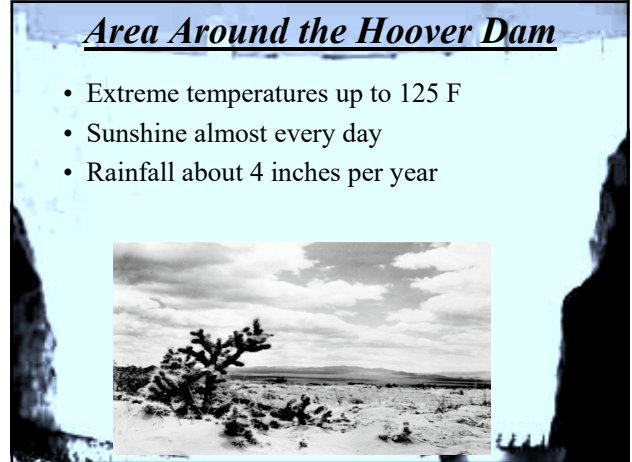
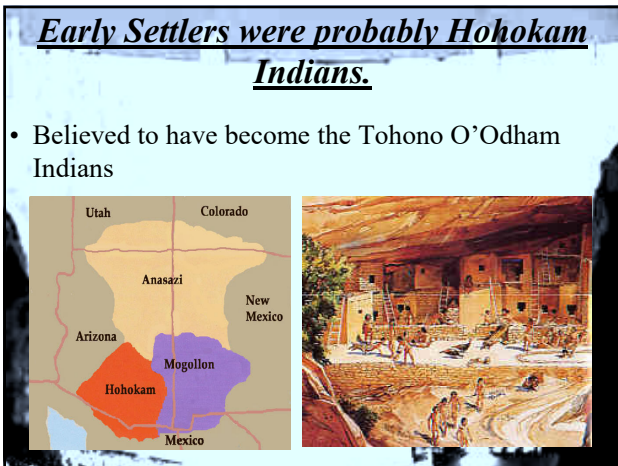


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5



6

- 1850 California Imperial Valley already wanted water from the Colorado River
- 1901 California Development Company constructed canals



7

- Created mistrust between California and Nevada and Arizona, "They (California) want to steal our water!"



8

Time Line Pre Construction

- 1902 - Bureau of Reclamation begins study of dam sites
- 1918 – Investigation of a "High Dam" for water storage and flood control

9

Pre Construction Timeline, cont.

- 1920 – Seven states discuss dam
- Herbert Hoover (Secretary of Commerce under President Harding) served as the Government's representative



10

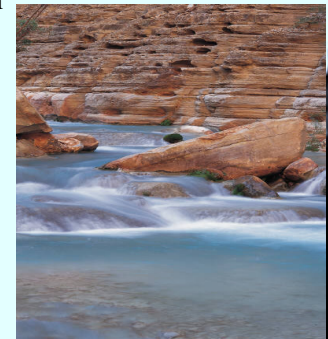
- Called the project, "The Boulder Canyon Project," even before the site was selected!



11

Two sites were selected as meeting the geological requirements for a high dam:

- * Boulder Canyon
- * Black Canyon



12

Pre Construction Timeline, cont.

- 1924 - Selection of the Black Canyon for dam site



13

Pre Construction Timeline, cont.

- 1924 – Design of a concrete arch gravity structure proposed
- 1928 –Engineering and Geological review completed

14

Pre Construction Timeline, cont.

- 1930 – Congress appropriated funds for the Construction
 - * 119 bid items
 - * Specifications were 100 pages with 76 drawings
 - * \$5 per set

15

Pre Construction Timeline, cont.

- * 3.7 million cubic yards of rock
- * 4.4 million cubic yards of concrete
- * 45 million tons of structural steel and pipe
- * 7 year construction schedule

16

Pre Construction Timeline, cont.

- Major Problems
 - * \$2,000,000 bid bond
 - * \$5,000,000 performance bond, if awarded contract
- Money was difficult to raise in Depression times

17

Bond requirements

- Too big for western companies
- Had to form alliances
- Most contractors gave up before bidding

18

Bids opened on March 4, 1931

- Government to provide cement and steel
- Contractor to provide manpower, machinery, tools, vehicles and supplies

19

First Bid

Edwin A. Smith, Kentucky
 \$80,000 less than lowest bid you get
 No Bid Bond
 Bid was invalid

20

Second Bid

- John Bernard Simon Company, New York
- \$200 Million or Cost plus 10%
- No Bid Bond
- Bid was invalid

21

Third Bid

- Arundel Corporation, Maryland
- \$53.9 Million
- Bid Bond provided
- Bid was valid

22

Fourth Bid

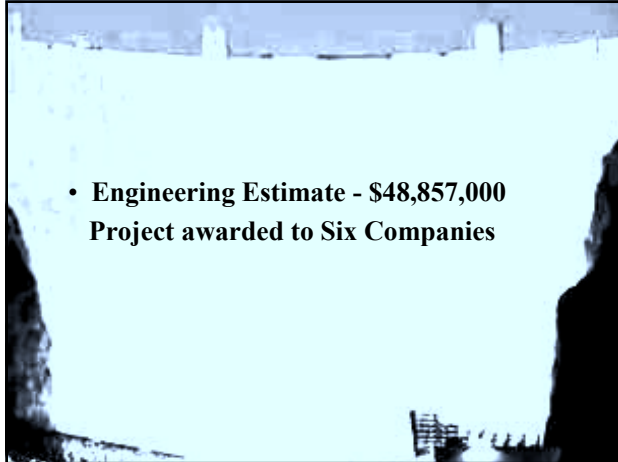
- Wood Brother Company, Nebraska
- \$58.6 Million
- Bid Bond provided
- Bid was valid

23

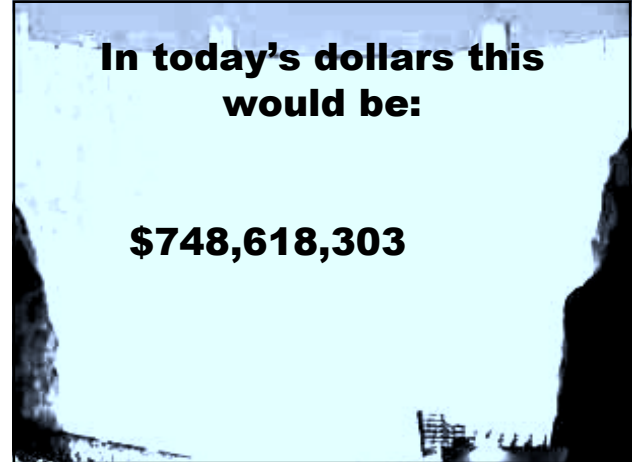
Fifth Bid

- Six Companies, California
- \$48,890,955
- Bond Provided
- Bid was valid

24



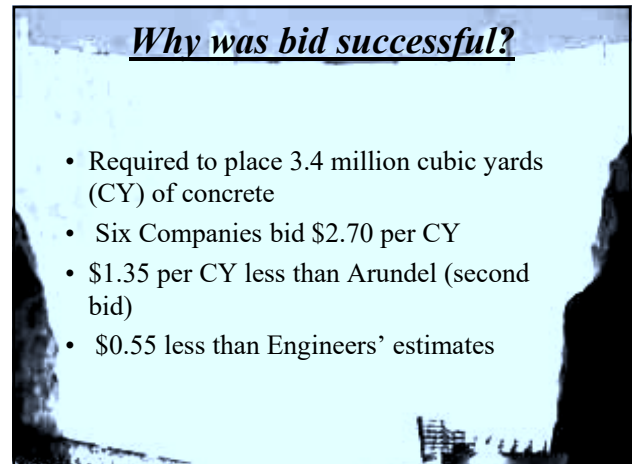
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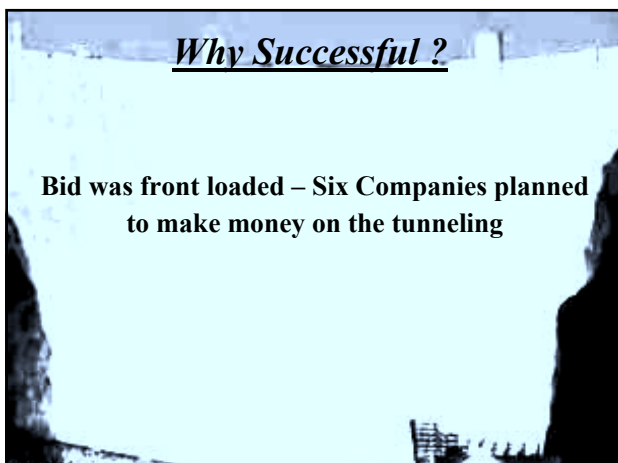
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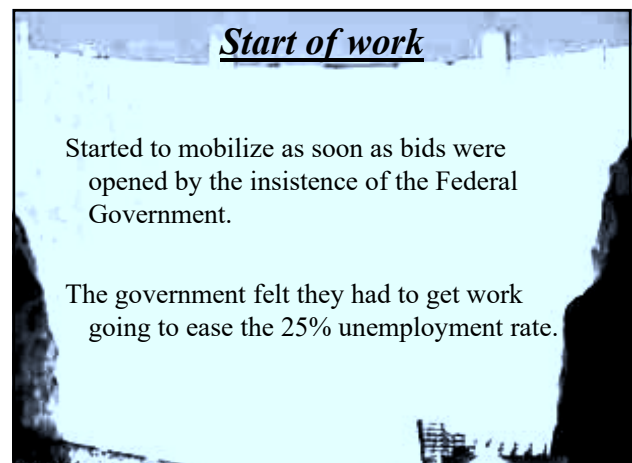
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28



29



30

Infrastructure to be Built

- Houses
- Provide power
- Dorms
- Dining facilities
- Hospital
- Police
- Fire department

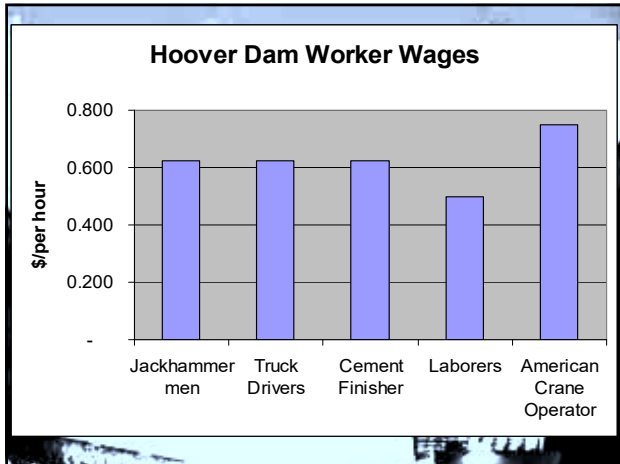
31

People needed jobs

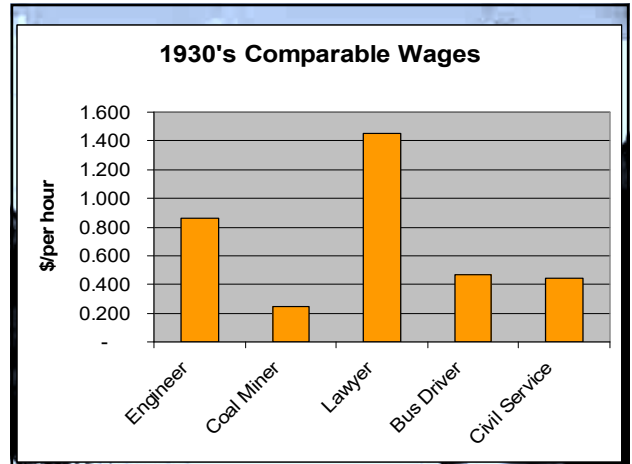


Created Ragtown

32



33



34

Working conditions were horrible by today's standards.

The workforce attempted to unionize and strike for safer working conditions.

This resulted in them being fired.

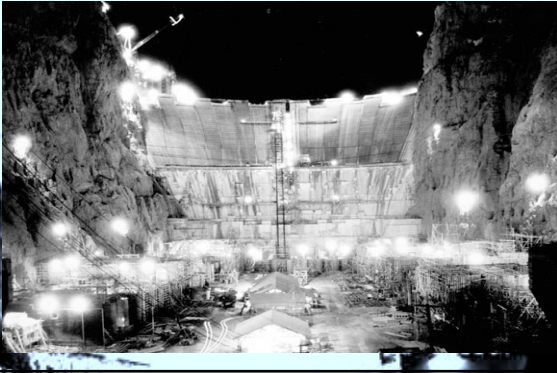
35

Challenges to Project

- 100 F + Temperatures
- 24 hour construction schedule
- (pleasure to work the night shift?)

36

Working the Night Shift

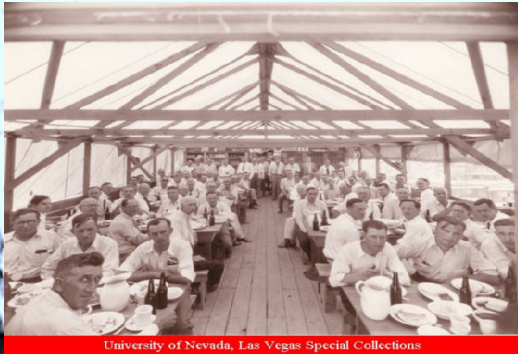


37

- Police – Prohibition still “enforced”
 - Majority of crimes were drunkenness
- Hospital – Dealt with accidents from Construction Site
 - State of the Art Orthopedic Care Unit
- Dorms – (\$1.60 per day)
- Married Housing Cottages - \$30 per month

38

Dining Hall



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39

Taking People to Work



The Bertha C. Asgard

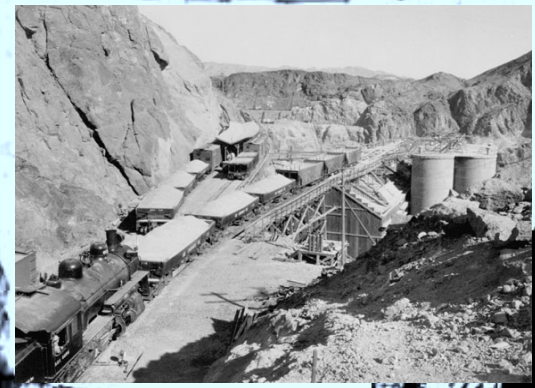
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40

Aggregates

- Found alluvial about 6 miles up stream in Arizona
 - Excavated by dragline
 - Moved by rail to screening and wash plant in Nevada

41



42

Aggregates, Cont.

- Screening into 4 sizes
 - Fine
 - Intermediate
 - Coarse
 - Cobble – 3-9 inch diameter
- If over 9 inches it was crushed, re-screened
- Moved to batch plant by rail.

43

Batch Plants

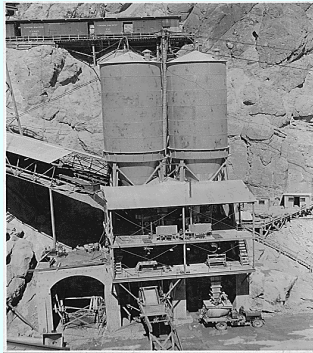
- Operational in 1932
 - Provided concrete for tunnels
- First concrete in Dam June 6, 1933



44

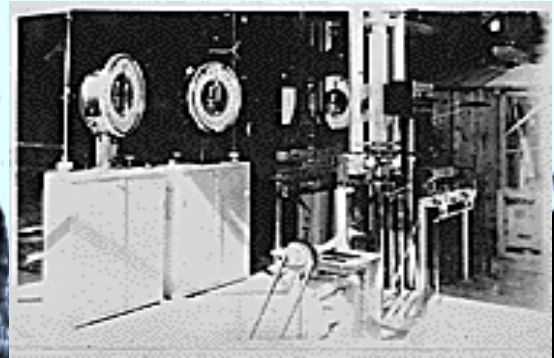
Second Batch Plant

- Added at the canyon rim
- Produced all concrete in top part of the dam



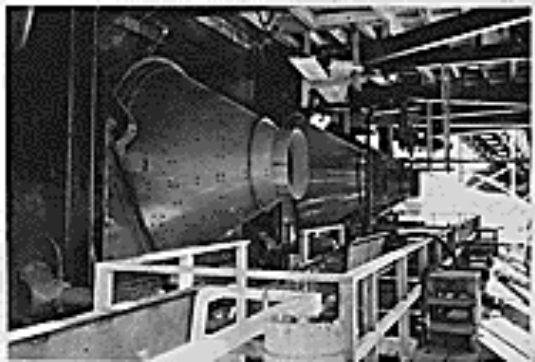
45

“Modern” Batching Facility



46

Central Batch Plant



47

Batching Details

- 4 cubic yard central mixers
- Capable of producing 24 cubic yards every 3 minutes
- Record total daily placement was over 10,000 cubic yards
- Four gradation's of aggregate blended together to give economy and workability

48

Details on Concrete Mixture

- Used Type IV Cement
 - Reduced C3A (lots of heat, little strength)
 - Increased C2S (slow strength gains)
- Thus reduced heat of hydration as much as possible

49

Mixture Design - General

- 4 sacks – Cement
- Maximum size aggregate - 9 inches
- W/C ratio - 0.58

50

Mixture Design – Detail
(pounds per cubic yard)

Cement	380	Type IV
Fly Ash	0	
Fine Aggregate	931	
Coarse Aggregate	2679	Limestone and Granite maximum size 9"
Water	220	
W/C Ratio	0.58	
Air Entrainment	0	
Water Reducers	0	
Slump	3"	
Density	155.9 pcf	

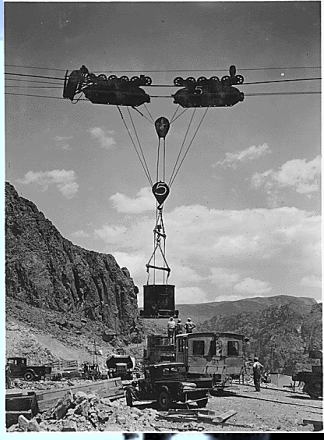
51

Final Concrete Properties

Compressive	Strength	PSI
	28 Day	3030
	90 Day	3300
	365 Day	4290
Modulus of Elasticity		10 ⁶ psi
	28 Day	5.5
	90 Day	6.2
	365 Day	6.8
Poisson Ratio	28 Day	0.18
	90 Day	0.20
	365 Day	0.21

52

Concrete moved to jobsite by 4 and 8 cubic yard buckets
Superintendent Frank Crowe was an expert on aerial cableways



53

A relatively new concept



Concrete placed, used internal vibrators to consolidate concrete

54

Concrete Construction

- Series of 5 feet high blocks with horizontal and vertical key ways
 - Varied between 25 to 60 square feet
- Concrete to cure 72 hours before next lift
- No more than 7 lifts in 30 days

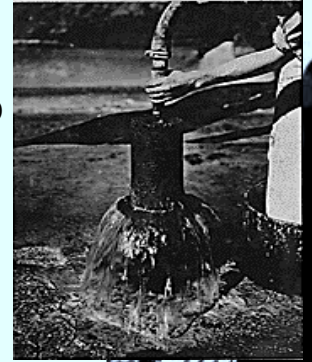


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55

Curing

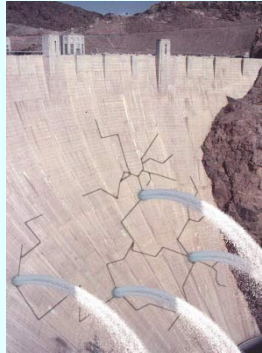
- **Dam was water cured**
 - During the summer, 20 men's sole job was to spray water on the dam's surface.



56

Cooling Concrete

- If Hoover Dam was placed in a continuous placement method, the heat stress would crack the dam.



57

Cooling Concrete, Cont.

- Experiments by the Bureau of Reclamation at Owyhee Dam in Idaho used piping throughout the concrete
- Used cooled water to remove heat

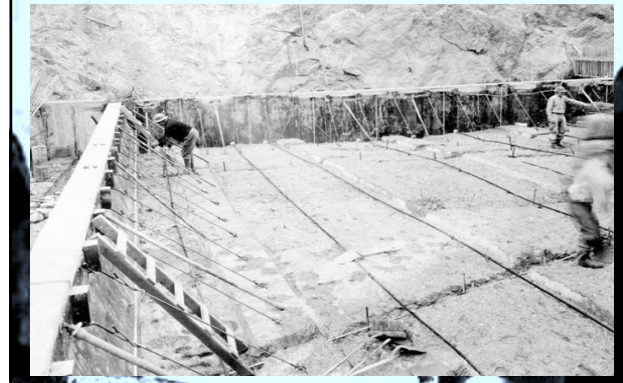
58

Cooling Concrete, Cont.

- At Hoover Dam – built in sections, one inch pipes were installed by looping thru concrete
 - River Water
 - Refrigerated Water
- When cooling in a section was completed, cooling pipes were cut off and pressure grouted

59

Piping to cool concrete



60

Cooling Concrete, Cont.

- By 1935, cooling was completed
- 590 miles of piping was used in the dam
- 159 billion BTU removed through cooling process

61

Testing of Concrete

- Excellent Quality Control due to the state of the art testing facilities



62

Testing of Concrete, cont

- Used 36" x 72" cylinders for design
- Wanted 4 times maximum size of the aggregates
- Had 4,000,000 pound testing machine

63

Mass concrete cylinder with apparatus for measuring longitudinal and lateral deformations



64

Typical Double - Cone Failure of 36" x 72" Cylinder



Mix 1-2.45-7.05 by weight with 9 inch aggregate
-W/C = 0.81 by volume 3 inch slump

65

Typical Cone failures from 36", 24", 12" and 8" cylinders



66

Safety Issues

- No one is entombed in the concrete
- Deaths during construction
 - 96 people, not counting heat related deaths

67

Major cause of deaths – not recorded

Heat prostration killed one worker every other day
– summer 1931

68

Major Study on Heat Related Sickness

Workers need to drink water

69

Safety Issues, Cont.

- State of Arizona paid more than the State of Nevada in death benefits.
 - Injured/Dead workers carried to Arizona
 - Stories of injured workers crawling to Arizona
 - Debated by experts if this is true

70

Last concrete placed May 29th, 1935



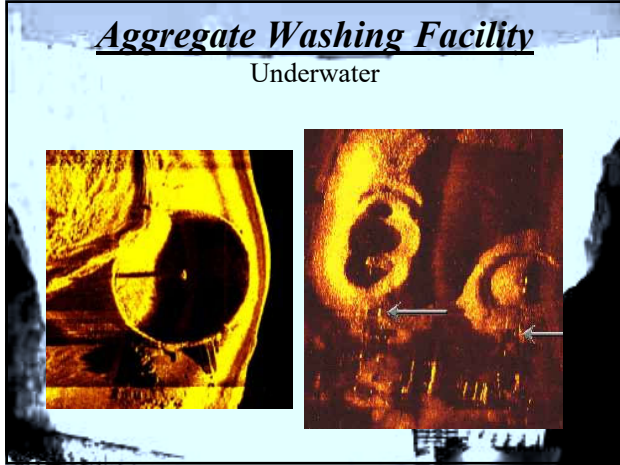
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Remains of the Construction

- Divers' Paradise



72



73



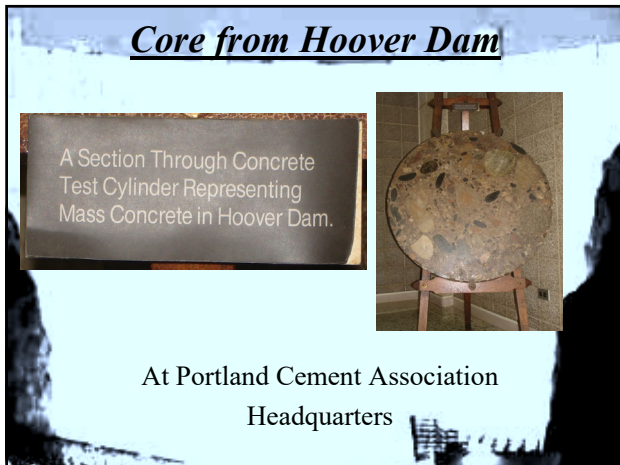
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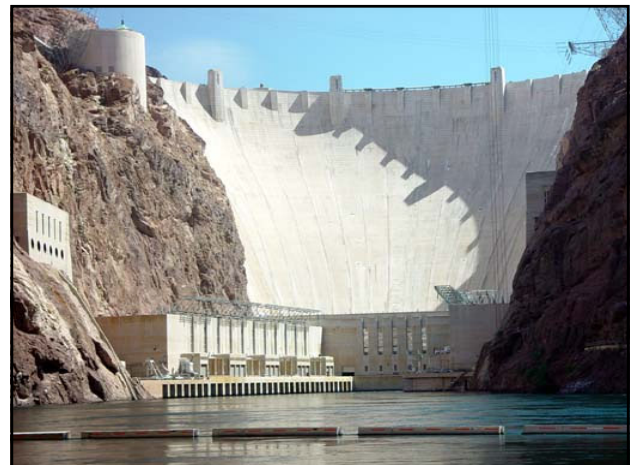
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