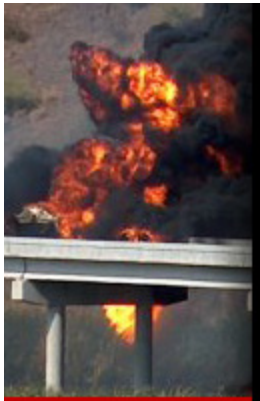

Bill Williams River Bridge Fire Damage Assessment & Repair

Martha Davis, PE
Paul Tremel, PE
HDR Engineering

September 25, 2007

Western Bridge Engineers' Seminar
Boise, Idaho

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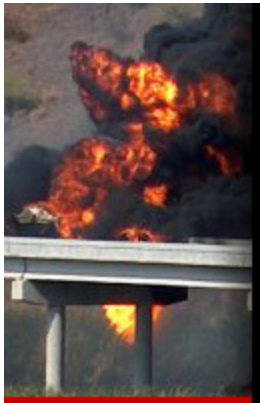
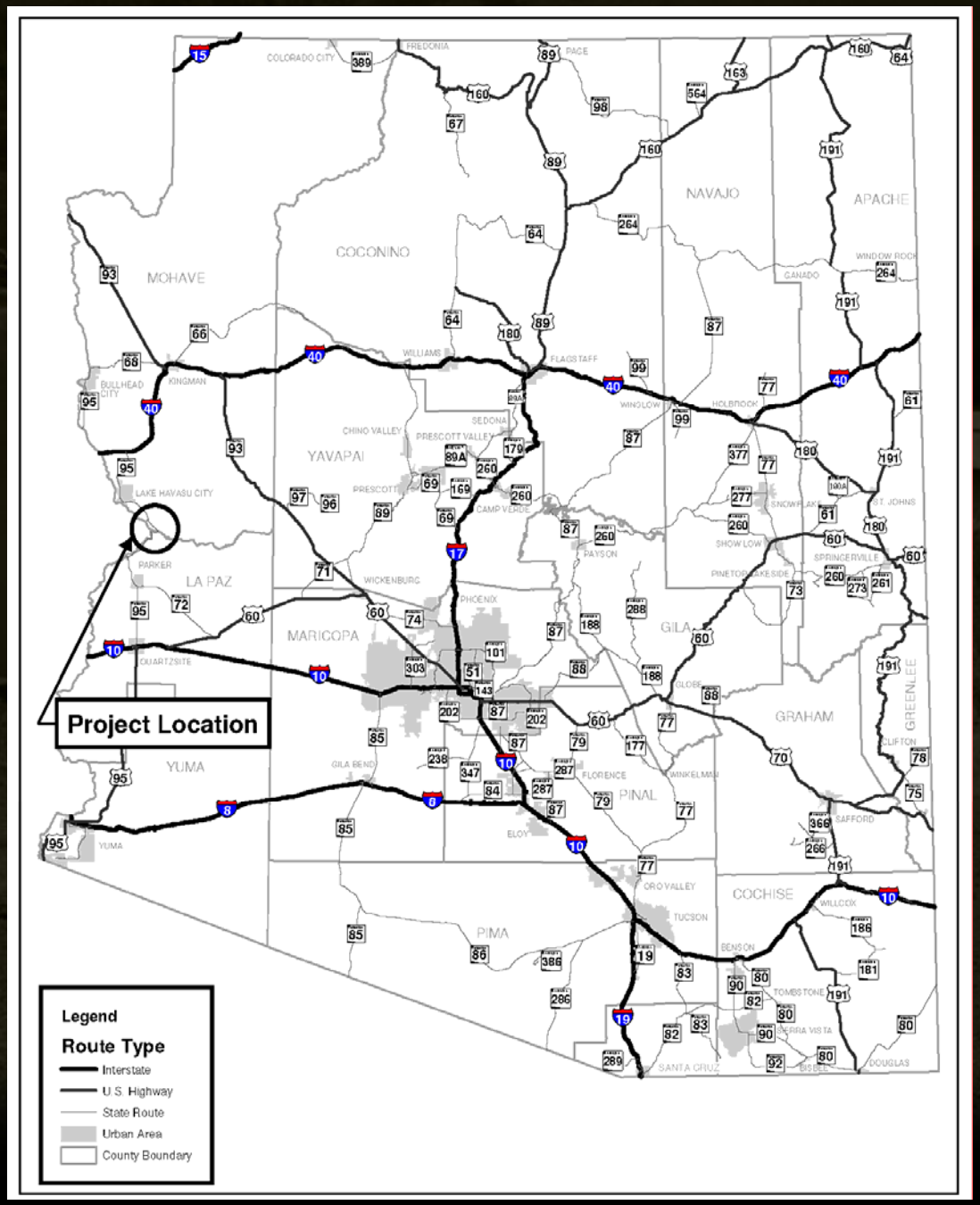


Project Location: Parker, Arizona



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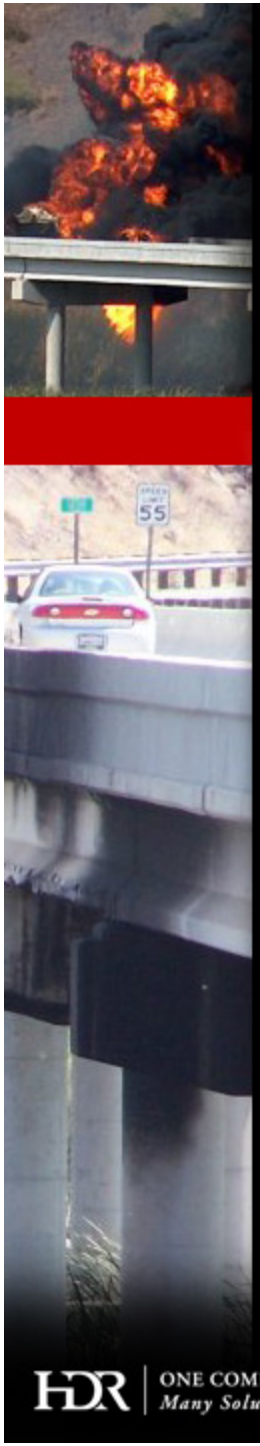
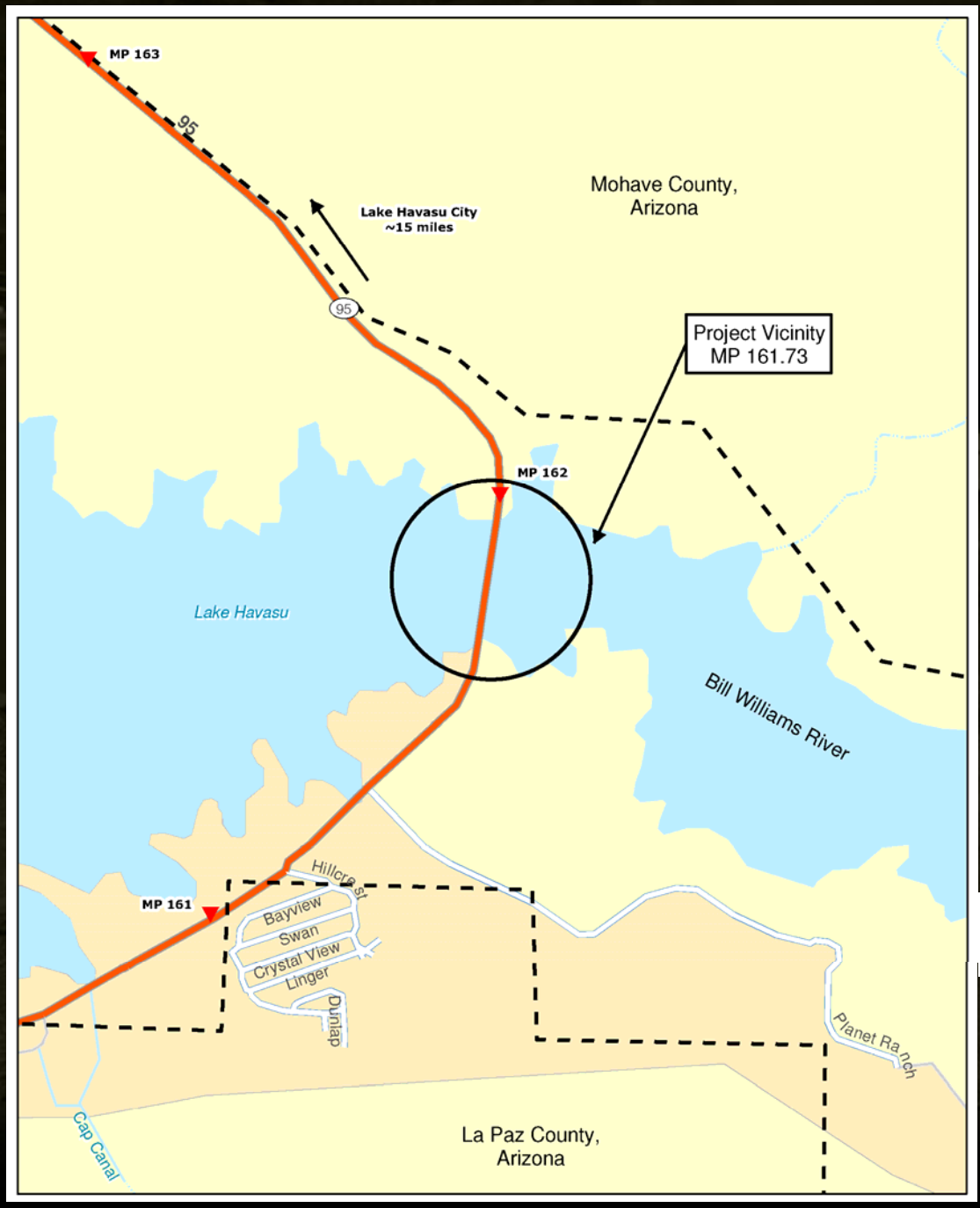


Project Location: Over Bill Williams River



Bill Williams River
National Wildlife Refuge

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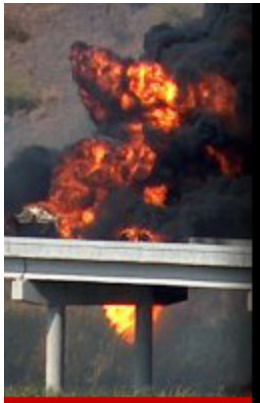
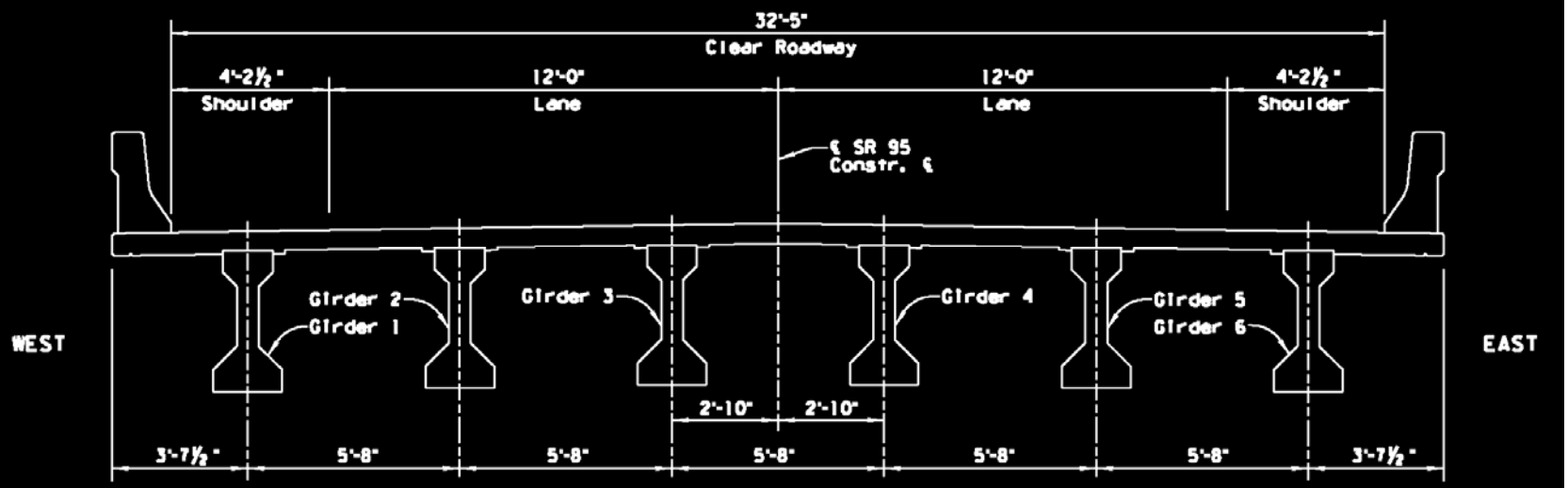


Bridge Basics

- Built in 1967
- Superstructure:
  - Two 30’ Approach Spans: Concrete Slabs
  - Fourteen 76’ Main Spans: 6 Precast Prestressed Concrete Type III Girders



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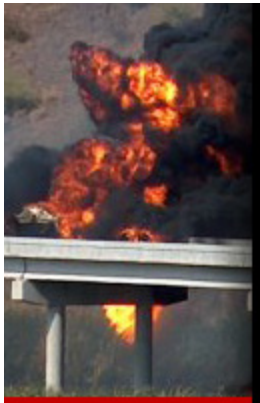
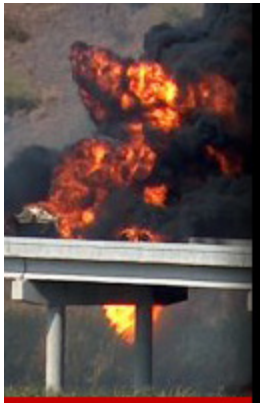


July 2006: Fire on Bridge

- July 28, 2006, approx. 3pm
- Diesel tanker overturned near middle of bridge
- ~7,600 gallons of fuel burned
- Fire lasted a few hours on bridge
  - Affected spans 8, 9, and 10
- Fire lasted over 2 weeks in adjacent wildlife area

July 2006: Fire on Bridge



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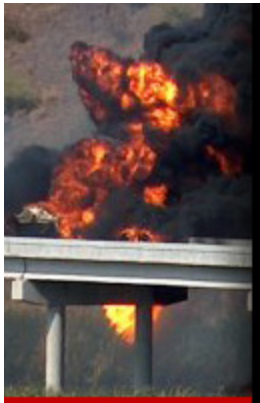

N

After the Fire

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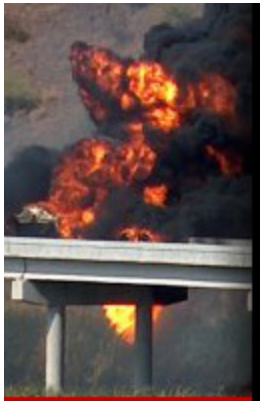

After the Fire

East Side of Bridge, Pier 8 & Span 9 (N →)

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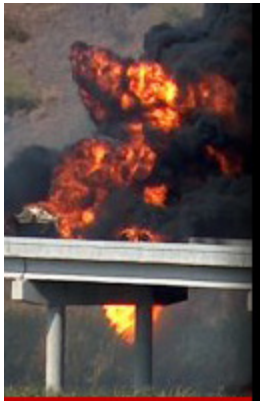

East

West

← Direction of wind during fire

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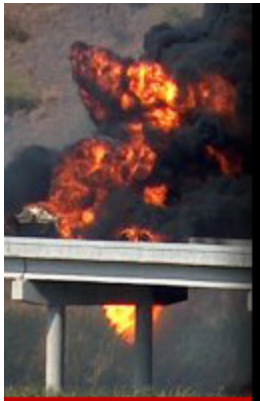
Girder/Deck Damage



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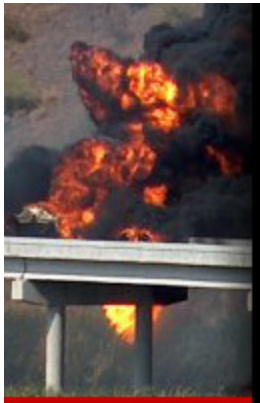
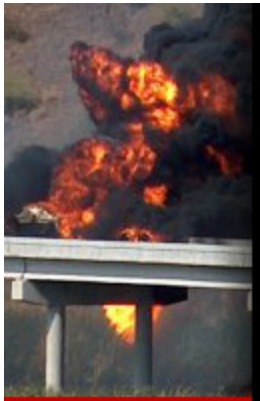


What to do?

- Inspect the damaged areas
- Perform materials testing
- Load rate the fire-damaged spans of bridge
- Develop alternative solutions
- Prepare PS&E documents for repair

Inspection



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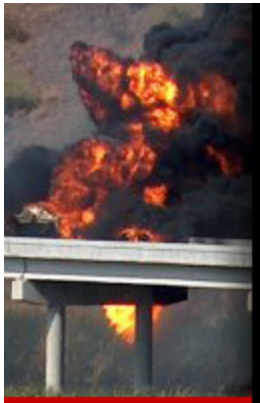
Inspection: Deck




Inspection:
Barrier
55
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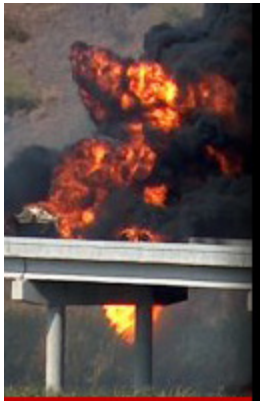
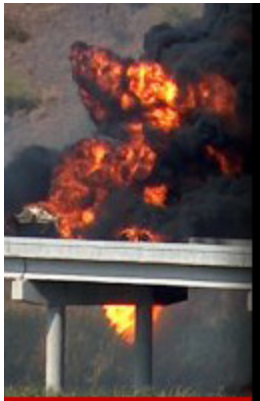
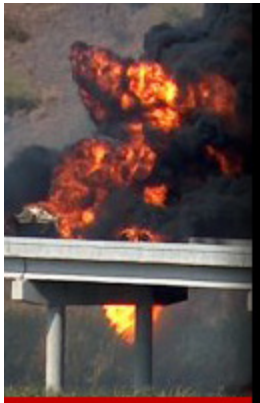
Inspection: Girders





Inspection: Girders

- Spalled concrete on top and bottom flanges
- No visible deflection

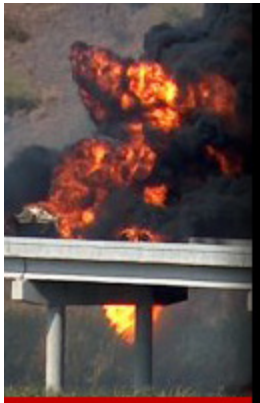


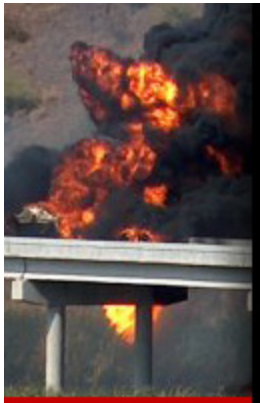
Inspection: Girders

- Exposed mild reinforcement
- Several locations of exposed prestressing strands

Inspection: Pier

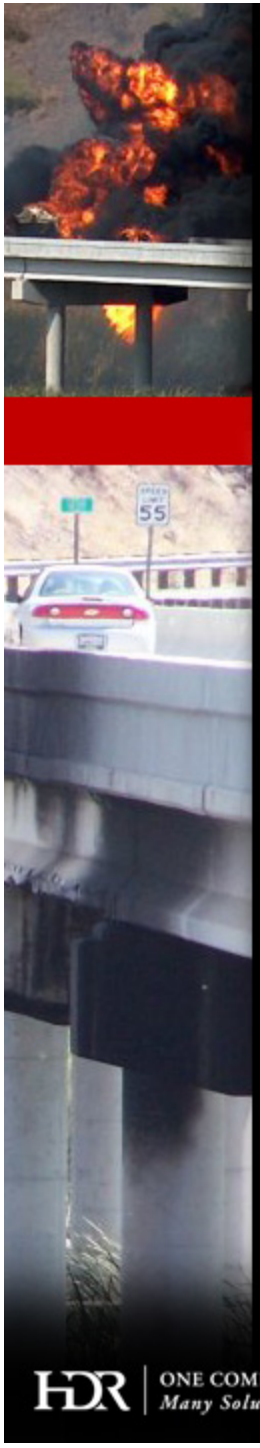
- Pier Cap
- Pier Columns





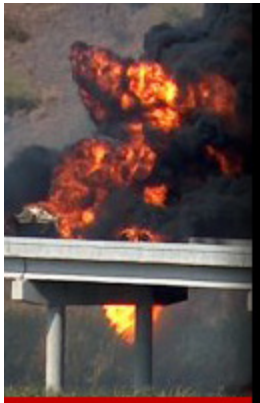
Materials Testing

- Performed by CTL Group (Skokie, IL)
- Non-destructive testing
- Concrete Cores
- Reinforcing & P/S Steel Samples



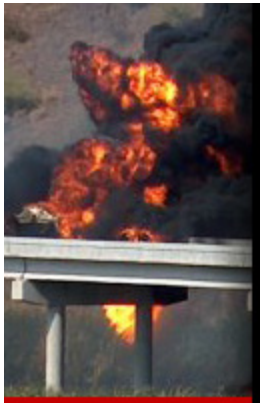
Materials Testing: Non-Destructive Evaluation

- Methods:
  - Impulse Response
  - Impact Echo
- Measures consistency and relative damage of material
- Results used to extrapolate the concrete cores to the rest of the bridge



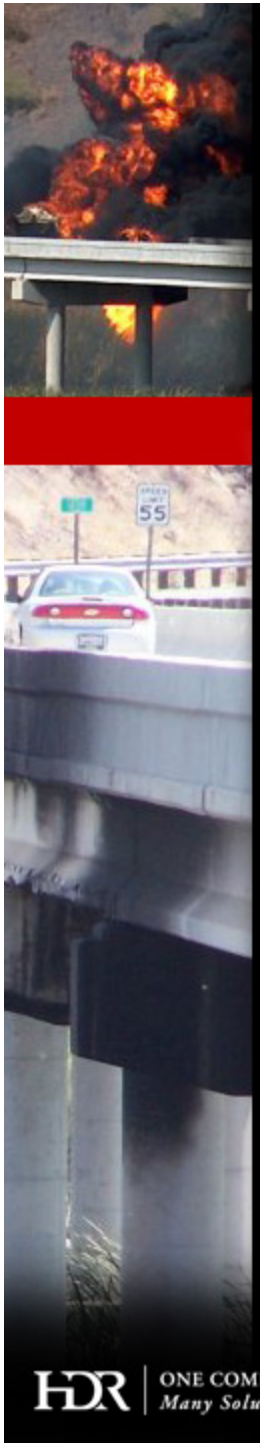
Materials Testing: Samples Taken

- Concrete Cores
  - Barrier
  - Deck
  - Girder Web
  - Pier Cap
- Reinforcing Steel
  - Mild: girder stirrup & deck
  - Prestressing: from end of girder



Materials Testing: Petrographic Analysis

- Depth of Microcracking
- Paste Alteration
  - Color Change
  - Softening
- Carbonation



Materials Testing: Sample Strengths

- Concrete Strengths

Element	Strength (f'c) per As-Builts	Post-Fire Test Results
Deck	3,000 psi	3,950 psi *
Girder	4,800 psi	5,800 psi
Pier Cap	2,500 psi	5,050 psi

* East overhang concrete lost significant portion of strength and should not be considered in structural evaluation

- Reinforcing Steel
  - Mild fy = 52,300 psi
  - P/S fy = 255 - 292 ksi per microhardness test

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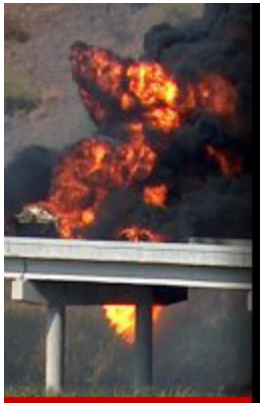


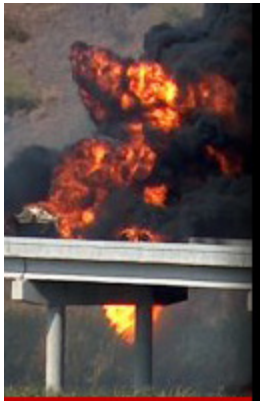
Materials Testing: How to use the results?

- Near-term assessment:

  Adjust section properties to neglect concrete that exhibits paste alteration, softening, and color change

- Long-term assessment:

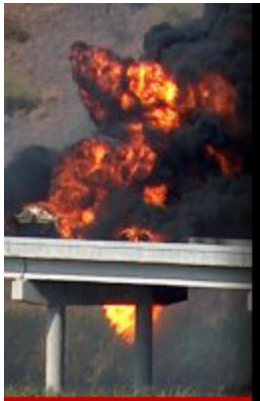
  Adjust section properties to neglect depth of abnormal microcracking

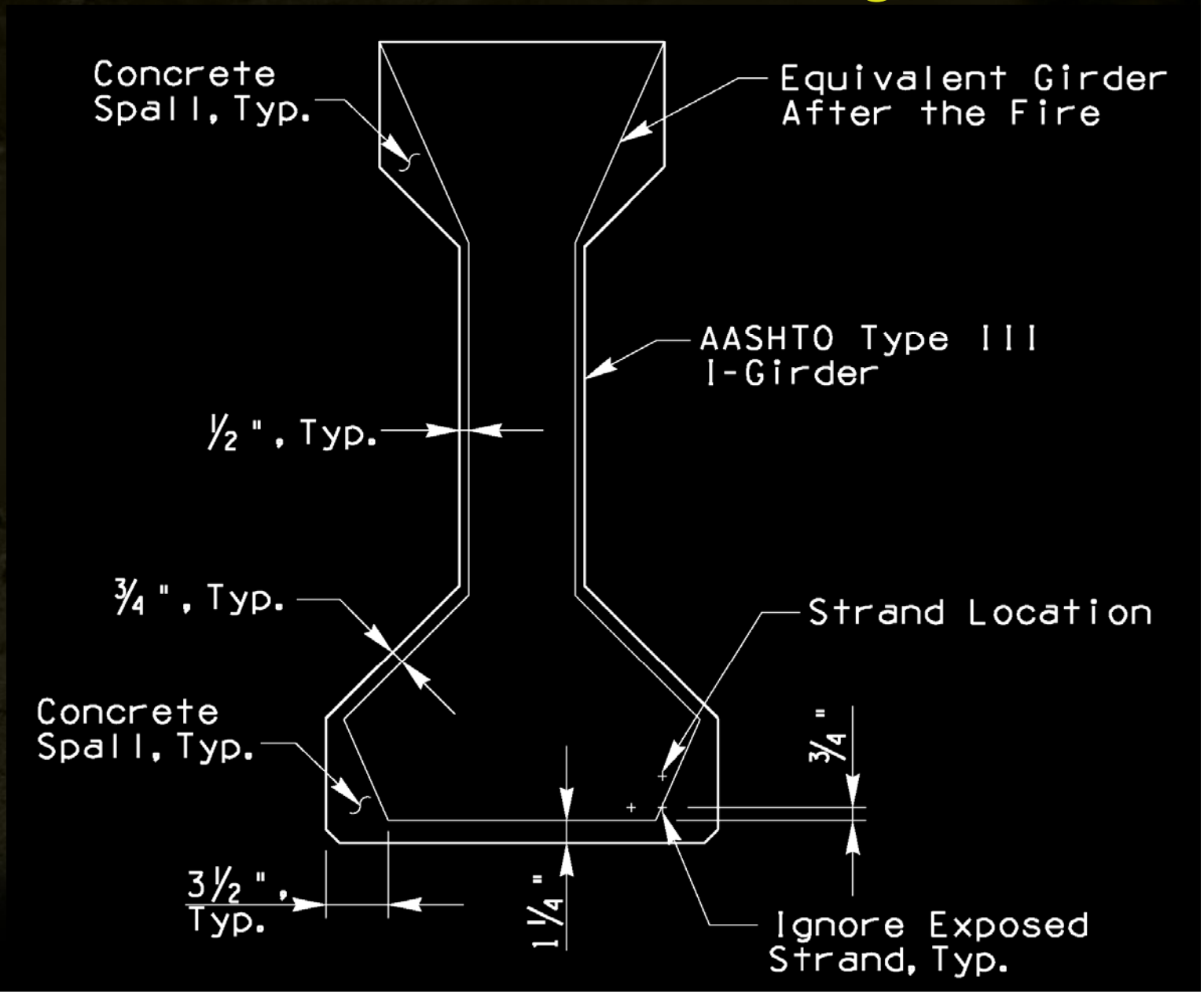


Load Rating: Deck

- Near-term (max. depth of paste alteration):
  - 0.8” on top
  - 0.2” on bottom
- Long-term (max. depth of microcracking):
  - 1.2” on top
  - 1.7” on bottom

Load Rating: Girder





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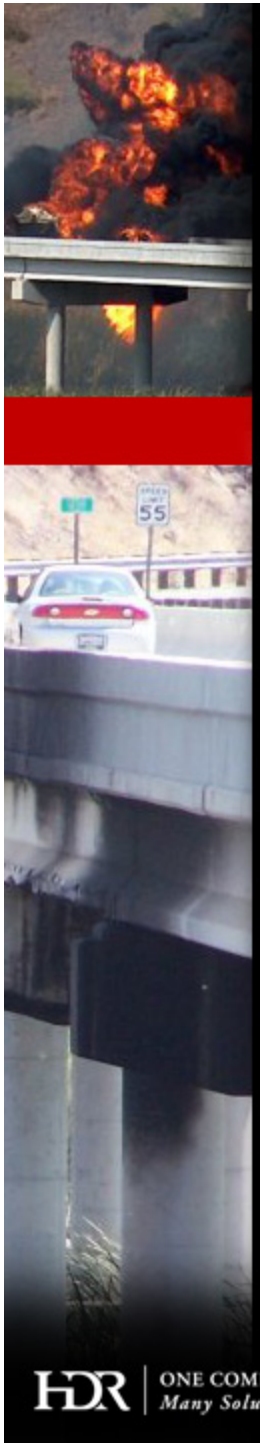


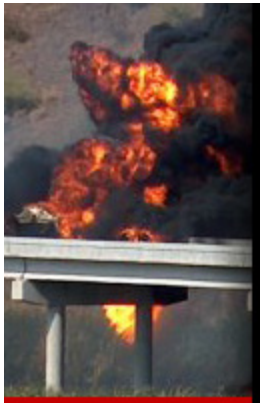
Load Rating: Results

Inventory Ratings

		Pre-Fire		Post-Fire: Short Term		Post-Fire: Long Term	
Element	**Mode**	**HS**	**Tons**	**HS**	**Tons**	**HS**	**Tons**
Deck	Flexure, LFD	28.2	50.8	26.2	47.2	***16.9***	30.4
Girder	Flexure, LFD	33.6	60.5	25.0	45.0	22.6	40.6
Girder	Flexure, ASD	24.9	44.8	20.4	36.8	***18.1***	32.6
Girder	Shear, LFD	***19.9***	35.8	***18.8***	33.9	***17.5***	31.5

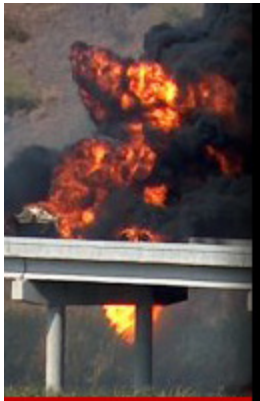
Operating Ratings

		Pre-Fire		Post-Fire: Short Term		Post-Fire: Long Term	
Element	**Mode**	**HS**	**Tons**	**HS**	**Tons**	**HS**	**Tons**
Deck	Flexure, LFD	47.0	84.6	43.7	78.7	28.2	50.8
Girder	Flexure, LFD	56.0	100.8	41.7	75.1	37.7	67.8
Girder	Shear, LFD	33.2	59.8	31.5	56.6	29.2	52.6



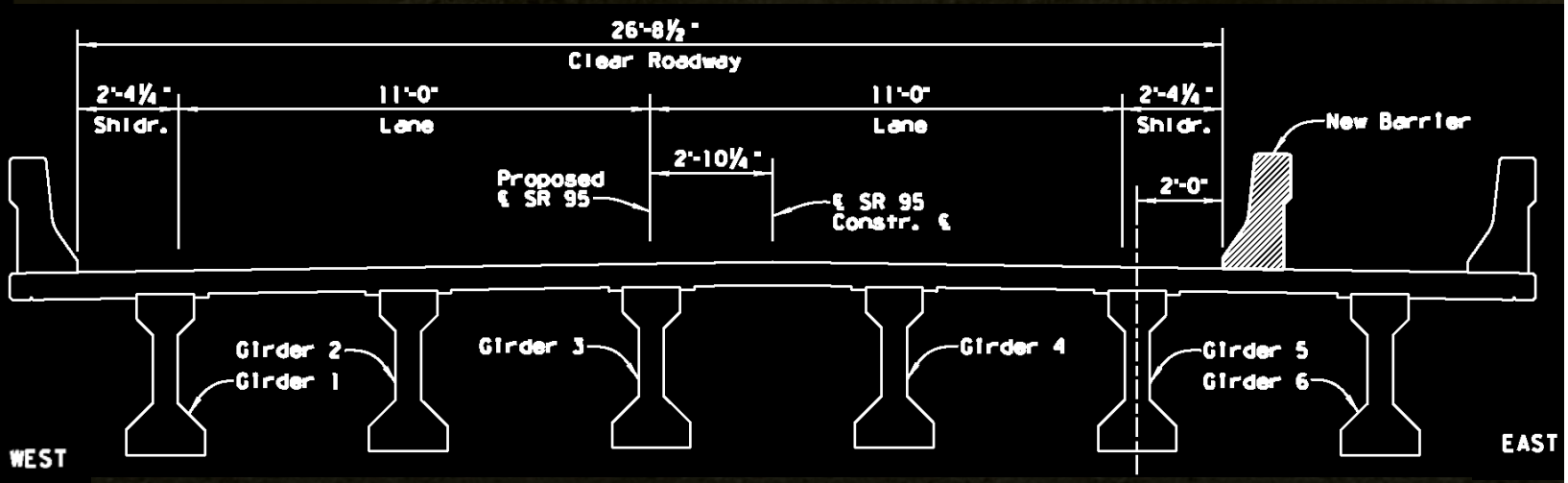
Alternatives

1. Close east shoulder
2. Replace east deck overhang in spans 8 - 10
3. Replace east girder in span 9 and east deck overhang in spans 8 - 10
4. Replace span 9 and exterior girders in spans 8 and 10



Alternative 1

- Install barrier between girders 5 & 6
- No structural rehabilitation or repair



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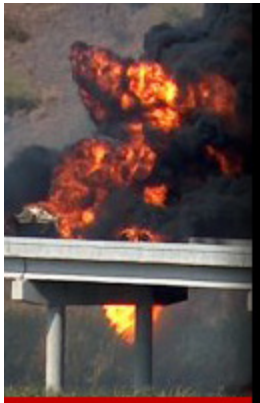
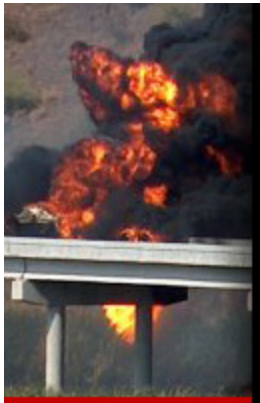


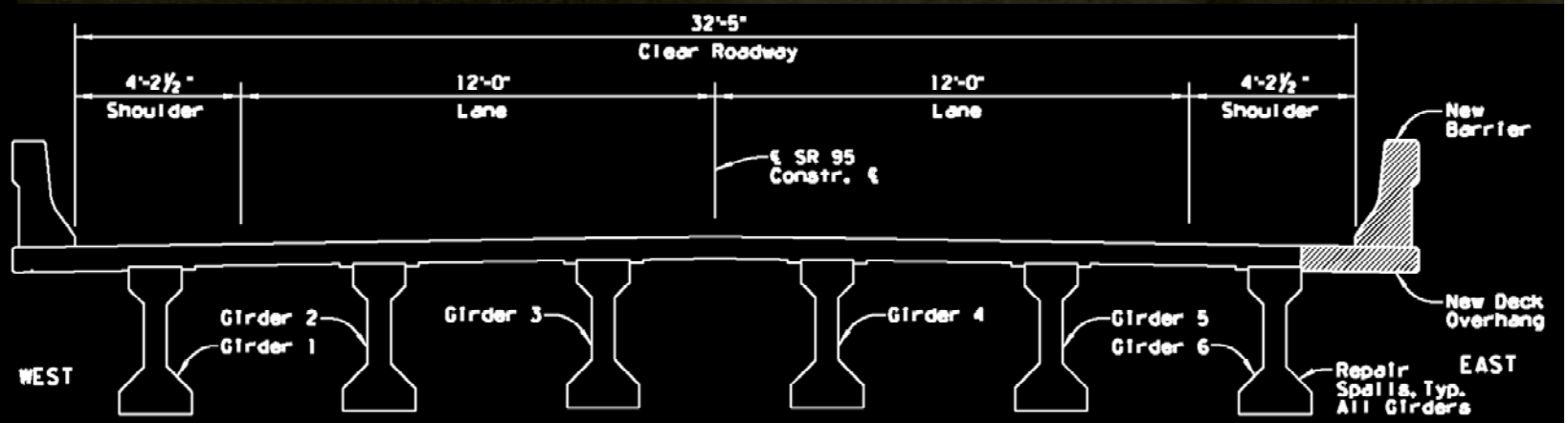
Alternative 1

- Advantages
  - Least cost
  - Least environmental & traffic impacts
- Disadvantages
  - Service life of bridge reduced
  - Roadway width permanently narrowed
  - Width of travel lane less than standard



Alternative 2

- Replace structural elements with significantly reduced section properties
- Surface remediation of other members (girders & pier cap)



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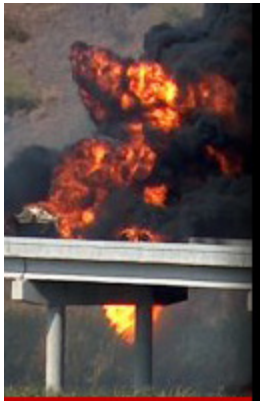
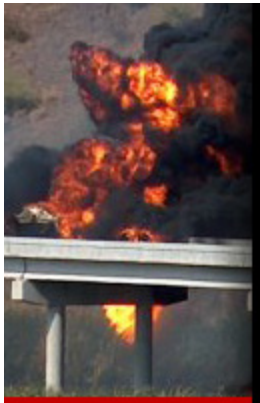


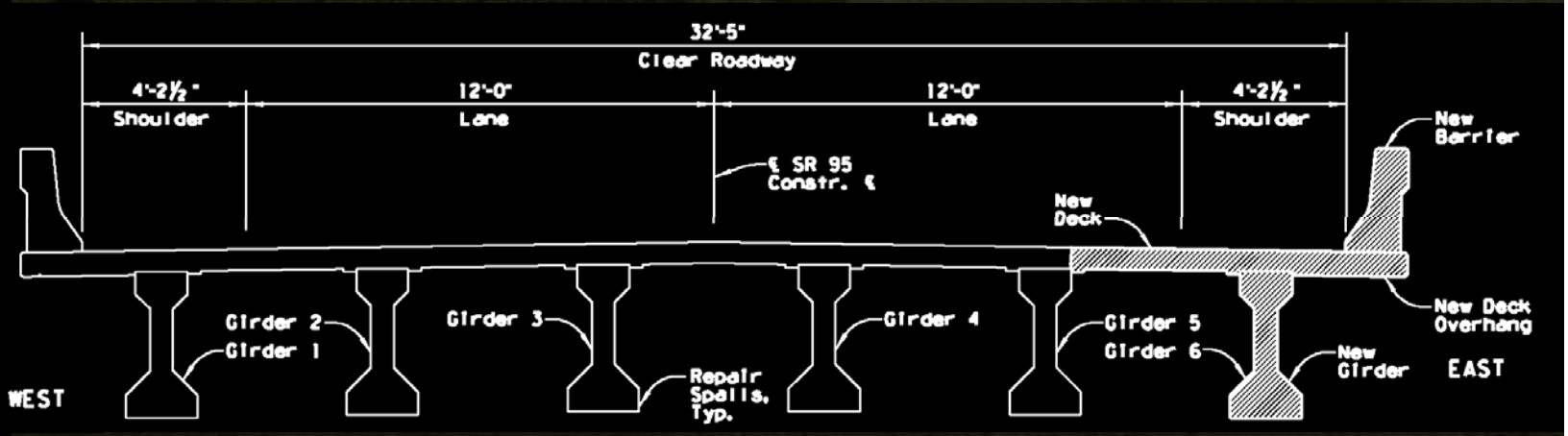
Alternative 2

- Advantages
  - Existing roadway width is maintained
  - Most severely damaged elements are replaced
  - Less expensive to construct than Alternatives 3 & 4
- Disadvantages
  - Longer construction time than Alt. 1
  - Will require future improvements to maintain long-term serviceability



Alternative 3

- Replace most severely distressed structural elements
- Surface remediation of other members



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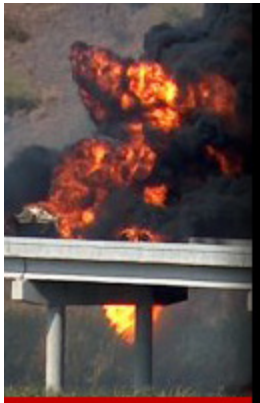
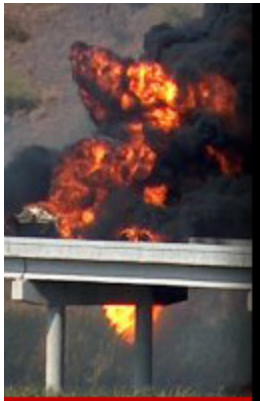


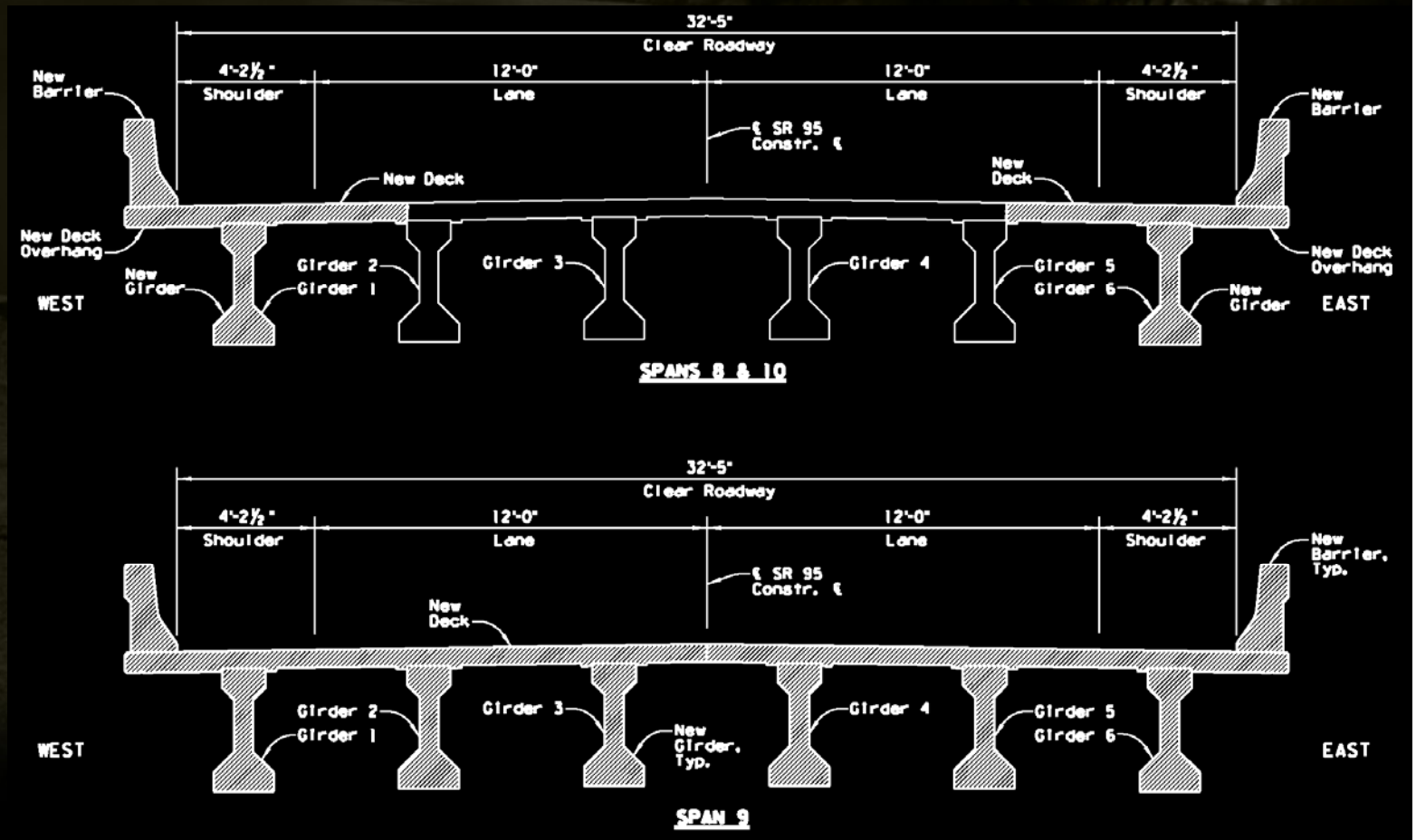
Alternative 3

- Advantages
  - Existing roadway width is maintained
  - Severely distressed elements are replaced
  - Less expensive to construct than full replacement of damaged spans
- Disadvantages
  - Longer construction time than Alts. 1 & 2
  - Will require future improvements to maintain long-term serviceability
  - Environmental impacts



Alternative 4

- Replace fire damaged structural elements
- Restore bridge to pre-fire condition



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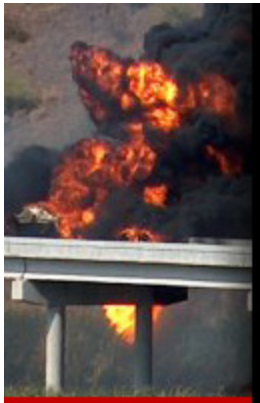
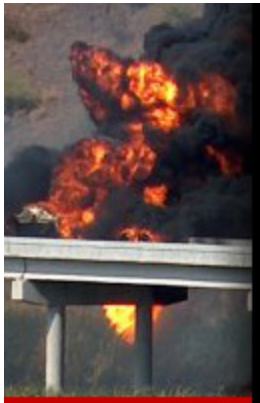


Alternative 4

- Advantages
  - Existing roadway width is maintained
  - Load capacity of bridge is restored to pre-fire capacity
  - Long-term serviceability of bridge is restored to its pre-fire condition
- Disadvantages
  - Most expensive to construct
  - Longest construction time
  - Environmental impacts



Alternatives: Construction Costs

- Alternative 1: $ 416,000
- Alternative 2: $ 711,000
- Alternative 3: $ 861,000
- Alternative 4: $ 1,859,000

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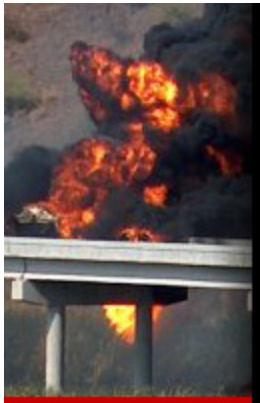
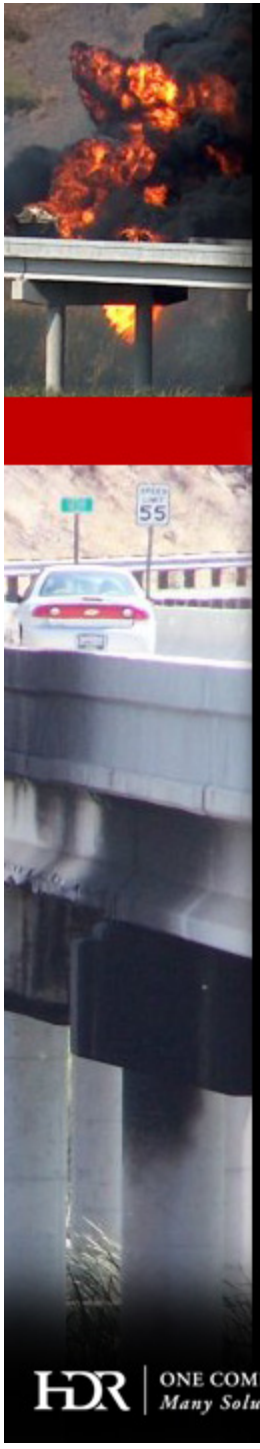


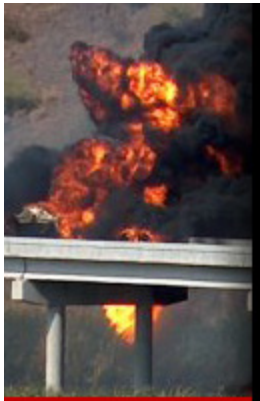
Recommendations

- Immediate
  - Close the east shoulder
- Near Term
  - Alternative 2: replace east side of deck to girder 5 in spans 8-10
  - Monitor bridge for further concrete deterioration
- Long Term
  - Alternative 4: replace span 9 and portions of spans 8 & 10



Conclusions

- Considering severity of fire, the bridge is in generally good condition, except east overhang
- Most severe damage localized to exterior girders and deck overhang
  - Fuel source through drain holes
  - Availability of oxygen
- Precast, prestressed girders performed well
- Concrete and reinforcing strengths were consistent with design values



Bill Williams River Bridge Fire Damage Assessment & Repair

Martha Davis, PE
Paul Tremel, PE
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September 25, 2007

Western Bridge Engineers' Seminar
Boise, Idaho

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