Brazos River Authority

CAASLE Project, Phase III

Presented by

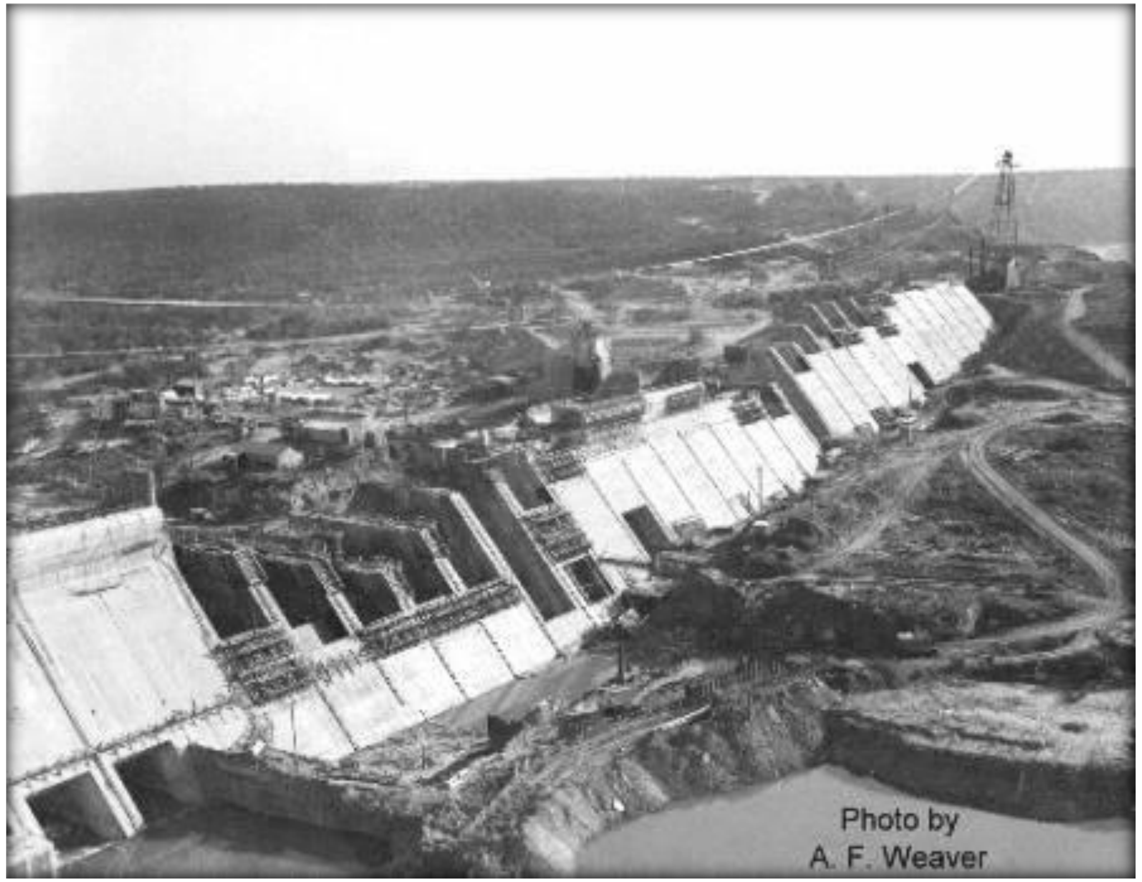
Michael McClendon - Upper Basin Regional Manager

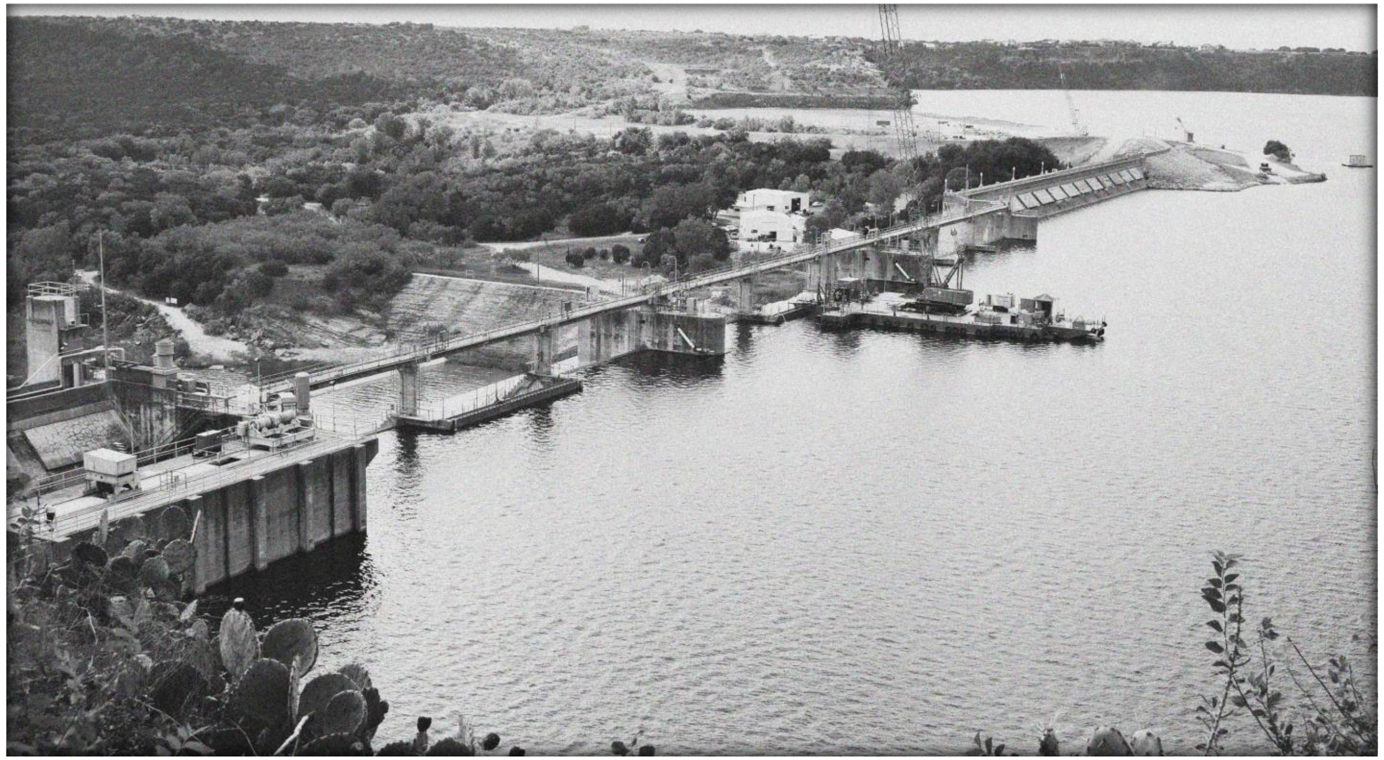
&

Stewart Vaghti P.E. - Gannett Fleming Inc.

Meeting Date: May 24, 2021

Morris Sheppard Dam





Goal - Extend the Service Life

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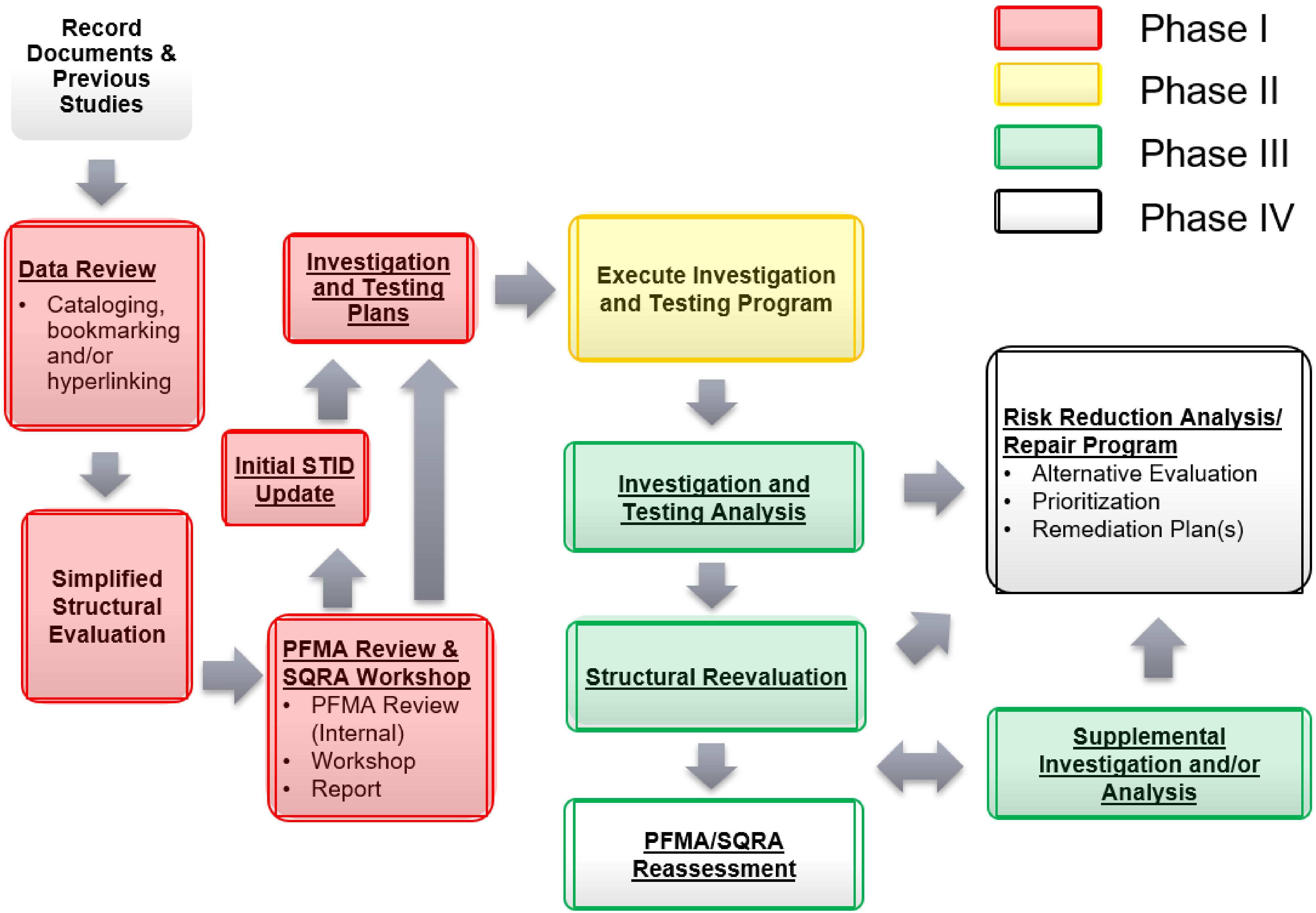
Scope Outline Flowchart



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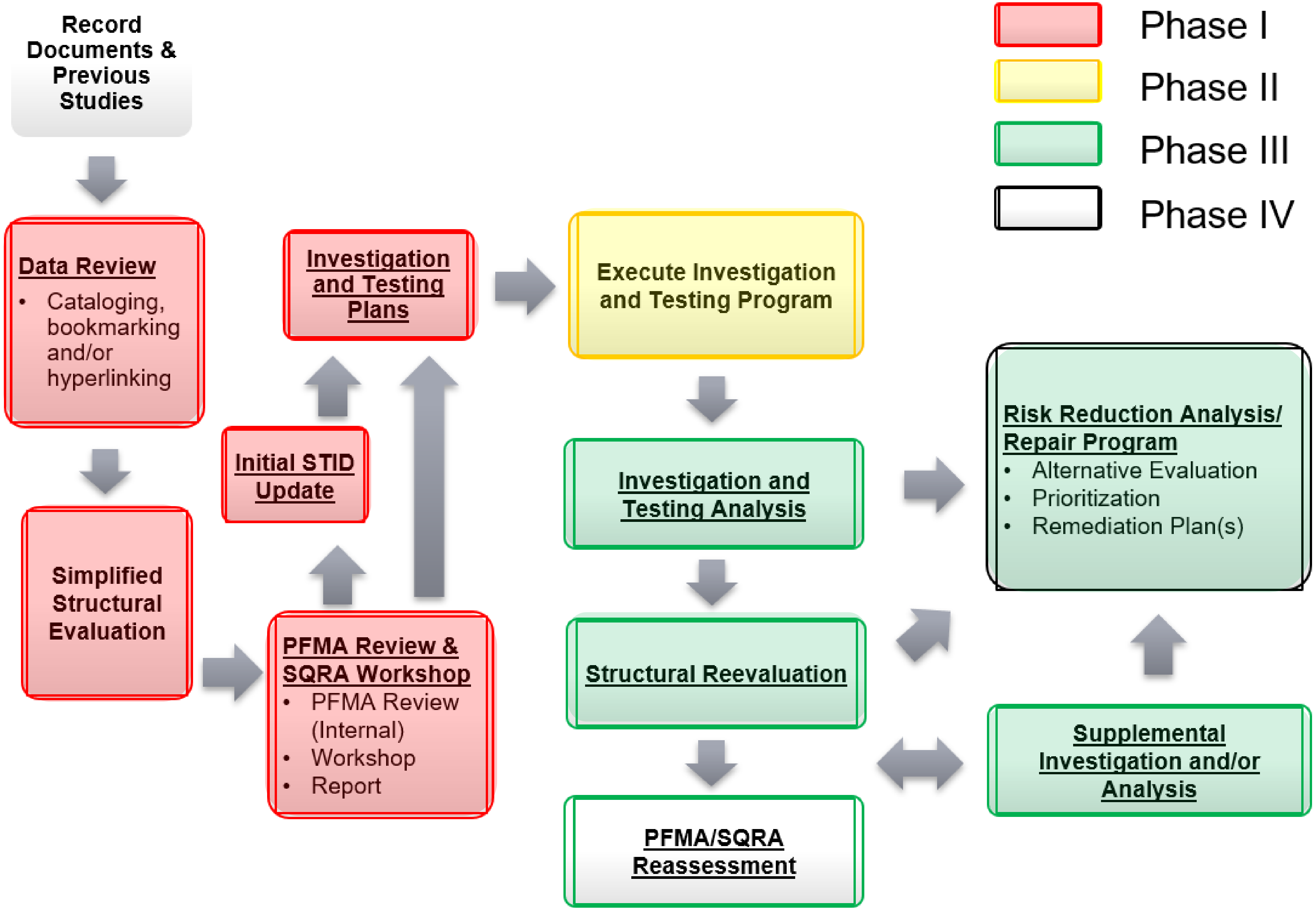
Scope Outline Flowchart



Scope of Services

Phase III: Analysis and Targeted Testing

Goal – *Guide decision making to achieve a longer service life*

Result – Assist BRA in prioritizing preventative maintenance, repairs, and/or modifications to extend Morris Sheppard Dam's service life

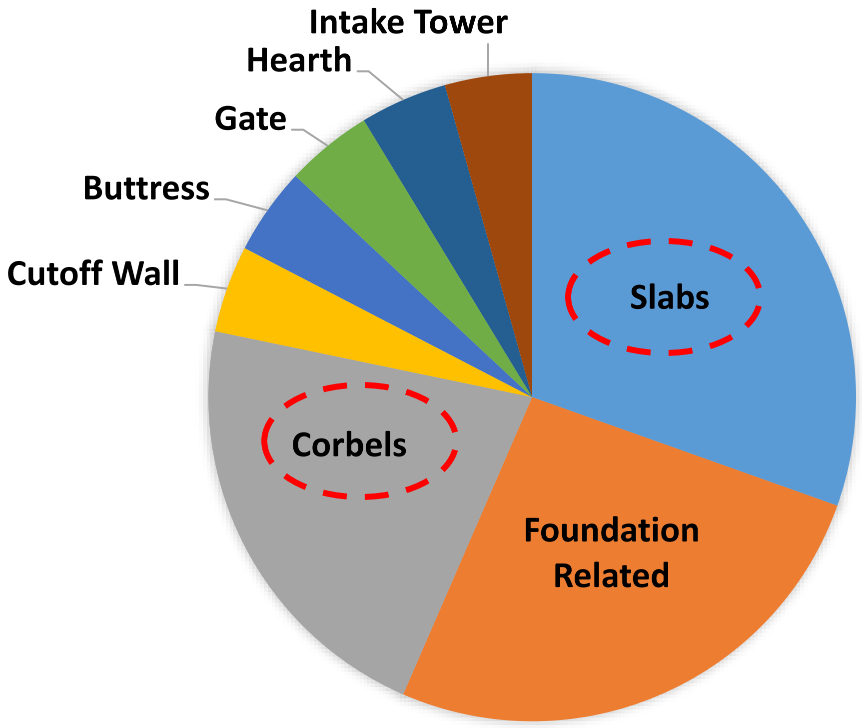
Phase III Schedule – Approximately 12 months

Overview of Phase III Tasks – Stewart Vaghti P.E.; Gannett Fleming Inc.

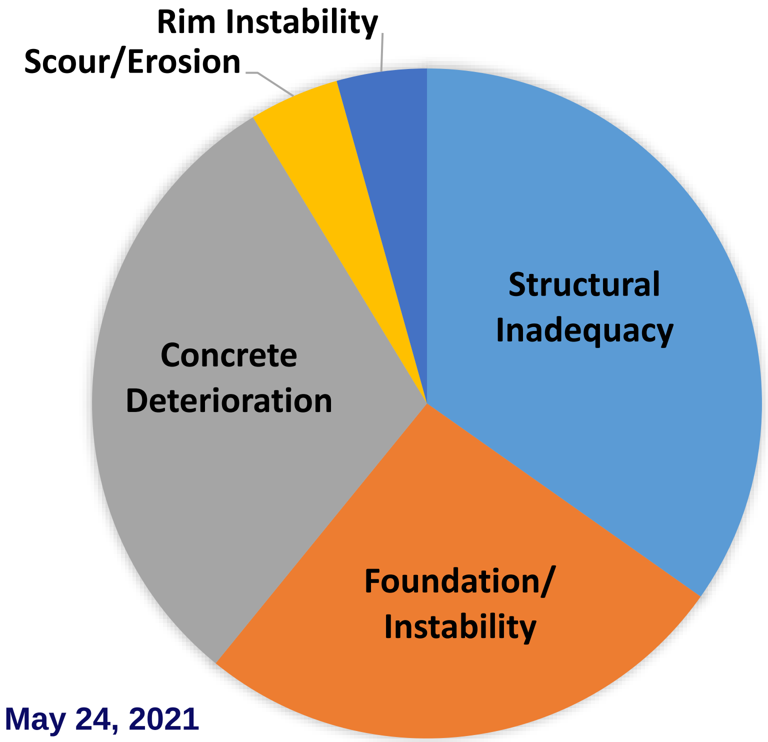
- Task 1: Targeted Destructive Testing
- Task 2: Failure Mode Progression Structural Analysis
- Task 3: Destructive Investigation and Repair Support
- Task 4: Long-term Structural Concrete Testing and Repair Program

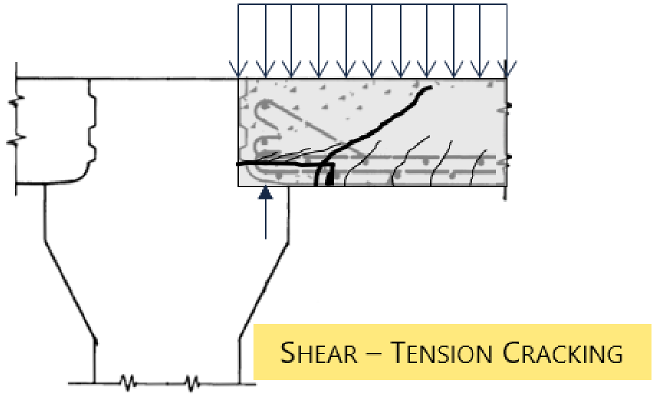
Priority Features

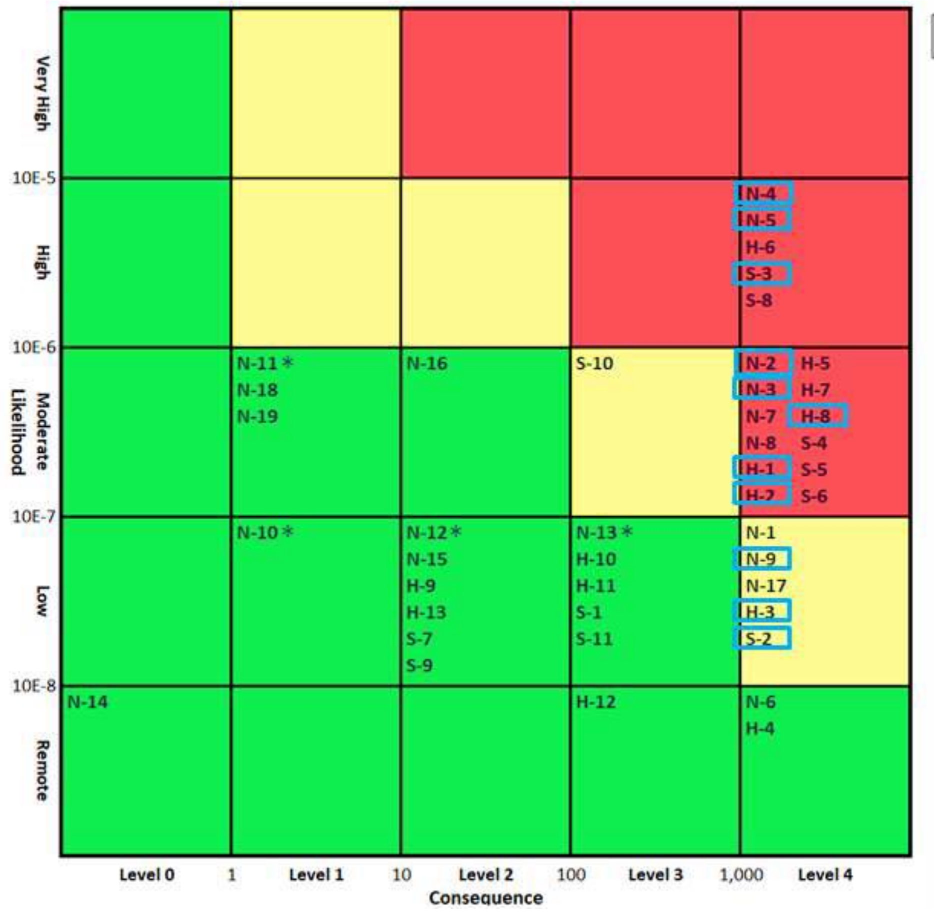
FEATURE SUMMARY

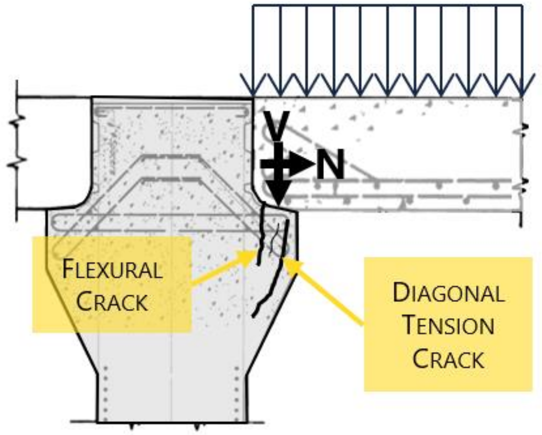


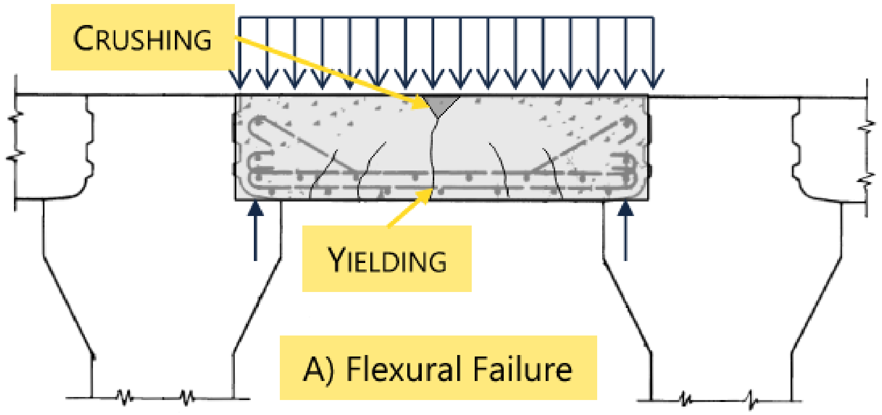
INITIATOR SUMMARY











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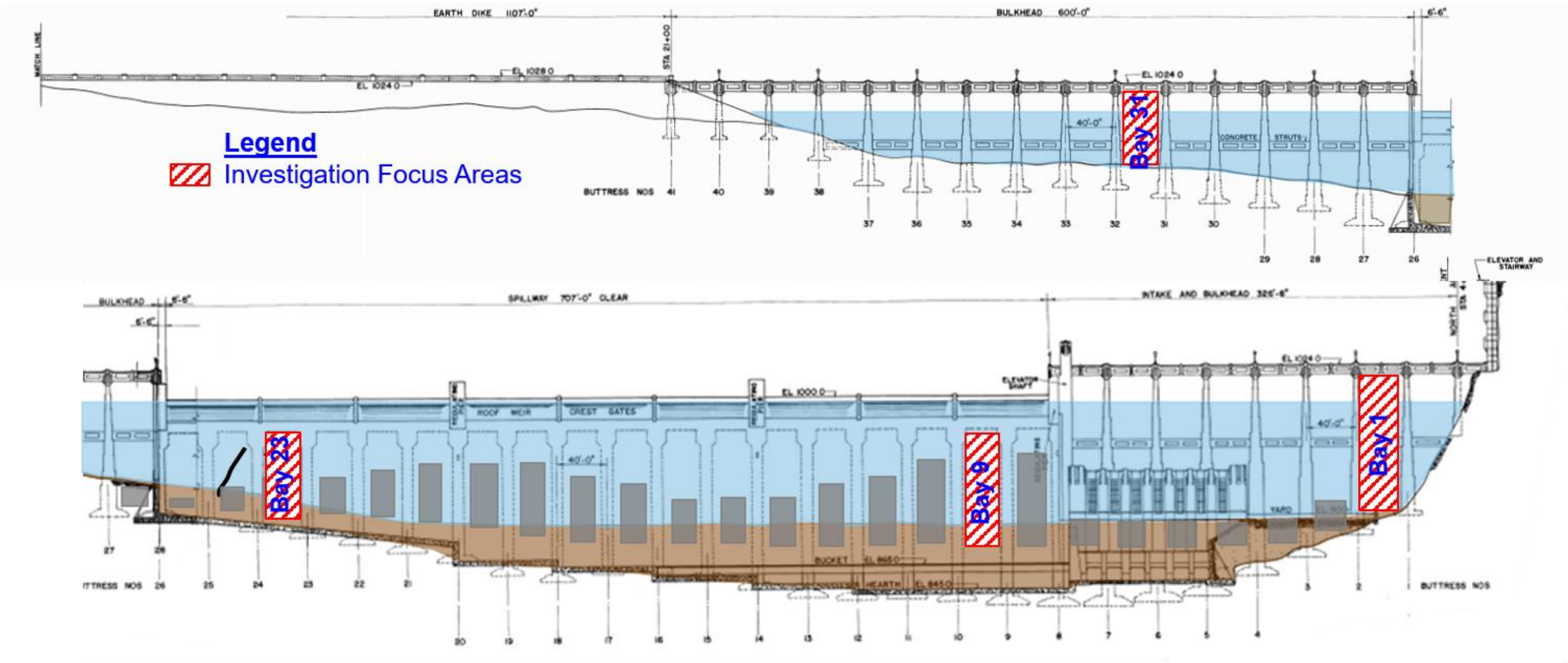
Phase II Investigation Recap



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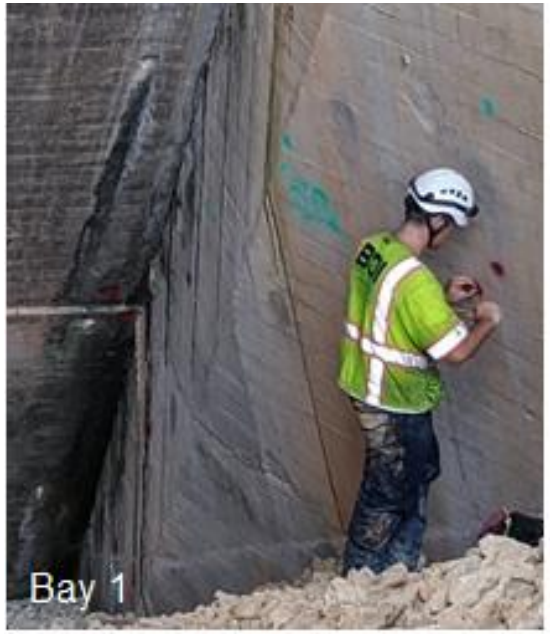
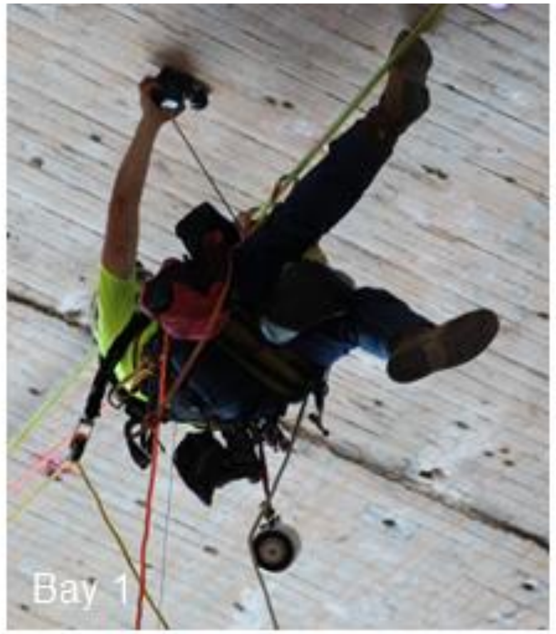
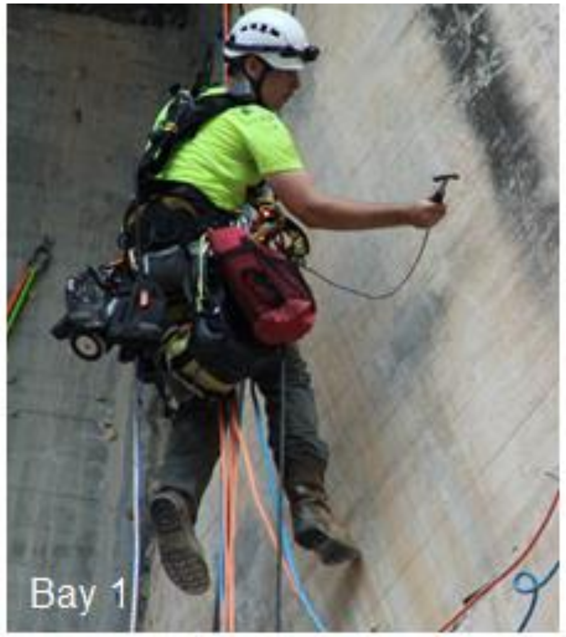
NDE Summary



Impact Echo



GPR



Hammer Sounding

MIRA

- Bays 1, 9, 23 and 31
- Slabs and Corbels

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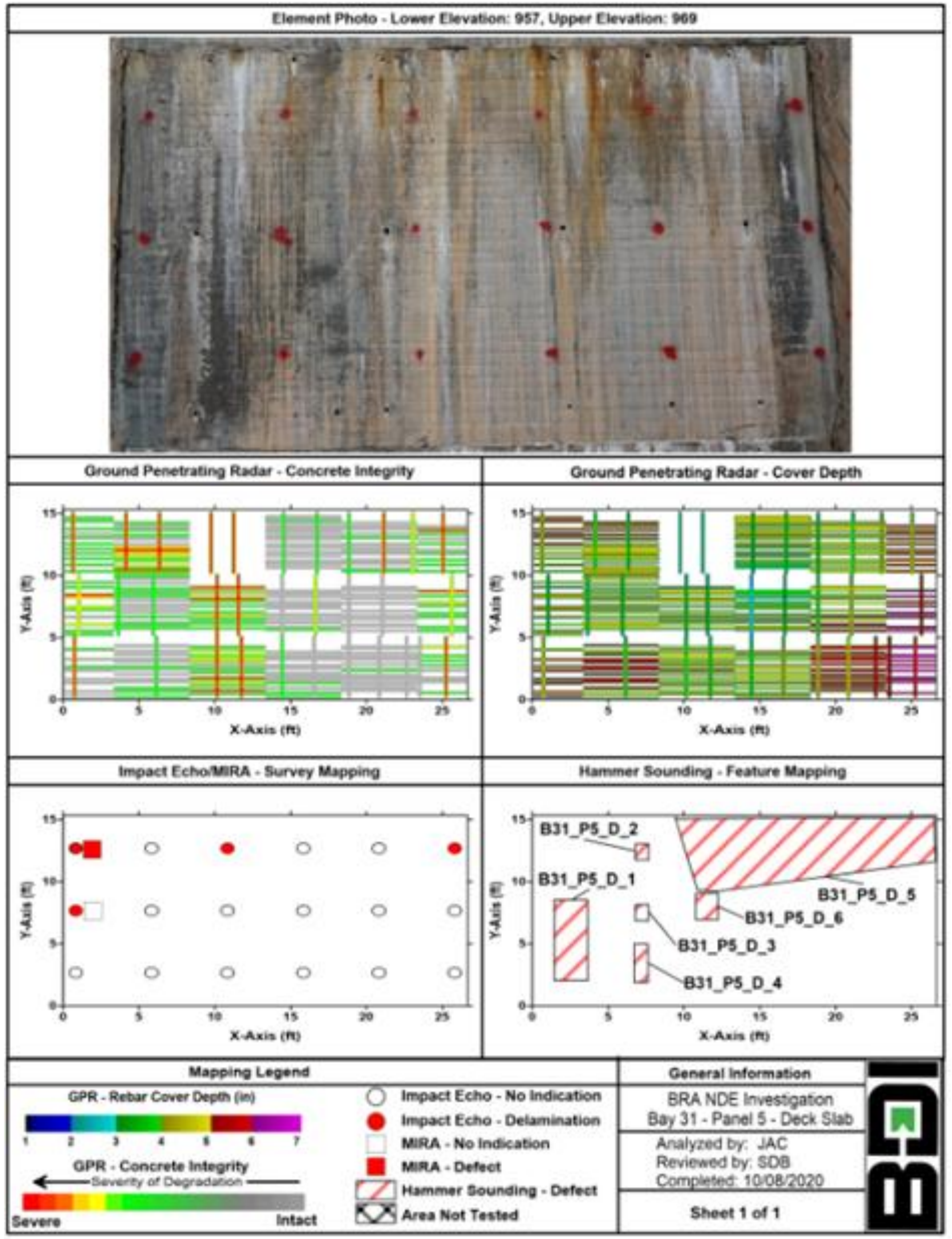
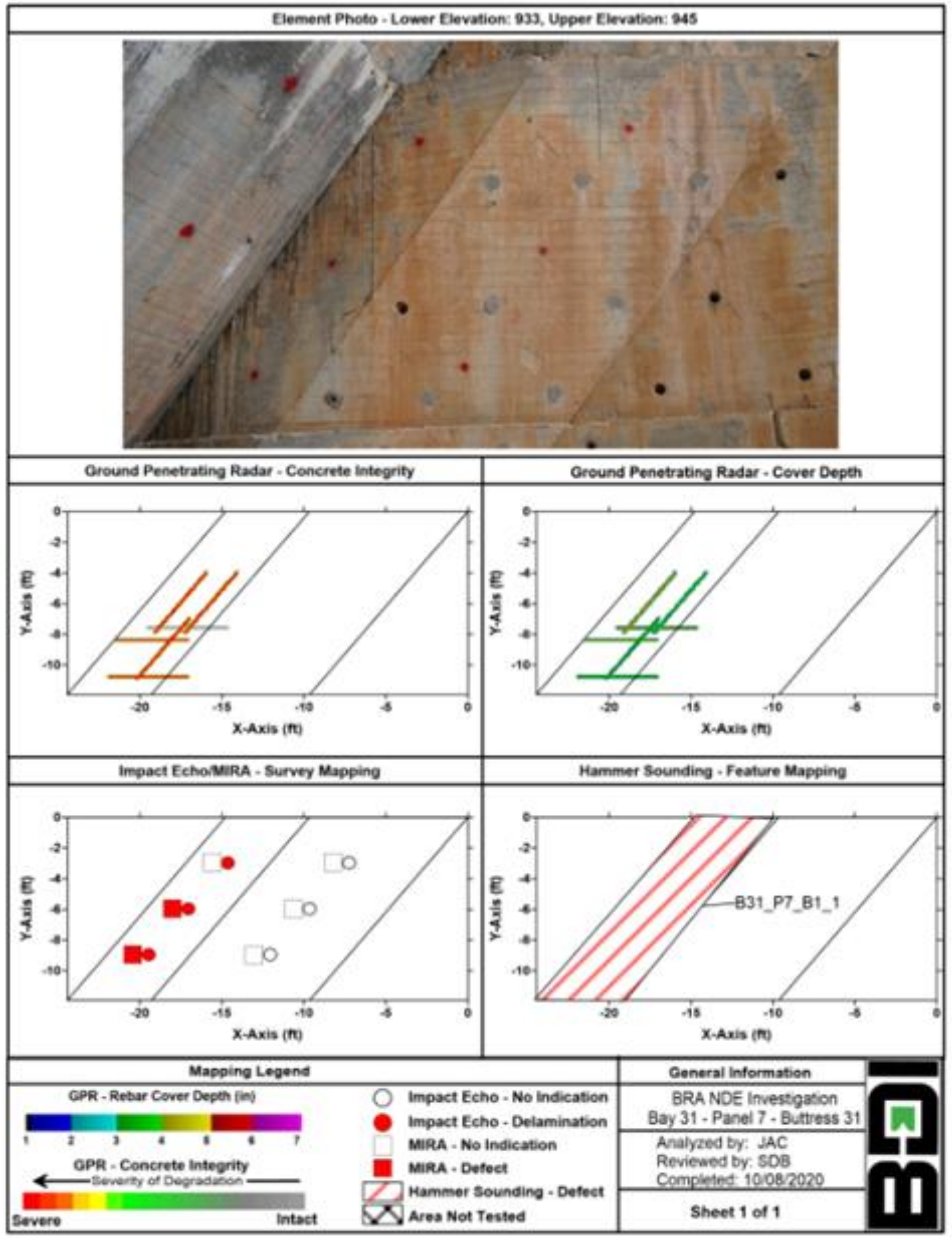
NDE Summary





NDE Summary of Findings

- Locations in the studied **non-overflow bays** (Bay 31 and Bay 1) were found to have test points where most or all NDE methods used identified a potential defect in the concrete.
- The **non-overflow** bays tested identified significantly shallower delaminations of the upper **corbel regions** compared to the spillway bays tested. Some delaminations are also visually evident by surface cracking, and various stages of spalling.

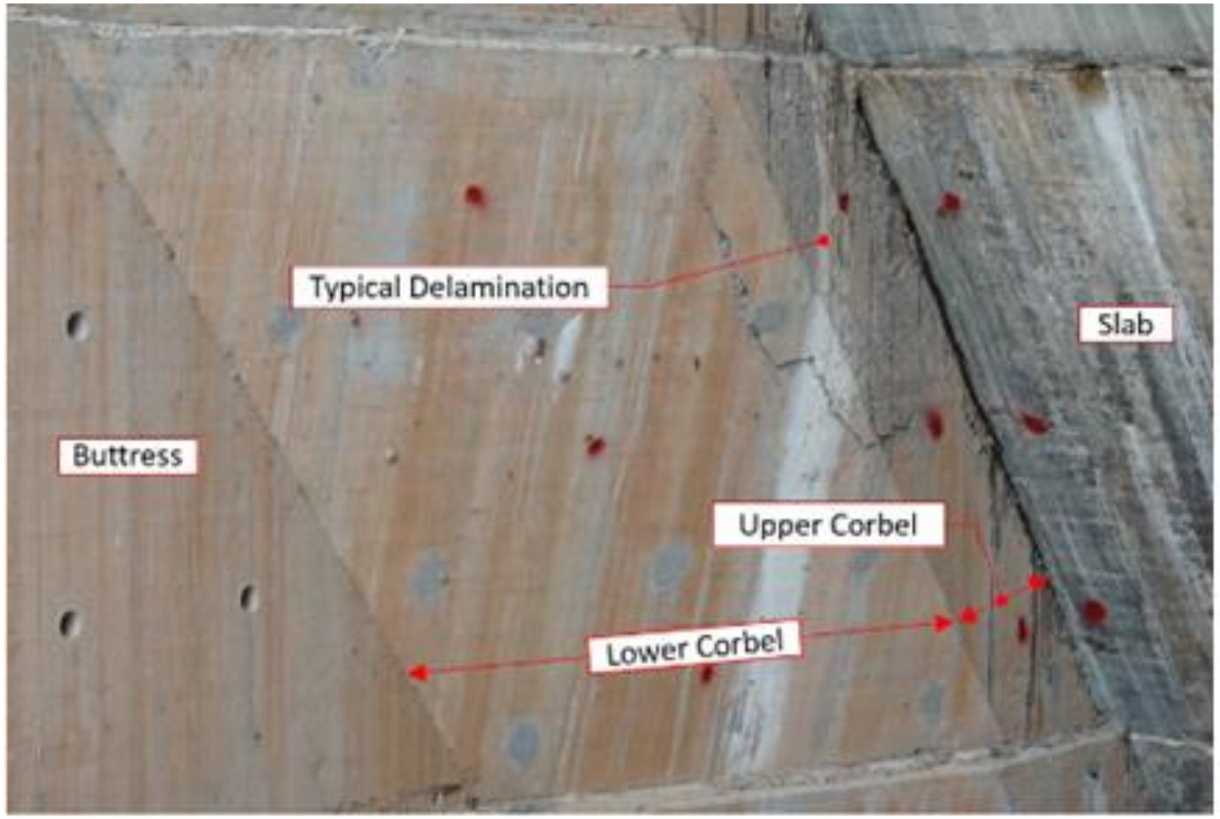


Figure 6-1 – Typical Corbel Delamination (Bay 31)

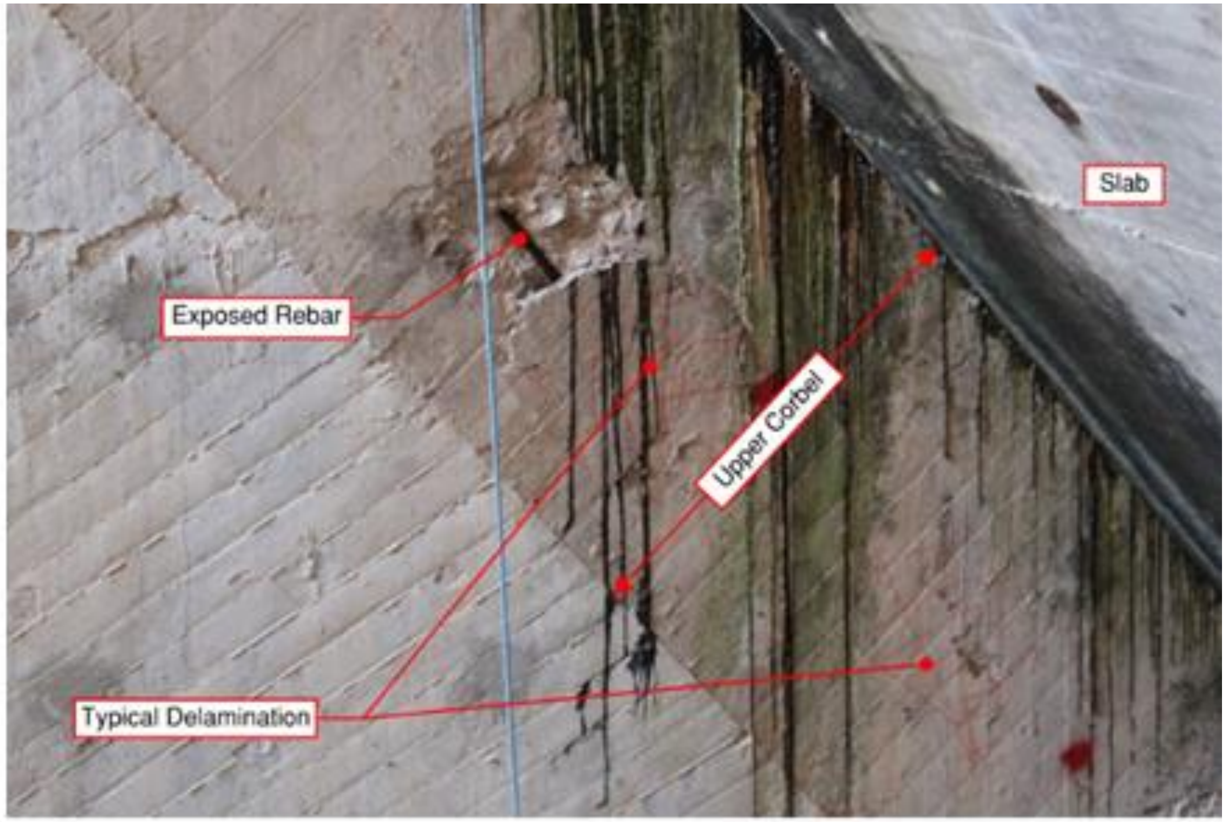


Figure 6-2 – Typical Corbel Delamination (Bay 1)

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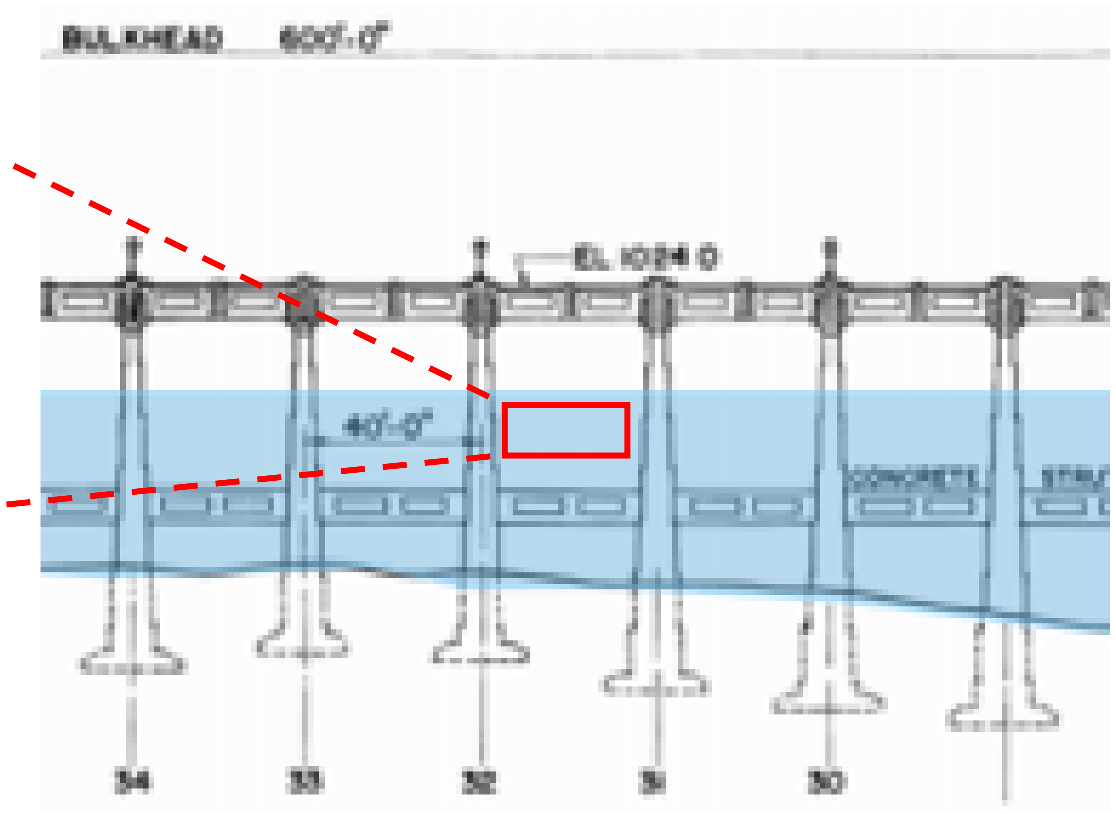
NDE Summary of Findings

- The **non-overflow bays** tested identified areas of shallow delaminations of the downstream sides of the upstream **slabs**, whereas the spillway bays tested identified no areas of slab delaminations. No visual evidence of cracking or spalling was observed at the areas of delaminations identified.

Approx. 25'

Approx. 12'



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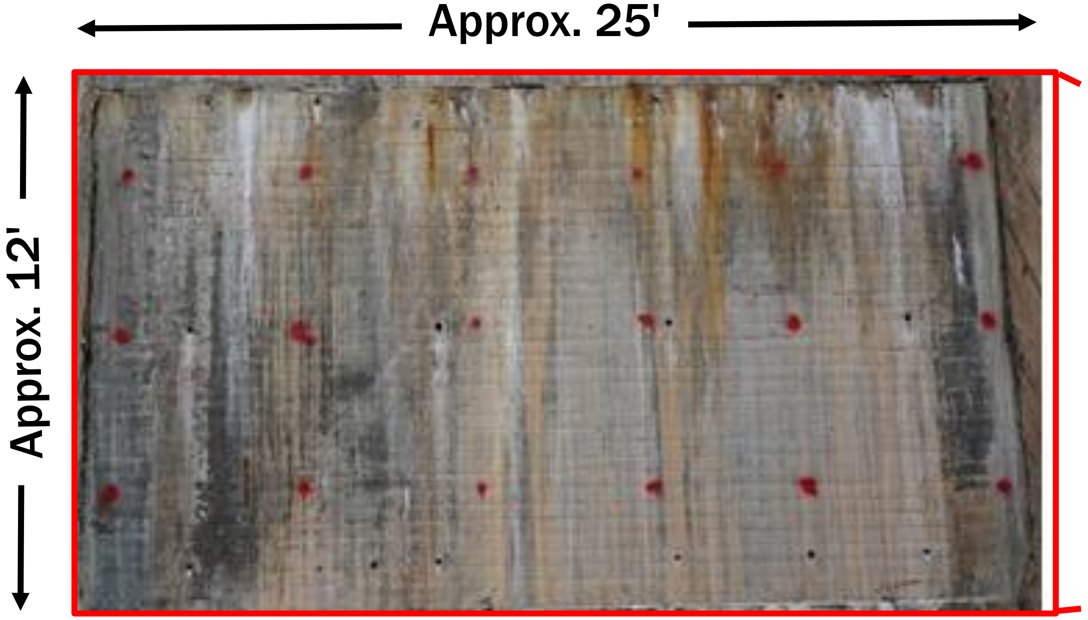

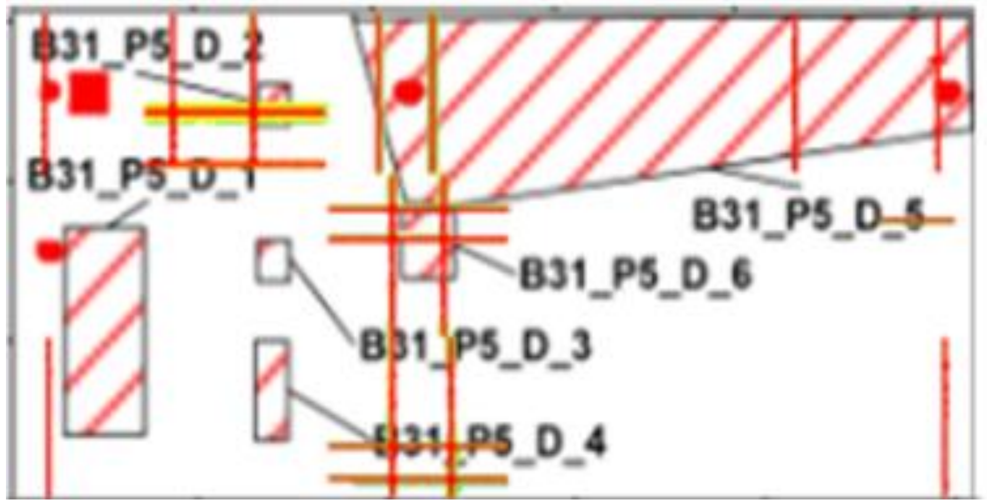

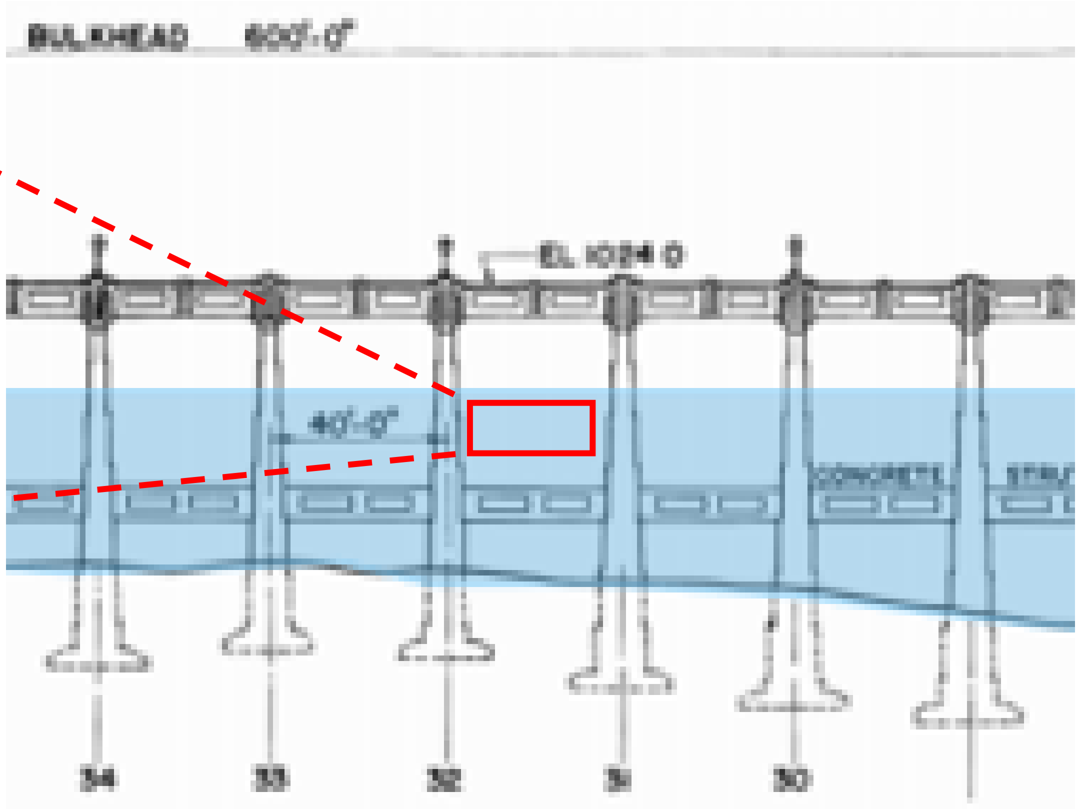

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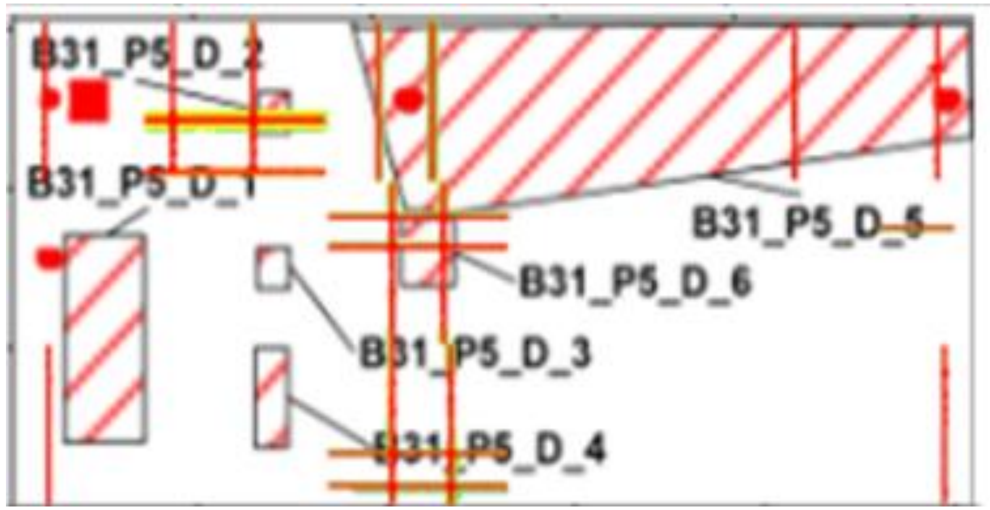

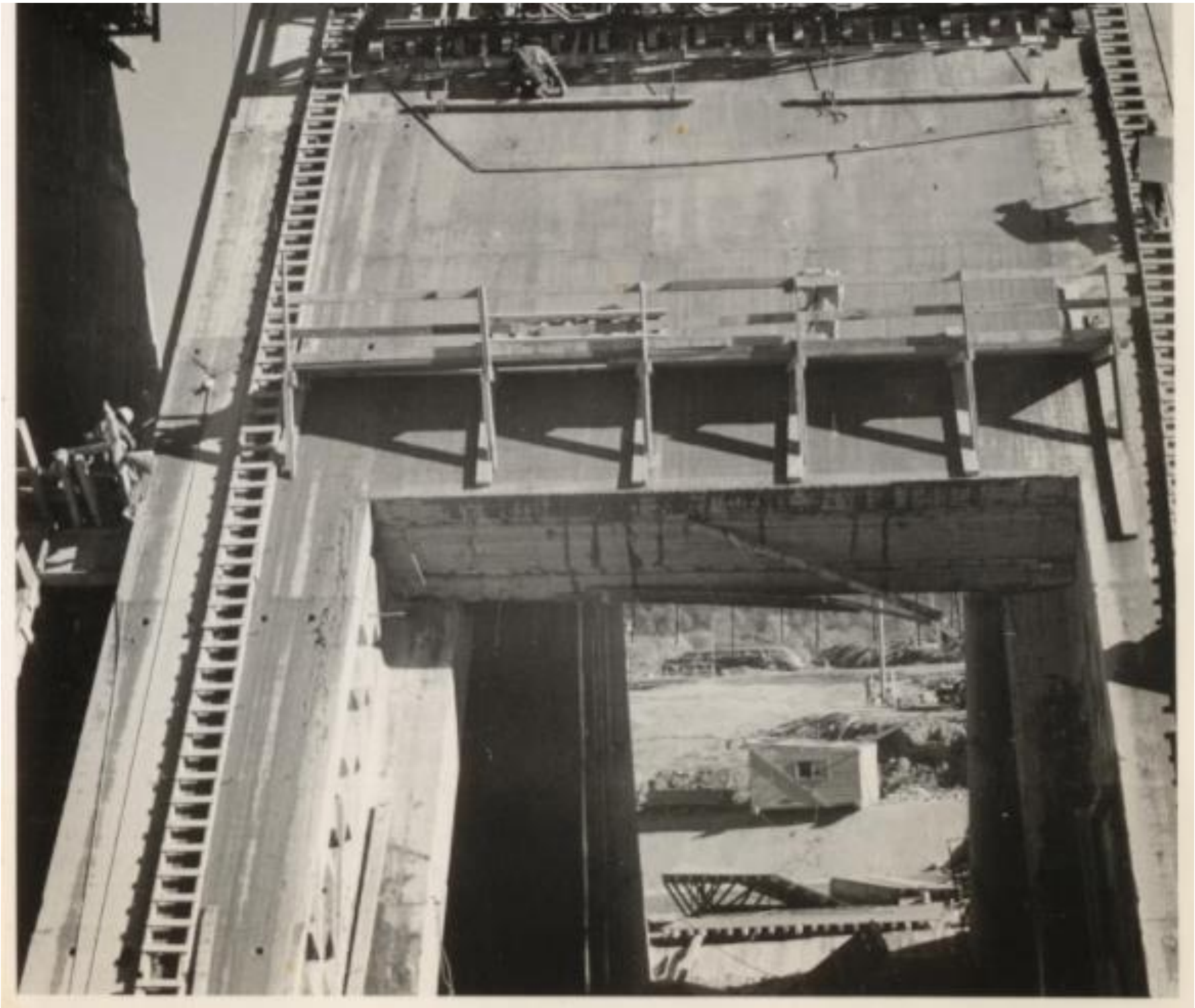

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Destructive Testing Summary of Findings

2020 CAASLE Investigation Compressive Strength Results (Appendix D)			
Spillway		Non-Overflow	
BUTTRESS	Strength (psi)	BUTTRESS	Strength (psi)
BTS9-DS-WZ-2	4,770	BTS2-DS-ND-2	2,820
BTS9-DS-ND-1	3,530	BTS31-DS-ND-1R	4,100
BTS10-US-NS-3	4,450	BTS32-DS-ND-3	3,610
BTS10-DS-ND-1	4,950	***Buttress Average Strength***	**3,510**
BTS23-DS-ND-1	5,180	**SLAB**	**Strength (psi)**
BTS24-DS-ND-1	4,370	SLB1-US-ND-2	5,200
Buttress Average Strength	**4,542**	SLB1-US-SS-1	5,730
No slabs in the spillway sections were analyzed for compressive strength.		SLB31-US-SS-1	7,230
		SLB31-DS-ND-2	6,210
		SLB31-US-ND-2	4,870
		Slab Average Strength	**5,848**

2018 Gate No. 2 Coring Investigation Compressive Strength Results (Appendix D of 2018 *Gate No. 2 Side Seal Replacement - Investigation, Testing and Analysis Report* [9])	
Core Sample (GFI / DRP Sample No.)	**Strength (psi)**
G2-NP-TP-1 / 22YD9333	5,380
G2-NP-NS-1 / 22YD9337	7,150
G2-NP-PS-3 / 22YD9343	7,700
G2-SP-NS-2 / 22YD9346	4,820
G2-SP-PS-2 / 22YD9350	6,420
Average Strength	**6,294**

1988 Freese and Nichol Compressive Strength Results (Appendix G of 1988 *Report on Structural Analysis of Morris Sheppard Dam* [8])			
Buttress	**Compressive Strength (psi)**	**Slab**	**Compressive Strength (psi)**
Buttress B-9	3,170	Bulkhead #30	3,040
Buttress B-15	4,760	Bulkhead #32	3,900
Buttress B-25	3,620	Bulkhead #34	4,060
Average Strength	**3,850**	**Average Strength**	**3,667**

Note: Test data at bulkhead locations were assumed to be at upstream slabs of the non-overflow sections.

25 total

1937 Compressive Strength Design Criteria (Section 5-21 of 1937 *Specifications for Constructing Possum Kingdom Dam and Power House on Brazos River, Texas* [6])		
Structural Element (Type)	Average 28-Day Design Strength (psi) (Based on average for any 25 consecutive cylinders)	Minimum 28-Day Strength for any one cylinder (psi)
Deck Slab (Class "A")	3,000	2,300
Buttress (Class "B")	2,500	1,800

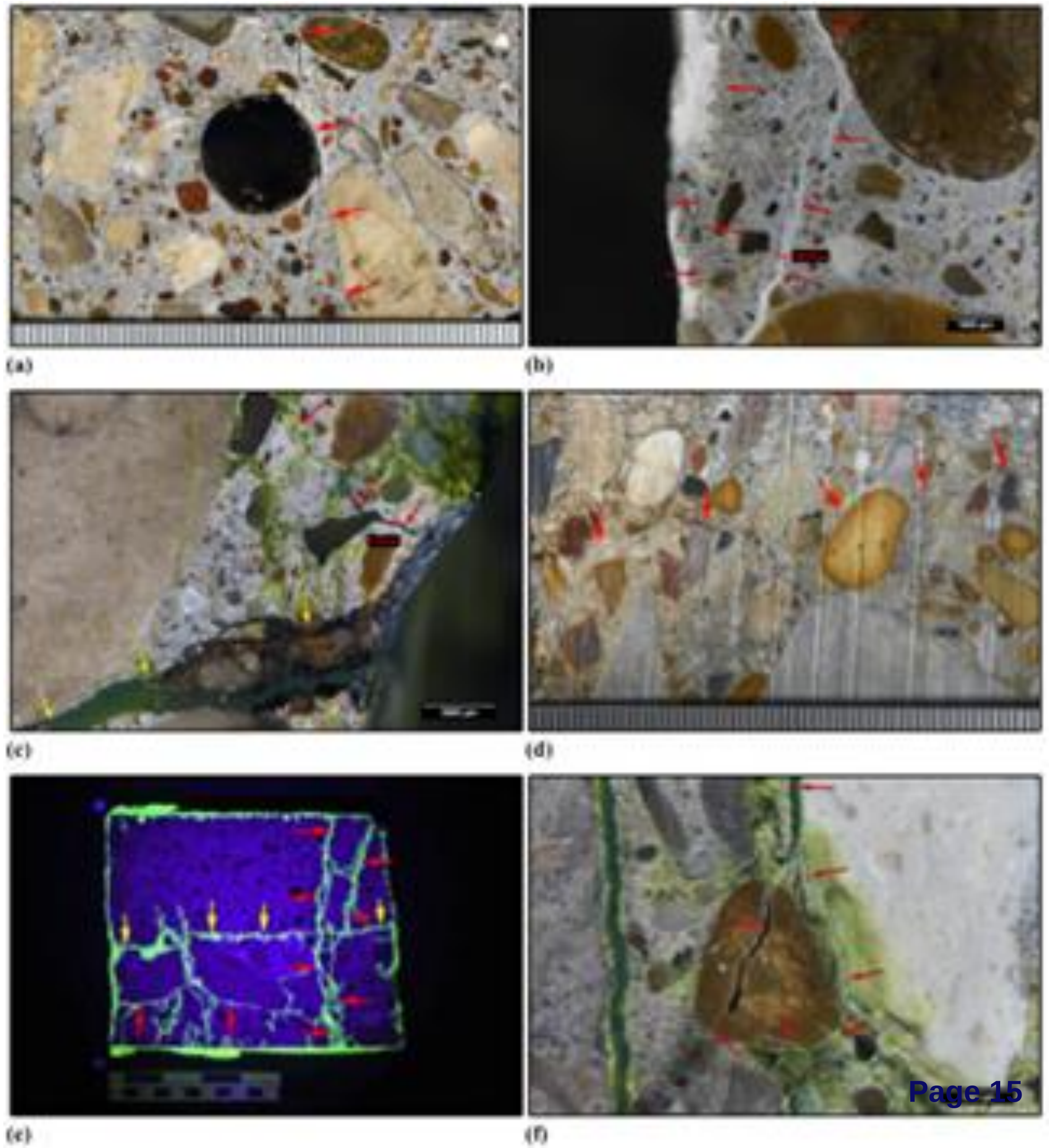
14 SLB1-US-ND-2

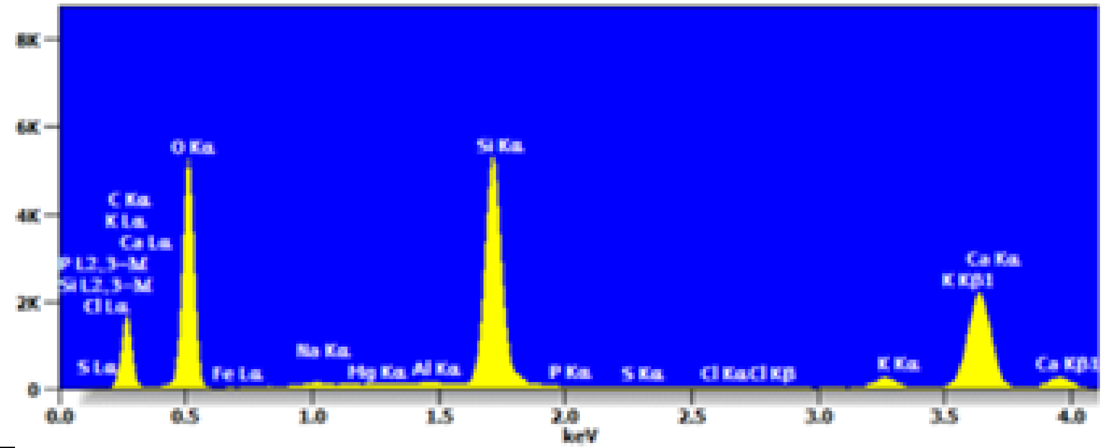
Photo No. 57 – SLB1-US-ND-2 (Isometric View) – 6" Diameter

Photo No. 58 – SLB1-US-ND-2 (Isometric View)

Destructive Testing Summary of Findings

- **Petrographic examination and scanning electron microscopy:**
  - 20 samples (18 cores, two grab samples).
- **Acid-soluble chloride content:**
  - 18 cores, three tests per core (two in cover and one at depth of steel).
- **Sulfate content:**
  - 18 cores, one test per core (at outer surface).
- **Formation factor (bulk resistivity):**
  - 11 cores.
- **Service life modeling:**
  - 5 cores (from Buttress 1, 10, 23, and 31).





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Destructive Testing Summary of Findings

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- **Overview:** Most core samples were sound, intact, well consolidated and in excellent condition consistent in composition and proportioning, with some exceptions.
- **ASR:** Nearly all core samples show no to negligible ASR damage. Two (2) cores were the exception.
    - BTS31-DS-ND-2R: Severe ASR damage observed; possibly stem from concrete batching conditions and placement during the original construction.
    - BTS1-US-SS-1: Minor ASR damage observed.
- **Sulfate Attack:** Only Bay 9 samples show clear evidence of sulfate attack.
    - BTS10-DS-WZ-1 and BTS10-DS-WZ-2: Severe sulfate attack was present in both grab samples.
    - BTS9-DS-WZ-1 and SLB9-DS-ND-1: Evidence of sulfate attack was observed in outer 4 mm and 2 mm.
- **Corrosion:** Only two cores show evidence of distress associated with corrosion of steel reinforcement.
    - BTS23-DS-ND-2: Microcracking associated with corrosion
    - BTS31-DS-ND-2R: Corrosion related to chloride ingress.
    - BTS32-US-NS-1: Negligible corrosion; however, rare deposits of Freidel's salt, a phase indicative of chloride ingress, are present in this core.
- **Calcium Carbonate:** Some do show relatively deep carbonation up to 25 mm (1 inch), which can promote further migration of chloride to steel reinforcement.

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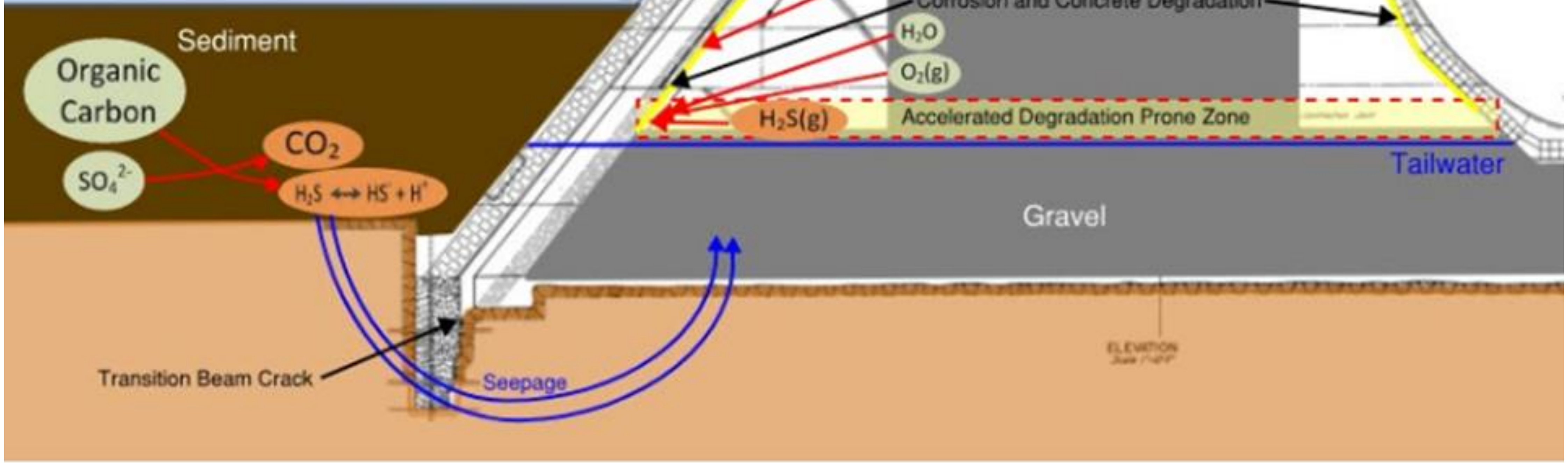
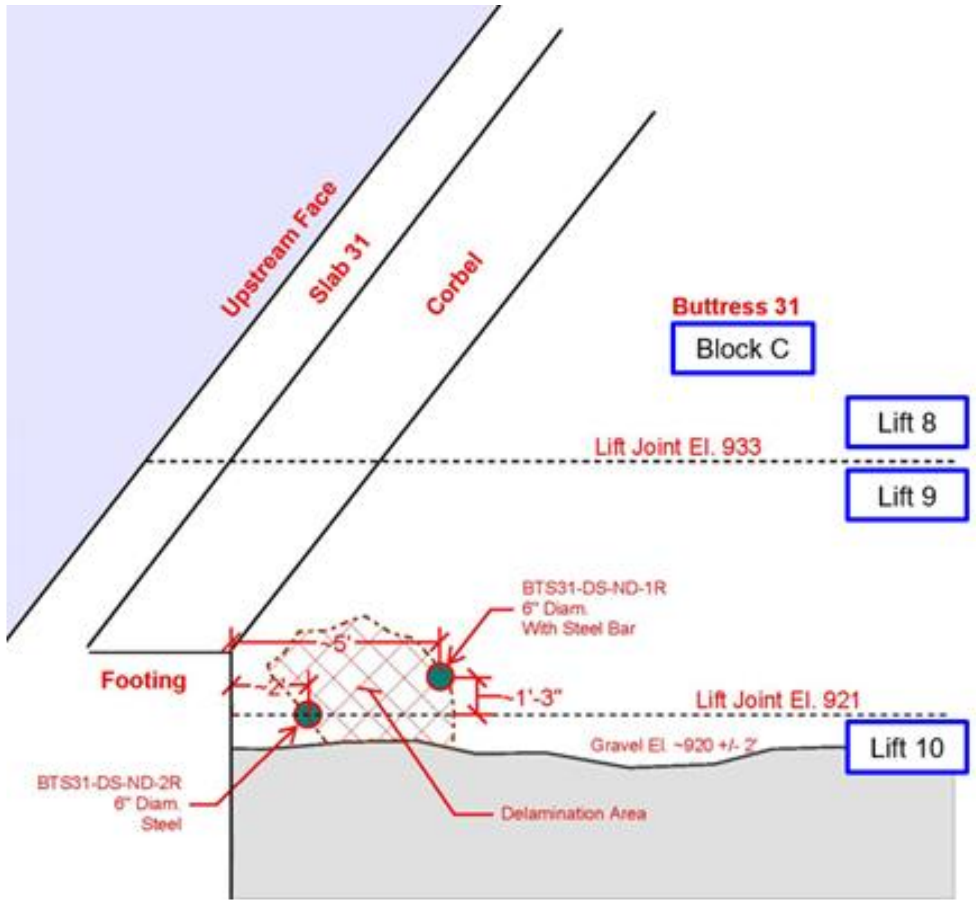
Water Quality Analysis Summary of Findings

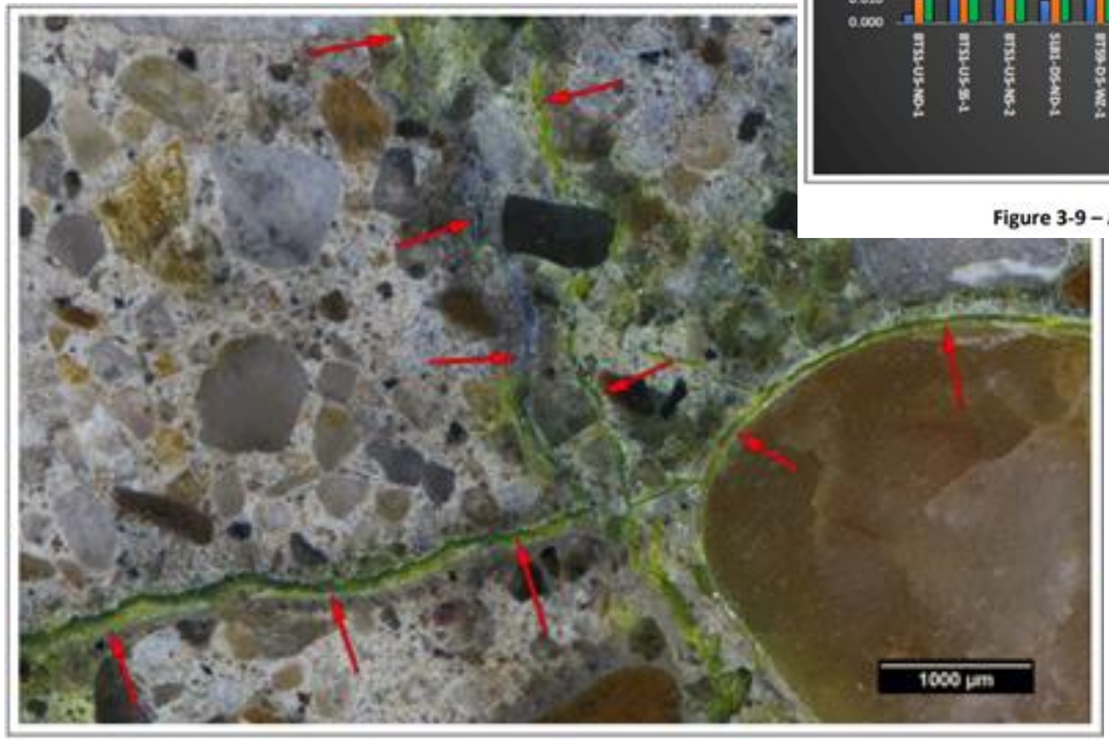
1. The reservoir is thermally stratified during the summer and fall.
2. The deeper water is devoid of oxygen (anoxic) when the reservoir is stratified.
3. The absence of oxygen allows sulfur-reducing bacteria to convert sulfate to sulfide within the sediments at the bottom of the lake.
4. The sulfide-containing water seeps through the dam joints, cracks, and foundation.
5. Hydrogen sulfide gas volatilizes from the seepage.
6. Sulfide-oxidizing bacteria then convert the sulfide to sulfuric acid.
7. Sulfuric acid causes the concrete and steel to deteriorate.



Task 1 – Targeted Supplemental Destructive Investigation and Testing

- Expand ASR and chemical testing to see if ASR and Chloride conditions found are more widespread.





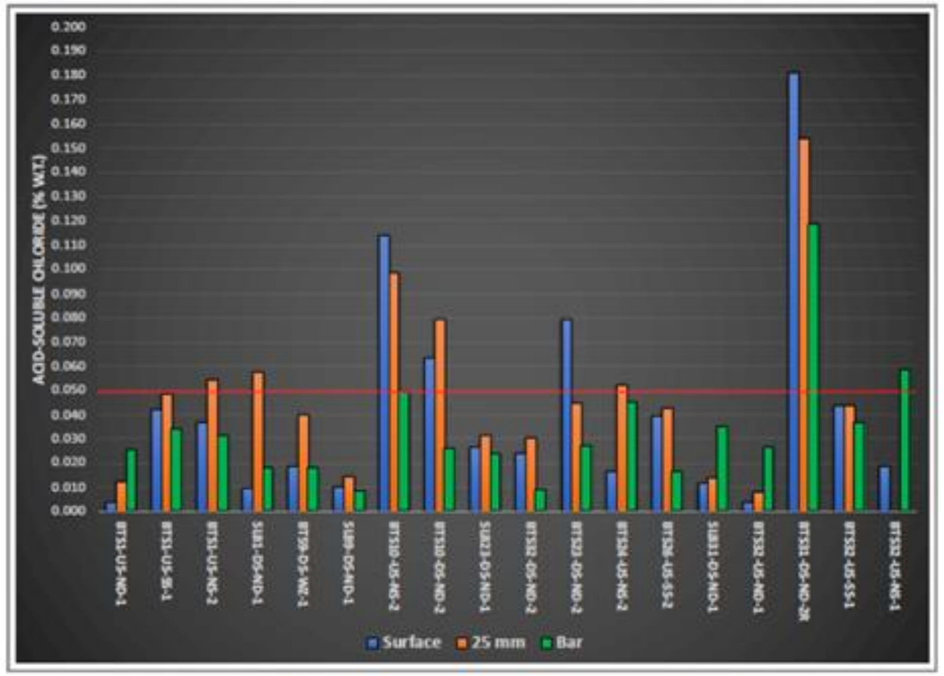


Figure 3-9 – Acid-Soluble Chloride Data Summary Bar Chart

Task 1 – Targeted Supplemental Destructive Investigation and Testing

- Expand ASR and chemical testing to see if ASR and Chloride conditions found are more widespread.

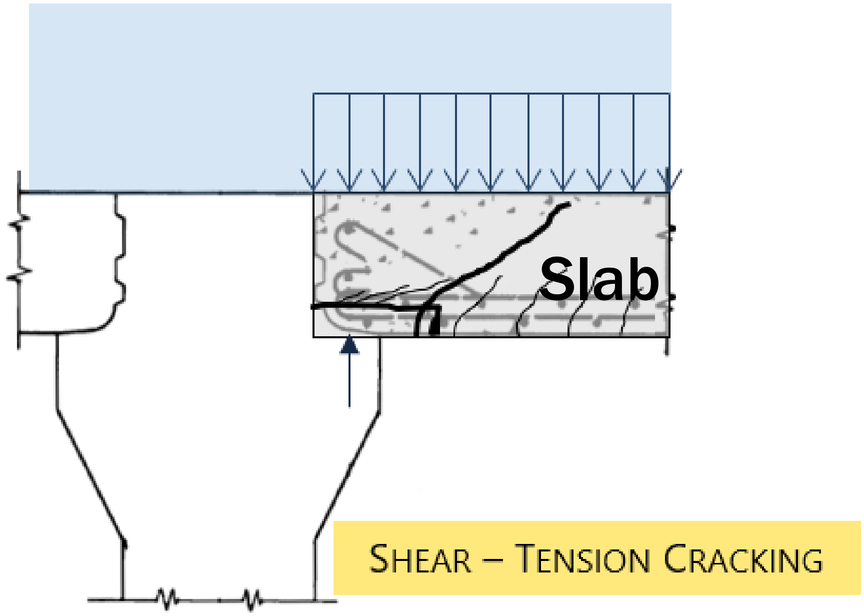
Sounding

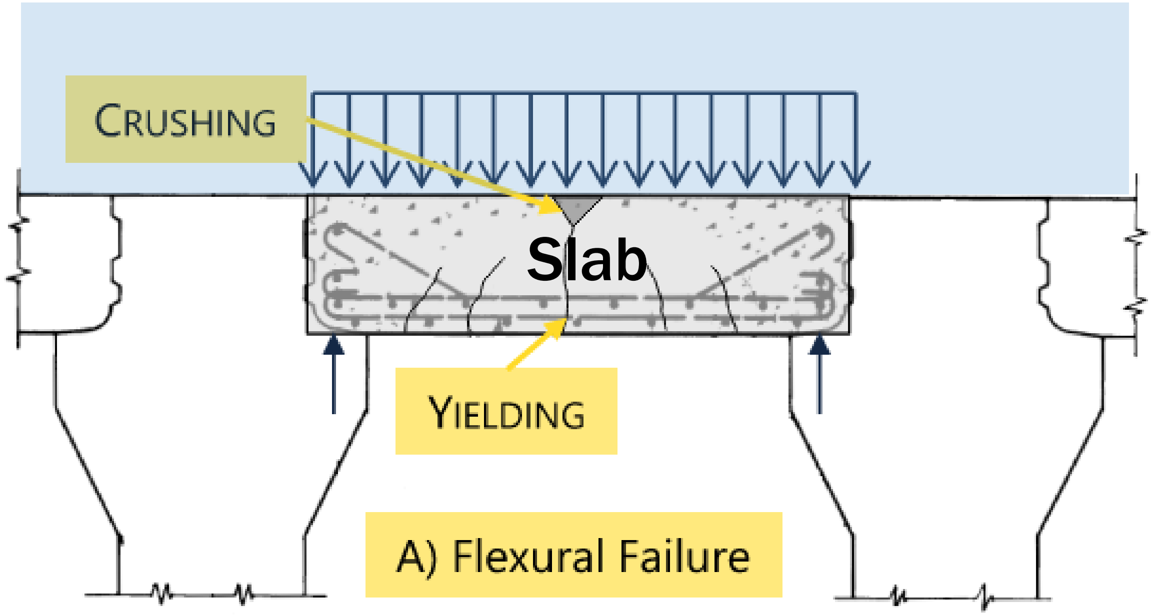
Powder Sampling

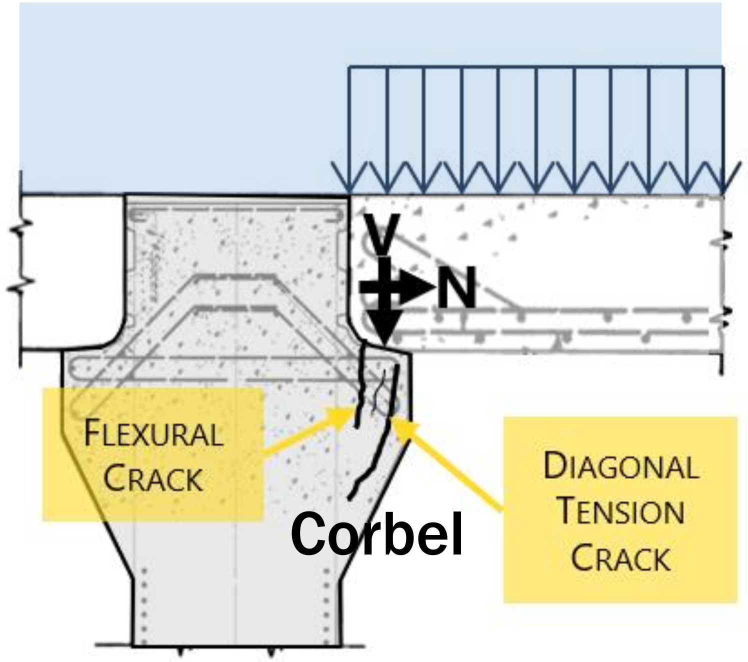
Coring (4" dia)

Task 2 – Failure Mode Progression Structural Analysis

- Evaluate 3 Key (Priority) Features x Scenarios
  - Slab in flexure
  - Slab in shear
  - Corbel in shear







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Task 3 – Destructive Investigation and Repair Support

- Slab Destrutive Investigation Plan and Repair
- Data Collection, Material Investigation and Analysis

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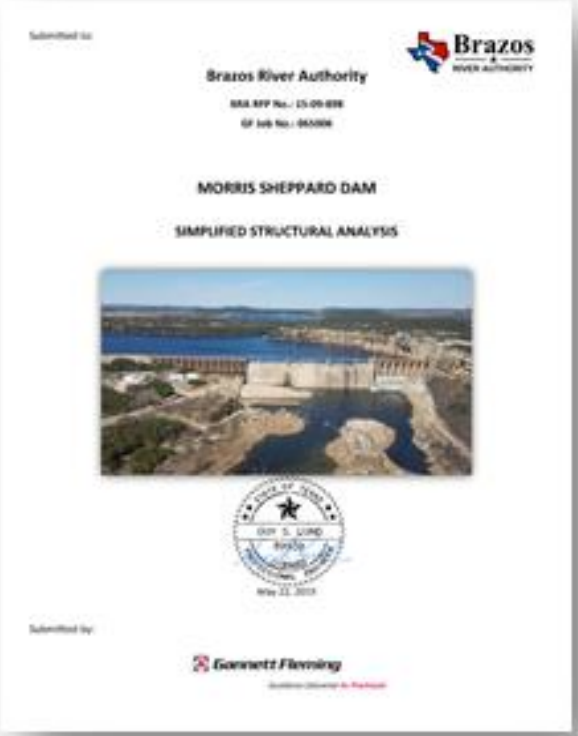
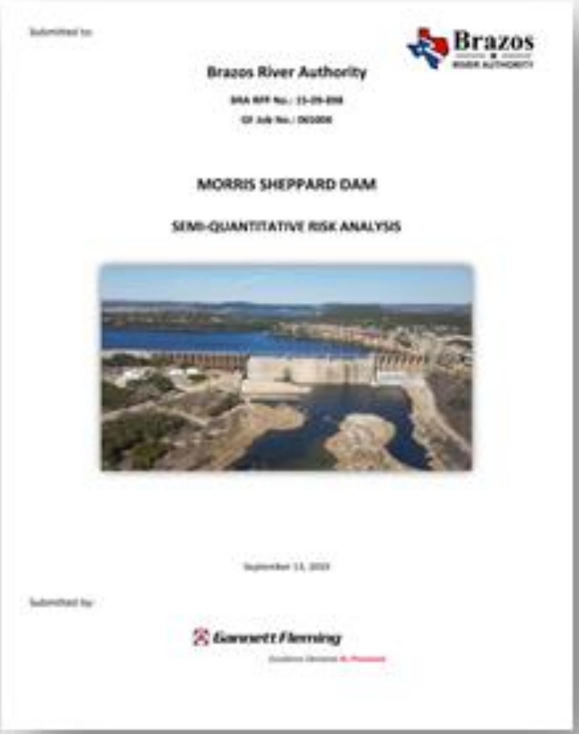
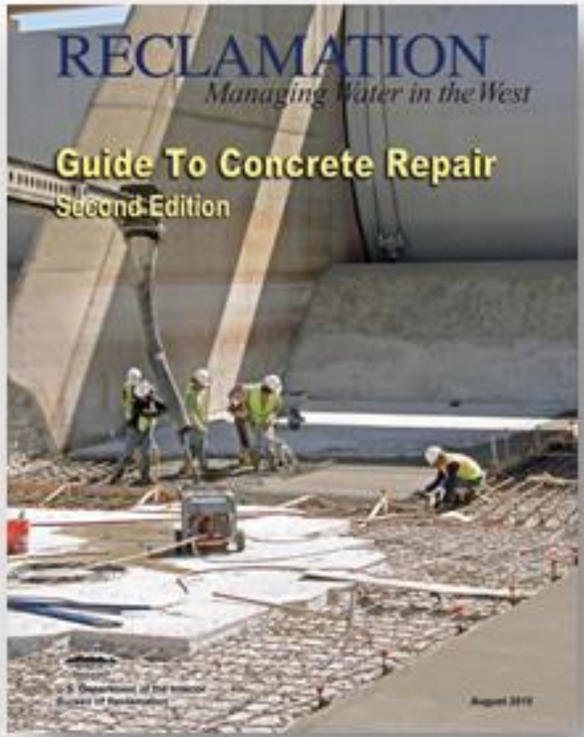
Task 4 - Long-term Testing and Repair Program

- Conduct Workshop w/BRA of program strategy and considerations of BRA's maintenance program, CIP, and RSMU capabilities.
- Prepare Prioritization of repairs.
- Prepare repair details
- Identify and prioritize additional testing (other 36 bays)
- Prepare Long-term structural concrete testing and repair program.







Task 4 - Long-term Testing and Repair Program

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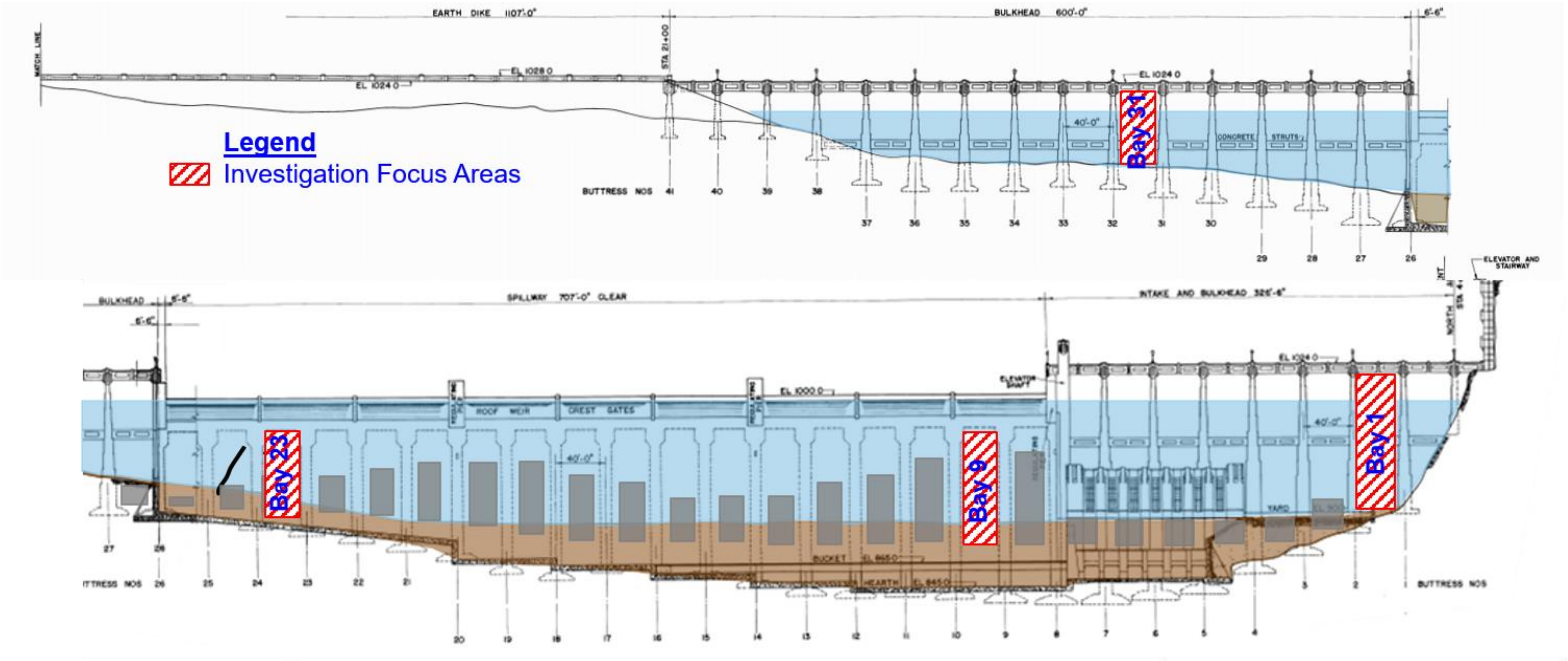
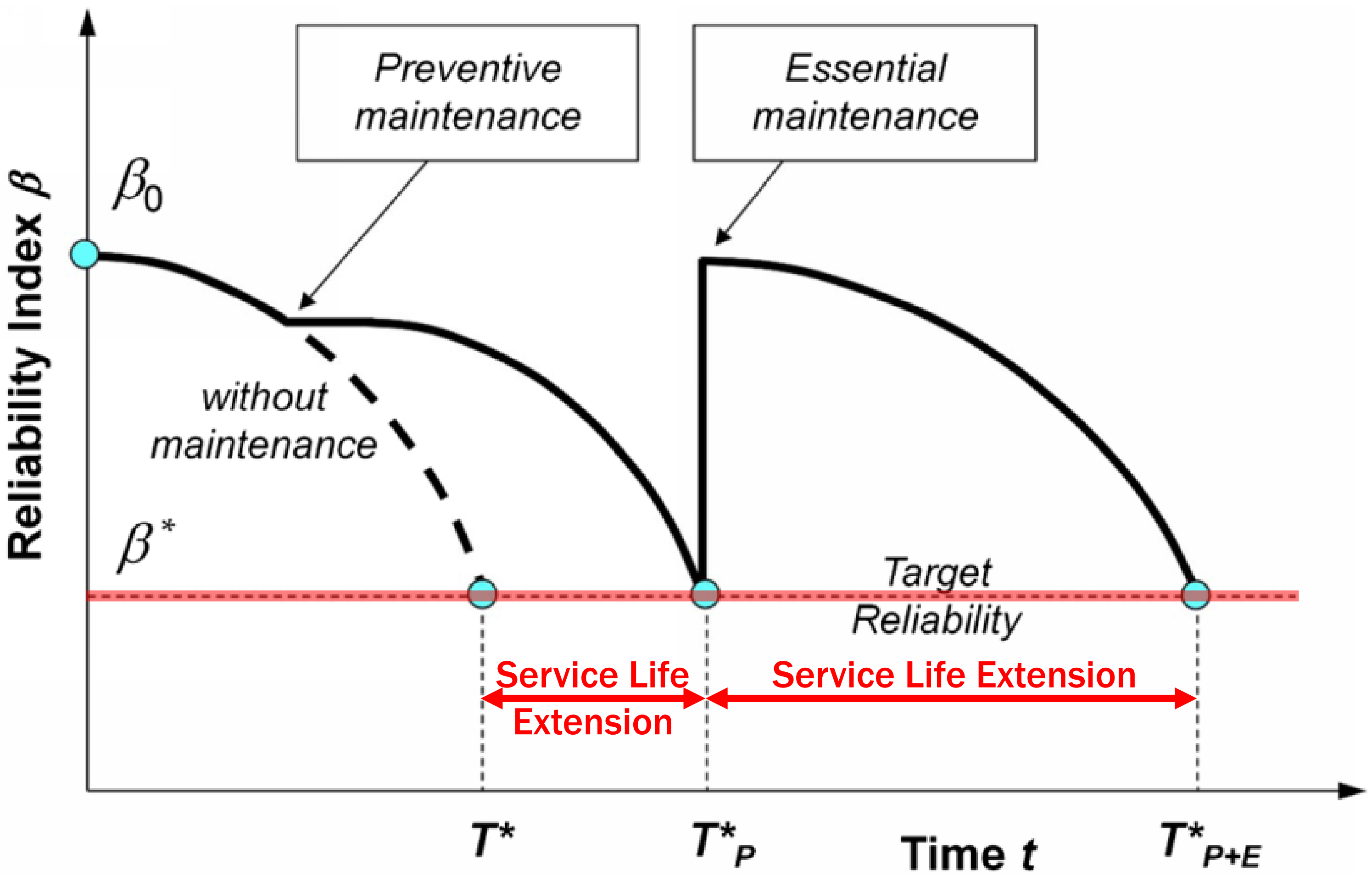


Goal


Preventive maintenance
Essential maintenance
Reliability Index β
β0
β*
without maintenance
Target Reliability
Service Life Extension
Service Life Extension
T*
T*P
Time t
T*P+E

Brazos River Authority

The following resolution is presented for consideration to the Board of Directors of the Brazos River Authority for adoption at its May 24, 2021 meeting:

“**BE IT RESOLVED** that the Board of Directors of the Brazos River Authority hereby authorizes the General Manager/CEO to amend the contract with Gannett Fleming Inc. to perform Phase III engineering services at Morris Sheppard Dam in an amount not exceed $800,000.”

Brazos

RIVER AUTHORITY


Possum Kingdom Reservoir
Non-Overflow Bulkhead Section
Spillway
Powerhouse
Non-Overflow Bulkhead Section
Brazos River
Embankment Dam
Emergency Spillway

Brazos River Authority

Phase II – Final Concrete Cores