Grand River Dam Authority

Stabilization and Reclamation of the Pensacola Dam West Abutment

Rock Fall Protection System Evaluation and Implementation By Means of Anchored Mesh

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Grand River Dam Authority

- Formed in 1935 by the State of Oklahoma
- Mission is to bring low cost public power to northeastern Oklahoma
- It is a self funded state authority
- The enabling action created the Pensacola Dam and Impounded the Grand Lake O' The Cherokees

Grand River Dam Authority

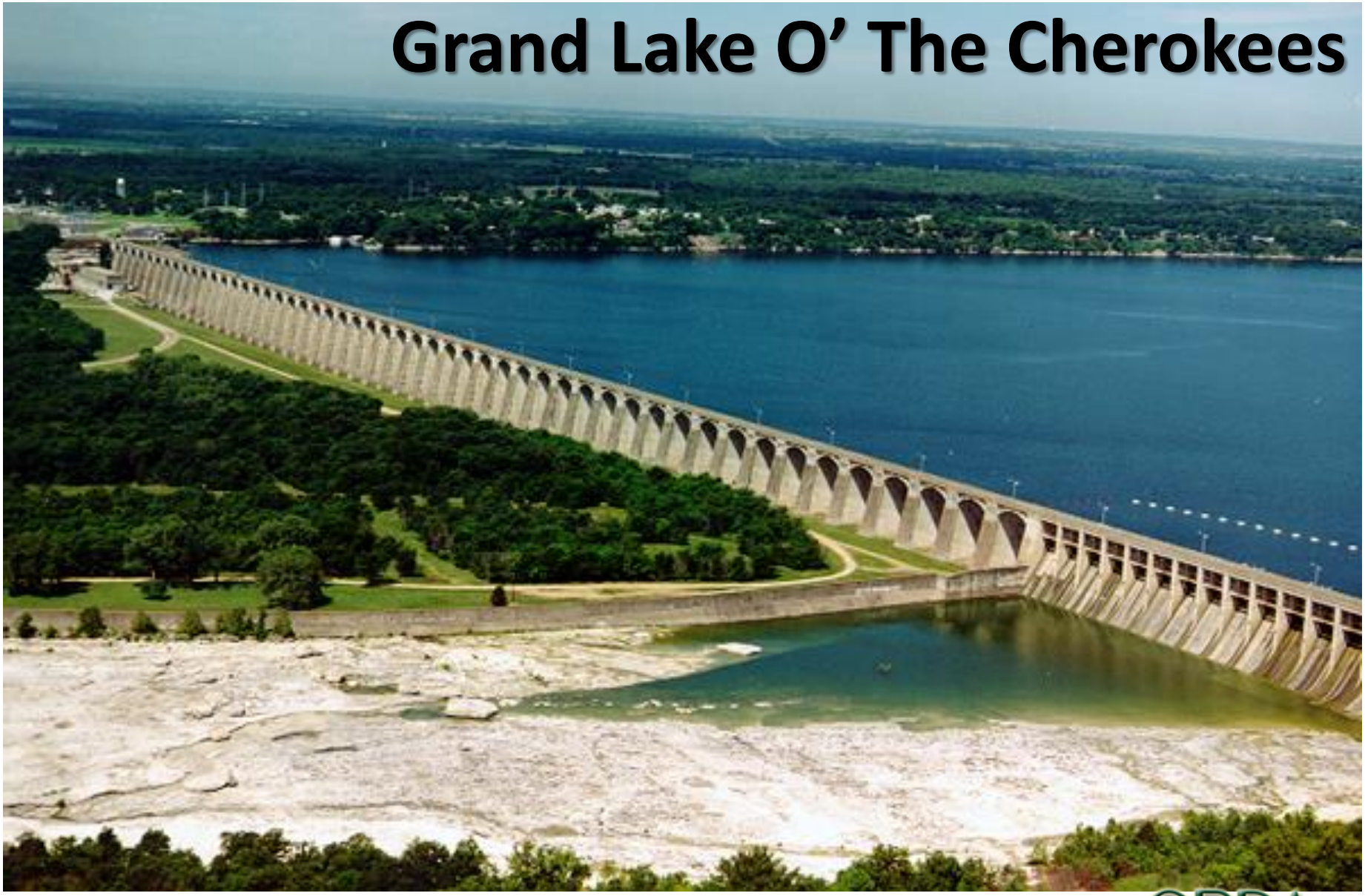
- Today GRDA provides a diversified energy portfolio of energy to 16 municipal customers across Oklahoma and 2 in adjacent states.
- Energy Portfolio:
  - Coal 1,010 MW
  - Natural Gas 443 MW
  - Wind 282 MW
  - Hydropower 512 MW
  - Total 2,247 MW

Robert S. Kerr Dam – Lake Hudson

Salina Pumped Storage Facility
Holway Reservoir

Pensacola Dam

Grand Lake O' The Cherokees



Pensacola Dam
Grand Lake O' The Cherokees

GRDA
Grand River Dam Authority

Grand Lake O' The Cherokees

- 46,500 Acre Reservoir in Craig, Delaware, Mayes and Ottawa Counties
- Longest Multiple Arch Dam in the World with a combined length of 6,567 feet
  - 150 feet maximum height
  - Multiple Arch Section 4284 feet
  - Main Spillway 851 feet
  - Two Secondary Spillways 887 feet
  - Non-Overflow Sections 545 feet
- Independent Powerhouse – 6 Francis Turbines
- 126 Megawatts of renewable hydropower energy

GRDA
Grand River Dam Authority

Pensacola Dam

- Constructed Between 1938 and 1940
- Powerhouse located on the original river channel
- Natural near vertical bank cut in Mississippian aged Boone Limestone of the Ozark Plateau
- Conformably overlying Devonian aged shale
- Osage Plateau is near horizontally bedded dipping northwest about 2 degrees

Pensacola Dam West Abutment

- Continued weathering in the exposed geology has resulted in personnel and equipment safety issues
- The formation is the result of repeated submergence, deposition, upilft and erosion
- Hard to very hard beds with some softer beds that result in differential weathering.
- Unconfined Compressive Strength of the beds vary between 8,000 psi and 1,000 psi
- Weathering progresses more rapidly in the softer beds

Pensacola Dam West Abutment

- Weathering and Slope Destabilization
- Significant Talus Accumulation
- Significant overhangs/eyebrows
- Personnel safety and equipment damage issues

Salina Pumped Storage Facility

Similar weathering and safety concerns at downstream Salina plant

1998 Vintage Reclamation

- Recover Valve Room
- Provide Valve Room Access
- Personnel Safety
- Remove Talus (partial)
  - Access
  - Safety
  - Structural pressure

- Marginally successful

1998 Reclamation

2013 work beginning

Significant talus accumulation in 12 years since 1998 reclamation activity

Valve vault access bridge and Bypass line

1998 Reclamation

2013 work in progress

Significant talus accumulation in 12 years since 1998 reclamation activity

Supplemental Reclamation Studies

- Given the continued weathering
- Study of additional levels of stabilization
- Shannon & Wilson out of St. Louis commissioned for additional evaluation and alternatives study
  - Geologic exploration and testing
  - Historical review
  - Alternatives evaluation and cost comparison

Study Results

- Conclusions
  - Surface runoff and abutment seepage contributing to weathering
  - Limestone and chert undergoing mechanical and possibly chemical weathering
  - Soft beds undercutting harder beds leading to rock fall failures

Reclamation Alternatives

- Surface Drainage Improvements
- Scaling
- Talus Removal
- Cliff Face Stabilization Improvements
  - Anchored Shotcrete Facing
  - Rock Bolt Anchorage
  - Anchored Mesh

Selected Alternative

- Surface Drainage Improvements
- Scaling
- Talus Removal
- Anchored Mesh Stabilization
  - All systems necessitate anchorage
  - Reliability of drainage for shotcrete and long term durability less reliable – higher initial and life cycle cost
  - Anchored Mesh requires tighter anchor spacing – provides increased durability and reliability

Selected Alternative

Stabilization of Pensacola Dam West Abutment Final Quantities and Costs				
Description	Unit	Units	Unit Cost	Cost
Mobilization and Demobilization	LS	1	$188,610	$188,610
Erosinon Control	LS	1	$6,214	$6,214
Fence Removal and Replace	LS	1	$46,455	$46,455
Excavate and Dispose of Spoil (Talus) up to 2,000 CY	CY	2000	$128	$256,800
Excavate and Dispose of Spoil (Talus) 2,001 - 2,500 CY	CY	487	$128	$62,531
Excavate and Dispose of Spoil (Talus) 2,501 - 3,000 CY	CY	0	$128	$0
Furnish and Install Ground Anchors	LF	12000	$70	$840,000
Furnish and Install Slope Mesh	SF	34578	$12	$414,936
Scale Rock Slope and Trim Overhangs	LS	1	$60,975	$60,975
Total				$1,876,521

Scaling

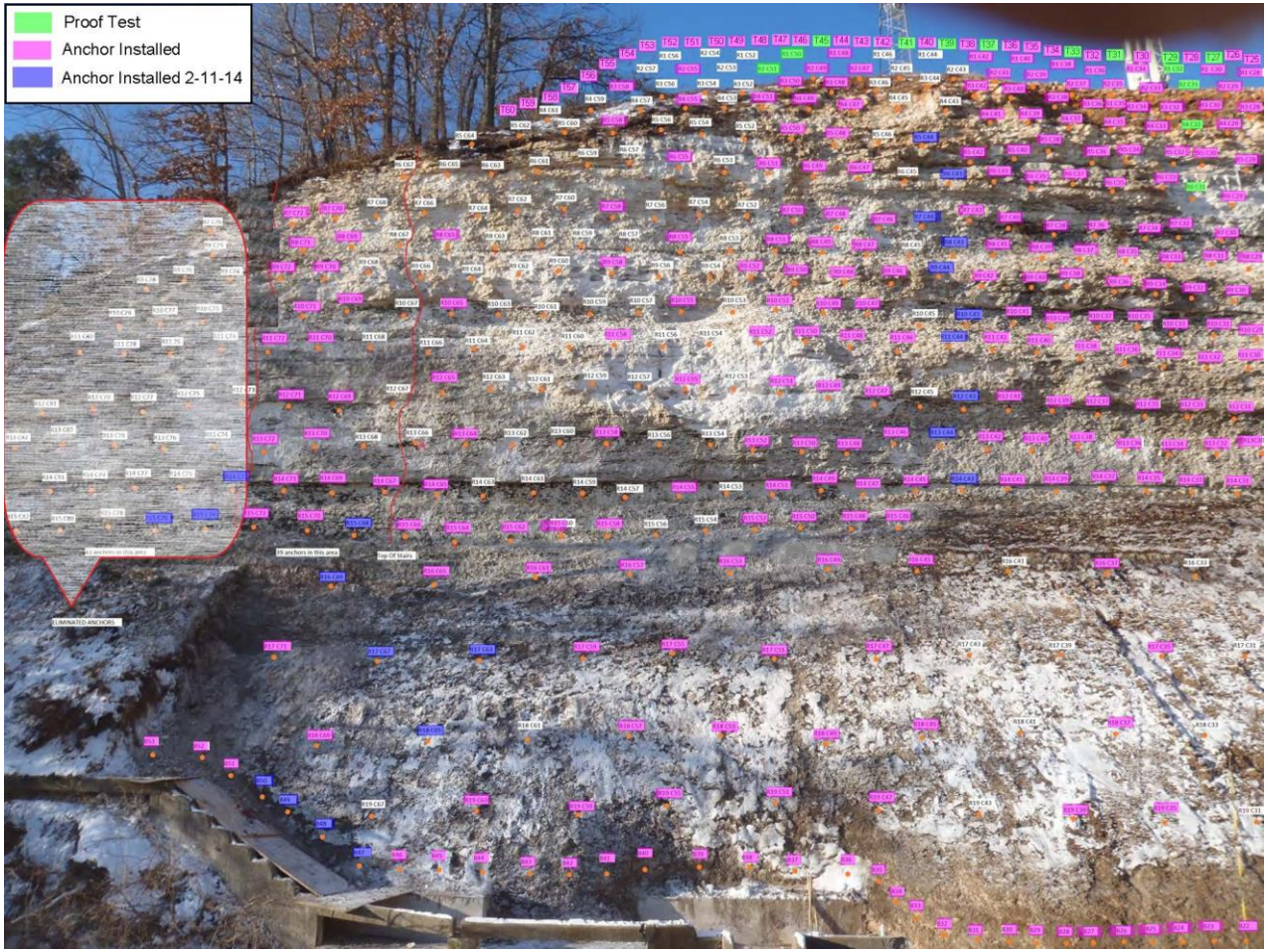
Scaling

Scaling

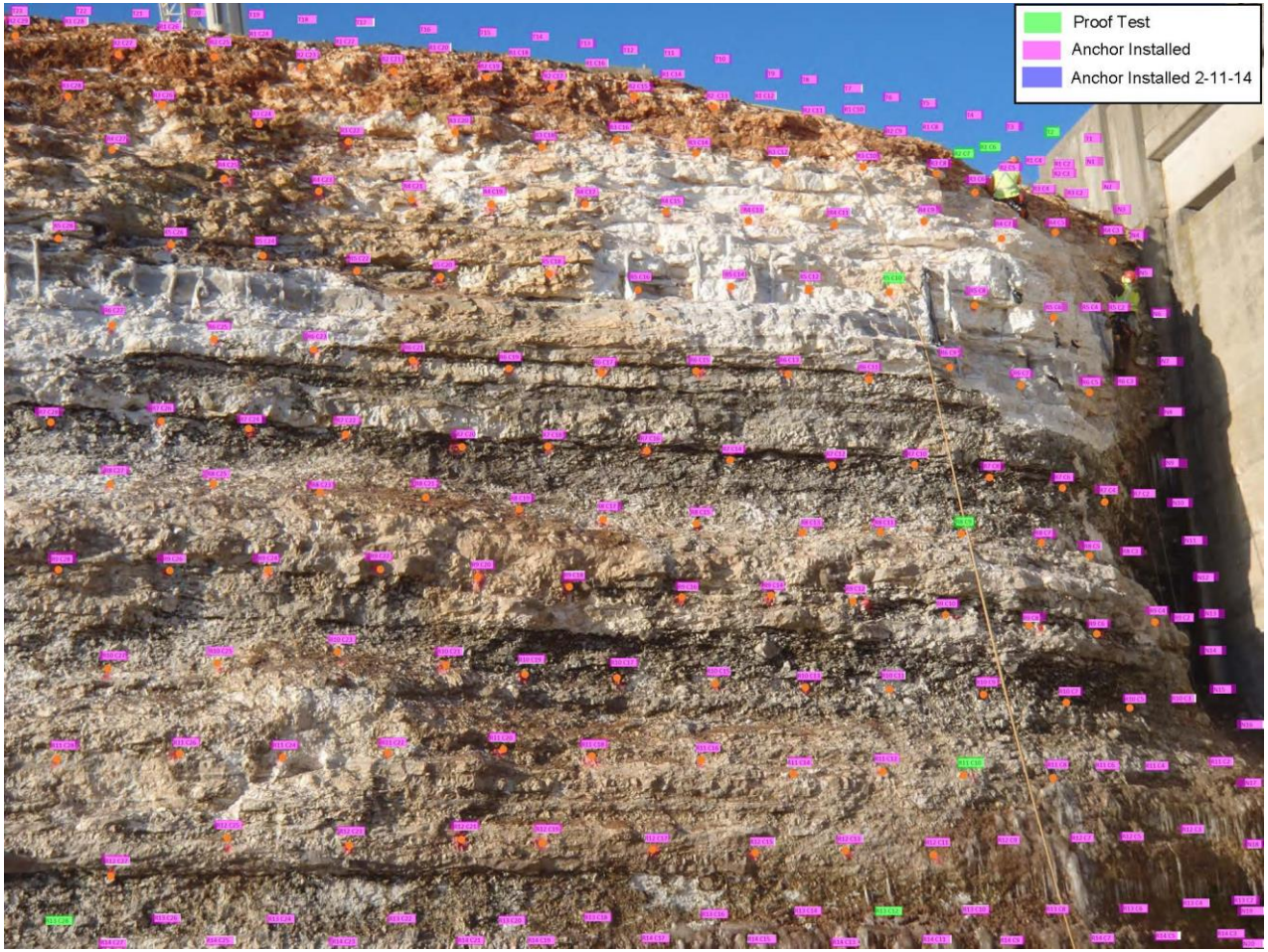
Excavation

Excavation

Anchor Pattern - Partial



Anchor Pattern - Partial



Anchor Drilling

Anchor Drilling

Anchor Drilling

Anchor Drilling

Cleaning Hole for Anchor Grouting

Anchor Grouting

Installing Underlayment

Erosion Control Mat - TECMAT

Installing Slope Mesh

Steel Mesh – Tecco G65

Anchor Tensioning

Anchor Tensioning

Anchor Testing

Anchor Testing

Anchor Testing

Final Installation

Mesh Connectors, Boundary Rope & Trimming Anchors

Mesh Connector with Boundary Rope

Completed Installation

Completed Installation

Other Applications

Mining High Walls

Other Applications

Highway Rock Fall Protection