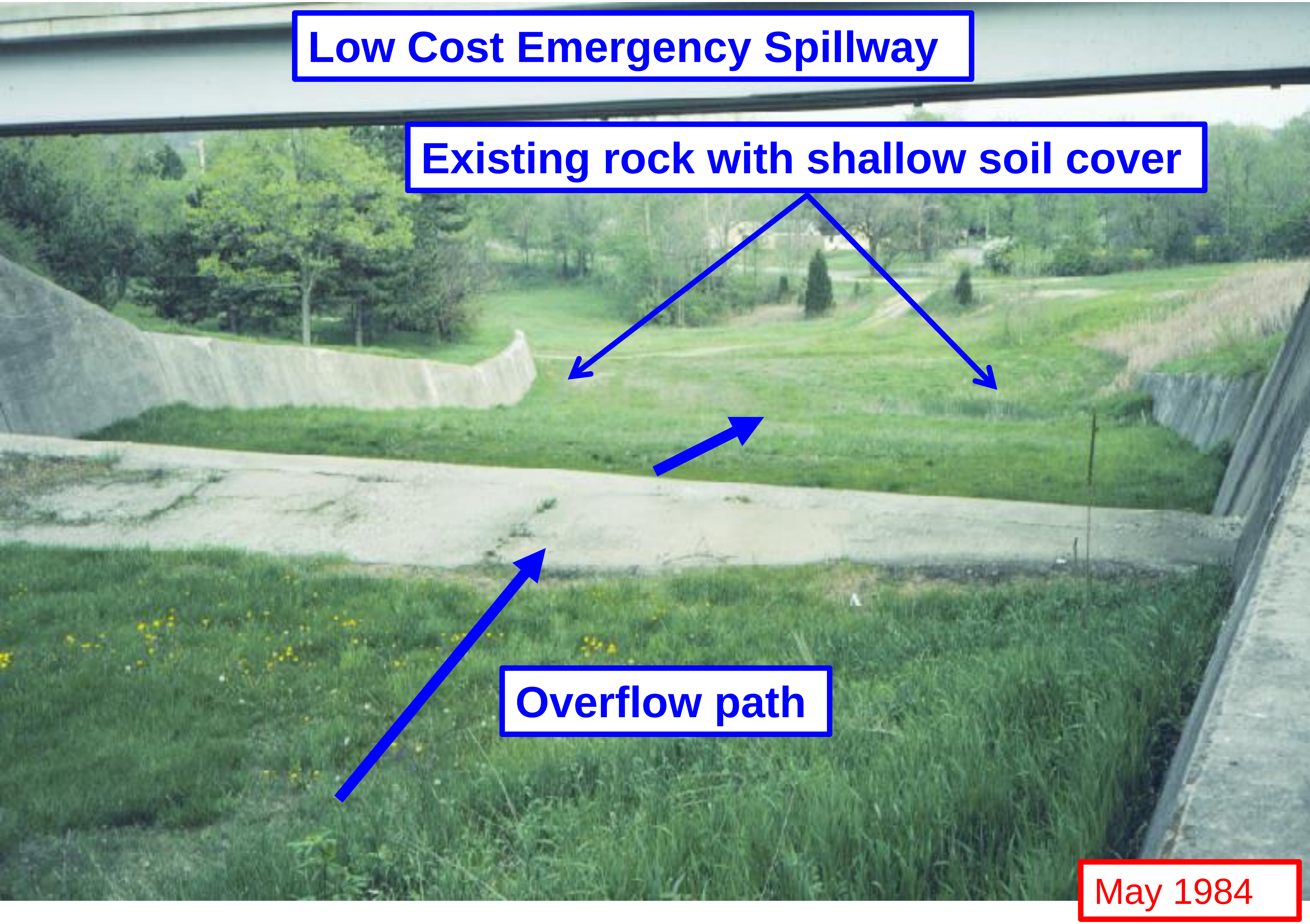
Englewood Dam and region

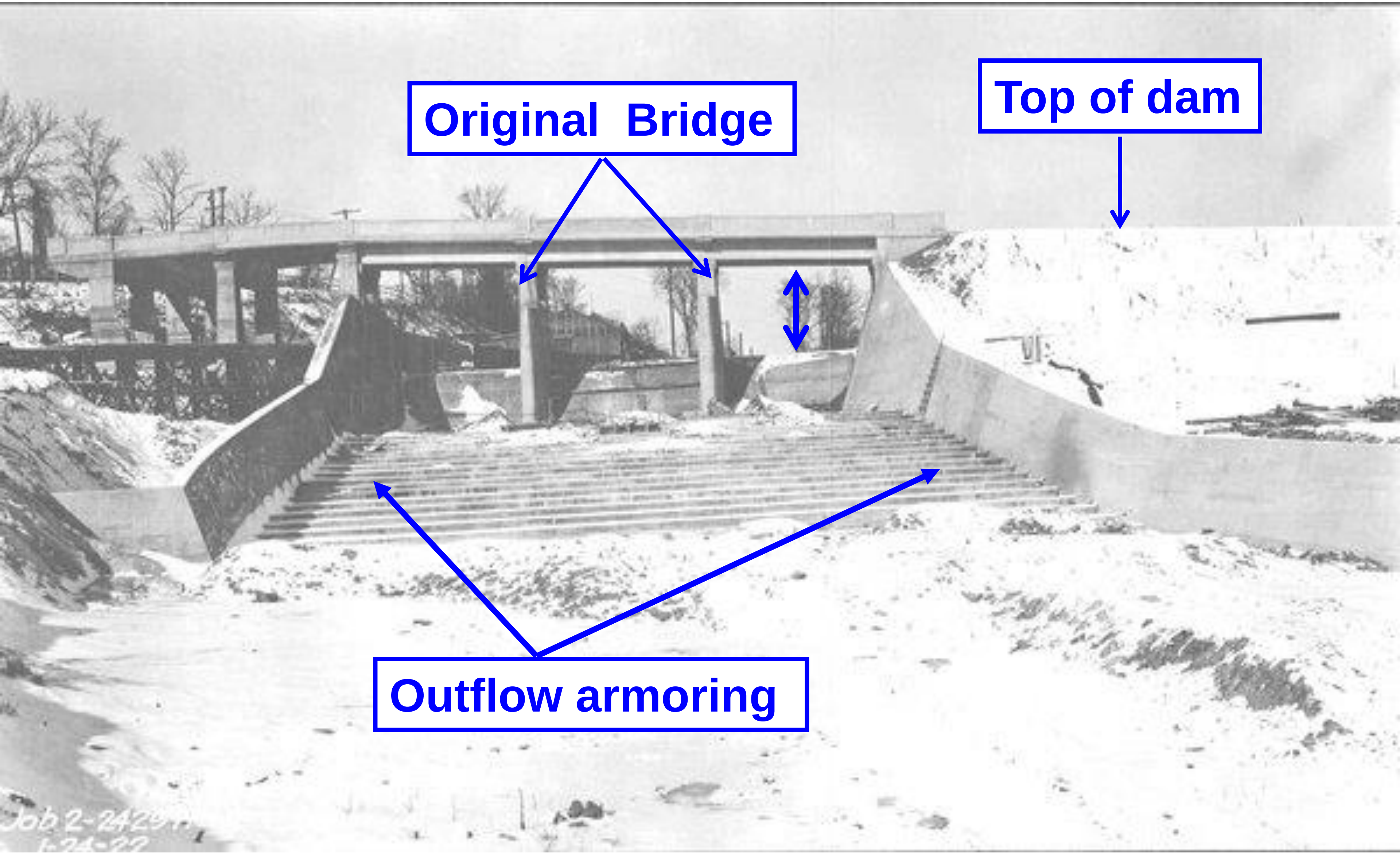

ENGLEWOOD
ONE OF FIVE DAMS
BUILT BY THE MIAMI
CONSERVANCY DISTRICT
FOR FLOOD CONTROL
IN THE MIAMI VALLEY
COMPLETED 1922
HEIGHT 125 FT. LENGTH 4700 FT.
WIDTH AT BASE 785 FT.
Granite sign

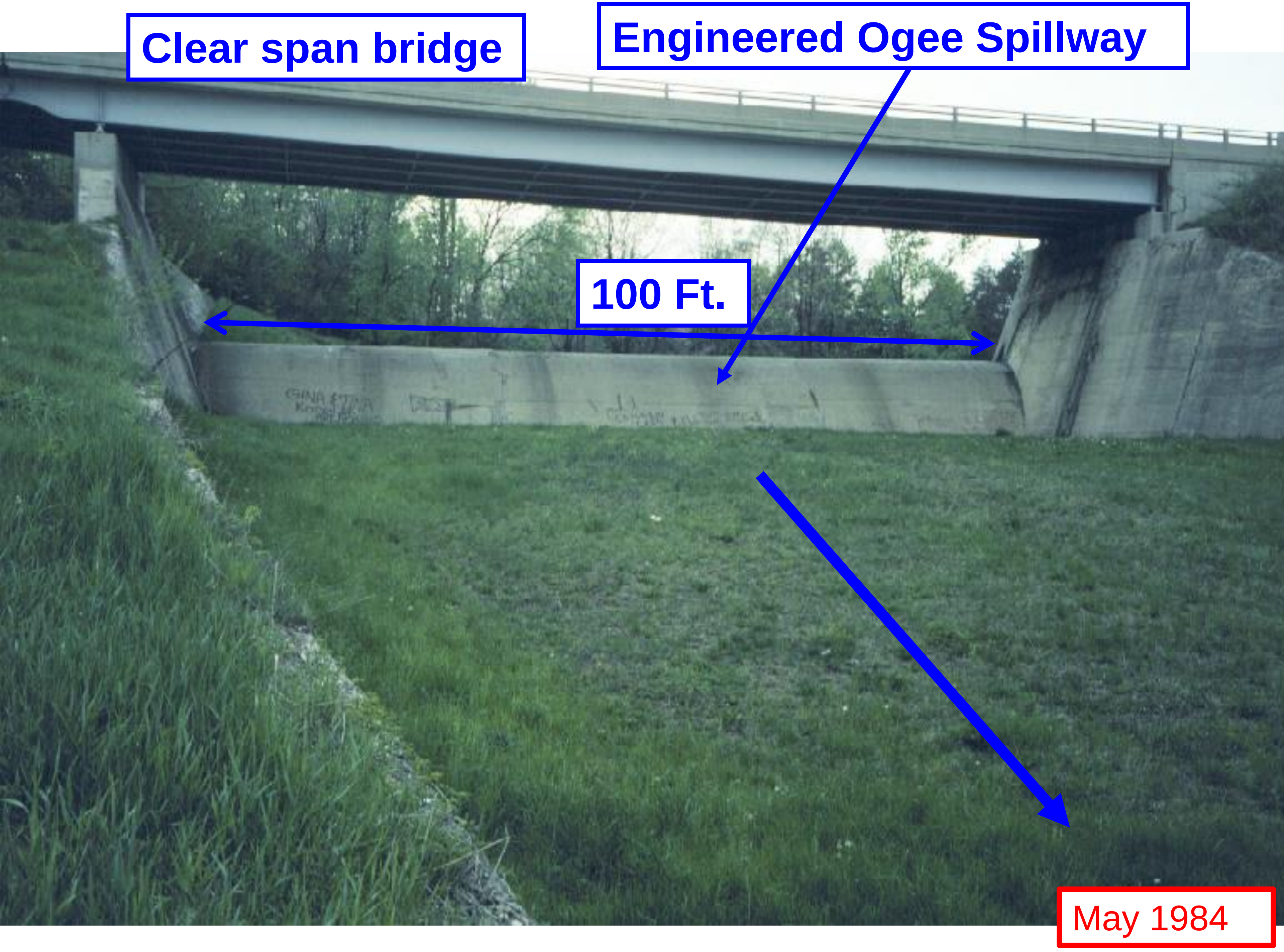

Englewood "Dry" Dam
Dry side - no "permanent flood"
1972 National Historic Civil Engineering Landmark, ASCE
0.1 miles
© 2014 Google
Google

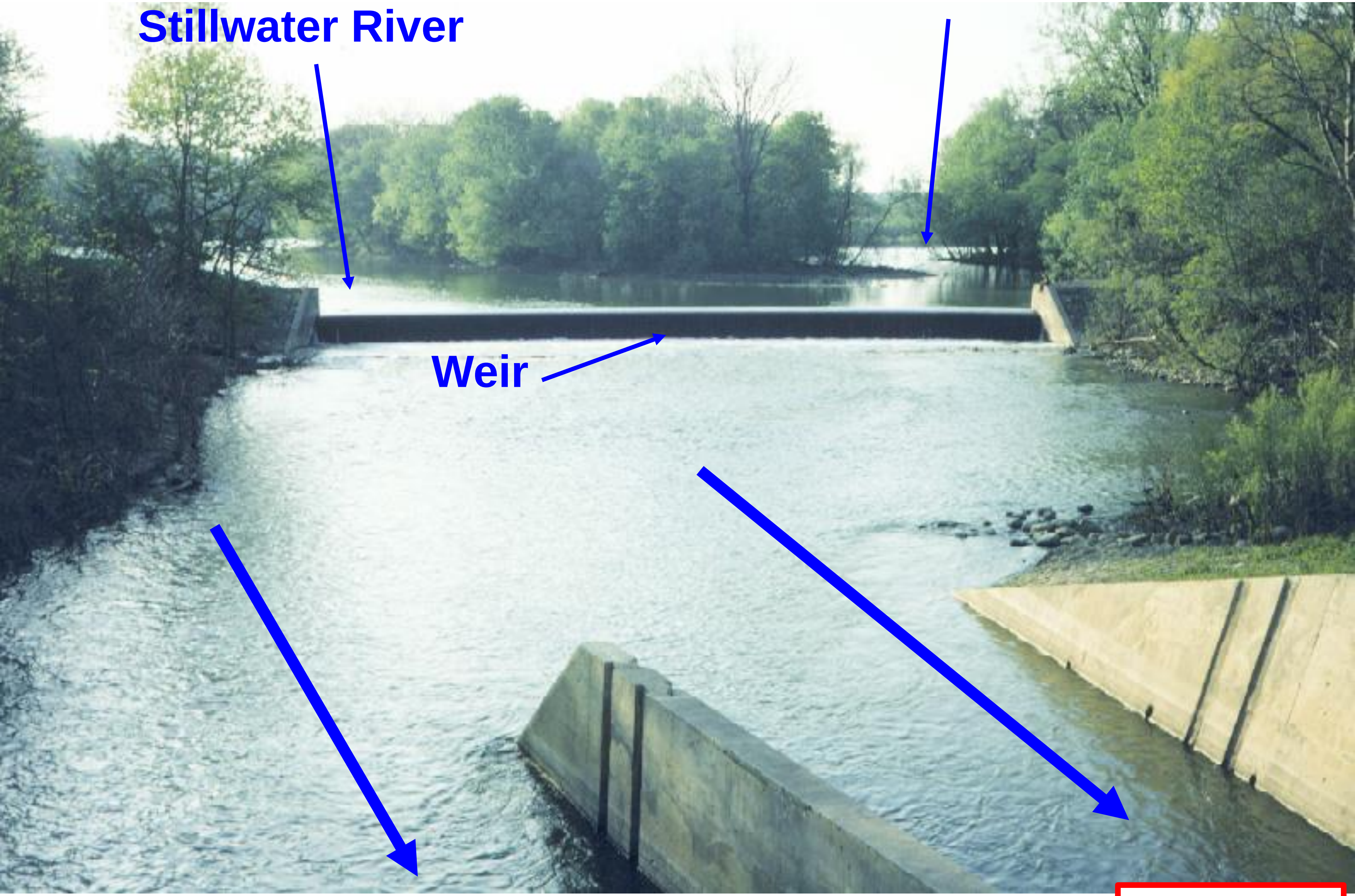

Outlet works
0.89 miles
Spillway
0.1 miles
© 2014 Google
Google


Relief wells to control under seepage - reduce uplift forces
Controlled seepage release structures
0.05 miles
6/29/2016
Google Earth


Low Cost Emergency Spillway
Existing rock with shallow soil cover
Overflow path
May 1984

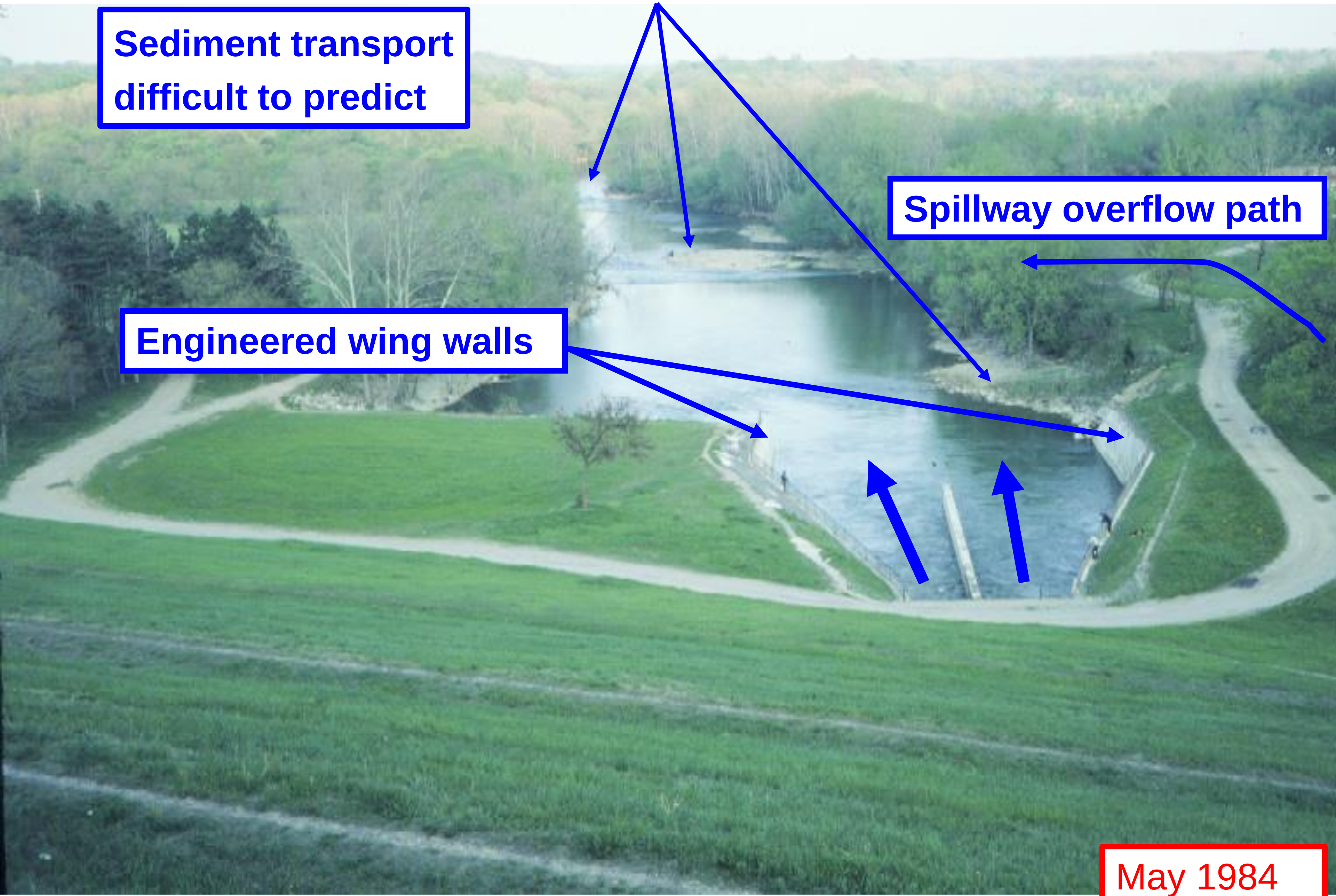

Original Bridge
Top of dam
Outflow armoring


Clear span bridge
Engineered Ogee Spillway
100 Ft.
May 1984

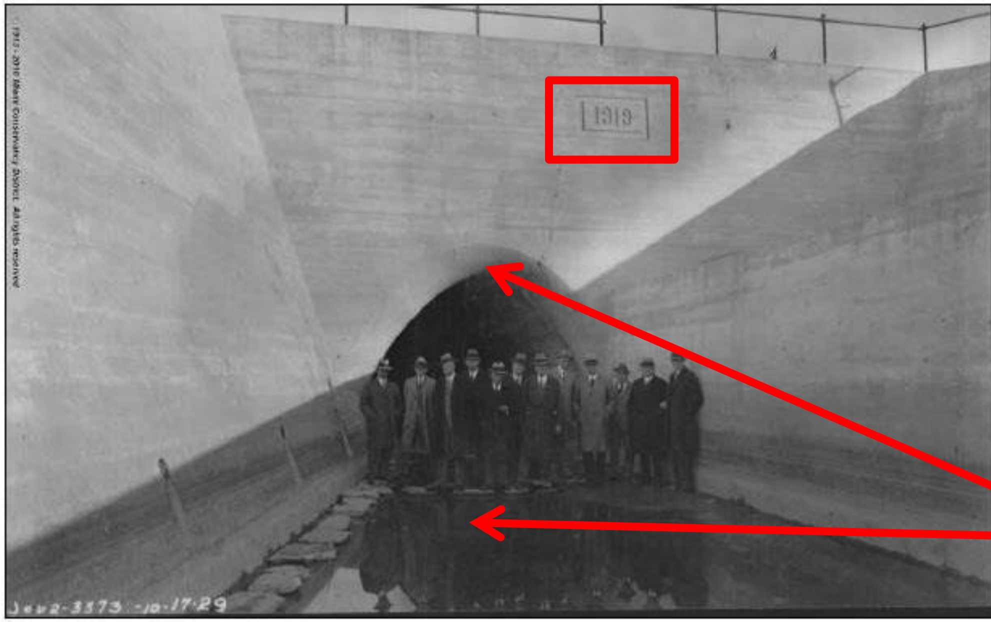


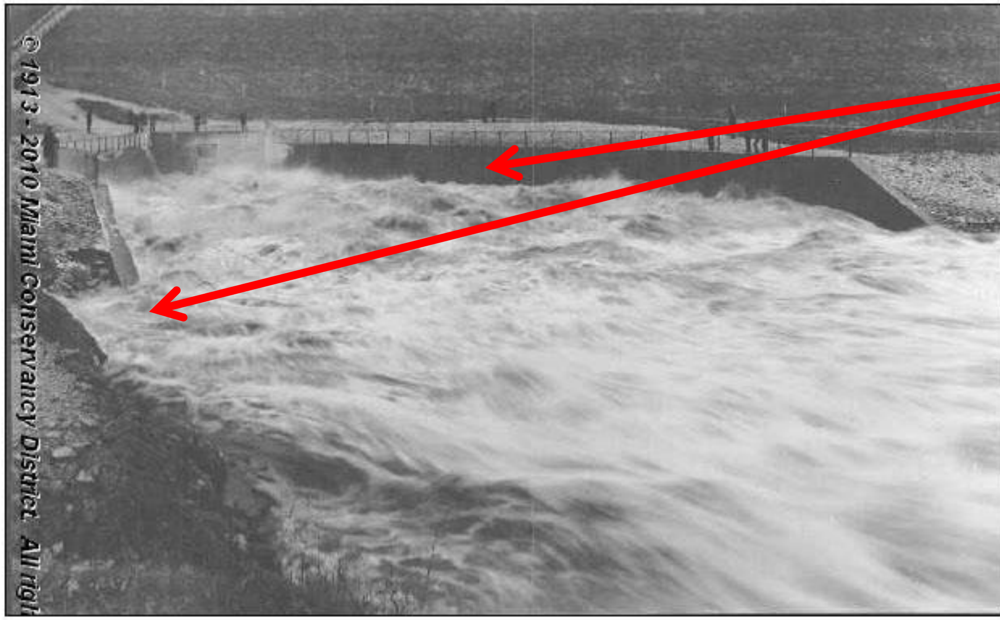
May 1984

Gravel Bed Stillwater River



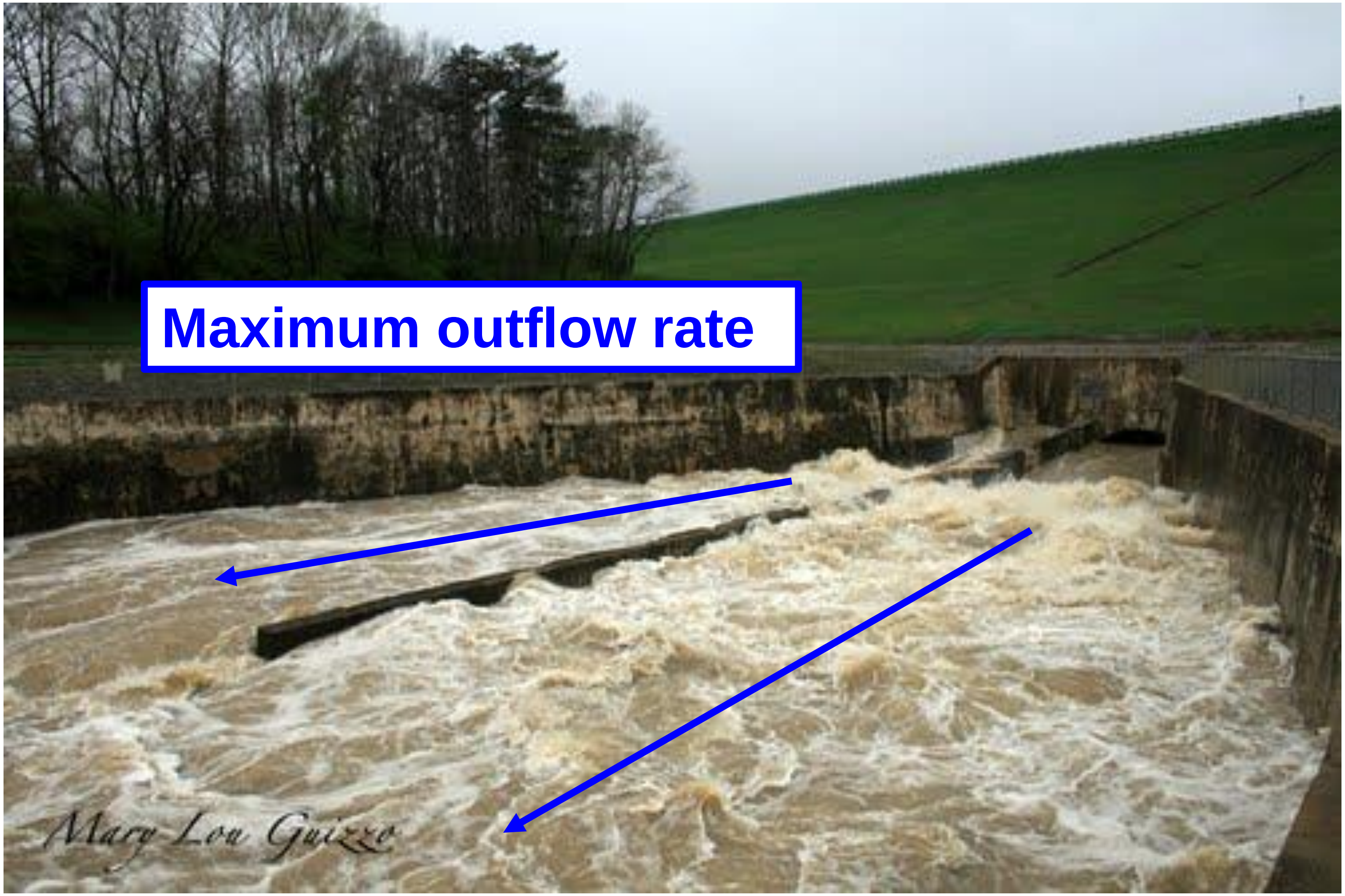
Englewood Dam Outlet





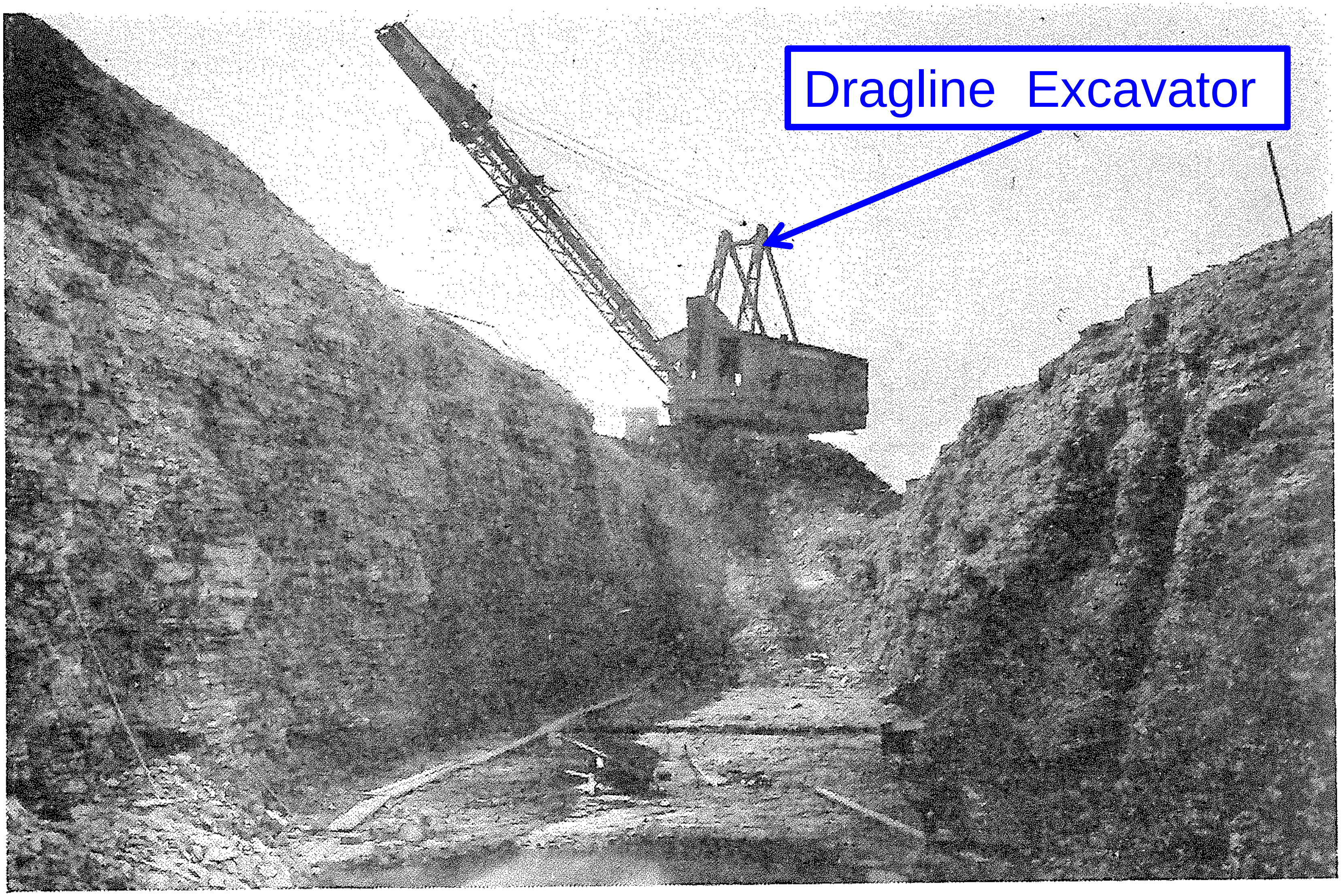
- The pass-through discharge outlet through Englewood Dam in 1929 (above) and during a flood event in January 1930 (lower)
- The critical elements of the five dams/detention basins were intended to function without human intervention

Slide courtesy of Professor J. David Rogers, Missouri University of Science & Technology

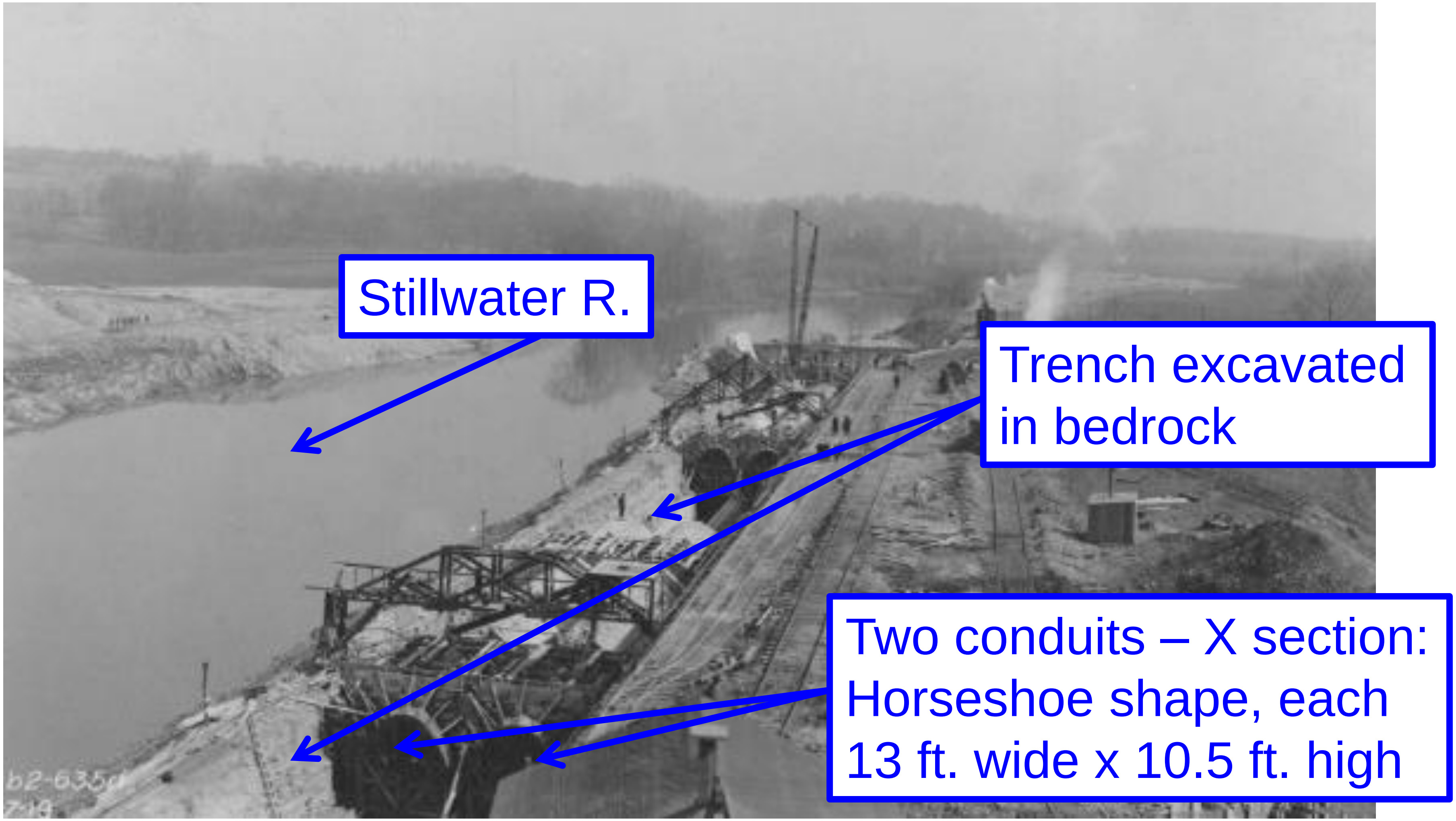


Maximum outflow rate
Mary Lou Guizze

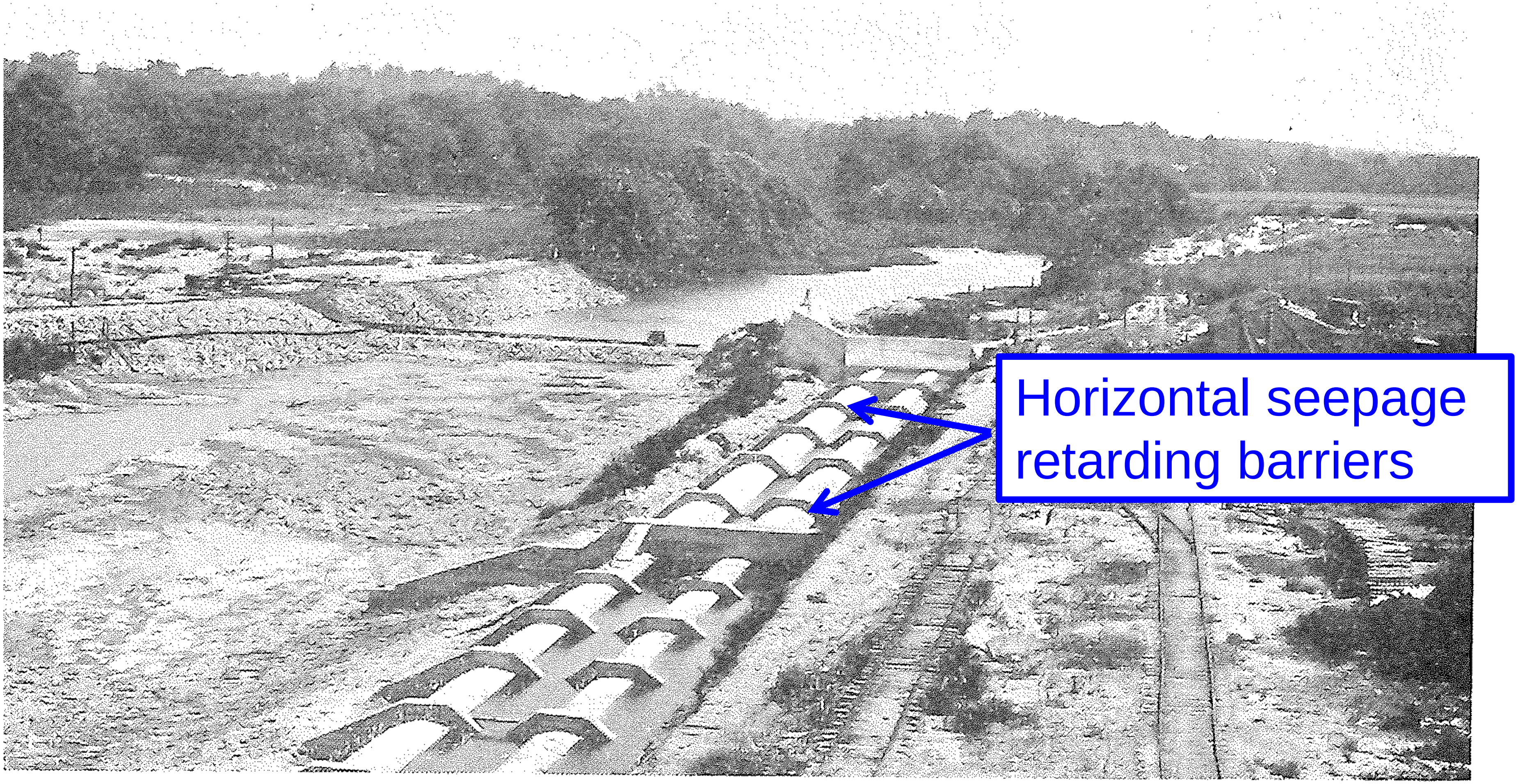
Englewood Dam construction



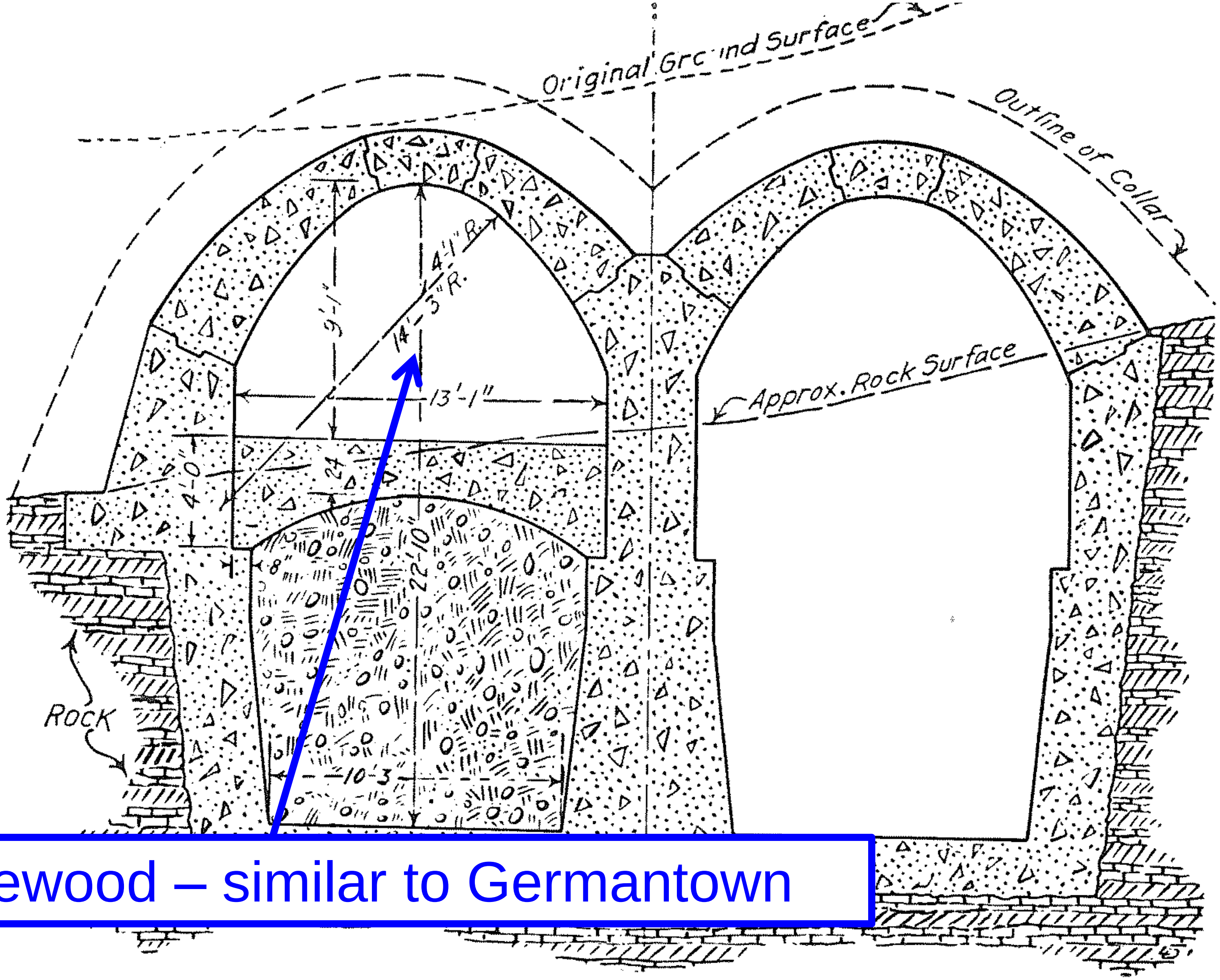
Rock excavation for outlet conduits at Englewood Dam.



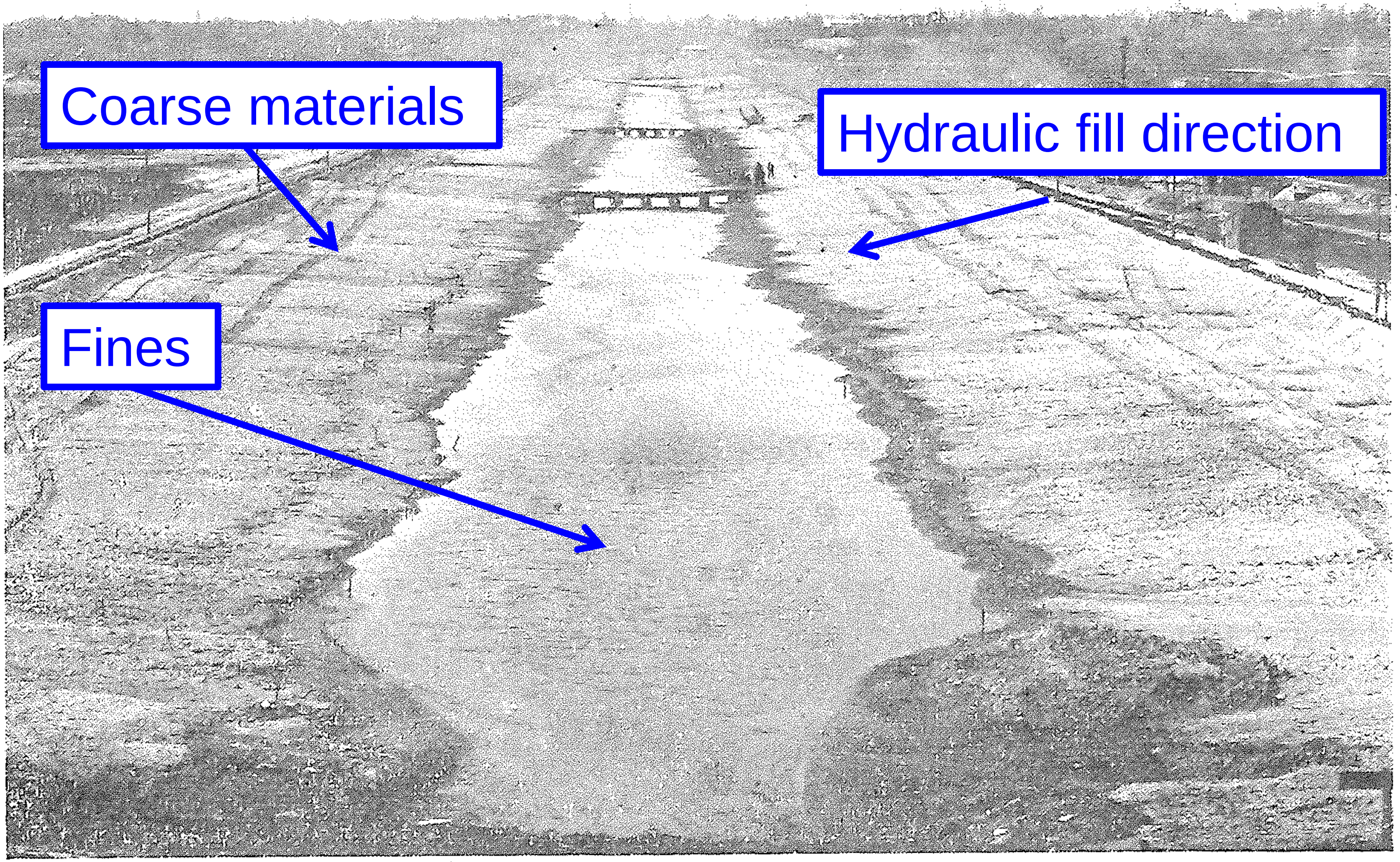
Conduits at Englewood Dam under construction



Conduits at Englewood Dam ready for dam to be built over them.

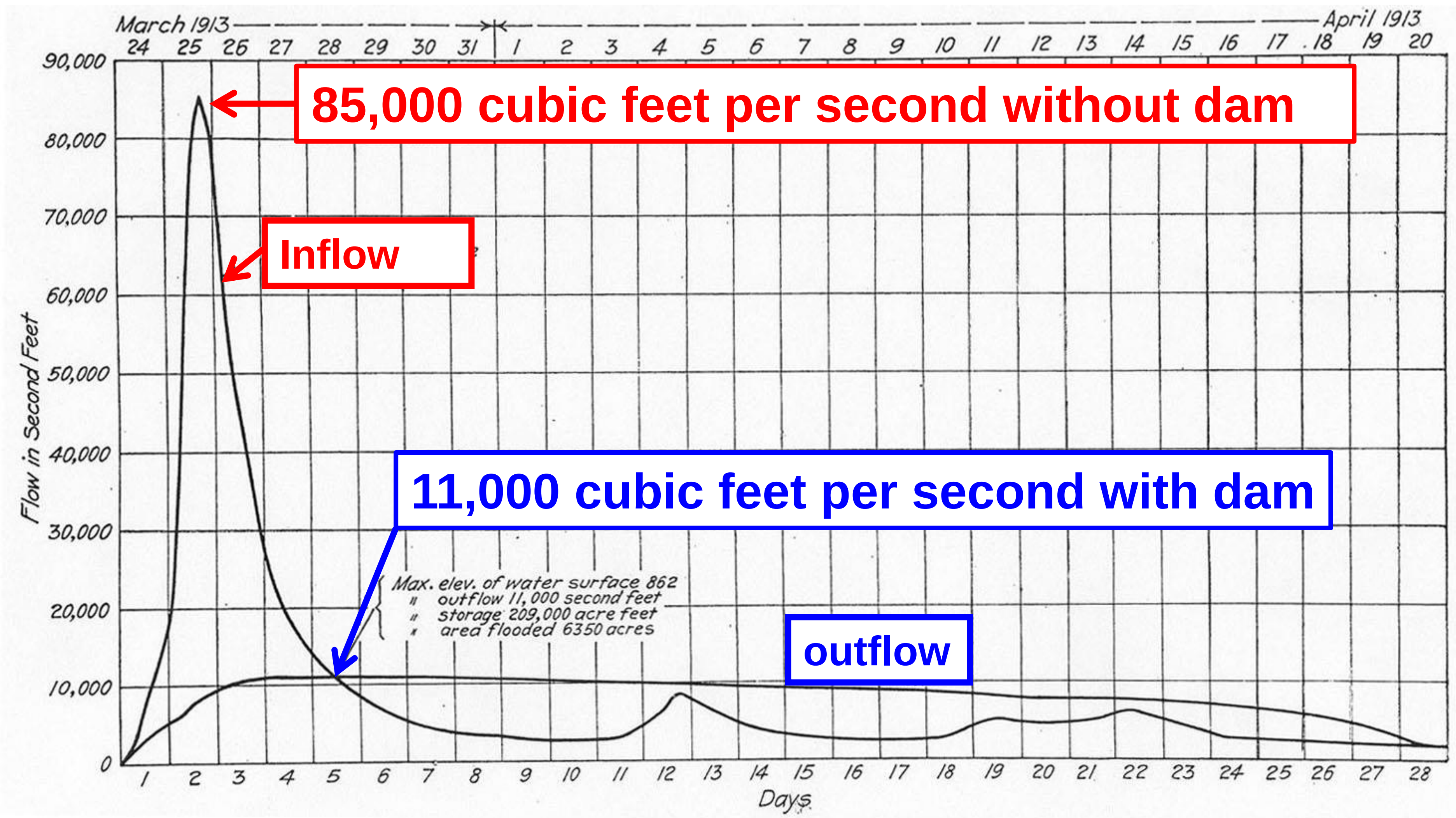


Section through Germantown Dam outlet conduits. The conduit on the right shows the large-capacity opening built to safeguard the dam during the construction period. On the left is shown the final form, with restricted opening required for the proper operation of the basin.

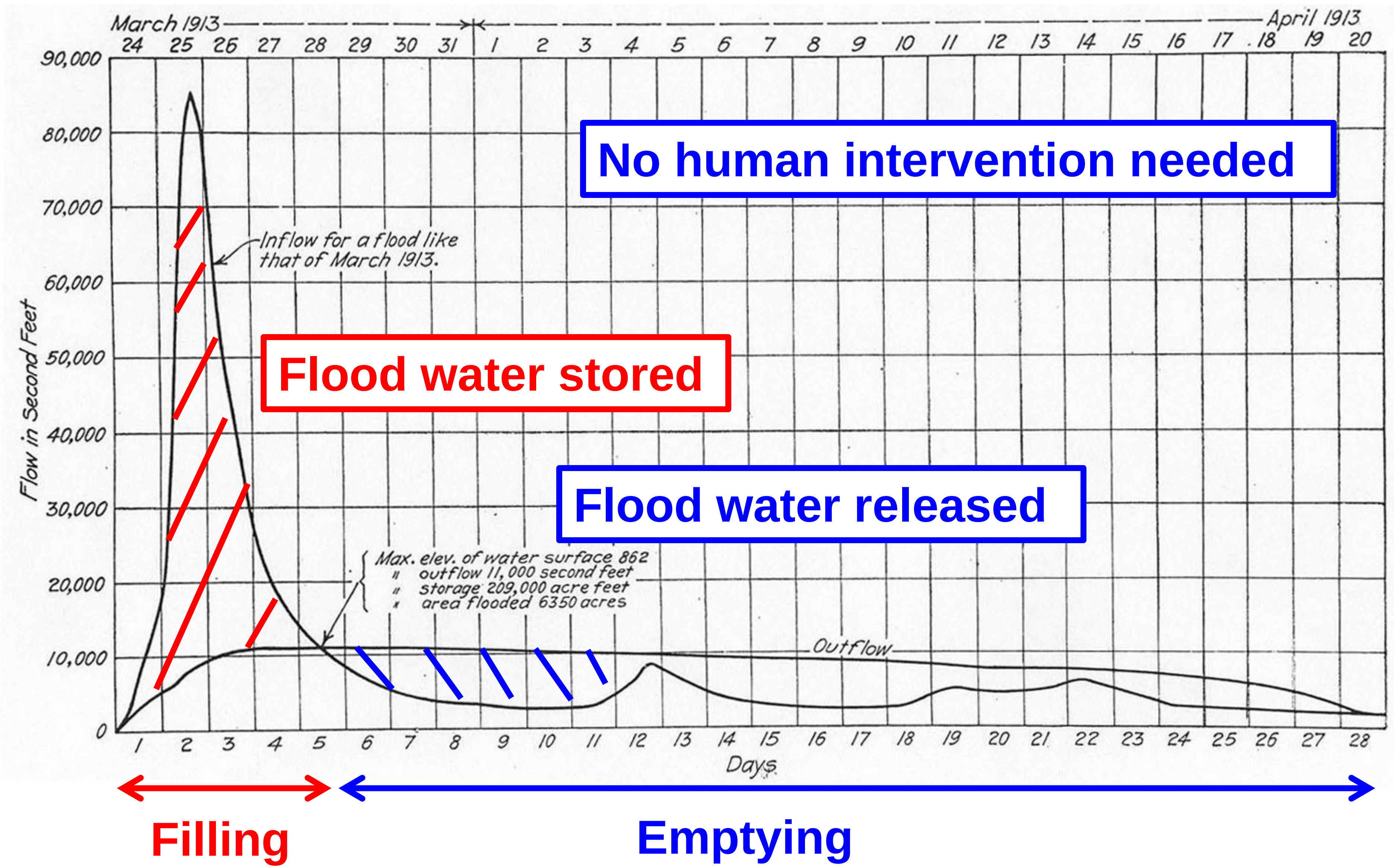


The pool of the hydraulic fill at Englewood Dam.

How does a “dry dam” work?



Design flood peak flow reduction – Englewood Dam



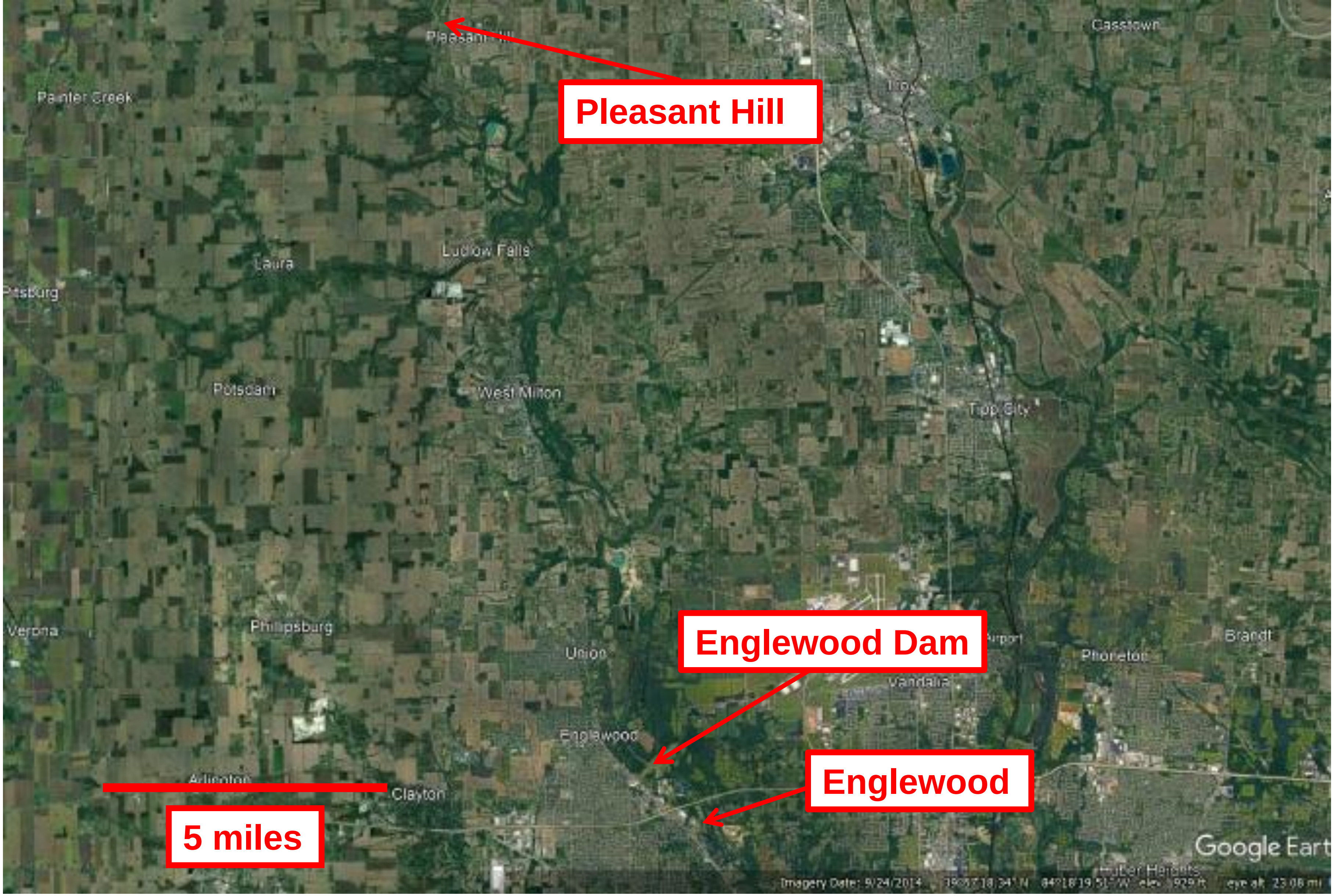
Design flood peak flow reduction – Englewood Dam

Flood peak flow reduction – Englewood Dam
January 1937

Inflow and outflow Stillwater River

Inflow measured at Pleasant Hill, Ohio

Outflow measured at Englewood, Ohio



Flood peak flow reduction – Englewood Dam

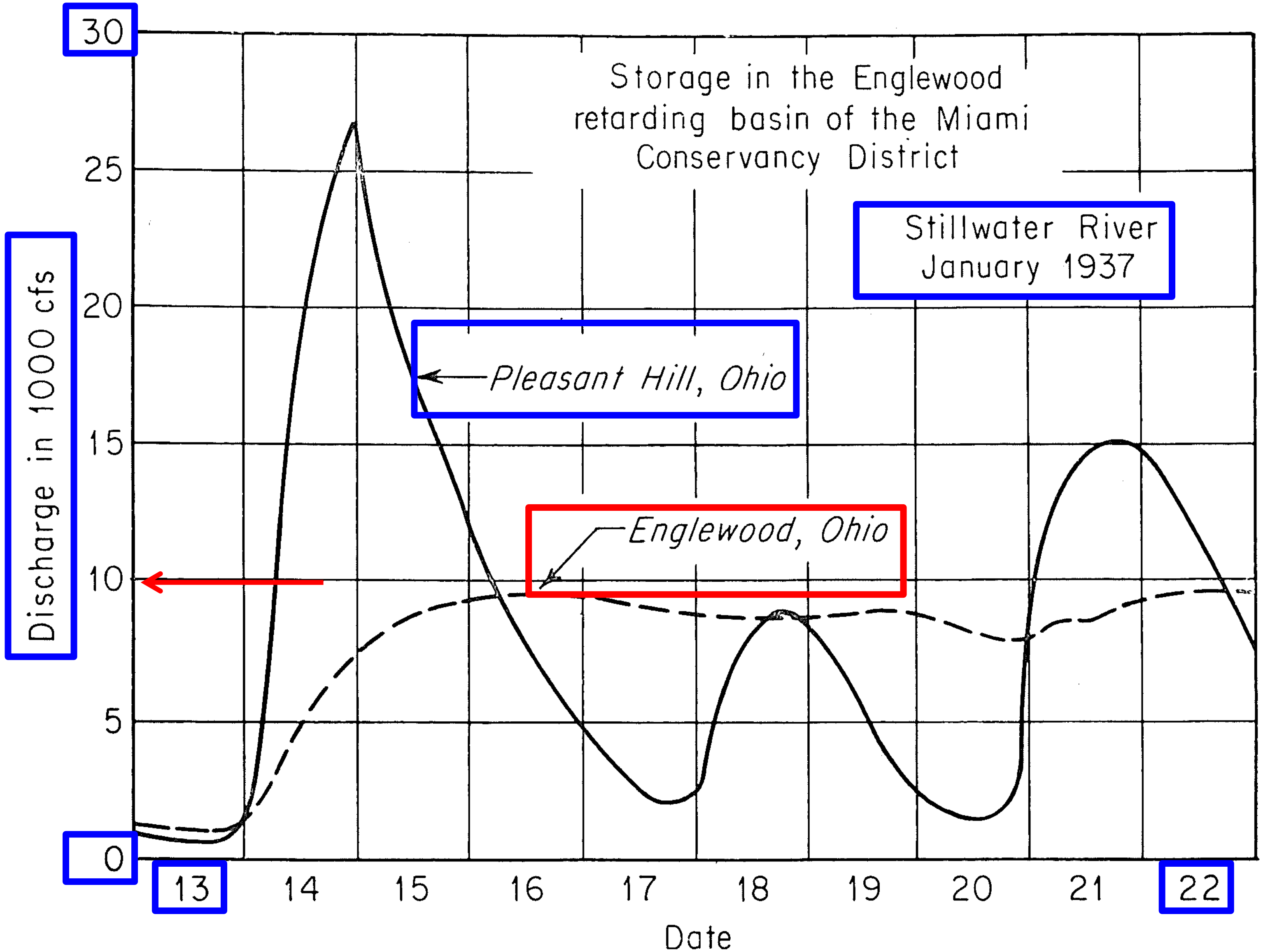
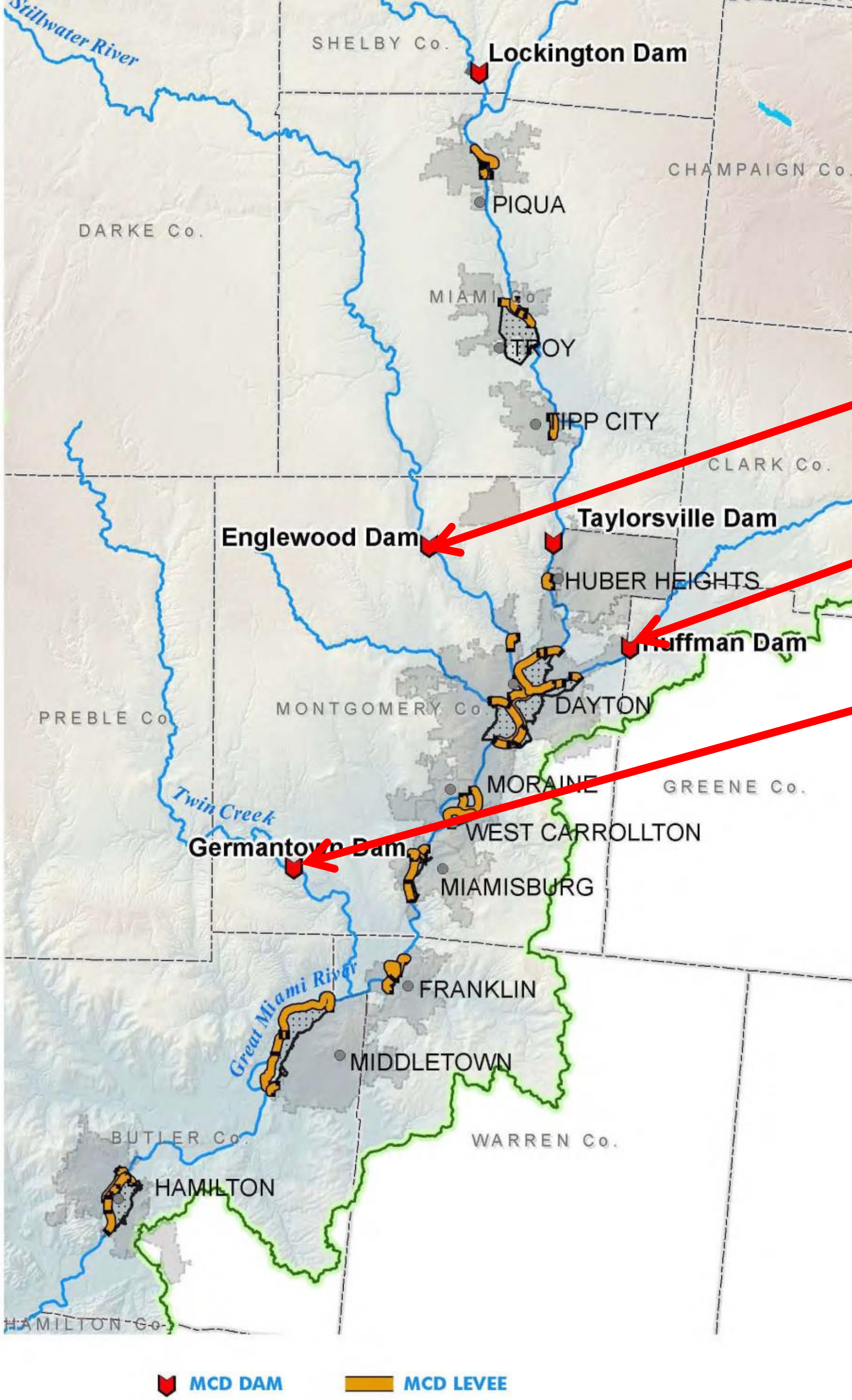


FIG. 10-5. Reduction of discharge through reservoir action, Stillwater River, Ohio.

Source: Linsley, Kohler, and Paulhus, “Hydrology for Engineers, 1958



Emptying times for dams from peak design flood stage

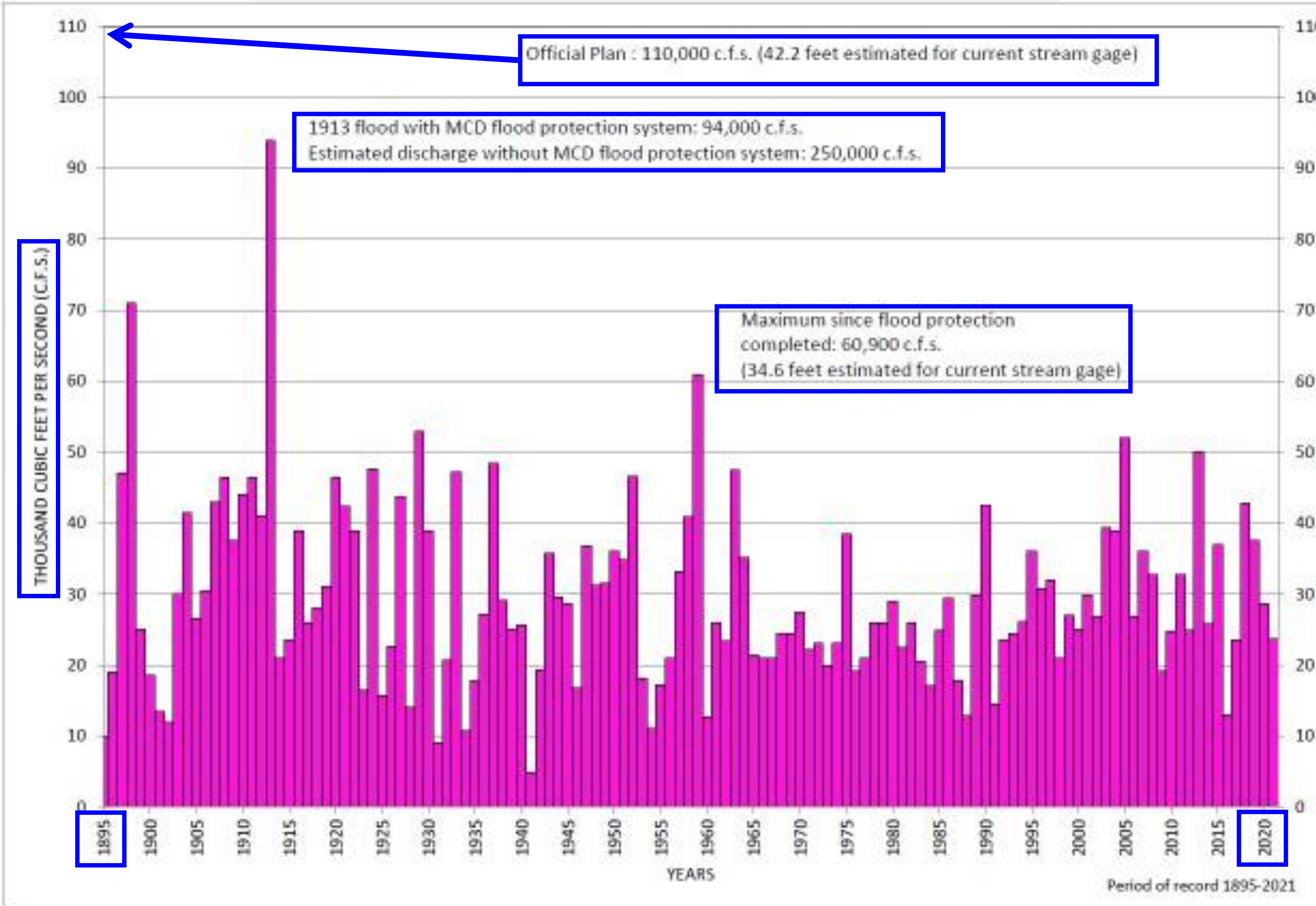
Englewood – 28 days

Huffman – 5 days

Germantown – 8 days

Annual flood peak flow rate at Dayton - 1895 - 2021

Figure 12—Annual Peak Discharges of the Great Miami River at Dayton, Ohio



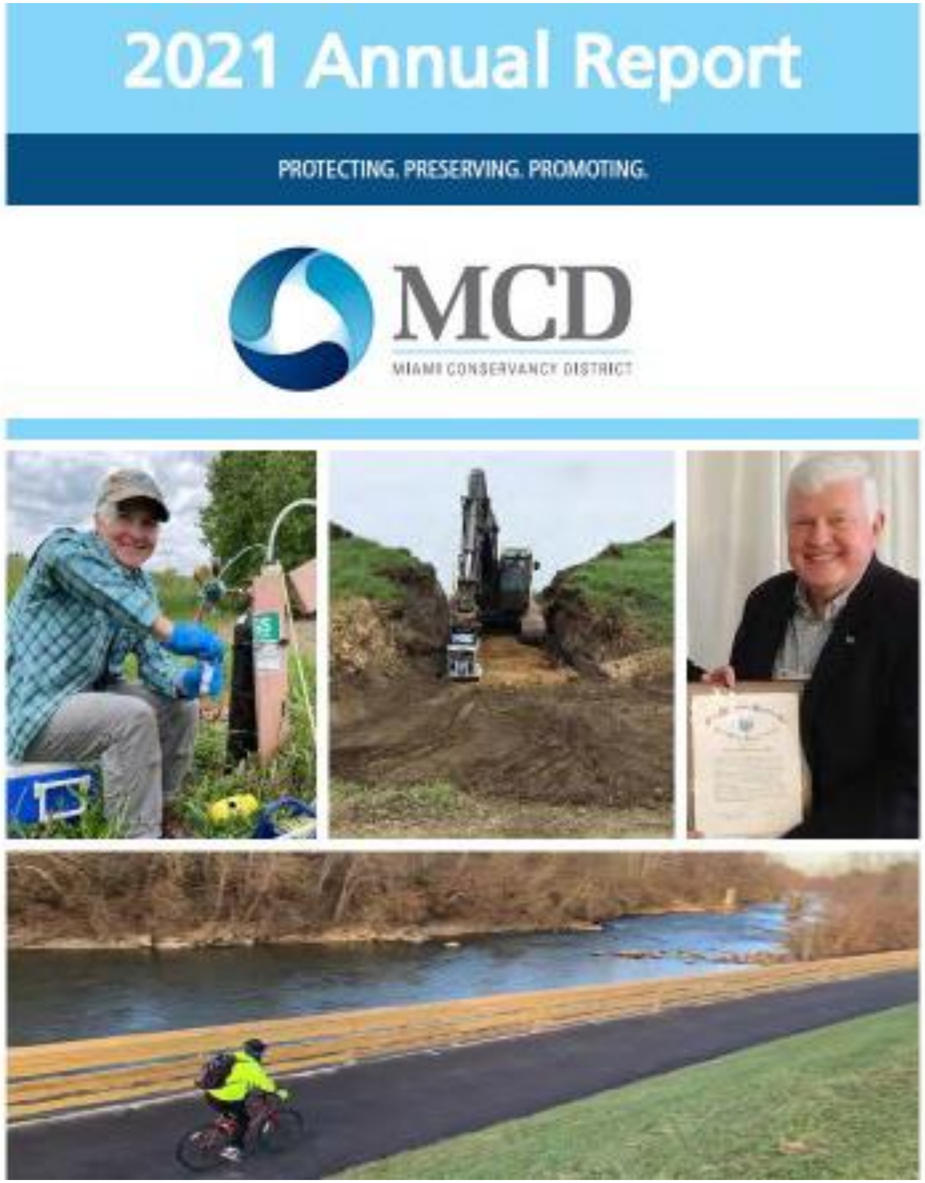
The 1913 flood was the "flood of record".

The facilities (levees, dams, and hydraulically efficient channels) were designed for the 1913 flood peak plus 40% additional runoff.

There has not been a flooding problem since implementation.

There is ongoing updating for dam and levee safety and repair and replacement of aged concrete.

Example - Lockington Dam Concrete replacement 2020 - Sunesis Construction



Latest details of life-cycle system updates in annual reports

2021 ANNUAL REPORT

AND

REPORT OF THE CHIEF ENGINEER

THE MIAMI CONSERVANCY DISTRICT

THE AQUIFER PRESERVATION SUBDISTRICT

THE RIVER CORRIDOR IMPROVEMENT SUBDISTRICT

THE WATER CONSERVATION SUBDISTRICT

December 31, 2021

Why is this work exceptional and inspiring?

First U.S. integrated river basin solution

Total community involvement

First U.S. dams and levees engineering solution

Much modern engineering was done here first

The work was done under the exceptional leadership of Arthur E. Morgan without Federal funding.

It was path setting, innovative, and inspires.

It includes fail-safe and safe-fail features worthy of study.

The 1917 Federal Flood Act required “Levees only” solutions to flooding.

The 1928 Flood Act included Dams and Spillways.

Project time-line:

Flooding and deaths – March 1913

Designs – 1915

Completion – 1922

Typical modern project 30 to 40 years

MCD detailed reports

https://www.mcdwater.org/resources/mcd-publications/

https://www.mcdwater.org/MCD-Flip/MCD-A-Flood-of-Memories-Book/

https://www.mcdwater.org/water-stewardship/state-of-the-water/all-about-the-great-miami-river-watershed/

MCD – Additional Observations

Miami Valley aquifers and aquifer recharge

Family connection - W Burges Report 1960

MCD – Additional Observations

Miami Valley aquifers and aquifer recharge

Family connection - W Burges Report 1960

Other notable features MCD and Dayton region:

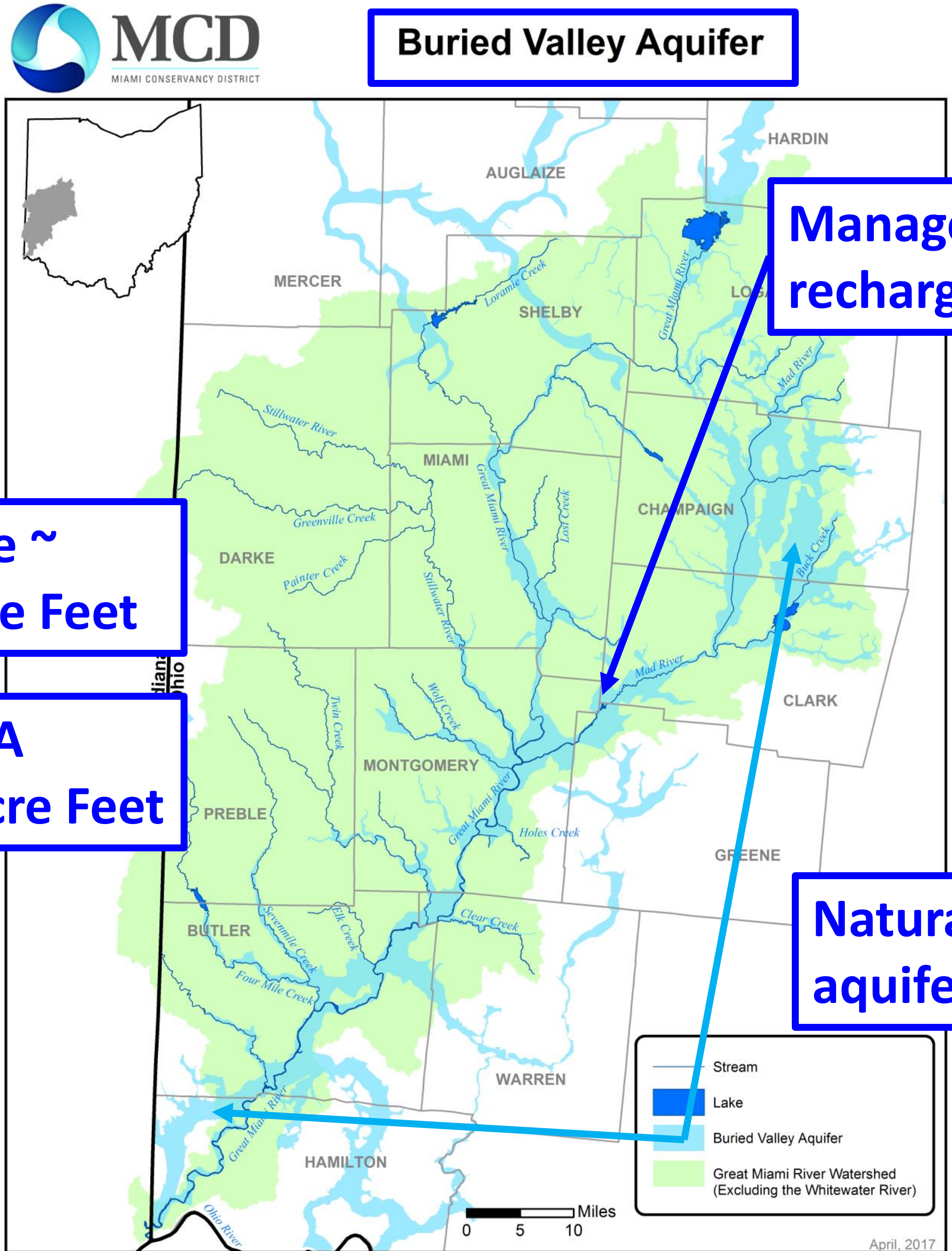
Major aquifer system

Sole source supply for approx. 2.3 Million people

Natural recharge - stream - aquifer connections

Artificial recharge in Mad River basin since 1930s

Buried Valley Aquifer

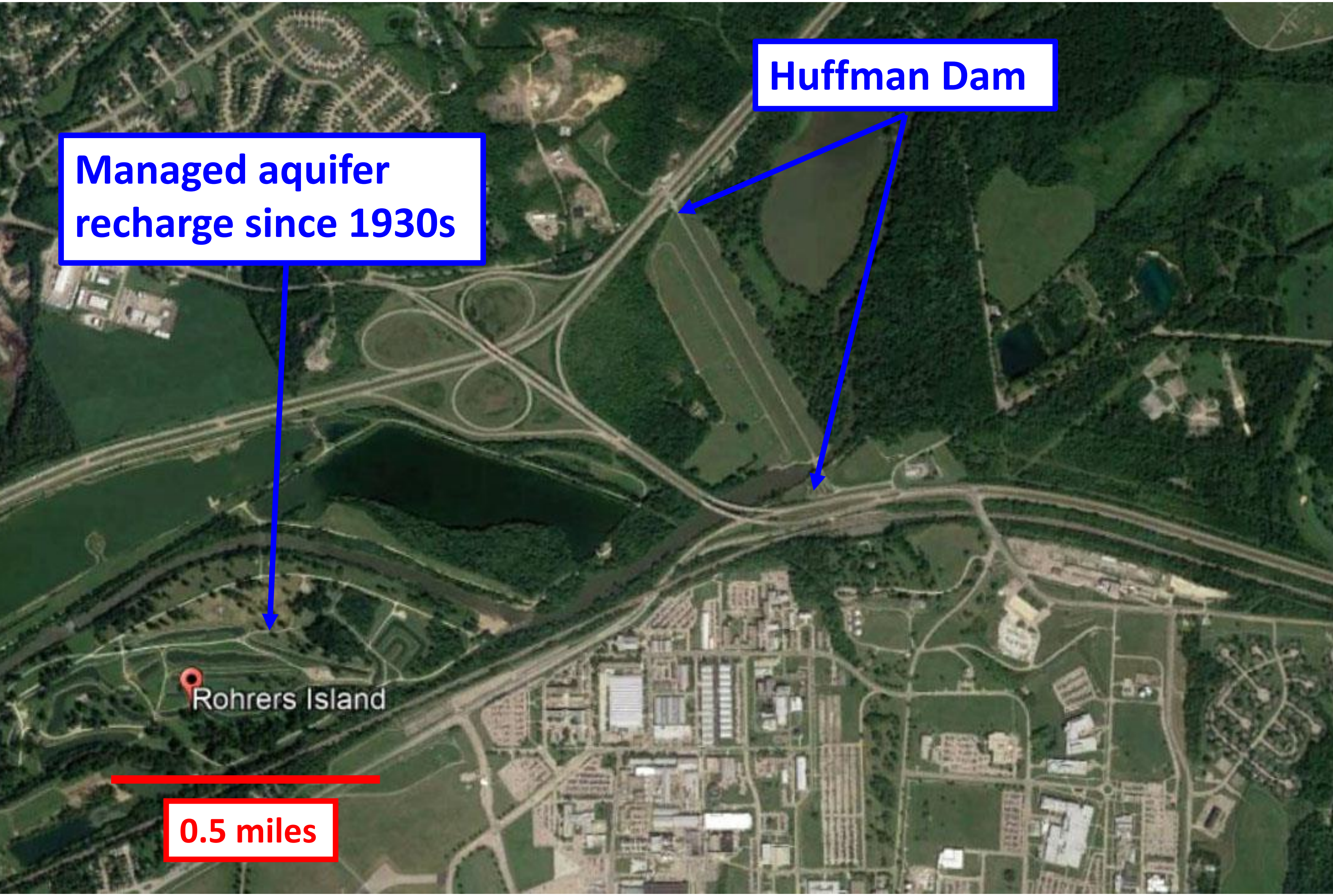


Managed aquifer recharge since 1930s

Aquifer storage ~ 4.6 Million Acre Feet

Shasta Dam, CA 4.55 Million Acre Feet

Natural River to aquifer recharge


Huffman Dam
Managed aquifer recharge since 1930s
Rohrers Island
0.5 miles


Huffman MetroPark
GATEWAY
Mad River
ins High School
Wright Brothers Memorial
Mad River
Wright Patterson Air Force Base Area B
ood MetroPark
0.2 miles
Google Earth
Imagery Date: 9/23/2019 39°47'54.43" N 84°06'11.10" W elev 0 ft eye alt 14882 ft

MCD – Additional Observations

Miami Valley aquifers and aquifer recharge

Family connection - W Burges Report 1960

SOME ASPECTS OF

CITY GOVERNMENT

AND OTHER

PRACTICES OVERSEAS

Report by

W. BURGES, A.A.S.A., A.L.C.A., L.G.A.
Town Clerk.

CITY OF NEWCASTLE, N.S.W.
1960

Scanned from University of Newcastle's Auchmuty Library copy

My Dad:

Findings from a 6-month world study tour in 1960.

I was 16, Dad was 44

I read the report in April 2018

W. C. (Bill) Burges (1916 – 2002), circa 1960

I did not know why Dad included Dayton in his study tour.

It became clear after I read his report.

Dayton … . In 1913 it became the first city in the United States with a population over 8,000 to adopt the Council-Manager form of government.

The City of Dayton is located on a flood plain and it was the result of severe flooding and subsequent devastation in 1913 which led to the then new form of Council-Manager city government being adopted to expeditiously and systematically restore and manage the city.

At that time also, the "Miami Conservancy District" was formed, about which I will report separately, and as a result of the work of the Conservancy District, Dayton is now safe from future flood-rains.

From page 110: "Some Aspects of City Government and Other Practices Overseas", Report by, W. Burges, Town Clerk, City of Newcastle, N.S.W., 1960, p221.

Sadly, I have not found Dad's report on the MCD.

Summary observations from personal experience and studying excellent water resources engineering works

Make sure that there is a “captain of the ship”. The captain has full knowledge of the operation and delegates.

Arthur Morgan was an exceptional “captain of the ship”. He had detailed understanding of every aspect of the flood protection scheme.

He and colleagues hired the best engineers they could find to do this innovative work.

The establishment with the full engagement of the community of the “Miami Conservancy District” and its governing structure guaranteed there would be no loss of “institutional memory” and ensured “life cycle” engineering and societal engagement.

The "District" is overseen by its chief engineer, board of directors and board of (world class) consultants who meet in Dayton for "five-year" inspection tours.

How do we replicate the spirit of Morgan and his approach?

In addition to a "ship's captain"

- **Seek out several wise colleagues 30+ years older including retired professionals to serve as mentors; engineering mistakes are repeated about every 30 years.**

- **Invite colleagues to help you think of all ways that your design or system could possibly fail and the societal consequences.**

- **"Hope" is not a strategy!**

Epilogue:

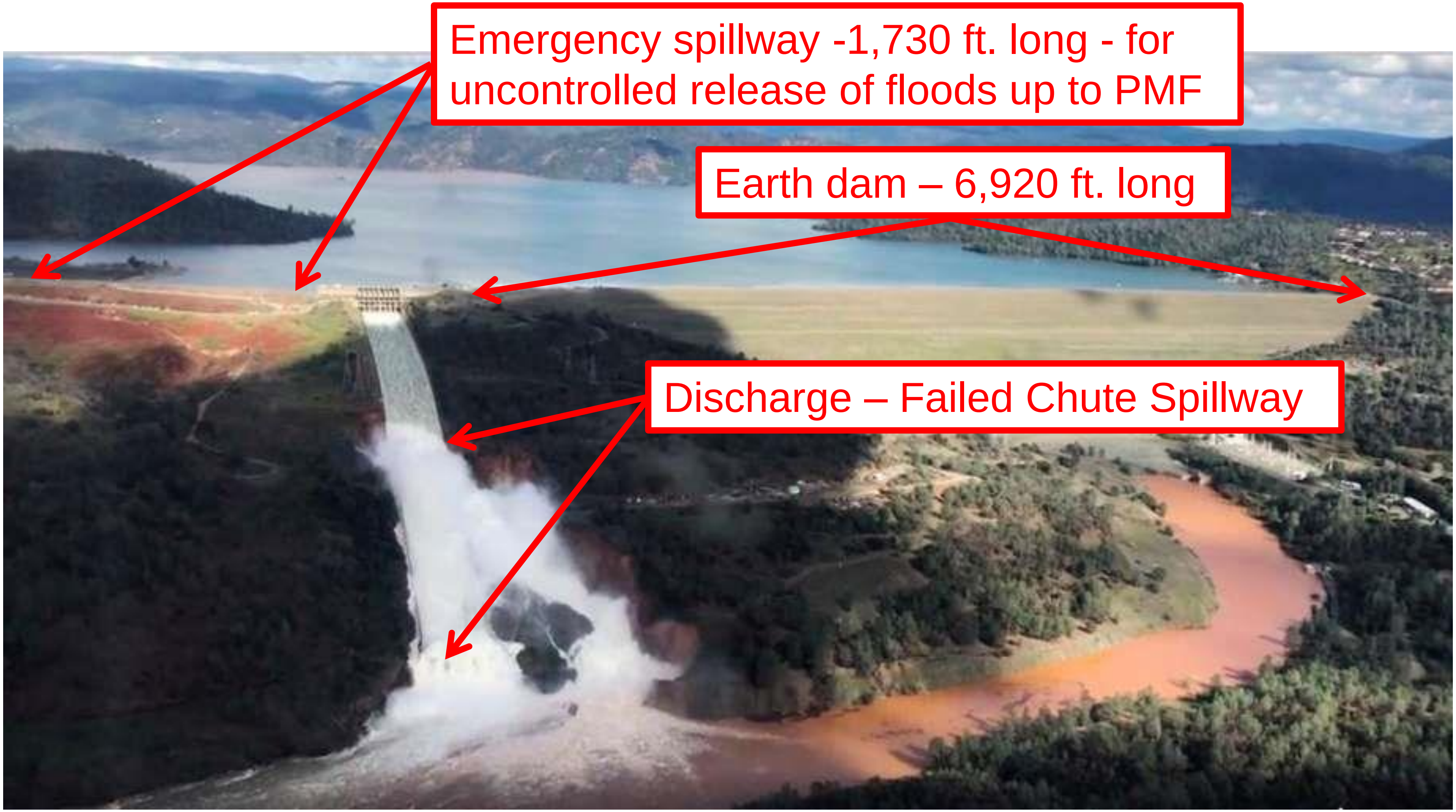
Oroville Dam chute spillway failure, February 2017

An example of the importance of loss of "institutional memory"

Failure of the spillway and severe damage from flow over the emergency spillway at Oroville Dam, California, the most important reservoir in the California State Water Project, in February 2017

The January 2018 Independent Team Forensic Report highlights the failure to consider full "life-cycle" design and maintenance.

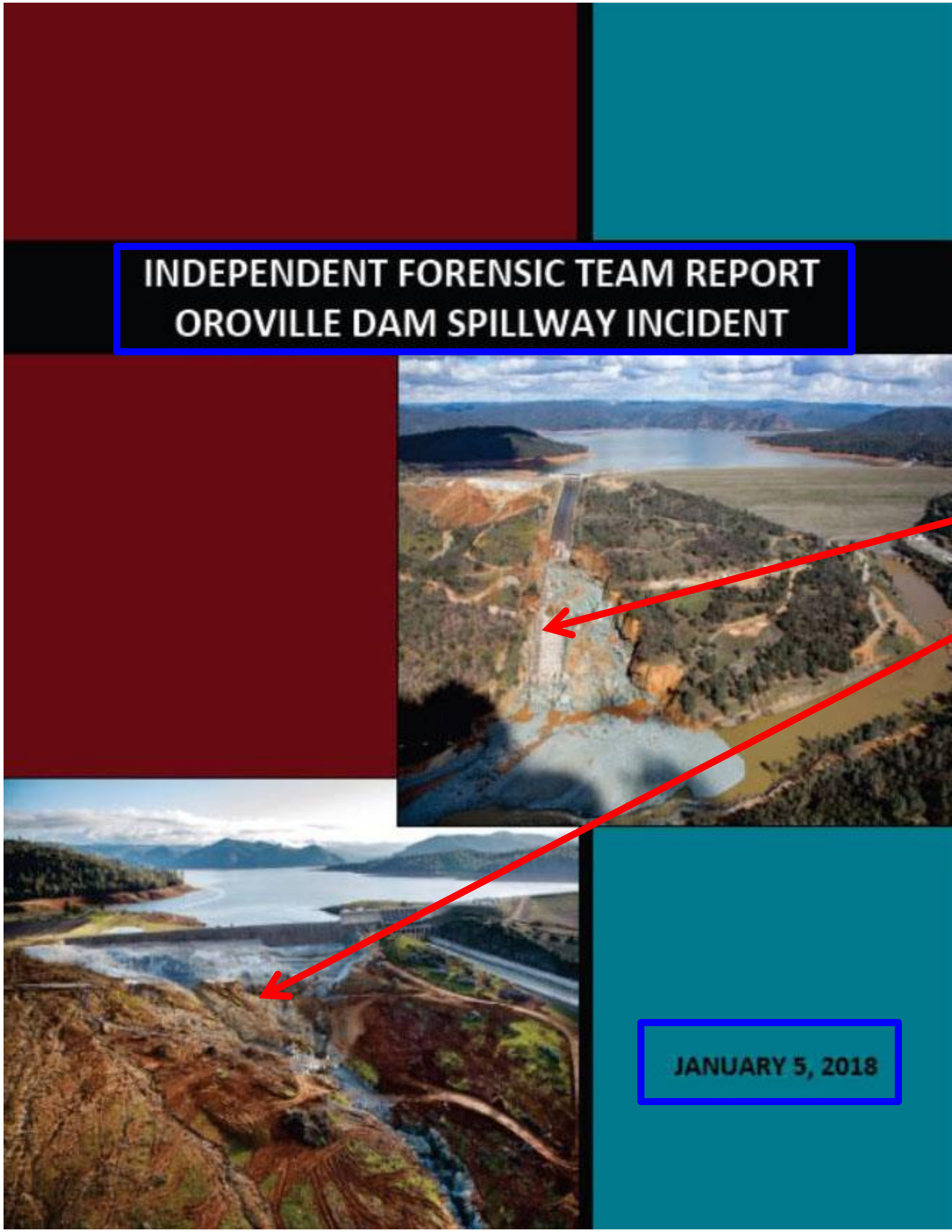
There was no oversight of the system of comparable robustness to that for the MCD


Emergency spillway -1,730 ft. long - for uncontrolled release of floods up to PMF
Earth dam – 6,920 ft. long
Discharge – Failed Chute Spillway

March 2017

Damage from use of emergency spillway

March 2017

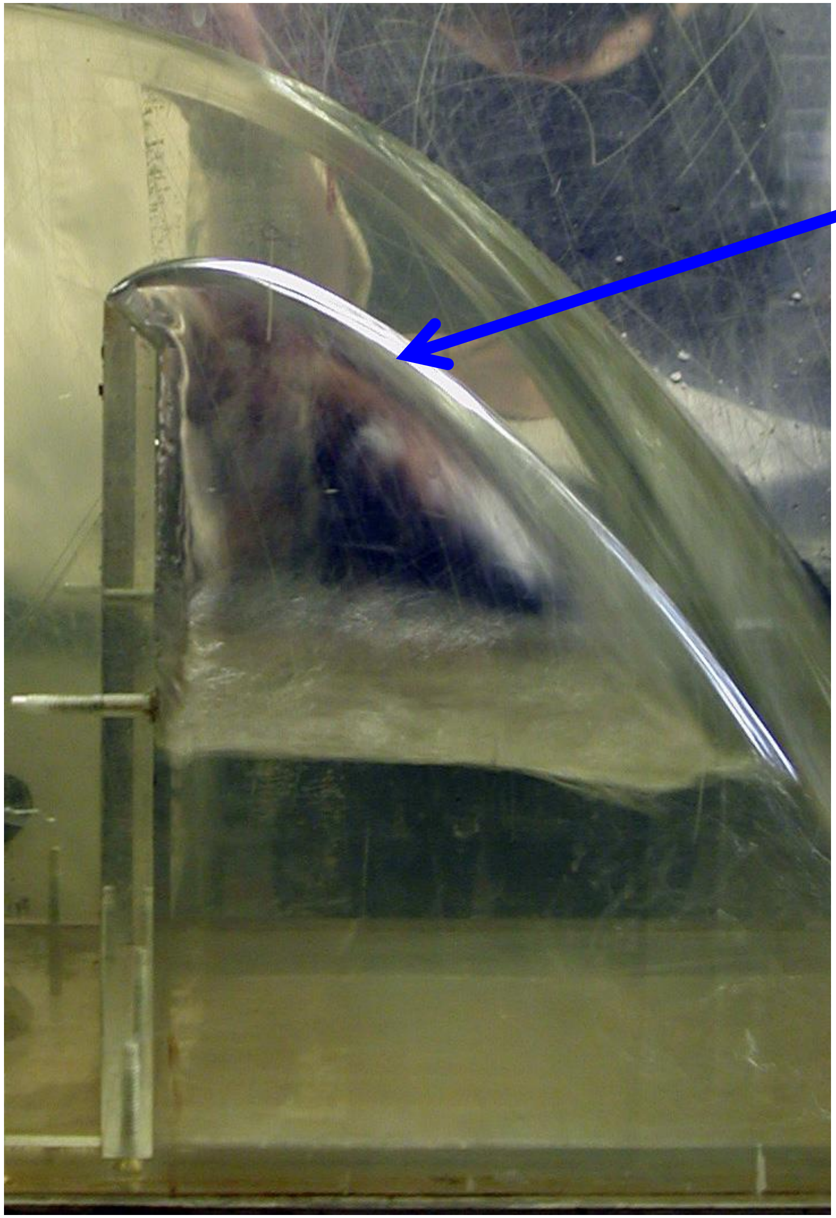


Cost of replacement of spillway 2017-2018 and stabilization below emergency spillway – 2018, $1.2B (DWR Feb. 2021)

Questions?

Major thanks to Sylvia who insists I refresh my field hydrologic observation skills.

High point above Iceline Trail, Yoho National Park, 9-17-2022. Takkakaw Falls is behind and to the right (not shown).



Sharp crested weir - free "Nappe"

Pressure is atmospheric

Ogee design emulates the free nappe to avoid negative pressures at water - weir interface

See pages 365-376 - U.S. Bureau of Reclamation, Design of Small Dams, Third Edition, Denver, Colorado, 1987, for details of discharge over an uncontrolled Ogee Crest

Two Oroville Spillway webinars:

Physical Aspects of the Oroville Dam Incident
https://www.youtube.com/watch?v=3JygTm8iiWQ
March 5, 2018, 2:00 PM EST
John W. France, PE, D.GE, D.WRE; Vice President, AECOM, Independent Forensic Team Leader

Lessons for Dam Safety from the Oroville Dam Incident
https://www.youtube.com/watch?v=YjgugkIfwWQ
March 14, 2018, 2:00 PM EST
Stephen J. Rigbey, Director Dam Safety at BC Hydro, Independent Forensic Team member

Independent Forensic Team Report Final 01-05-18.pdf 584 p
https://damsafety.org/sites/default/files/files/Independent%20Forensic%20Team%20Report%20Final%2001-05-18.pdf

Access to the Technical Reports of the MCD

Arthur Morgan and colleagues published Ten comprehensive "Technical Reports" between 1917 and 1922.

The reports describe some of the best scientific hydrology and hydrologic engineering work that has been done.

Technical reports of The Miami Conservancy District

Available at:

https://depts.washington.edu/sjbx/

Download file "MCD Reports.zip"

There are ten reports starting in 1917 and ending in 1922. There is an updated version of Report V (Rainfall) published in 1936. I did not know about this report until I requested all the reports from our UW Library. I scanned in its entirety the 1936 report (it is the largest file). The other ten reports were all scanned initially by Google. I found numerous badly copied, unreadable, and missing pages (particularly fold out figures). I copied and replaced such pages in all the reports. I was restricted to copying from bound copies of the reports hence a few pages are a bit out of alignment. The pages I scanned are all at 300 dpi. I found this necessary to ensure that dimensions on figures etc., were readable.

I have also included scans of two figures and a location map. I do not know from which report they were extracted; my source was pages at the end of a single bound copy of reports 1-V.

I have also included a copy of a 1928 paper by Arthur Morgan. That paper provides essential background about how he located his top engineers and their experience coming to the Miami Valley flood problem.

Reading Guide - Extreme Flood Issues and System Design:

1. Burges-Water Systems Planning-ASCE-WRPM-1979 pages 98-100 for a brief coverage of The Miami Conservancy District flood mitigation work.

2. “Storm Rainfall of Eastern United States - The Engineering Staff - Miami Conservancy District Technical Reports Part V, 1917” for investigations to determine major flood producing rain.

Recommended initial reading: Chapter XI (page 241) and then Chapter XII (page 268).

There was a follow up to Report V published in 1936 (“Storm Rainfall of Eastern United States - The Engineering Staff - Miami Conservancy District Technical Reports Part V, Rev 1936-sjb”) that included 20 more years of data. See: Chapter 1 pages 1 - 5.

3. “Hydraulics of the Miami Flood Control Project - Sherman M. Woodward - Miami Conservancy District - Technical Reports Part VII, 1920” for details of the actual design. Most notable are Chapters XII and XIII. This was exceptional water resources engineering.

Report	Pages
The Miami Valley and the 1913 Flood - Arthur E. Morgan - Miami Conservancy District - Technical Reports Part I, 1917	123
History of the Miami Flood Control Project - C. A. Bock - Miami Conservancy District - Technical Reports Part II, 1918	193
Hydraulic Jump and Backwater Curves - Sherman M. Woodward - Miami Conservancy District - Technical Reports Part III, 1917	123
Calculation of Flow in Open Channels - Ivan E. Houk - Miami Conservancy District - Technical Reports Part IV, 1918	303
Storm Rainfall of Eastern United States - The Engineering Staff - Miami Conservancy District - Technical Reports Part V, 1917	311
Contract Forms and Specifications - The Engineering Staff - Miami Conservancy District - Technical Reports Part VI, 1918	188
Hydraulics of the Miami Flood Control Project - Sherman M. Woodward - Miami Conservancy District - Technical Reports Part VII, 1920	351
Rainfall and Runoff in the Miami Valley - Ivan E. Houk - Miami Conservancy District - Technical Reports Part VIII, 1921	241
Accounting and Cost Keeping - F. L. Cavis - Miami Conservancy District - Technical Reports Part IX, 1922	109
Construction Plant, Methods and Costs - Chas. H. Paul - Miami Conservancy District - Technical Reports Part X, 1925	433
Storm Rainfall of Eastern United States - The Engineering Staff - Miami Conservancy District - Technical Reports Part V, Rev 1936	362

Arthur Morgan had an extensive knowledge of flood hydrology - see, e.g.

Discussion by Arthur Morgan (pages 618 - 621) of paper by W. B. Fuller, Flood Flows, ASCE Transaction Paper 1293, 1914