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TRANSPORTATION RESEARCH BOARD

Hydrodemolition for Bridge Rehabilitation

April 22, 2021

2:00-3:30 PM Eastern

@NASEMTRB
#TRBwebinar

PDH Certification Information:

- 1.5 Professional Development Hours (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
- Questions? Contact Reggie Gillum at RGillum@nas.edu

#TRBwebinar

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

Learning Objectives

1. Determine when hydrodemolition is appropriate for deck replacement

2. Identify best practices in using hydrodemolition for bridge deck replacements

#TRBwebinar

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NCHRP Domestic Scan Study 18-01

Successful Approaches for the Use of Hydrodemolition For Partial Depth Removal of Bridge Decks

Cheryl Hersh Simmons

Utah Department of Transportation

Objective

Learn and disseminate experiences associated with hydrodemolotion as a tool for bridge preservation and rehabilitation.

Scope

- Examine current hydrodemolition and aged hydrodemolition decks
- Study hydrodemolition process and long-term performance
- Gather perspectives of agencies, contractors, and consultants

About Hydrodemolition

- Construction specifications
- Wastewater permitting, control, collection, reuse or disposal
- Reinforcement steel location and protection
- Existing patch materials
- Field conditions or damage caused by the operation
- Removal depth limitations, if any
- Preferred replacement materials
- Costs for design, construction, maintenance
- Lessons learned and suggestions for improvement

Cheryl Hersh Simmons - Chair
Chief Structural Engineer
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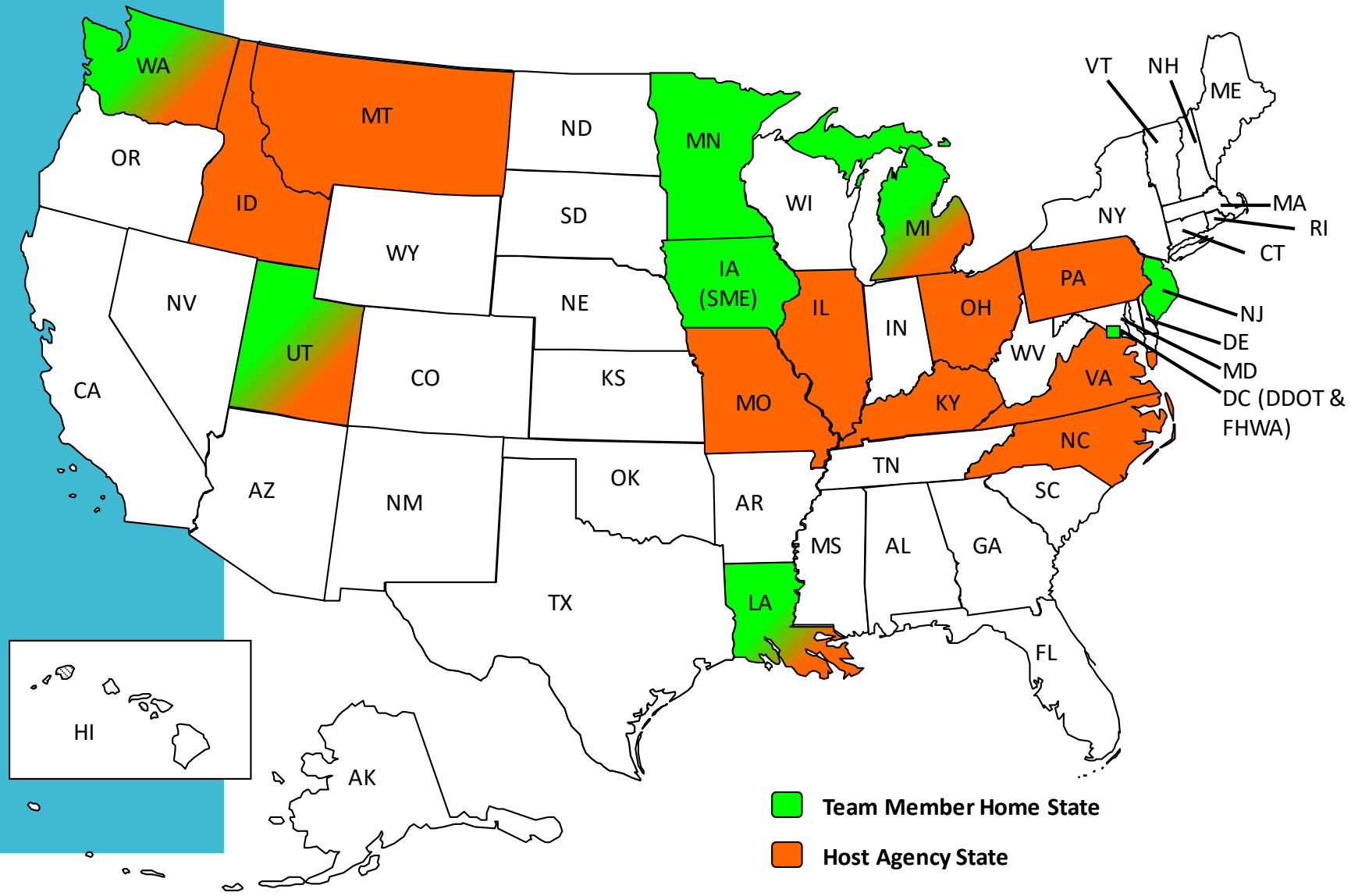
Bridge Construction Engineer
Construction Management Team
Federal Highway Administration (FHWA)

Brent Phares, PhD, P.E. - SME
Director, Bridge Engineering Center, Institute for Transportation
Associate Research Professor, Iowa State University
Advanced Structural, LLC

Scan Team

Scan 18-01 Team and Invited Agency States



Highlights of Participating Agency Programs

- 13 agencies shared experiences
- Historical use of hydrodemolition
  - Early 1980's (1)
  - 1990's (5)
  - 2000 to 2015 (7)
- Decision making
  - No systematic approach
  - Based on % deck delamination (15% to 30%)
  - Matrix (deck condition, traffic volumes, cost)
  - Robust preservation matrix
- Data collection
  - GPR, thermal, acoustic measurement, chloride testing
  - Deck coring
  - Visual assessment from beneath
  - Sounding

Lessons Learned

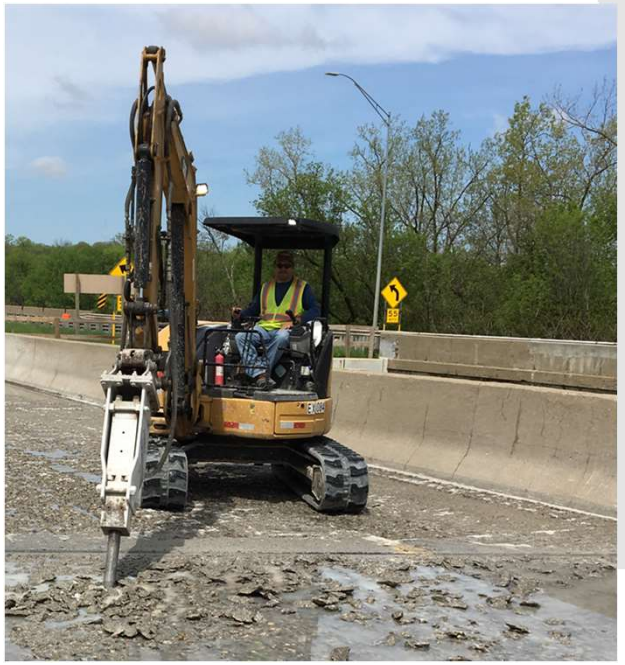
- Mechanical scarification of the deck
- Depth of concrete removal
- Test section for calibration
- Environmental challenges
- Replacement materials and overlays
- Experience of contractors and inspectors
- Alternate uses

Forms of Removal

John Belcher
Michigan Department of Transportation

Shallow Removal

- Scarification
  - Usually a ¼" with cold milling machine
- Hydrodemolition to a set depth
  - Typically determined by the minimum required depth of the overlay material (i.e. Latex Modified vs Silica Fume Modified Concretes)
  - At least ¼" to ¾" of total removal should be accomplished with hydrodemolition to achieve proper surface profile (depends on overlay material
- Chipping needed at barriers and joints

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Case Study: Pennsylvania DOT Shallow Removal with Fast-Track Hydrodemolition

State Route (SR) 65 in PennDOT District 11, Beaver County

Latex Modified Concrete (LMC) Overlay on SR 8029 Ramp Structures

- 2017 overlay on 8 span, 798 ft, 1975 steel girder structure
- Two ½" scarification passes were done (1" total removal)
- ¼" hydro in sound areas and total removal of unsound areas
- Full depth repairs anywhere the bottom mat exposed
- 1-1/4" LMC overlay (deeper in unsound areas)
- Actual Quantity of LMC: 76.98 cyds = 1.34" average placement
- Longitudinal mechanical texturing/grooving of surface

Case Study: Pennsylvania DOT Shallow Removal with Fast-Track Hydrodemolition

Deep Removal

- Scarification
  - Usually a ¼" minimum up to just above top mat of steel
- Hydrodemolition to desired removal
  - Many states target chloride penetration depth while others target a combination of depth and deterioration
  - Still needs the minimum hydro removal of ¾"
  - Commonly uses two passes with the hydro equipment or chipping
- Chipping needed at barriers and joints

Case Study: Michigan DOT Deep Removal with Hydrodemolition

I-96 over the Grand River, Marquette Railroad, and West River Drive at US-131 Interchange, Grand Rapids

Silica Fume Modified Concrete (SFMC) Overlay on 4 structures

- 2018 overlay on two 768 ft and two 544 ft steel girder structures
- Structures were previously overlaid with deep and shallow LMC
- Joint Replacements, Deep Overlays, and Crown Correction
- Part width construction to facilitate concrete delivery
- Single scarification pass to 1" above top mat of reinforcement
- Deep hydro to the top mat in sound areas and total removal of unsound areas (standard 2 pass operation)
- Exposed and unbonded reinforcement chipped under ¾"
- Locations with full depth removal were "formed up" for monolithic placement of the SFMC
- Depth could have utilized a 7 sack with SCM mix as an option
- Transversely textured surface as part of placement/finishing

Case Study: Michigan DOT Deep Removal with Hydrodemolition

To Overlay or Not To Overlay….

And if so, do I go shallow or deep?

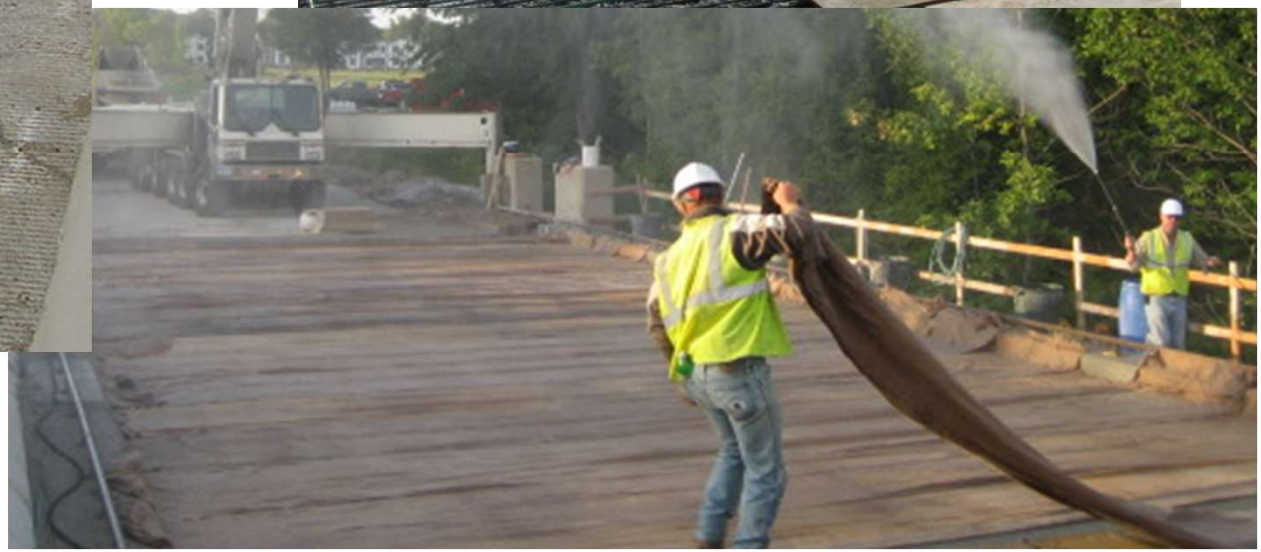
- What is my goal for the repair?
  - Short-Term or Long-Term Preservation
  - New wearing surface, chloride penetration, deterioration
- Can the deck handle a hydro and is the bottom in good condition?
- What material do I plan to use for the overlay?
- Which option will traffic conditions allow for ?
  - Hydro, Placement, and Curing

Calibration

- Trials on both sound and deteriorated areas
- Typically 30-50 sft each
- Pressures typically range from 14,000 psi to 18,000 psi
- Some structures require more than one calibration

Field Control and Inspection

Challenges and Limitations

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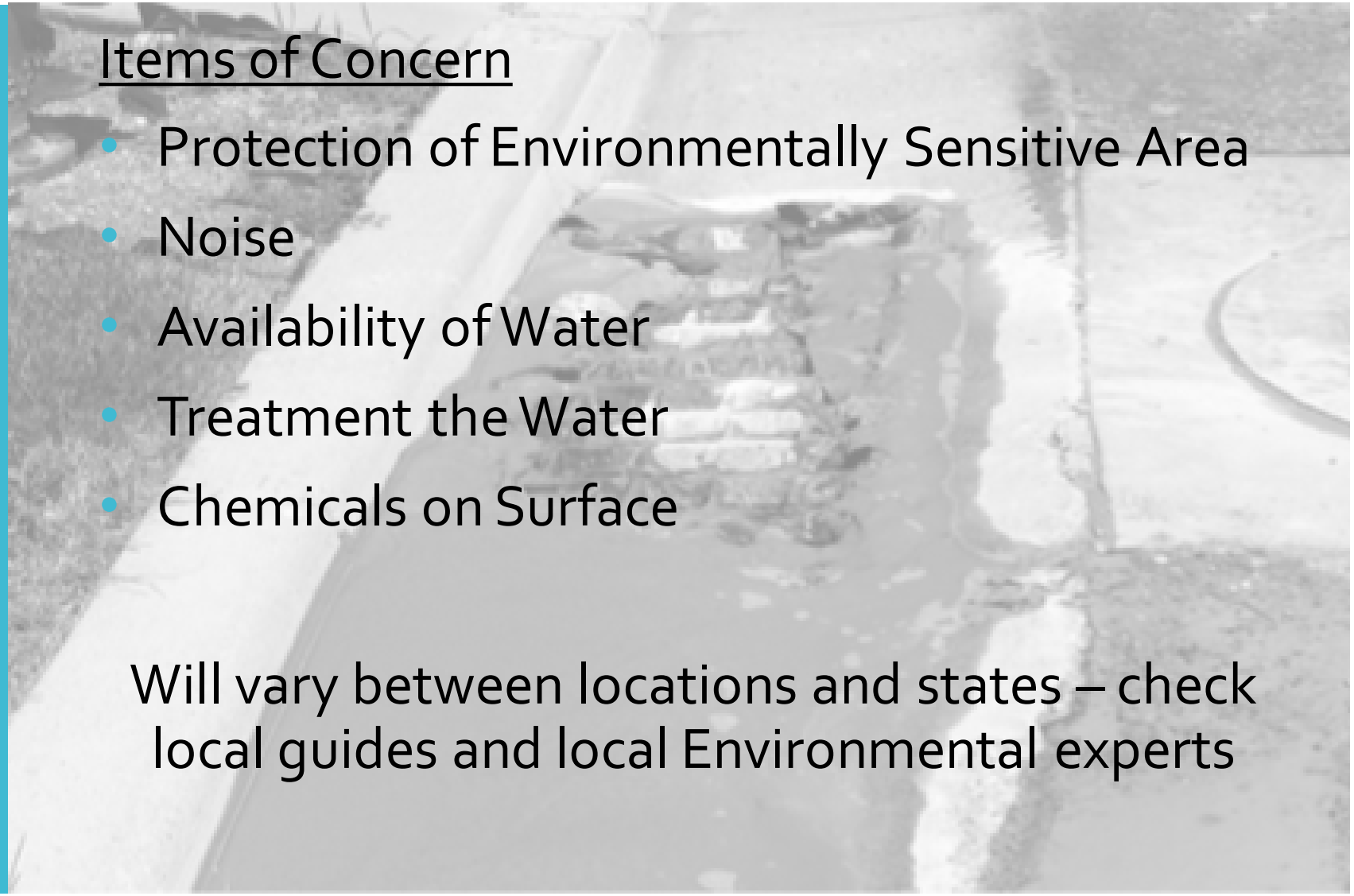
Water Control

Nick Clark
Utah Department of Transportation

Environmental Considerations



Items of Concern

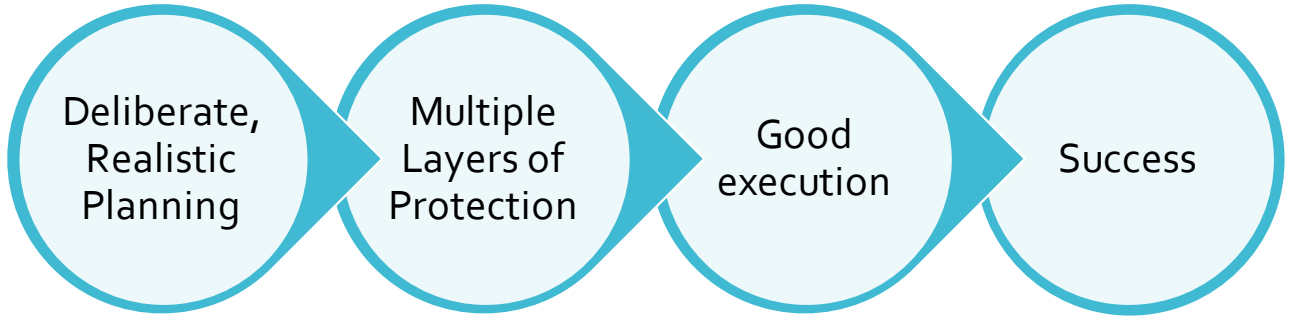
- Protection of Environmentally Sensitive Area
- Noise
- Availability of Water
- Treatment the Water
- Chemicals on Surface

Will vary between locations and states – check local guides and local Environmental experts

Waste Water Control

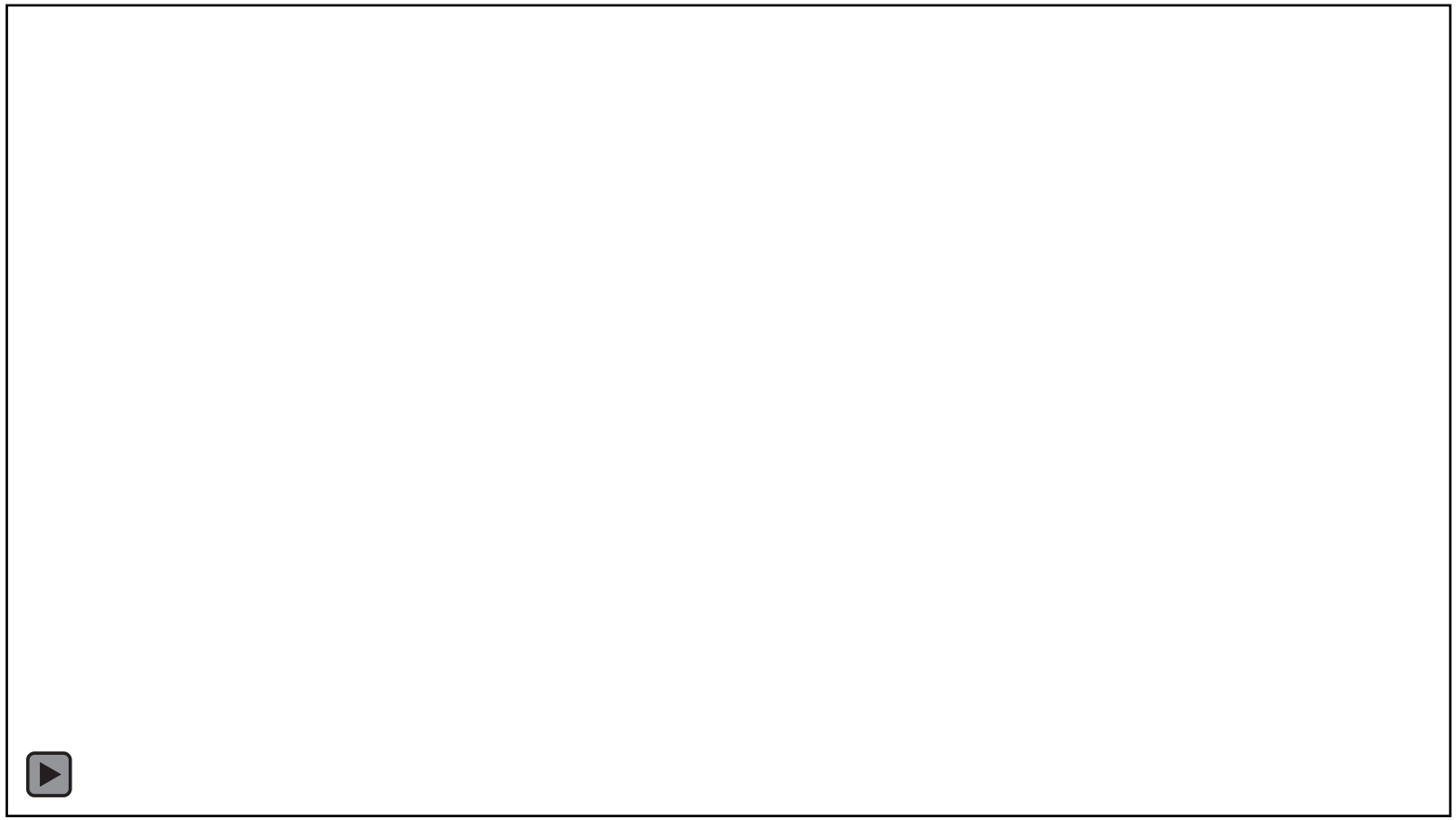
Basic Principles

- Water Flows down hill
- Given time and volume of water, water will always find a way out
- Containing water to the deck is always the best, but not necessarily easiest or practical



Waste Water Control

Problems with Work Sequence



Waste Water Control

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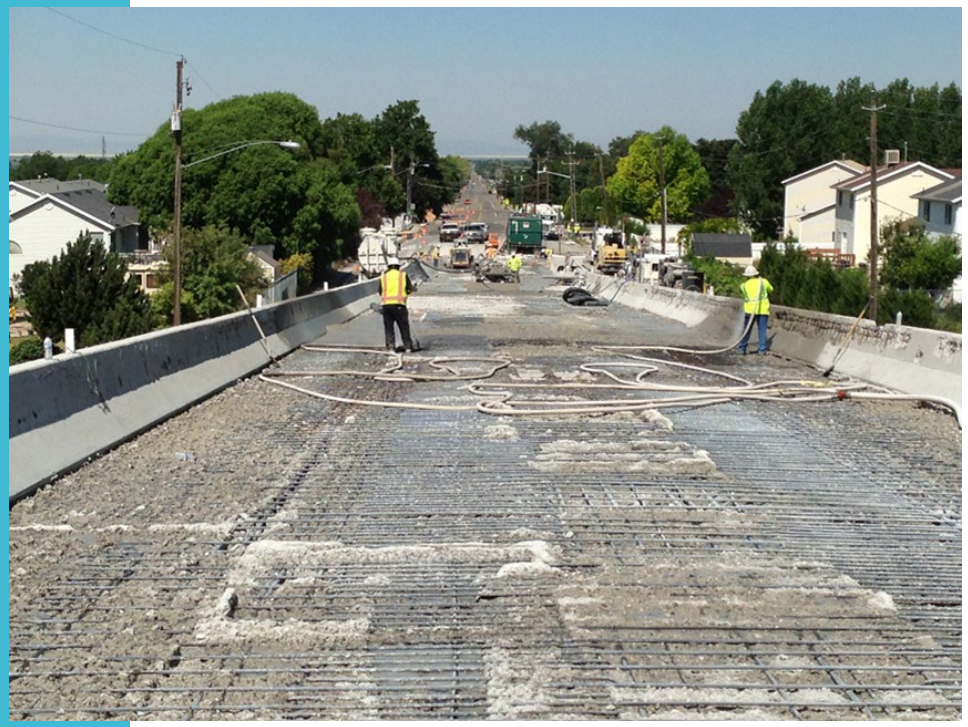


Waste Water Control

Problems with Containment

Waste Water Control

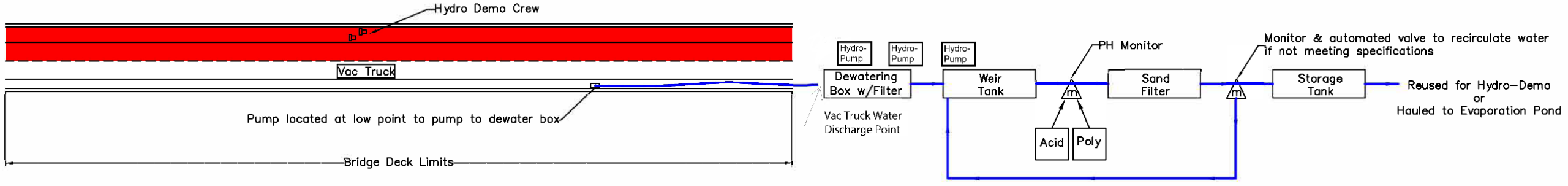
Consequences of lack of wastewater control

Waste Water Control

Submittals

- Sequence of work and how water will be controlled through that sequence
- Identify critical points in process that may require change in strategy
- Requirements:
  - Define how all wastewater generated by the hydro-demolition operation will be contained, stored, tested, and deposed of.
  - Prevent any wastewater from leaving deck surface including through deteriorated joints, deck drains and holes in the deck.
  - Deck blow through: immediately stop operation. Use approved methods to create a watertight seal at the hole.

H Y D R O – D E M O W A T E R C O L L E C T I O N & F I L T E R P R O C E S S



Waste Water Control

Success is Achievable

Deliberate, Realistic Planning

Multiple Layers of Protection

Good execution

Success

Decision Making: When to Use Hydrodemolition

Paul Pilarski

Minnesota Department of Transportation

Consideration of hydrodemo

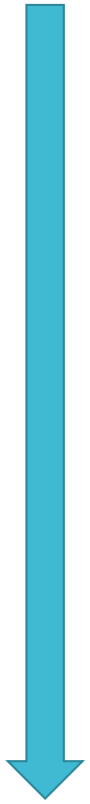
- Local preservation strategies and exposures

METHOD	LIFE	COST	TIME
Pothole Patch	5-10 years		
Hydro-Demo	20-25 years		
Deck Replacement	25 Years +		

- Local bridge improvement or preservation guidelines (Barrier upgrade policy, minimal load ratings, remaining element life)
- Traffic control costs
- User ~~costs~~ impact considerations

Deck Life Cycle

Traditional deck work spectrum (MnDOT):



- Sealants and sealers
- Local Patching
- Mill and Concrete Wearing Course with Patching
- Second Generation Mill and Concrete Wearing Course
- Redeck
  - Sealants and sealers
  - Local Patching
  - Mill and Concrete Wearing Course with Patching
  - Second Generation Mill and Concrete Wearing Course
    - Replacement

Deck Life Cycle

Traditional deck work spectrum (MnDOT):

Potential Hydrodemo →
Likely Hydrodemo →

- Sealants and sealers
- Local Patching
- Mill and Concrete Wearing Course with Patching
- Second Generation Mill and Concrete Wearing Course
- Redeck
  - Sealants and sealers
  - Local Patching
  - Mill and Concrete Wearing Course with Patching
  - Second Generation Mill and Concrete Wearing Course
    - Replacement

Potential Hydrodemo →
Likely Hydrodemo →

(MnDOT)

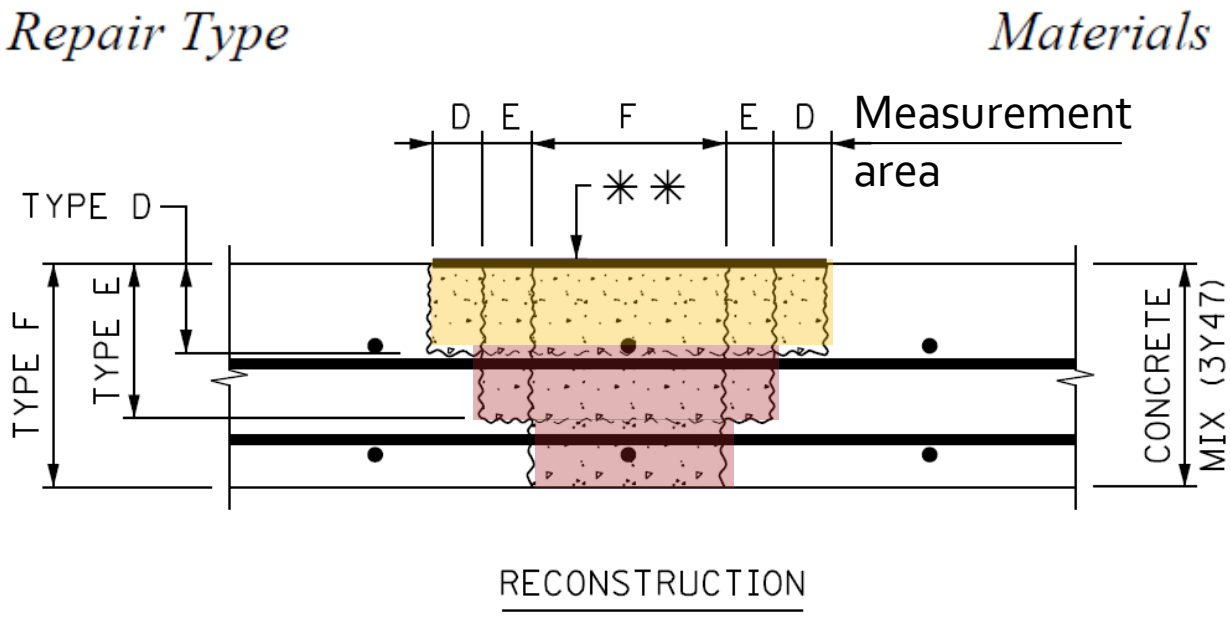
Local Patching/
Spot repairs

Repairs with
Concrete Wearing
Course

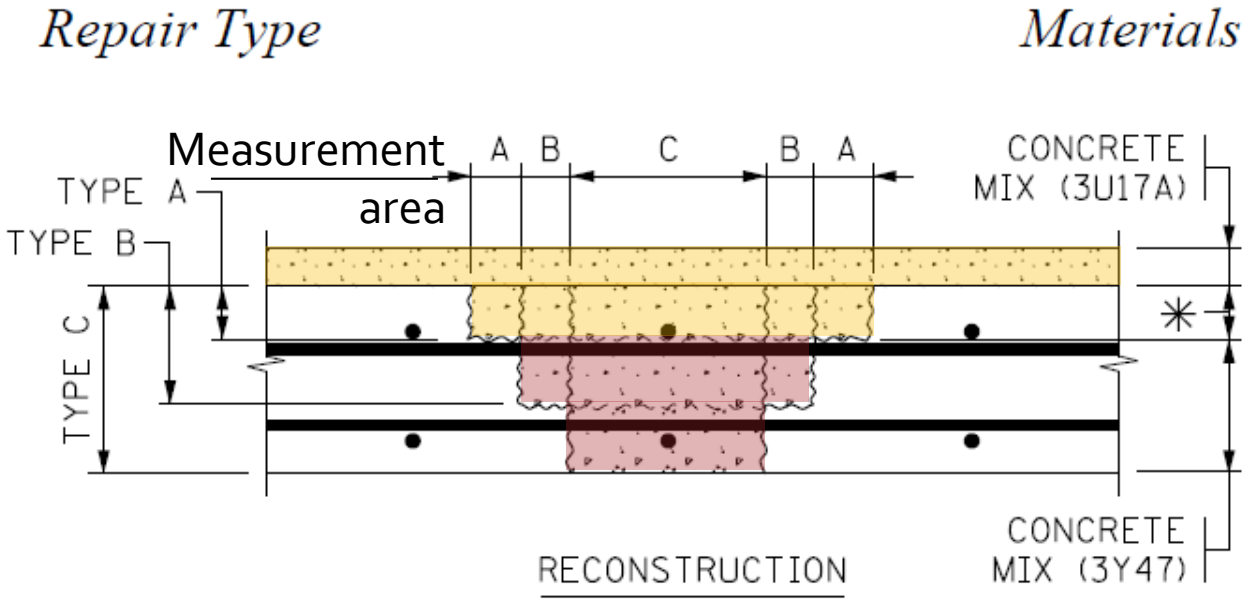
(MnDOT)

Local Patching/
Spot repairs

Repairs with
Concrete Wearing
Course



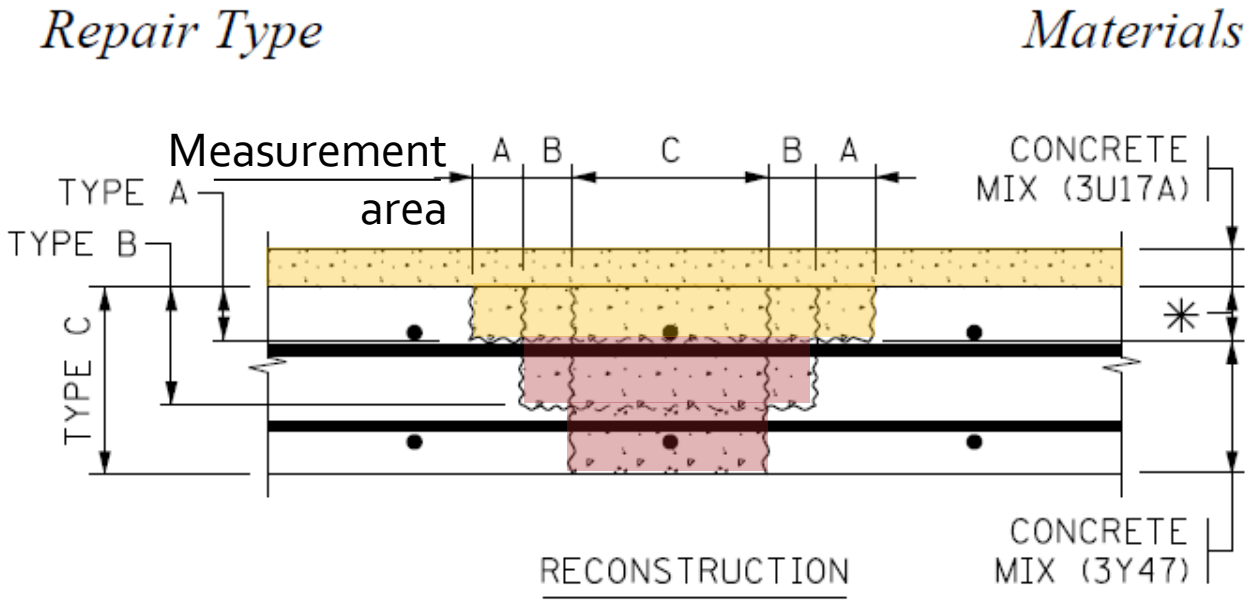
MnDOT 2020 average pricing:
D = $55/SF
E= $90/SF
F= $100/SF



A = $40/SF
B= $60/SF
C= $85/SF

(MnDOT)

Repairs with Concrete Wearing Course



Simple cost analysis:

Assume less than full-depth manual removals= $50/SF

Economics (MnDOT)

O = Optional with some concrete overlays up to a certain depth

	Traditional Mill and Concrete Overlay	Hydrodemolition Mill and Concrete Overlay
Remove Concrete W.C./Scarify $2.75/SF	X	X
New Concrete Wearing Course	X	X
Remove and Patch Type A	X	
Remove and Patch Type B	X	
Remove and Patch Type C (Not used)	X	
Water Control		X
Hydrodemolition		X
Remove Existing Patches		X
Remove Existing Patches (Full depth)		X
Prefill and cure deep patches		O

Economics (MnDOT)

O = Optional with some concrete overlays up to a certain depth

		Traditional Mill and Concrete Overlay	Hydrodemolition Mill and Concrete Overlay
Remove Concrete W.C./Scarify	$2.75/SF	X	X
New Concrete Wearing Course	$7.00/SF lg deck $11.00/SF sm deck	X	X
Remove and Patch Type A	$50.00/SF	X	
Remove and Patch Type B	$50.00/SF	X	
Remove and Patch Type C (Not used)		X	
Water Control	$50K +2.50/SF		X
Hydrodemolition	$4.30/SF		X
Remove Existing Patches	$30.00/SF		X
Remove Existing Patches (Full depth)	(Not used)		X
Prefill and cure deep patches	$24.00/SF		O

Michigan

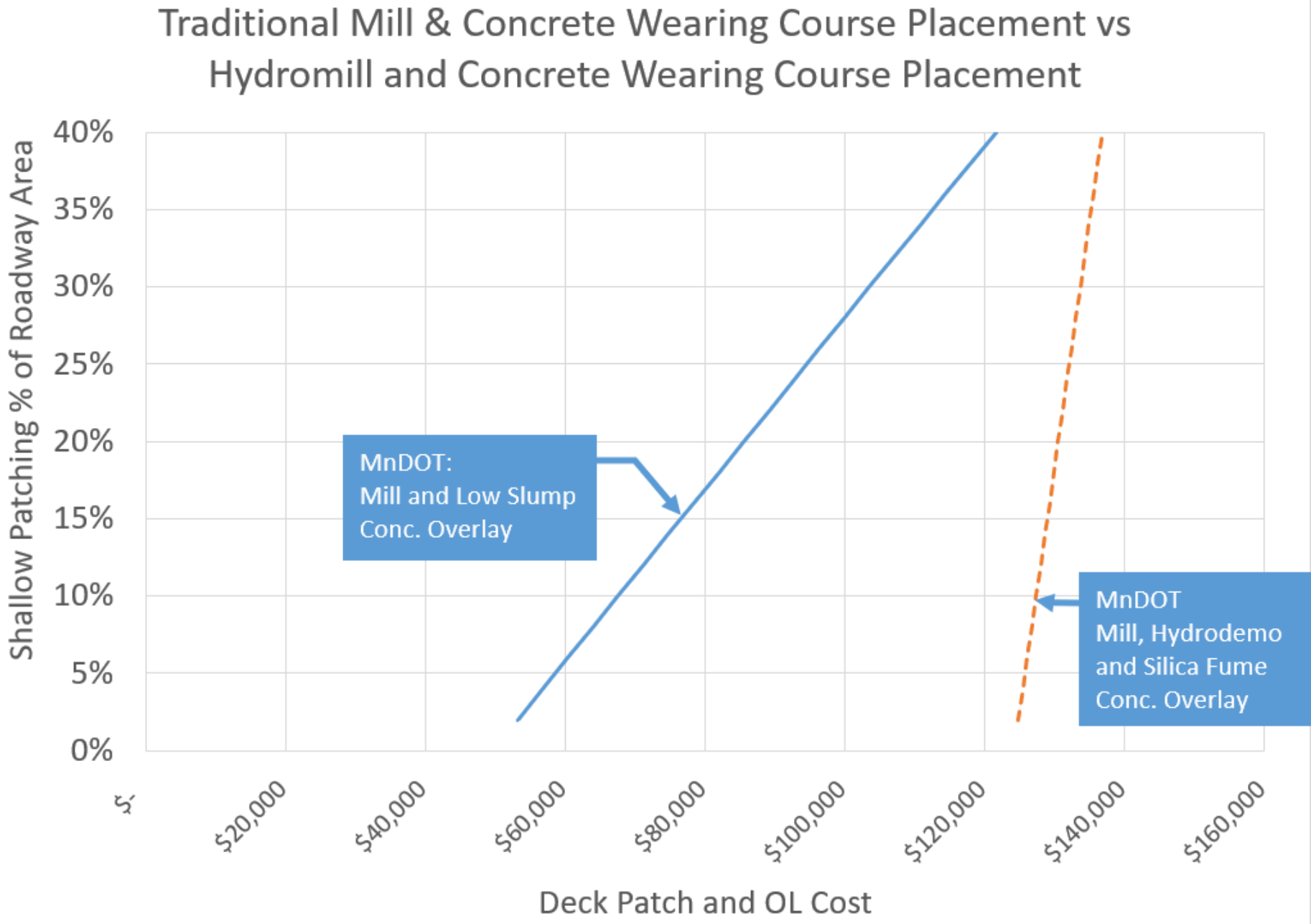
Michigan

- $1.50/SF scarification
- $6.50/SF hydrodemo
- $400/CYD for Silica Fume Concrete with fibers
- $10.00/SF Placing, finishing and curing concrete

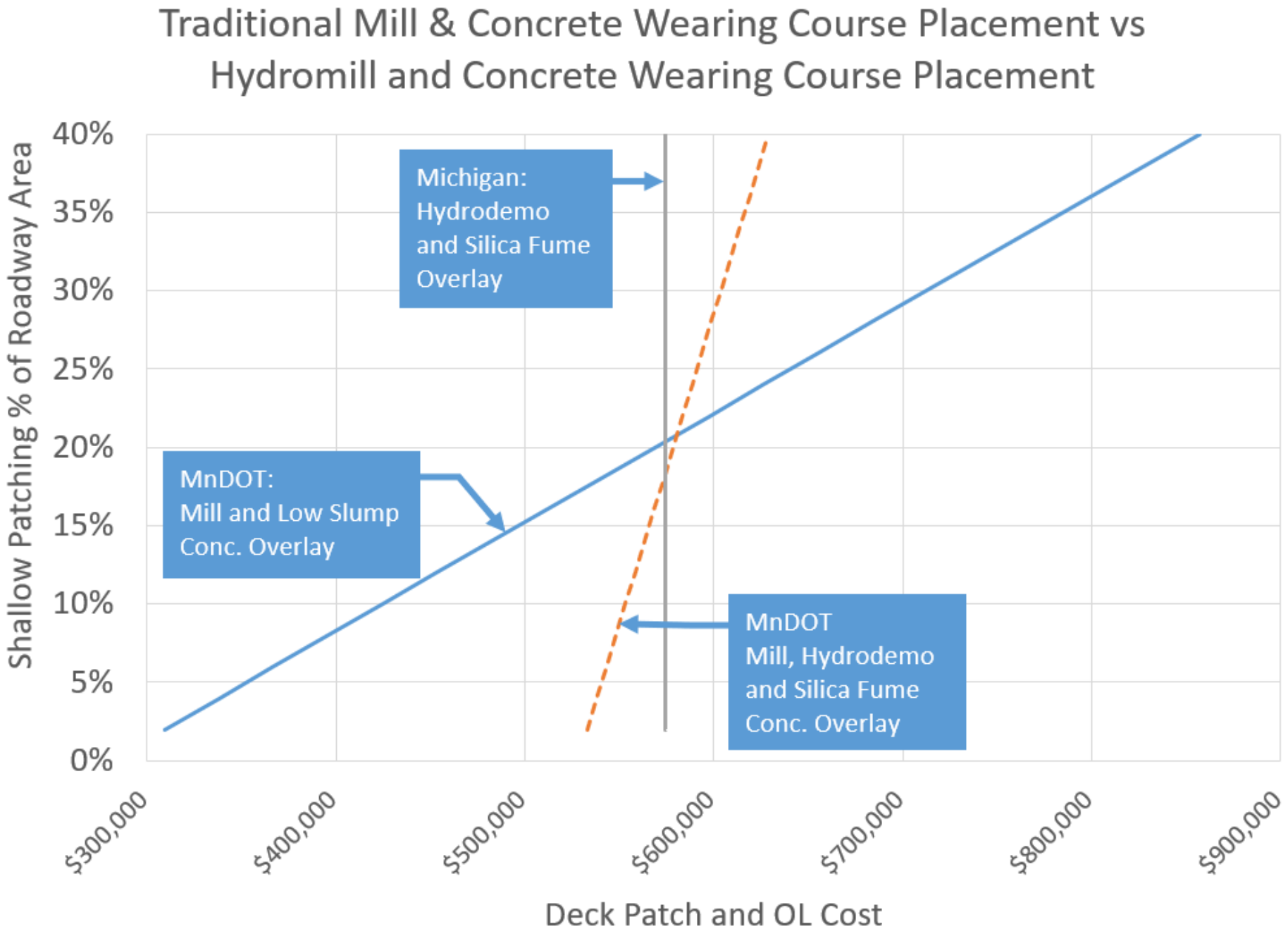
➔$20/SF Shallow - $27/SF Deep

(No separate payment for patch removal, scarifying separate)

Construction cost:
36' x 100'
Treatment area – depending on mobilization and water control costs, hydrodemo is cost prohibitive



Construction cost:
36' x 800'
Treatment area – depending on mobilization and water control costs, hydrodemo is cost prohibitive



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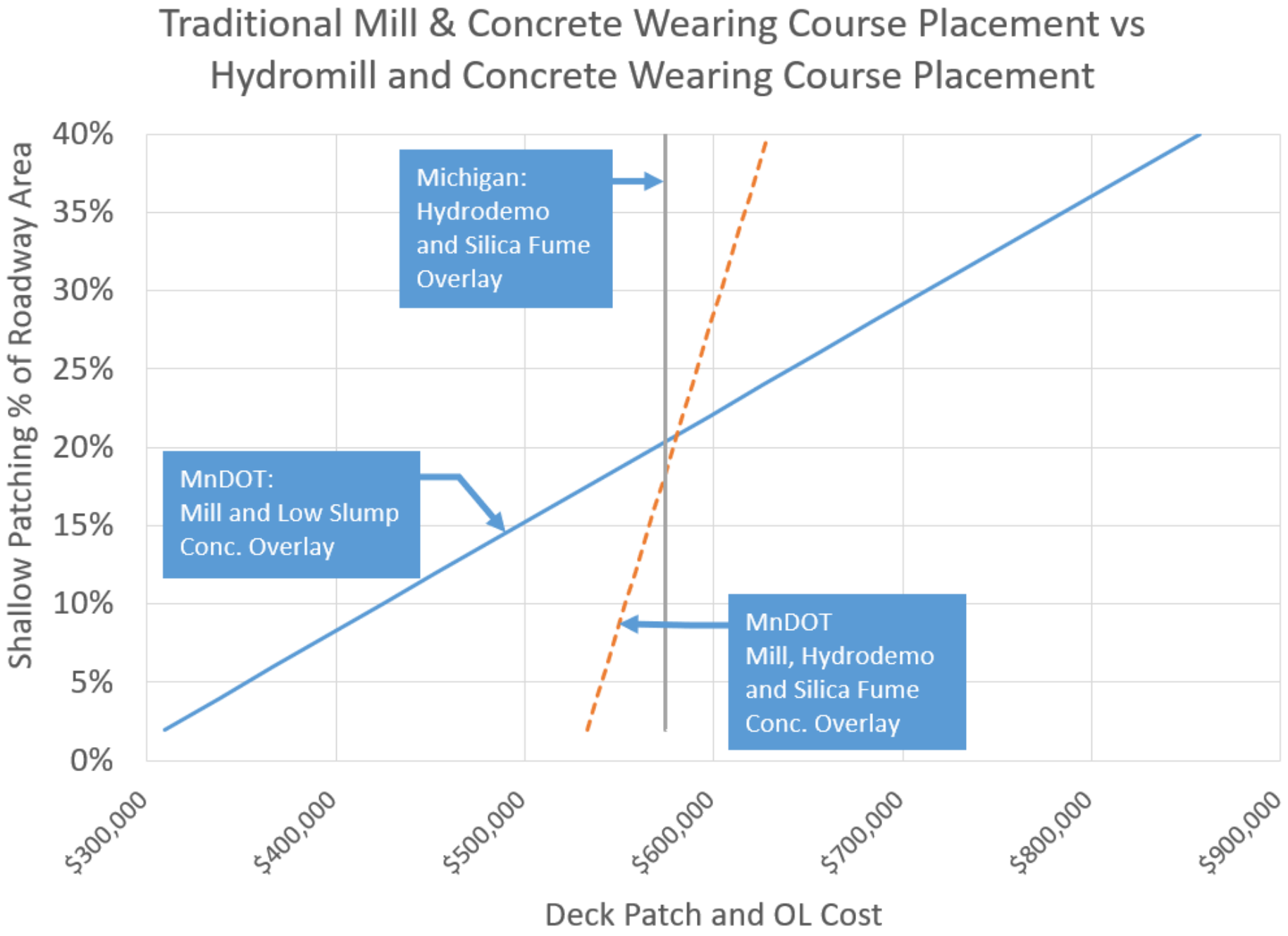
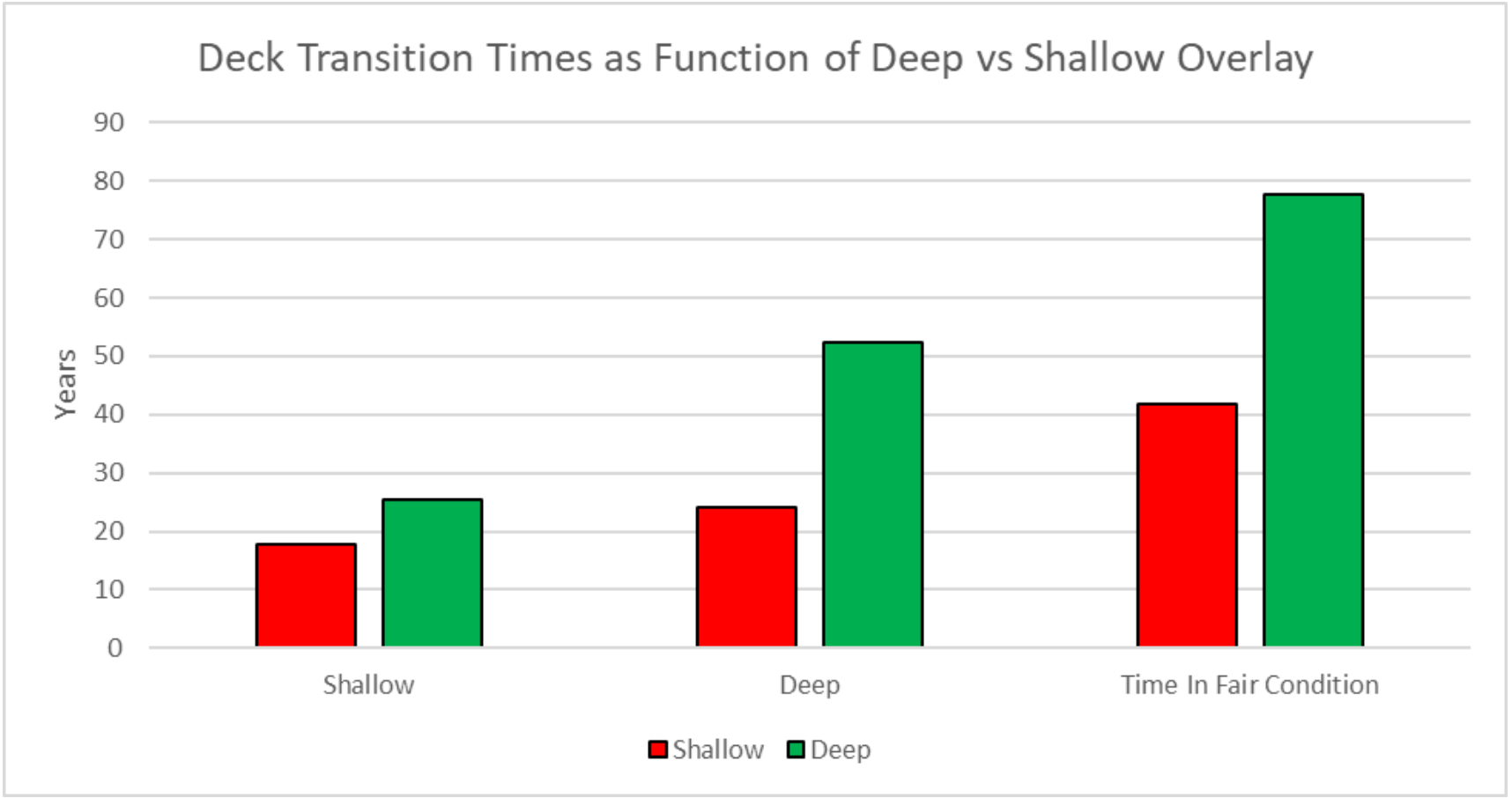


High patching levels is where hydrodemolition brings cost efficiency

Economics – Life Extension

Several states have utilized hydrodemolition for more than 25 years as a preparation technique

Michigan projections from 25+ years of experience



Conclusion: Decks spend over 85% more time in fair condition with a deep overlay than with a shallow overlay.

Economics – Life Extension

Economics includes:

1. Immediate work cost
2. Service life
3. Project delivery cost
4. Service interruption cost

Redeck alternative:

- brings barrier replacement cost
- increased service outage (construction time)
- additional upgrade pressures (>$$)
- longer life (Generally positive but may be out of sync with remaining life of rest of bridge)

Decision Matrices - MDOT

MDOT Decision Makers:

- Biennial Inspection Rating
- Region Bridge Engineer
- MDOT Design Squad
- BoBS Bridge Construction
- Local Construction Office

BRIDGE DECK PRESERVATION MATRIX – DECKS WITH UNCOATED "BLACK" REBAR

DECK CONDITION STATE				REPAIR OPTIONS	POTENTIAL RESULT TO DECK BSIR		ANTICIPATED FIX LIFE
Top Surface		Bottom Surface					
BSIR #58a	Deficiencies % (a)	BSIR #58b	Deficiencies % (b)		Top Surface BSIR #58a	Bottom Surface BSIR #58b	
≥ 5	N/A	N/A	N/A	Hold (c) / Seal Cracks	No Change	No Change	N/A
				Silane			5 years
				Healer Sealer (d)			8 to 10 years
	≤ 10%	≥ 6	≤ 2%	Epoxy Overlay (f)	8, 9	No Change	15 to 20 years
	≤ 10%	≥ 4	≤ 25%	Deck Patch (e, j)	6, 7, 8	No Change	5 to 10 years
4 or 5	10% to 25%	≥ 5	≤ 10%	Deep Concrete Overlay (h, j)	8, 9	No Change	25 to 30 years
		4	10% to 25%	Shallow Concrete Overlay (h, i, j)	8, 9	No Change	20 to 25 years
				HMA Overlay with water-proofing membrane (f, i)	8, 9	No Change	8 to 10 years
		2 or 3	> 25%	HMA Cap (g, i)	8, 9	No Change	2 to 4 years
≤ 3	>25%	≥ 6	< 2%	Deep Concrete Overlay (h, j)	8, 9	No Change	20 to 25 years
		4 or 5	2% to 25%	Shallow Concrete Overlay (h, i, j)	8, 9	No Change	10 years
				HMA Overlay with water-proofing membrane (f, i)	8, 9	No Change	5 to 7 years
		2 or 3	>25%	HMA Cap (g, i)	8, 9	No Change	1 to 3 years
				Replacement with Epoxy Coated or Stainless Rebar Deck	9	9	60+ years

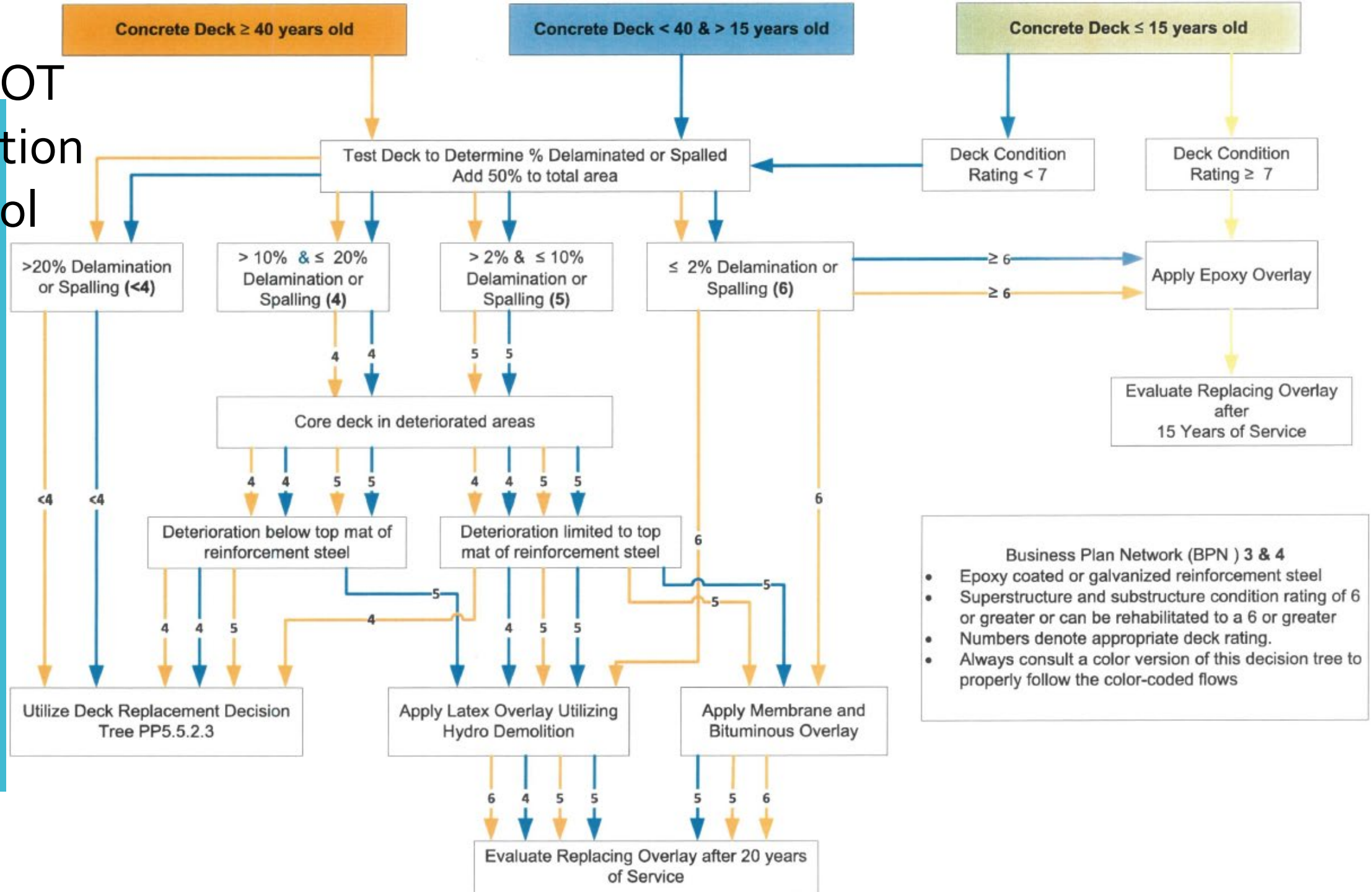
(a) Percent of deck surface area that is spalled, delaminated, or patched with temporary patch material. Top surface decision making based on concrete surface, not the condition of thin epoxy overlays or other wearing surfaces.
(b) Percent of deck underside area that is spalled, delaminated or map cracked.
(c) The "Hold" option implies that there is on-going maintenance to sustain current ratings.
(d) Seal cracks when cracks are easily visible and minimal map cracking. Apply healer sealer when crack density is too great to seal individually by hand. Sustains the current condition longer.
(e) Crack sealing must also be used to seal the perimeter of deck patches and joint replacements.
(f) Deck patching required prior to placement of epoxy overlay or waterproofing membrane.
(g) Hot Mix Asphalt cap without waterproofing membrane for ride quality improvement. Deck should be scheduled for replacement in the 5 year plan.
(h) If bridge crosses over traveled lanes and the deck contains slag aggregate, do deck replacement.
(i) When deck bottom surface is rated poor (or worse) and may have loose or delaminated concrete over traveled lanes, sidewalks or non-motorized paths, an in-depth inspection should be scheduled. Any loose or delaminated concrete should be scaled off and false decking should be placed over traveled lanes where there is potential for additional concrete to become loose.
(j) Some full depth repairs should be expected where top surface deficiencies align with bottom surface deficiencies.

Bridge Deck Preservation Matrix **July, 2017 Rev.**

MDOT BRIDGE DECK PRESERVATION MATRIX – DECKS WITH UNCOATED "BLACK" REBAR

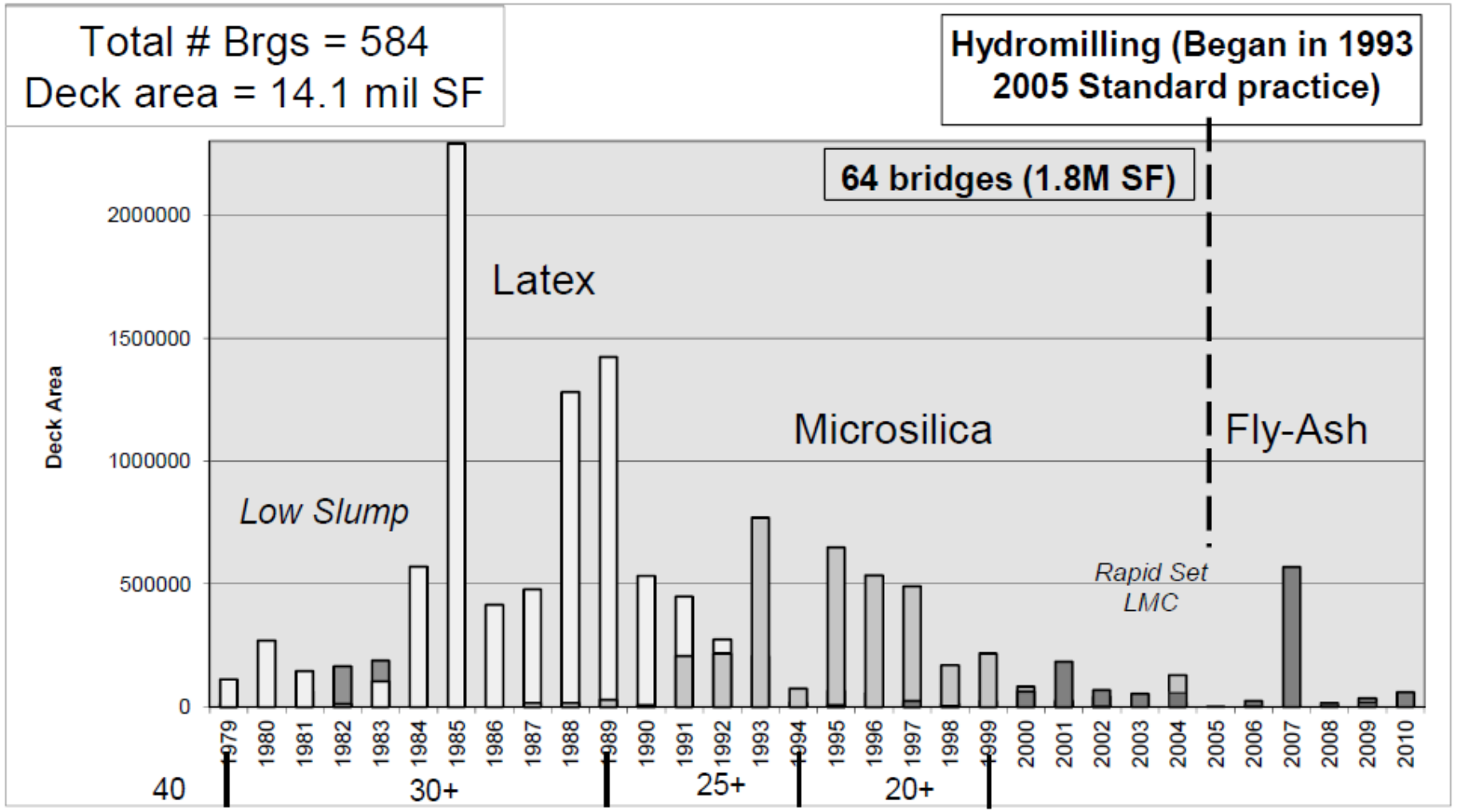
DECK CONDITION STATE				REPAIR OPTIONS	POTENTIAL RESULT TO DECK BSIR		ANTICIPATED FIX LIFE
Top Surface		Bottom Surface			Top Surface BSIR #58a	Bottom Surface BSIR #58b	
BSIR #58a	Deficiencies % (a)	BSIR #58b	Deficiencies % (b)				
≥ 5	N/A	N/A	N/A	Hold (c) / Seal Cracks	No Change	No Change	N/A
				Silane			5 years
				Healer Sealer (d)			8 to 10 years
	≤ 10%	≥ 6	≤ 2%	Epoxy Overlay (f)	8, 9	No Change	15 to 20 years
	≤ 10%	≥ 4	≤ 25%	Deck Patch (e, j)	6, 7, 8	No Change	5 to 10 years
4 or 5	10% to 25%	≥ 5	≤ 10%	Deep Concrete Overlay (h, j)	8, 9	No Change	25 to 30 years
		4	10% to 25%	Shallow Concrete Overlay (h, i, j)	8, 9	No Change	20 to 25 years
				HMA Overlay with water-proofing membrane (f, i)	8, 9	No Change	8 to 10 years
		2 or 3	> 25%	HMA Cap (g, i)	8, 9	No Change	2 to 4 years
≤ 3	>25%	≥ 6	< 2%	Deep Concrete Overlay (h, j)	8, 9	No Change	20 to 25 years
		4 or 5	2% to 25%	Shallow Concrete Overlay (h, i, j)	8, 9	No Change	10 years
				HMA Overlay with water-proofing membrane (f, i)	8, 9	No Change	5 to 7 years
		2 or 3	>25%	HMA Cap (g, i)	8, 9	No Change	1 to 3 years
				Replacement with Epoxy Coated			

PennDOT Evaluation Protocol



Every state struggles with achieving overlay quality

WashDOT overlay evolution



Summary of decision factors

1. Historical owner experience with mill and overlays
2. Quantity of deck repair/level of deterioration
3. Quantity of deck area (High mob + water control costs)
4. Long service life needs/expectations
5. Redeck alternate cost comparison
6. Redeck alternate service interruption tolerance
7. Remaining life of bridge/capital improvement

Summary of Findings

- Hydrodemolition has been successfully used in multiple states for many years.
- There are two basic classes of hydrodemolition:
  - Shallow removal
  - Deep removal
- Both classes of hydrodemolition can be effective and the selection is principally one of economics.

Summary of Findings

- Variety of repair/overlay mixes used
- Multiple states have very mature specifications for hydrodemolition
- Need experienced inspection staff for success
- Environmental permitting and job controls vary greatly between different states

Closing/ Q & A

- NCHRP 18-01 Final Report

http://onlinepubs.trb.org/onlinepubs/nchrp/docs/SCAN18-01-8.pdf

- Domestic scan program

https://www.domesticscan.org

- Construction specifications

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Other TRB events for you

- *May 17:* **Visualizing Transportation System Performance**

- *Aug 10-12:* **National Conference on Transportation Asset Management**

https://www.nationalacademies.org/trb/events