

# Pavement Condition Assessment: To Measure is Human

February 21 , 2023

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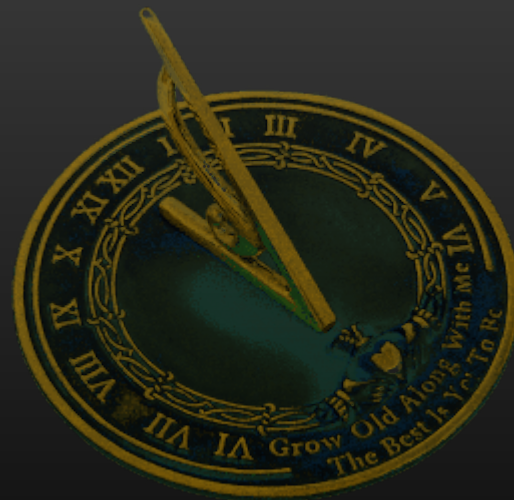
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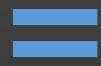
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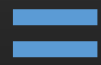
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# Complex Concepts



Speed



Flow Rate



Density



# Is your life ruled by performance measures?

- Hours worked
- Times late to work
- Number of deadlines missed
  
- Tons of asphalt produced
- Yearly profit
- Number of bids won
- Gross sales
  
- Blood pressure
- BMI
- Cholesterol





# What is a Performance Measure?

A performance measure is a discrete data element used as routine assessment to support management decisions. They are indicators of qualities that are predicative of a specific outcome.

**In other words.....**

Repeated data used to make better decisions leading to good things.



# Direct Performance Measure

- Finish times
- Lap times / splits

**Fast finish time = Win**





# Indirect Performance Measure

- 40-yd dash
- Vertical jump
- Bench press
- Broad jump
- Three-cone drill
- 20-yd shuttle
- $VO_2$  Max



**Strong, Fast, and Agile Team = usually you win**







# Pavement Performance Metrics

- Condition assessment
  - Focus on distress measures
- Ride/Roughness
  - Measure of user comfort
- Physical aspects
  - Measure features like structure or skid resistance



# Why Do We Do Condition Assessment?

- Network wide metric
- Model future condition of network
- Determine what work to do
- Determine how a road will change over time
- Determine value of fixes
- Determine funding impact
- Research





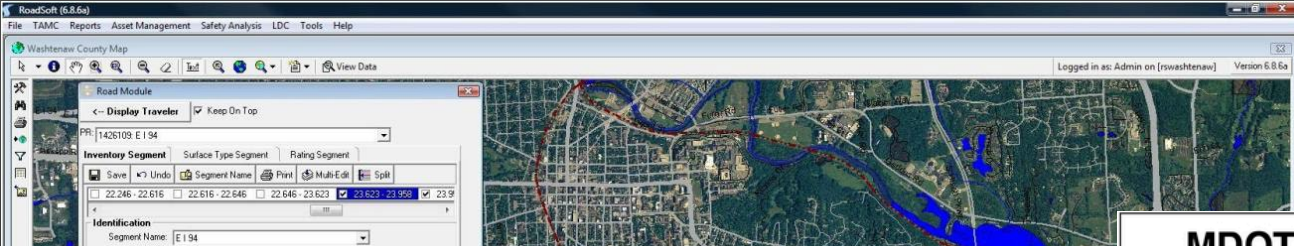
# Network Level Metric

## Paved Federal-Aid Road Condition

2012-2021



# Network Level Modeling



**Strategy Evaluation**

Current Network: Asphalt

Current Strategy: Test

Work this year?  Inflation: 0 % Years: 10

Strategy Definition	Budget	Miles	Yr From	Yr To
Asphalt-All Season: 127.338				
Asphalt-Standard: 364.681				
Reconstruction - 6" base, 3" top (Asp) - (\$ 98,560 / mile)	\$985,600	10	1	10
Reconstruction - 6" base, 3" top (AspAS) - (\$ 96,213 / mile)				
Reconstruction - 9" base, 3" top - (\$ 119,680 / mile)				
Mill & Overlay - 3" Thick (Asp) - (\$ 49,280 / mile)				
Modeled Overlay - (\$ 33,440 / mile)	\$167,200	5	1	10
Overlay - 2" Thick (Asp) - (\$ 37,195 / mile)				
Overlay - 3" Thick - (\$ 37,195 / mile)				
Sealcoat Double - (\$ 7,744 / mile)				
Sealcoat Single - (\$ 4,312 / mile)	\$194,040	45	1	10
Sealcoat Single + - (\$ 5,925 / mile)				
Crack Seal - (\$ 1,291 / mile)				
	\$9,035	7	1	10

**Network Summary (Lane Miles)**

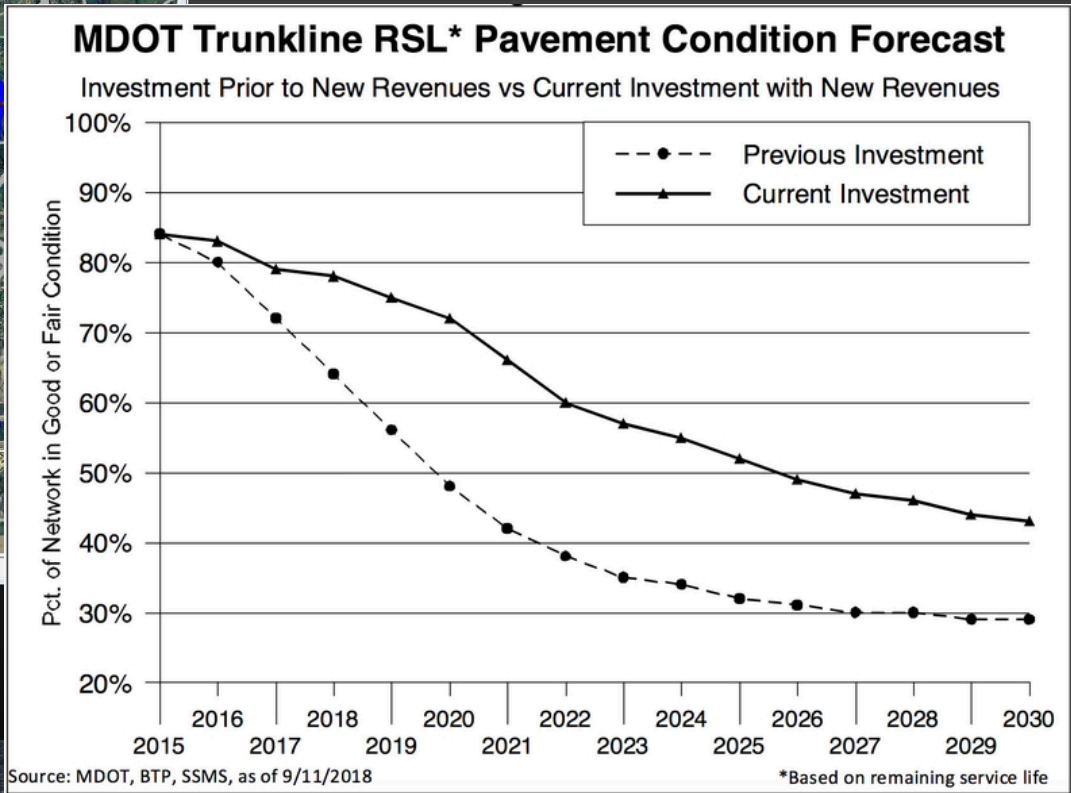
- Asphalt-All Season: 127.338
  - Good: 1.970
  - Fair: 107.654
  - Poor: 17.714
  - RSL 0: 2.000
  - RSL -1: 7.082
  - RSL -3: 5.426
  - RSL -4: 3.206
- Asphalt-Standard: 364.681
  - Good: 0.584
  - Fair: 186.267
  - Poor: 177.830

**Asphalt-Standard Cost by Year Test - Asphalt-Standard**

**Percent of Good (grn) Fair (blue) Poor (red) by Year Test - Asphalt-Standard**

**Lane Miles of Activity Performed by Year Test - Asphalt-Standard**

**Average RSL by Year Test - Asphalt-Standard**

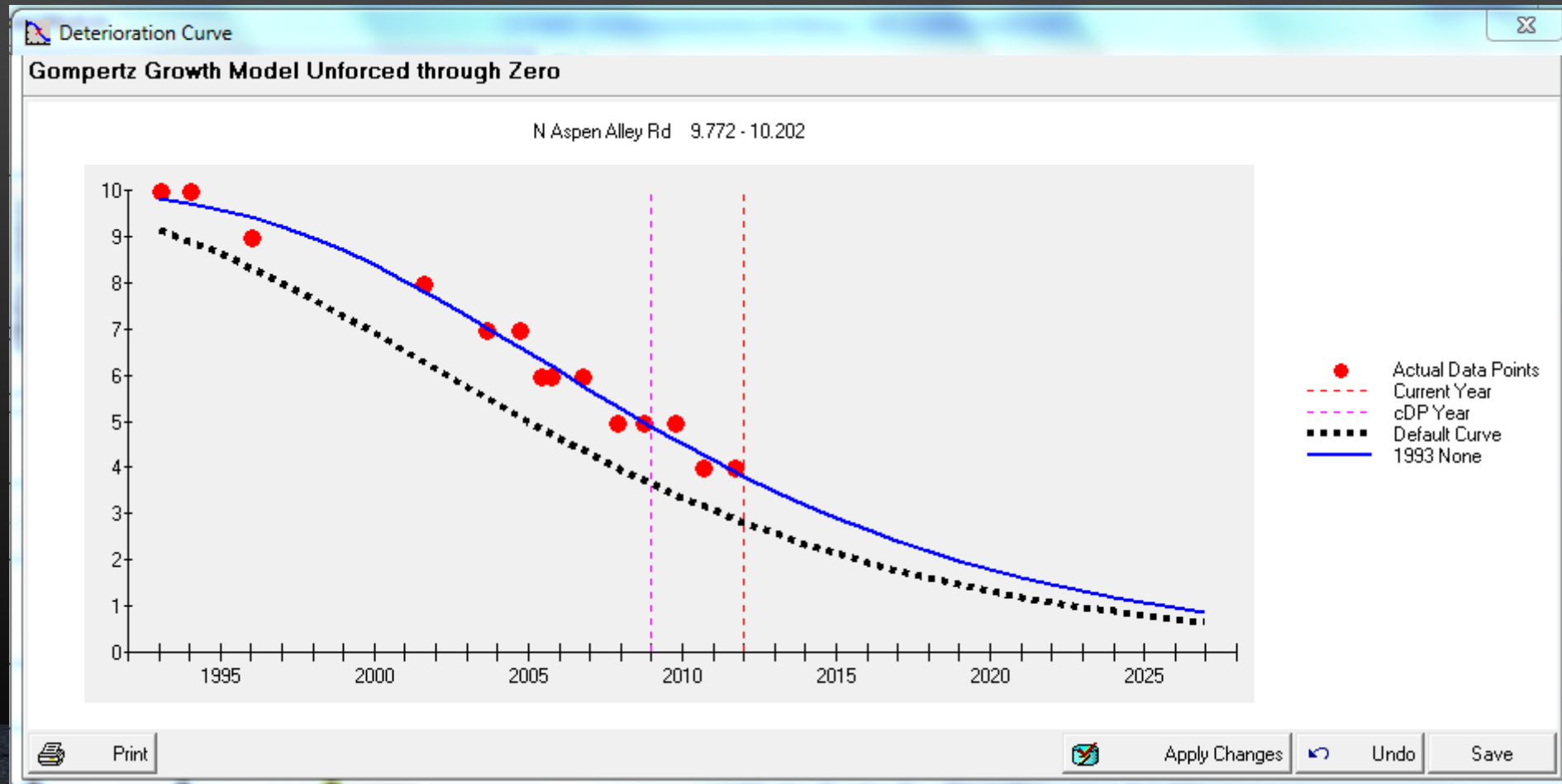




# What Work To Do?

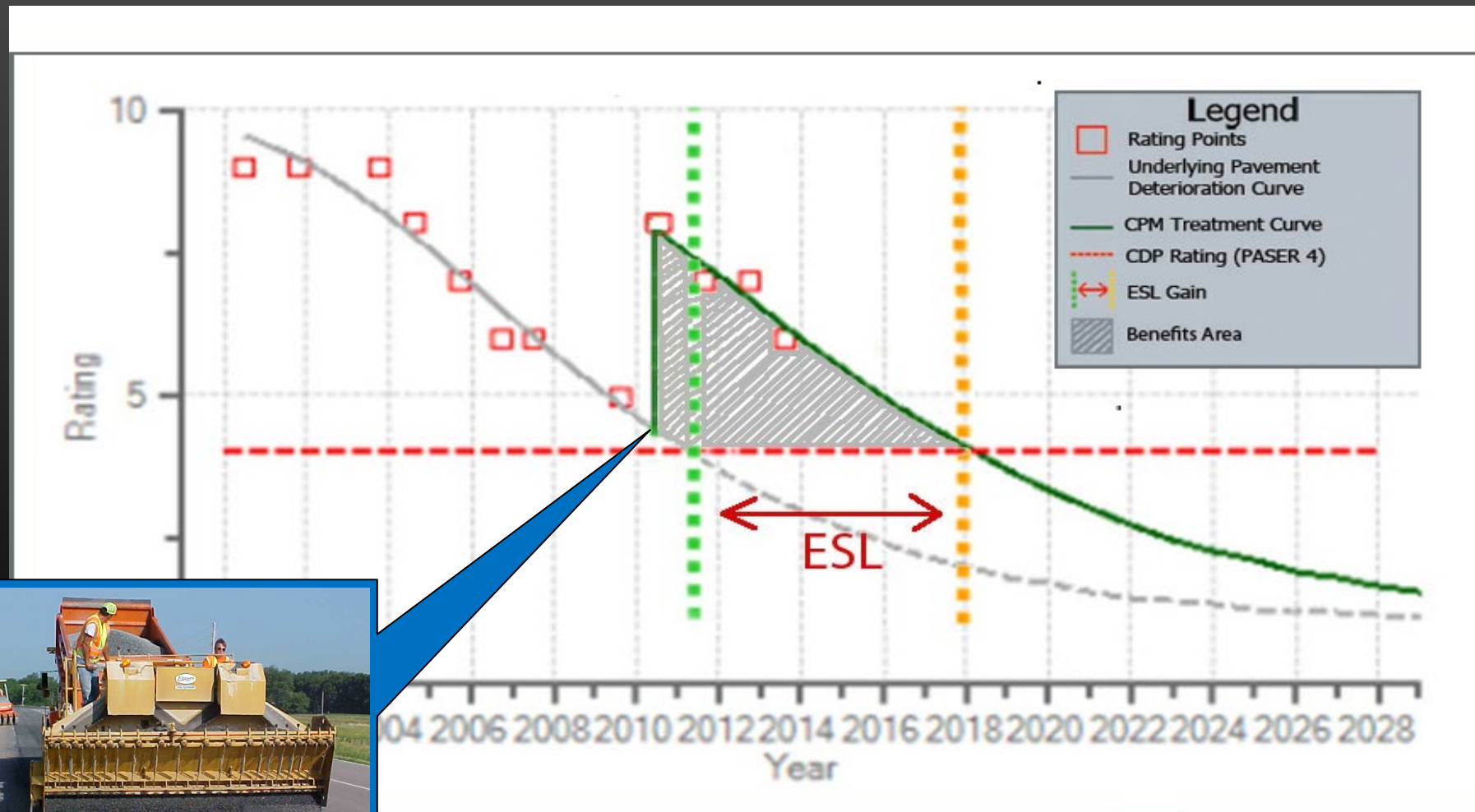


# Modeling— How will a specific road change?





# Measure Value of Fixes



# Research

- Refine timing of fixes
- Refine materials used in pavements
- Refine construction technique
- Refine design methods
- Measure impact of treatments
- Relating distress to use





# Simple Rating Systems vs. Complex Systems

**Simple Systems:** Provides one overall condition rating, and does not record individual distress measures

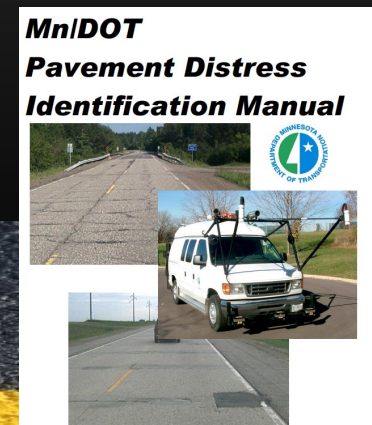
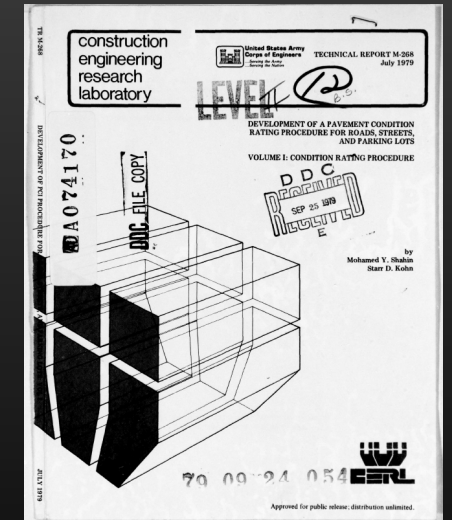
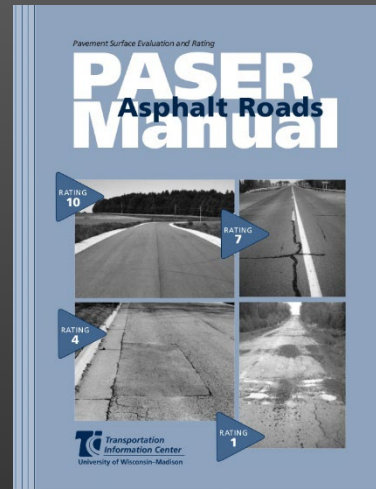
Examples:

- PASER – Pavement Surface Evaluation and Rating
- RSMS – Road Surface Management System (New Hampshire)
- MDOT – Sufficiency Rating System
- FHWA – Present Serviceability Rating

**Complex Systems:** Provides component measures of distresses which may or may not roll up to an overall condition rating.

Examples:

- PCI – Pavement Condition Index
- MDOT – Distress Index
- MNDOT SR – Surface Rating



# Example Detail For Different Systems

## PCI 45

Minor rutting 120 sqft  
Moderat Joint distress 120 lf  
Med. T – Crack 178 lf  
Moderate B-Crack 270 sqft  
Alligator cracking 0 sqft  
Bleeding 0 sqft  
Bumps and sags 0 sqft  
Corrugations 0 sqft  
Depressions 0 sqft  
Edge cracking 0 lf  
Joint reflections NA  
Lane/shoulder drop-off NA  
Patching and utility cut NA  
Polished aggregate NA  
Potholes NA  
Shoving NA  
Slippage cracking NA

PASER 5





# Cardinal Distresses

Fatigue Crack



Shear Crack



Rutting



Shoving



Edge Crack



Transverse



Reflective





# Cardinal Distresses

Joint Crack



Block Crack



Bleeding



Polishing



Raveling



Patches



Potholes





# Basis of a System - PCI

Source: Mohamed Shahin 1976 –US Corps of Engineers

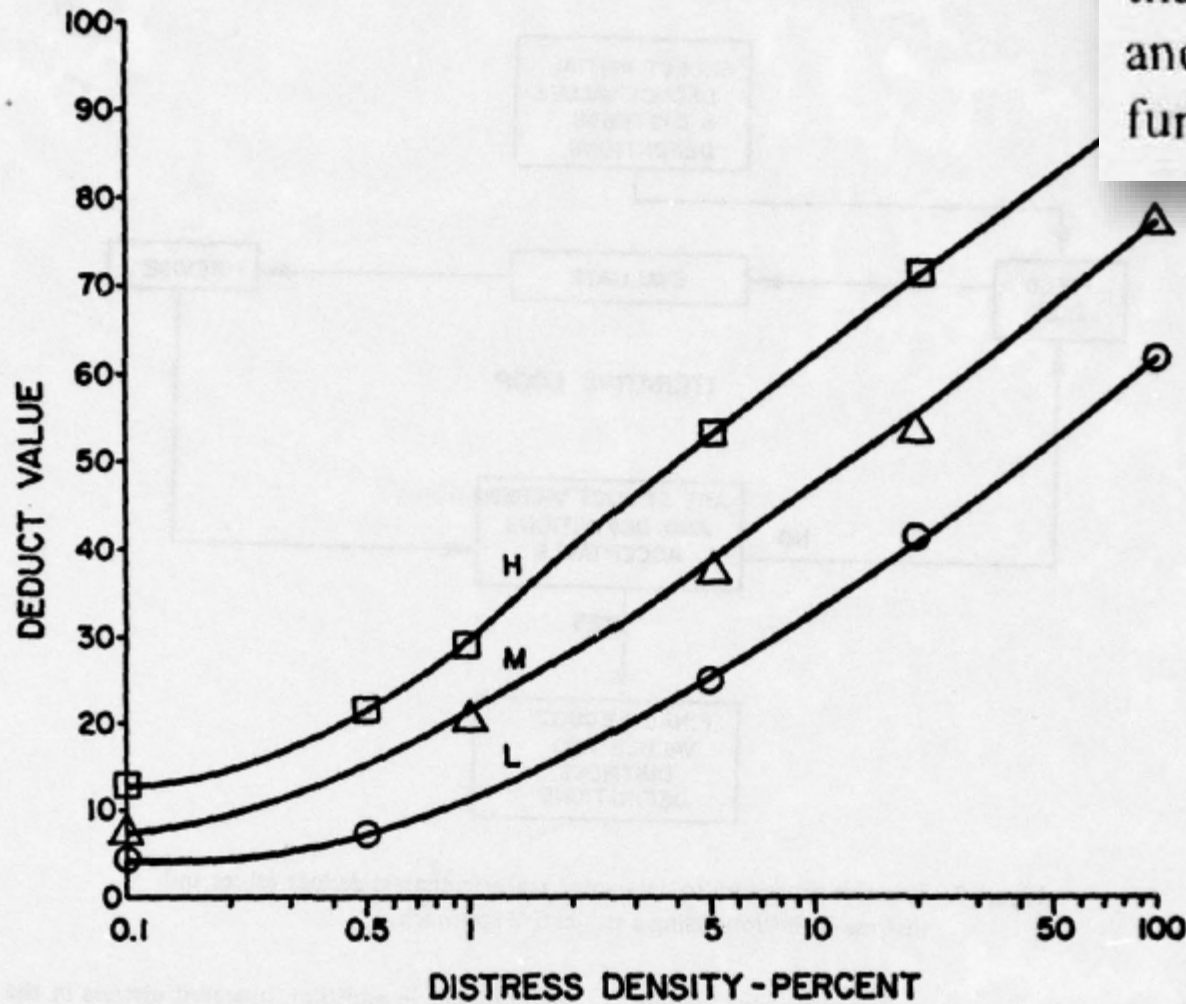


Figure 6. Example development of deduct value curves for alligator cracking.

## Development of Deduct Values

Deduct values are numbers that represent the effects that distresses have on a pavement's structural integrity and surface operational condition. A deduct value is a function of the type, severity, and density of a distress.



# Basis of a System - PASER

## *Asphalt pavement distress*

PASER uses visual inspection to evaluate pavement surface conditions. The key to a useful evaluation is identifying different types of pavement distress and linking them to a cause. Understanding the cause for current conditions is extremely important in selecting an appropriate maintenance or rehabilitation technique.

Source: Don Walker 1987 –University of Wisconsin

### **RATINGS ARE RELATED TO NEEDED MAINTENANCE OR REPAIR**

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<b>Rating 9 &amp; 10</b>	No maintenance required
<b>Rating 8</b>	Little or no maintenance
<b>Rating 7</b>	Routine maintenance, cracksealing and minor patching
<b>Rating 5 &amp; 6</b>	Preservative treatments (sealcoating)
<b>Rating 3 &amp; 4</b>	Structural improvement and leveling (overlay or recycling)
<b>Rating 1 &amp; 2</b>	Reconstruction



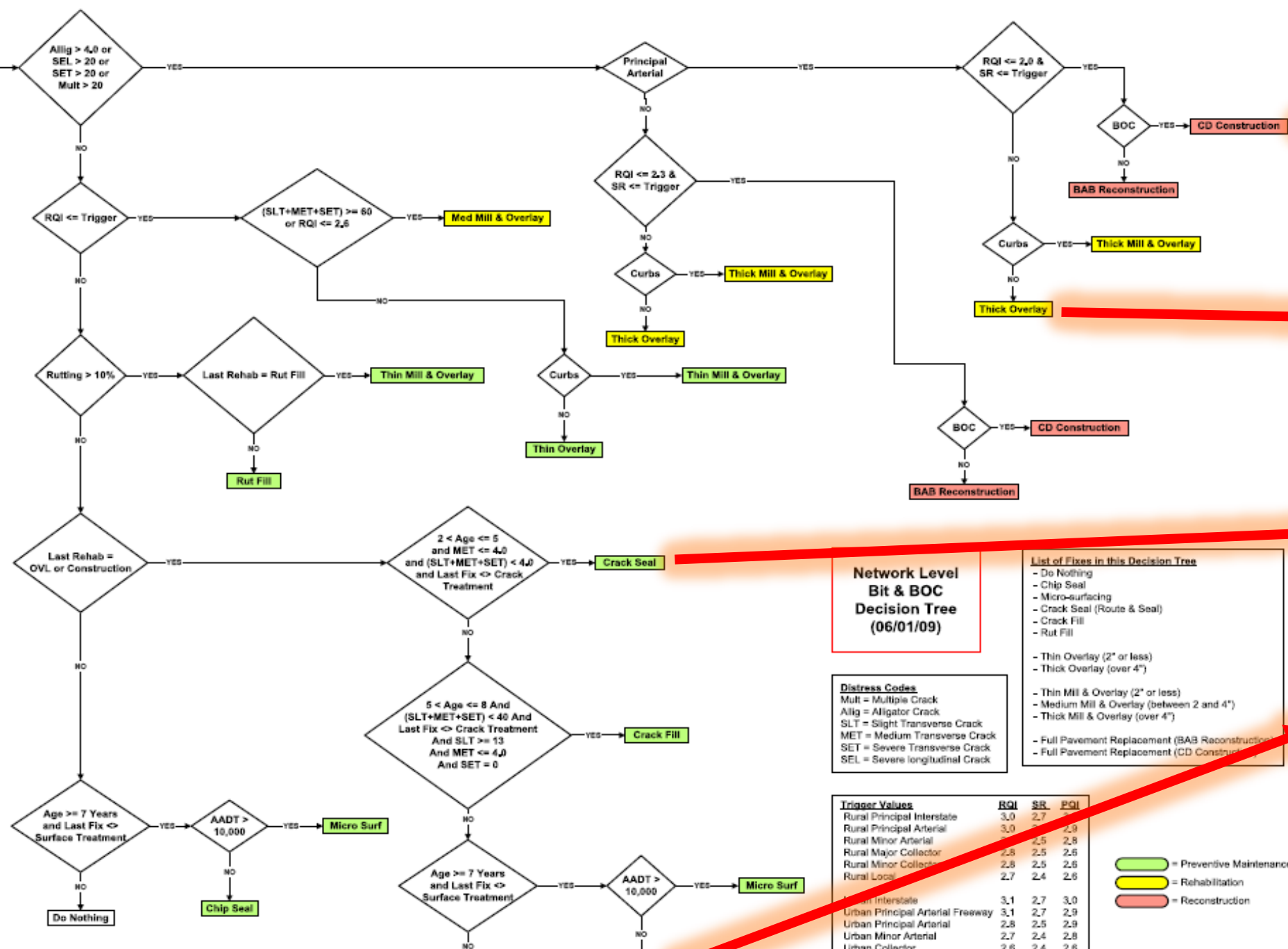


## Rating system

Surface rating	Visible distress*	General condition/ treatment measures
<b>10</b> Excellent	None.	New construction.
<b>9</b> Excellent	None.	Recent overlay. Like new.
<b>8</b> Very Good	No longitudinal cracks except reflection of paving joints. Occasional transverse cracks, widely spaced (40' or greater). All cracks sealed or tight (open less than 1/4")	Recent sealcoat or new cold mix. Little or no maintenance required.
<b>7</b> Good	Very slight surface raveling, surface shows some traffic wear. Occasional longitudinal cracks (open 1/4") due to reflection or paving joints. Transverse cracks (open 1/4") spaced 10' or more apart, little or slight crack raveling. No patching or very few patches in excellent condition.	First signs of aging. Maintain with routine crack filling.
<b>6</b> Good	Slight raveling (loss of fines) and traffic wear. Longitudinal cracks (open 1/4" - 1/2"), some sealed less than 10'. First sign of block cracking. Sight to moderate flushing or polishing. Occasional patching in good condition.	Shows signs of aging. Sound structural condition. Could extend life with sealcoat.
<b>5</b> Fair	Moderate to severe raveling (loss of fine and coarse aggregate). Longitudinal and transverse cracks (open 1/2") show first signs of slight raveling and secondary cracks. First signs of longitudinal cracks near pavement edge. Block cracking up to 50% of surface. Extensive to severe flushing or polishing. Some patching or edge wedging in good condition.	Surface aging. Sound structural condition. Needs sealcoat or thin non-structural overlay (less than 2")
<b>4</b> Fair	Severe surface raveling. Multiple longitudinal and transverse cracking with slight raveling. Gradual cracking in wheel path. Block cracking (over 50% of surface). Patching in fair condition. Slight rutting or distortions (1/2" deep or less).	Significant aging and first signs of need for strengthening. Would benefit from a structural overlay (2" or more).
<b>3</b> Poor	Closely spaced longitudinal and transverse cracks often showing raveling and crack erosion. Severe block cracking. Some alligator cracking (less than 25% of surface). Patches in fair to poor condition. Moderate rutting or distortion (1" or 2" deep). Occasional potholes.	Needs patching and repair prior to major overlay. Milling and removal of deteriorated surface and the thin overlay.
<b>2</b> Very Poor	Alligator cracking (over 25% of surface). Severe raveling and distortions (over 2" deep). Extensive patching in poor condition. Potholes.	Severe deterioration. Needs reconstruction with extensive base repair. Pulverization of old pavement is effective.
<b>1</b> Very Poor	Severe distress with extensive loss of surface integrity.	Failed. Needs total reconstruction.

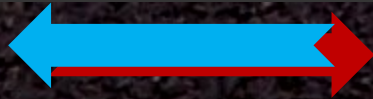




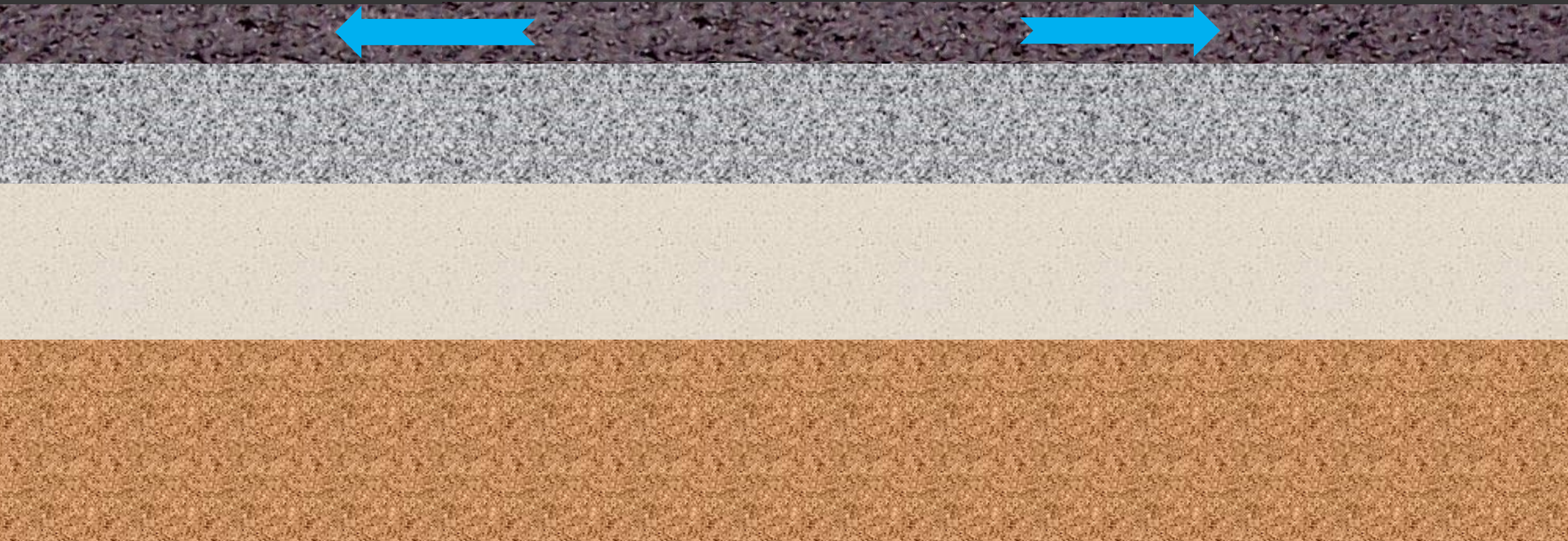




# Environment



# Environment

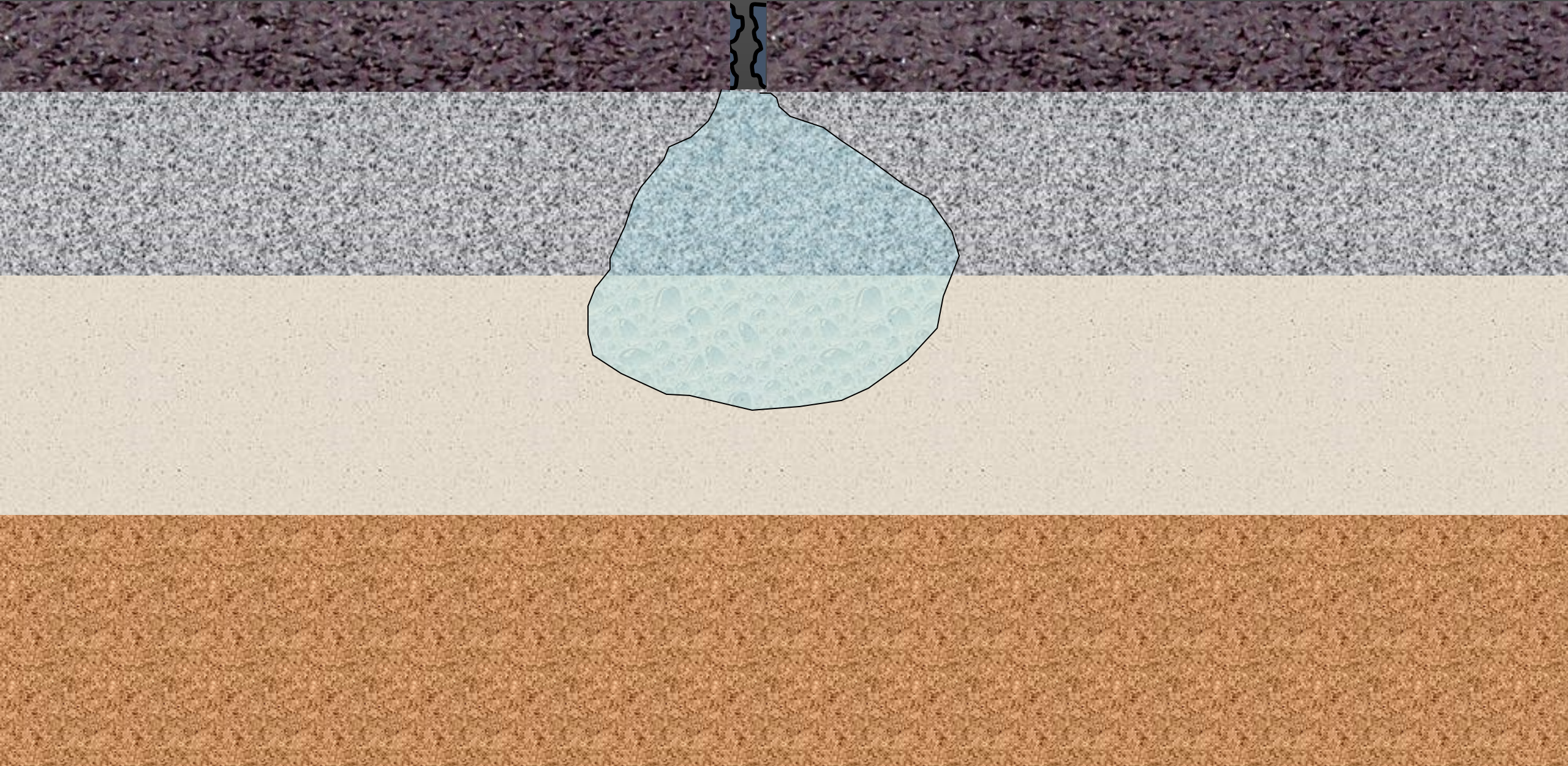




# Minor Distress

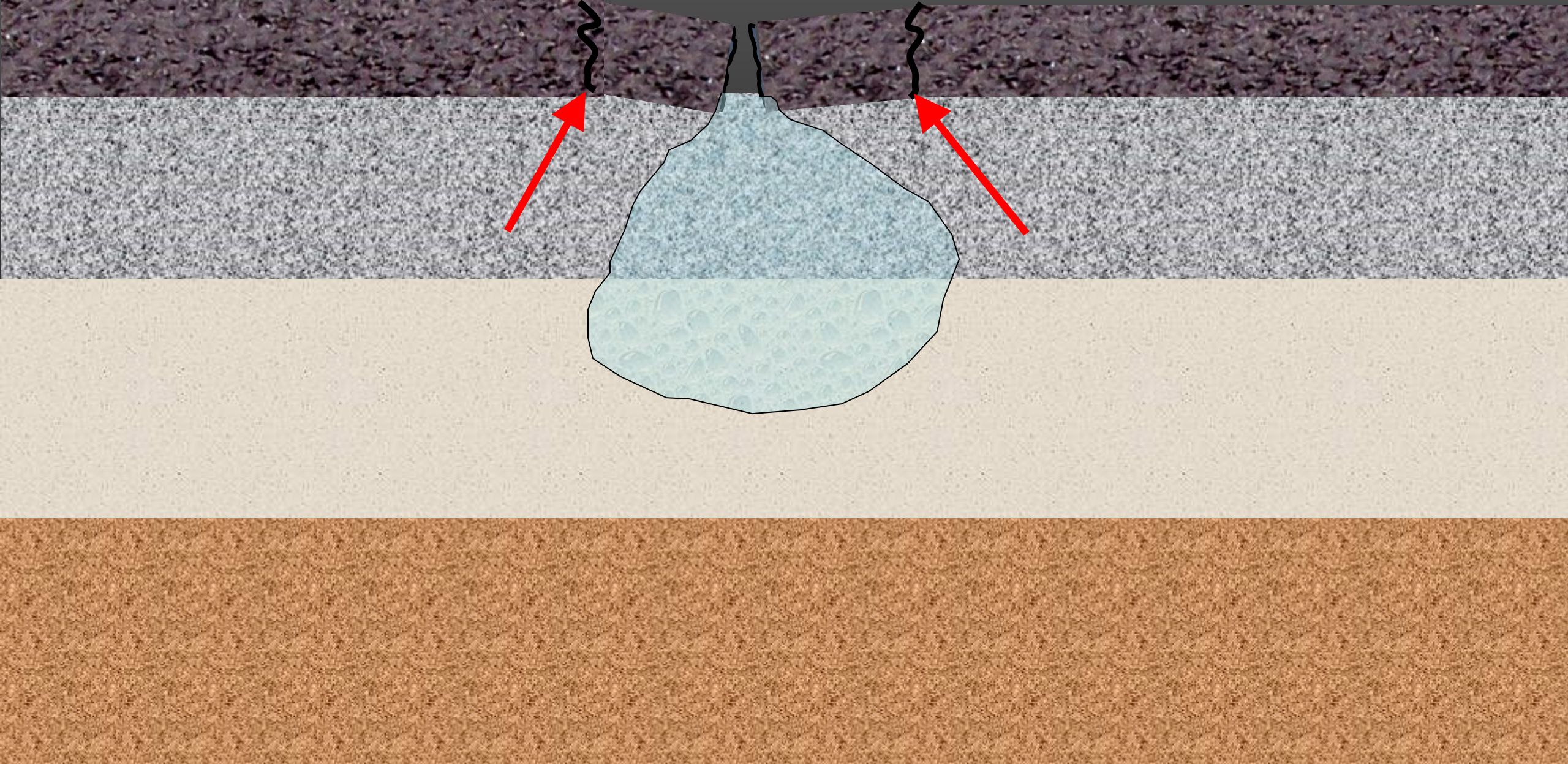


# Water Intrusion

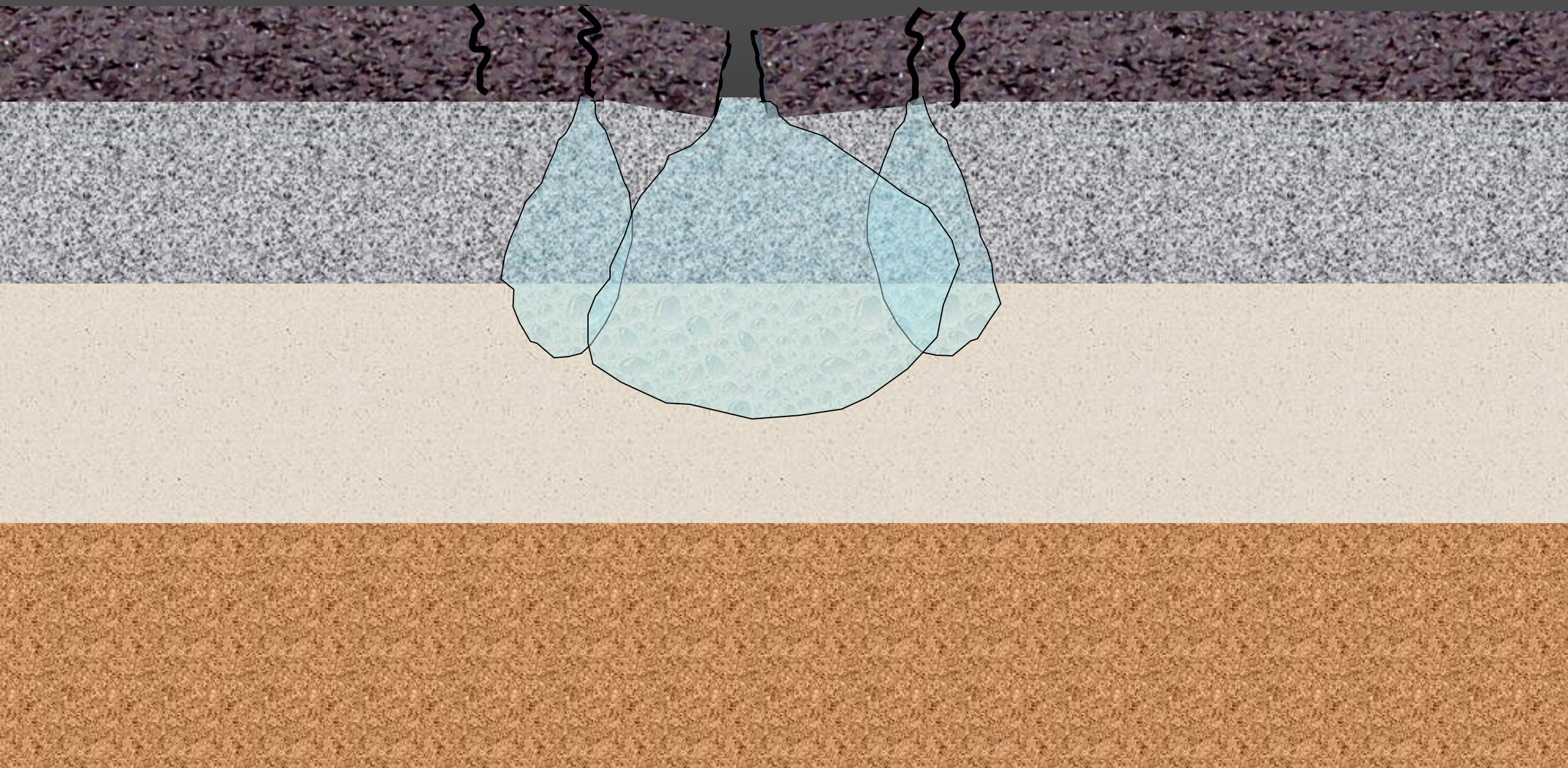




# Base Weakening & Loss of Support



# Distress Propagation











Video Credit: South Dakota DOT



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# Human Visual Inspection

- Only cost effective for simple systems
- Usually focuses on estimation vs measures
- Provides wide access to the method
- Data is immediately ready for use
- Requires a large force of collectors for wide area collection



# Specialized Sensors Package-equipped Vehicle

- Most widely used method for complex systems
- Wide array of vendors / sensor packages
- Providers range from DIY to full service
- AI is starting to present opportunities for analysis vs. human review



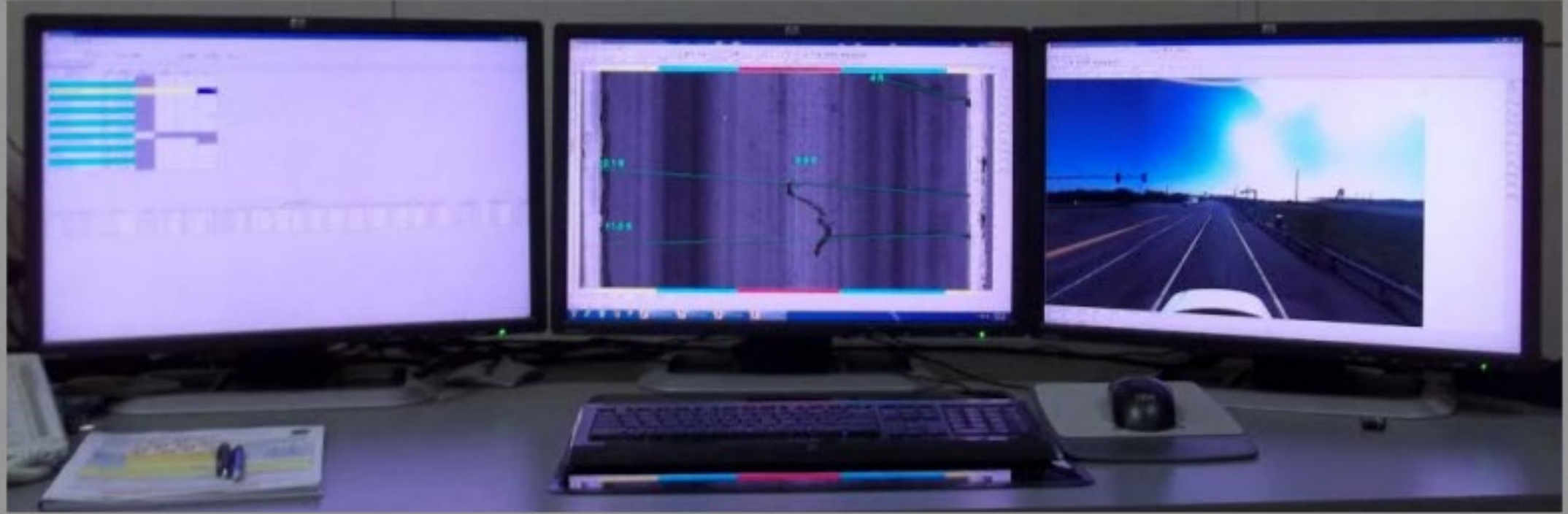
Photo source: <https://www.ara.com>





# Downward and Panoramic Imagery

Manual (human) detection and classification of distresses



**Video Workstation**

Source Pennsylvania DOT



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# Laser Profilometer (point) with accelerometer

IRI, longitudinal profile, transverse profile



Source Romdas



Source PaveTesting





# Laser Crack Detection (Laser Linescanner)

- High resolution camera with laser linescanner
- Integrated system
  - Rutting
  - Profile
  - Crack detection
  - IRI
  - Raveling
  - Joint spalling and faulting
  - Bleeding
  - Can produce a PASER scale



Source PaveMetrics



# Smartphone Applications

- Emulate specialized sensor package collection with lower cost equipment (cell phone)
- Primary sensor is camera and accelerometer (IRI proxy)
- Heavy use of AI processing
- Usually a custom distress scale but PCI and PASER can be produced by some vendors
- Highly proprietary processes (black box)



Photo source: [www.vaisala.com](http://www.vaisala.com)





# Research in Progress

- Embedded Sensors



Source: Purdue University

- Vehicle ECM Units



Source: Flickr user "3ndymion"

- Remote Sensing



Source: Michigan Tech University

# Cost of Collection

- Human Visual Collection with PASER \$12 to \$14/mile

44,000 miles = \$528,000 to \$ 616,000

- Sensor Enabled Vans \$40 to \$150/mile

44,000 miles = \$1,760,000 to \$ 6,600,000 **3X to 11X**

- Smartphone Applications \$50 to \$100/mile

44,000 miles = \$2,200,000 to \$ 4,500,000 **3.8X to 7.7X**





# Tips Pavement Condition Assessment

- Know how your data is going to be used
- Pick something you can afford
- Pick something you can do repeatedly
- Only collect what you need



# Questions







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