Lime & LAS

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ASU Pavement Materials Conference

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Agenda

Moisture Susceptibility

Adhesion/Cohesion

- Adhesion Promoters

Performance Tests Data

- LAS/WMA vs Lime

Supply

- Source
- Logistics
- Materials Handling

Cost Comparisons

- Where is Lime and LAS/WMA used?
- Environmental Costs Estimates

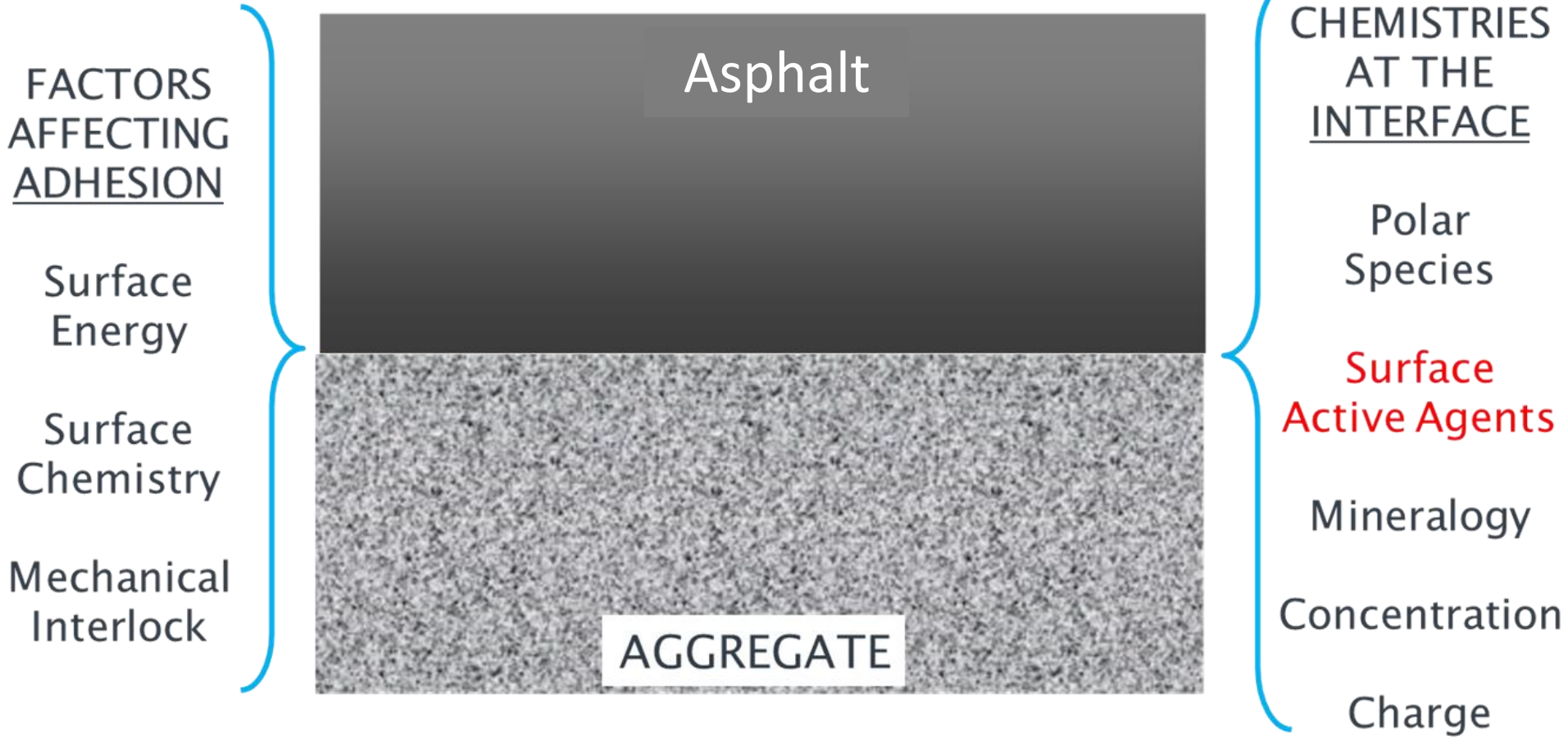
Summary

Conclusions

Stripping and Moisture Susceptibility Failures

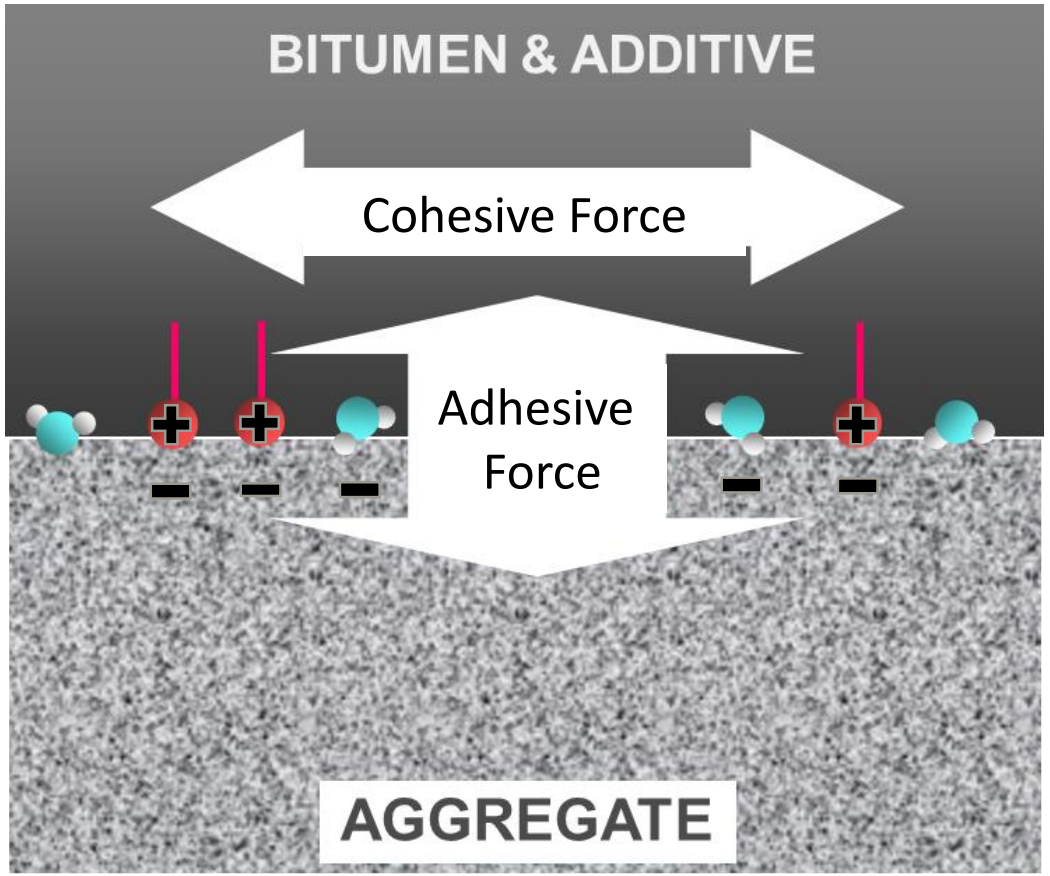
Stripping and Moisture Susceptibility Failures

The Adhesive Interface



The Adhesive Interface: Adhesion versus Cohesion

In asphalt mixes, a balance must be maintained between adhesion and cohesion



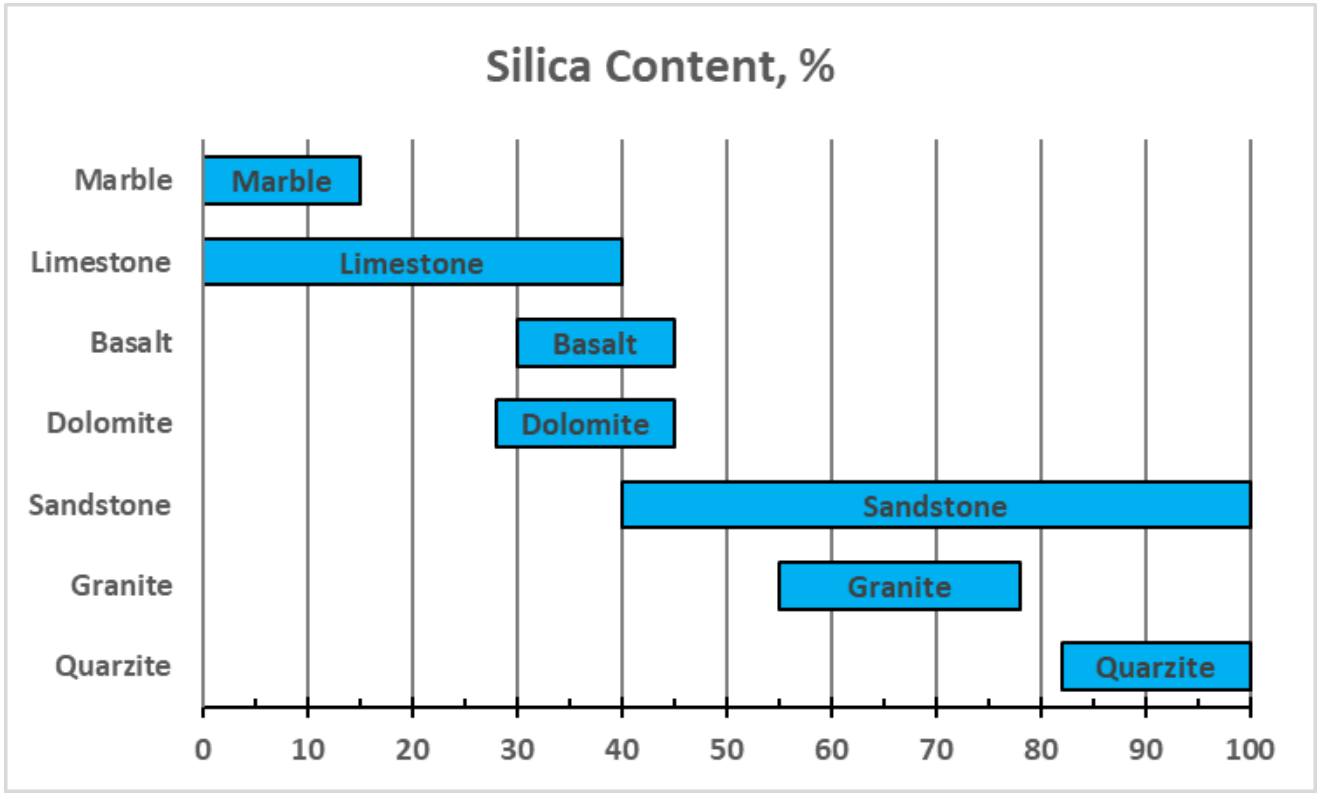
In colder temperatures, cohesive forces in the bitumen may cause the film to contract

Water can also migrate into the interface, causing negative charges to develop

Sufficient adhesive force must be present to counter-balance the cohesive force

Silica Content

- The higher the silica content, the less likely the asphalt and aggregate will adhere well
- Higher silica content aggregates respond well to LAS/WMA



Liquid Anti-Strips (LAS) dosed at 0.25 to 0.75% w/w asphalt

- Alters aggregate surface charge
- **Product performance tailored for the materials**
- Reduced aged hardening of asphalt, likely due to oxygen scavenging capabilities and reducing mixing and compaction temperatures when used as Warm Mix Asphalt
- **Many Warm Mix Asphalt (WMA) have LAS properties for better workability and compaction**

Hydrated Lime dosed at 1-2% w/w aggregate

•Hydrated lime is quicklime rehydrated with H_2O and pulverized; acts similar to Portland cement; acts like mineral filler and stiffens the asphalt binder & mix
•Can improves fracture toughness at low temps
•Alters oxidation kinetics to reduce their effects
•Alters plastic properties of clay fines to improve moisture stability and durability
•Process more effective if the aggregate is coated with hydrated lime prior to mixing with asphalt

Adhesion Promoters


Lime Vs
LAS/WMA
Performance
Testing

Example Project Data – South Central US

- Measure performance of 1.5% Lime and 0.5% LAS/WMA
- Hamburg Wheel Tracker
- Materials
  - Crushed Gravel, Type C Surface Mix
  - 16% RAP Blend
  - PG 64-28

- HMA Curing
  - HMA mixtures cured for 2 hr. ±5 min. at temperature listed in Table 2, TEX 241-F based on Binder PG before molding

Testing Objectives

- Contractor's existing blend adjusted to account for removal of lime P200
- Remove lime from blend, adjust to account for lost of fine material & add 0.5% LAS/WMA
- Confirm Volumetric Properties
- Run HWT

Contractor Field Blend

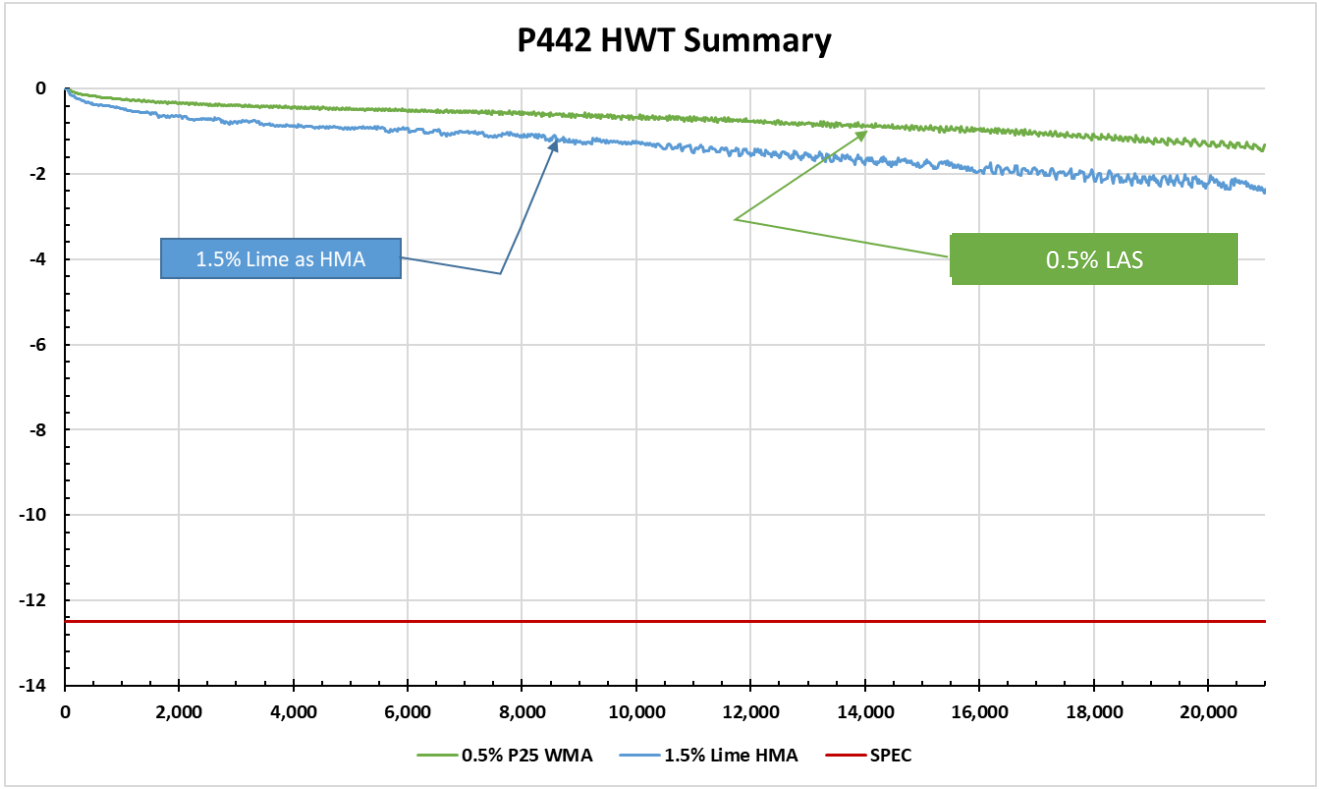
Adjusted blend to remove Lime

Gradation verification

	C-JMF	A-JMF			GV-J11
C-Rock	32.5	32.5			
D-Rock	14.0	14.0			
F-Rock	14.0	14.0			
MS	12.5	5.0			
Scrns	7.5	16.5			
H-Lime	1.5				
GV-J1					82.0
RAP	18.0	18.0			18.0
	100.00	100.00	0.00	0.00	100.00
Sieve Size	C-JMF	A-JMF	0.00	0.00	GV-J11
19.00	100.0	100.0	0.0	0.0	100.0
12.50	91.3	91.3	0.0	0.0	93.1
9.50	77.8	77.8	0.0	0.0	81.1
4.75	48.3	48.3	0.0	0.0	51.0
2.36	32.0	32.5	0.0	0.0	32.3
1.18	23.3	24.0	0.0	0.0	25.5
0.60	16.8	17.5	0.0	0.0	20.0
0.30	12.2	12.5	0.0	0.0	14.6
0.150	8.4	8.3	0.0	0.0	9.4
0.075	5.7	5.3	0.0	0.0	5.8

Hamburg Wheel Tracking Data

- LAS/WMA successfully substituted into adjusted aggregate blend
- Volumetric properties for both blends were similar
- Performance Tests indicate mix can be produced with LAS/WMA in lieu of Lime



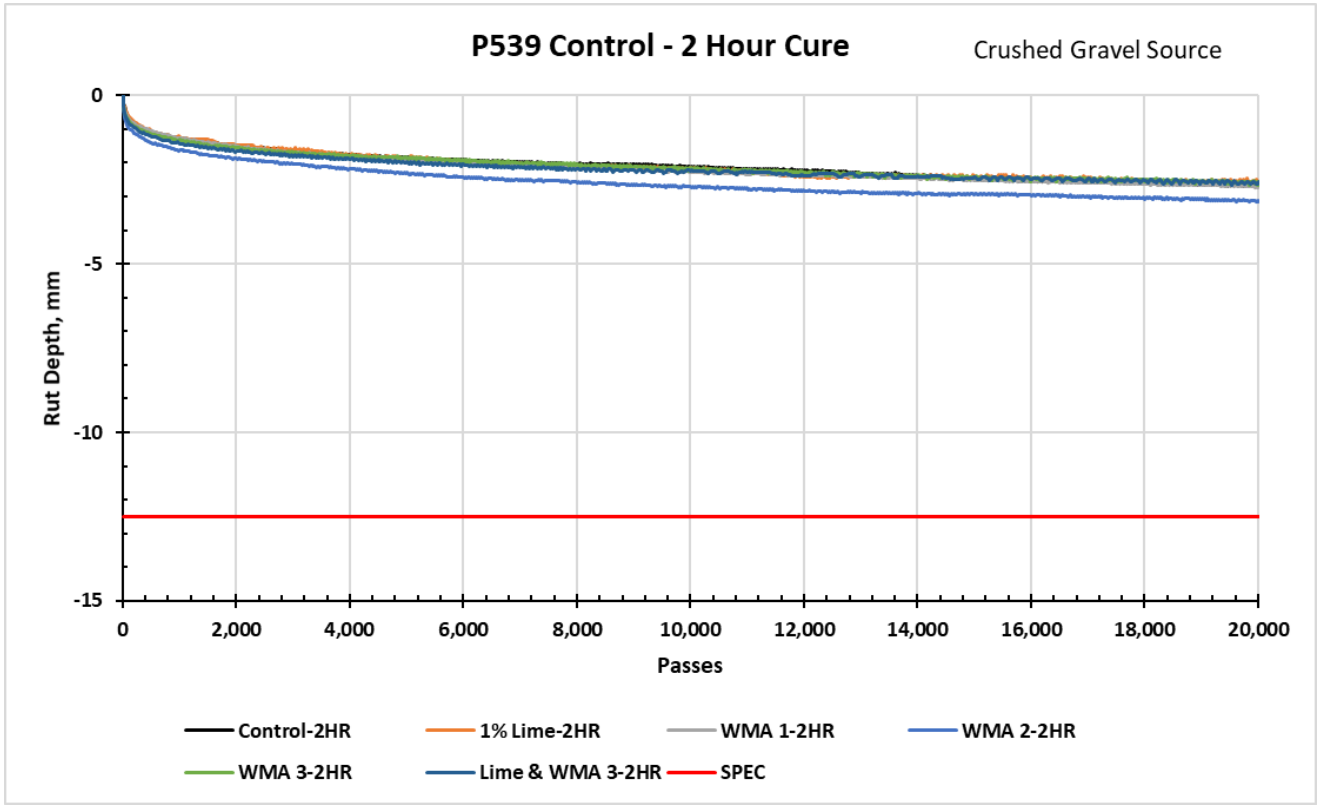
Example Project Data – South Central US

- Measure performance of
  - 1% Lime
  - 0.5% LAS/WMA
  - 1% Lime + 0.5% WMA
- Hamburg Wheel Tracker
- Materials
  - Crushed Gravel
  - 10% RAP Blend
  - Specified PG 64-28
- Confirm Volumetric Properties

- HMA Curing
  - HMA mixtures cured for 2 hr. ±5 min. at temperature listed in Table 2, TEX 241-F based on Binder PG before molding
- WMA Curing
  - Cure warm-mix asphalt (WMA) mixtures at 275°F for 4 hr. ±5 min. before molding.
  - WMA is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using WMA additives or processes

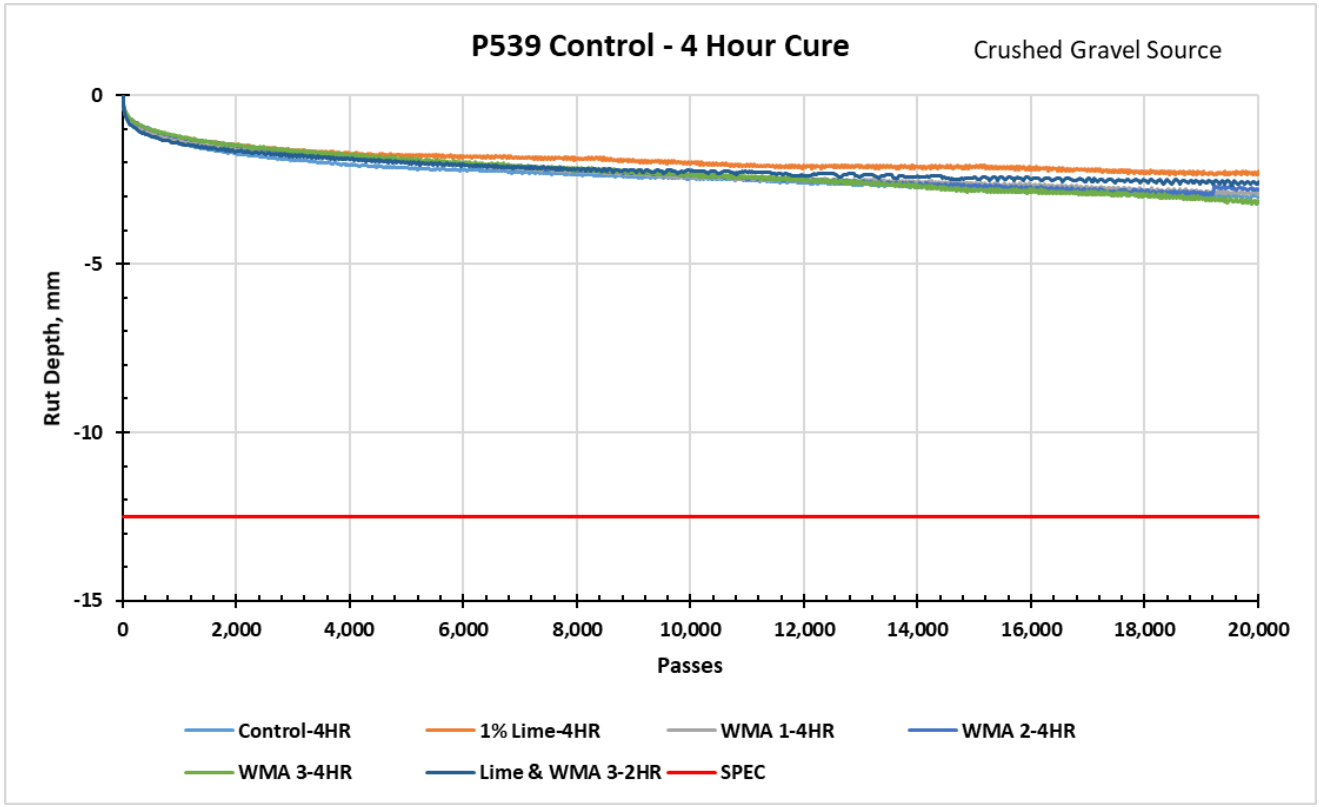
Hamburg Results HMA Curing

- HMA mixtures cured for 2 hr. ±5 min. at temperature listed in Table 2, PG 64-28 = 275F
- Evaluated several products
  - 1% Lime
  - 0.5% WMA 1
  - 0.5% WMA 2
  - 0.5% WMA 3
  - 1% Lime + 0.5% WMA 3



Hamburg Results WMA Curing

- WMA Mixtures cured at 275°F for 4 hr. ±5 min. before molding
- Evaluated products
  - 1% Lime
  - 0.5% WMA 1
  - 0.5% WMA 2
  - 0.5% WMA 3
  - 1% Lime + 0.5% WMA 3



Example Project Data

South Eastern US

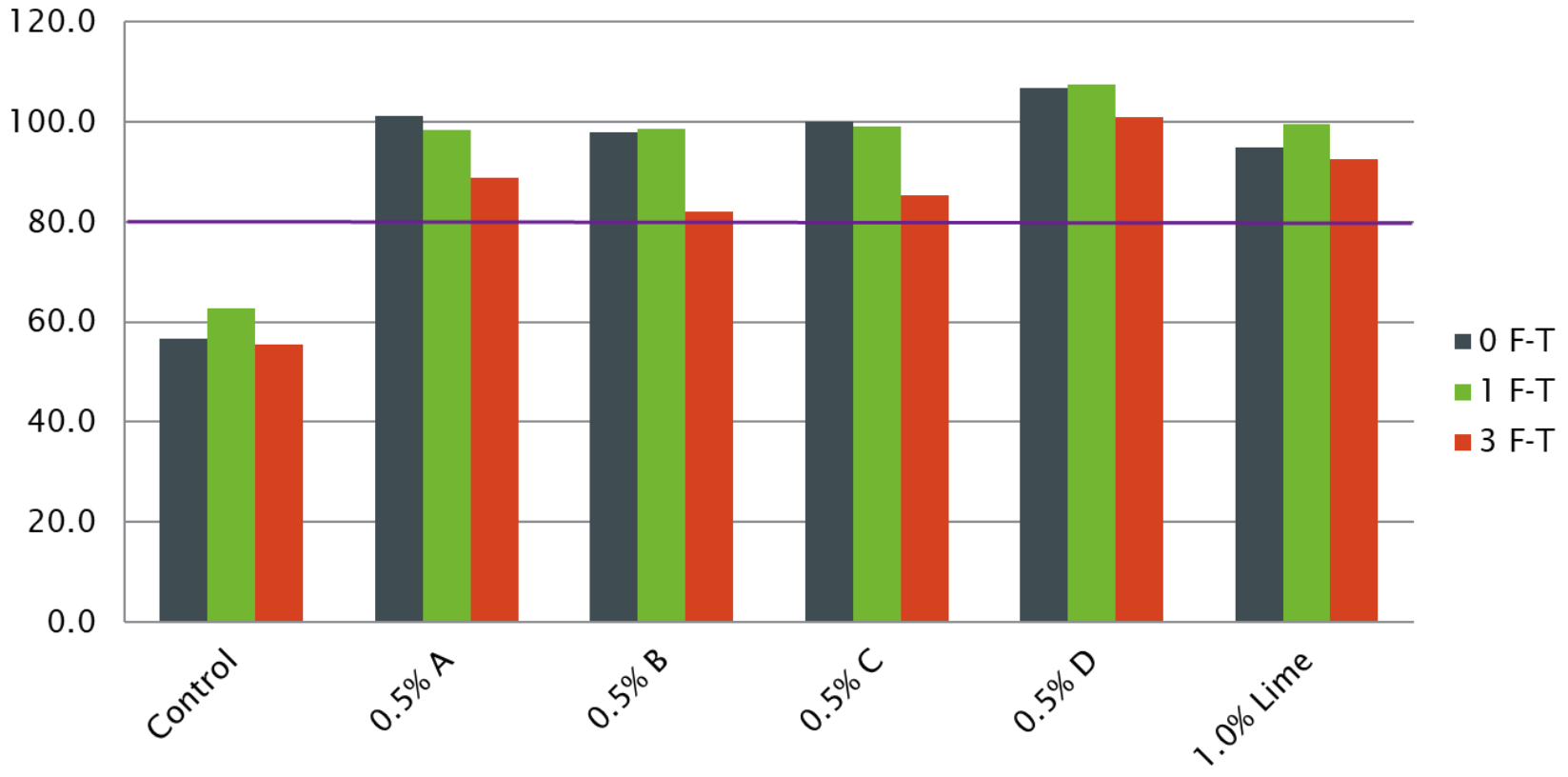
Measure performance of LAS and lime utilizing:

- Tensile Strength Ratio
- 24 hour conditioning
- 1 freeze-thaw cycle
- 3 freeze-thaw cycles
- Hamburg Wheel Tracker

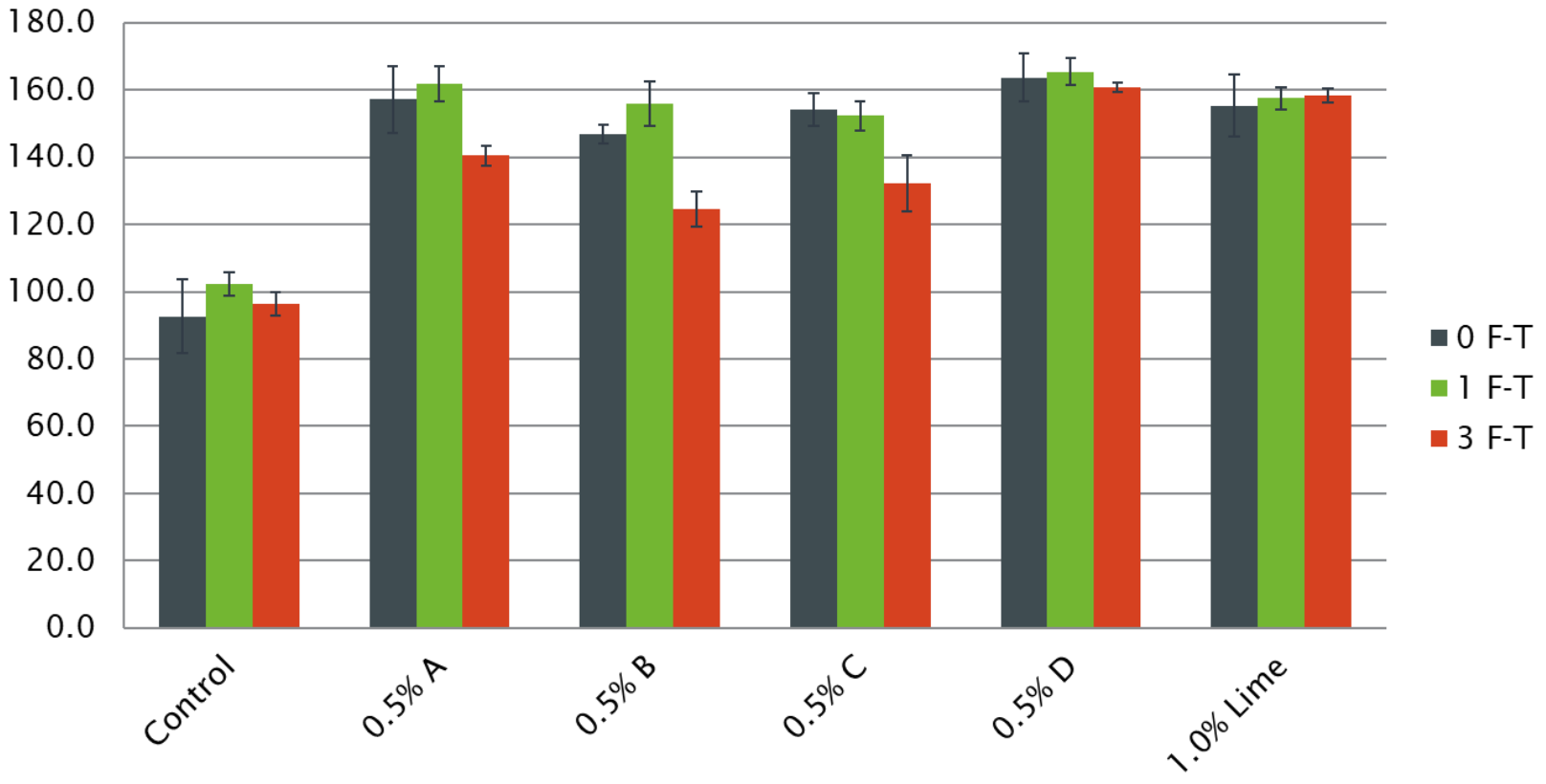
Materials Used

- Nova Scotia Granite
- PG 64-22 Venezuelan base asphalt

Test Results - TSR

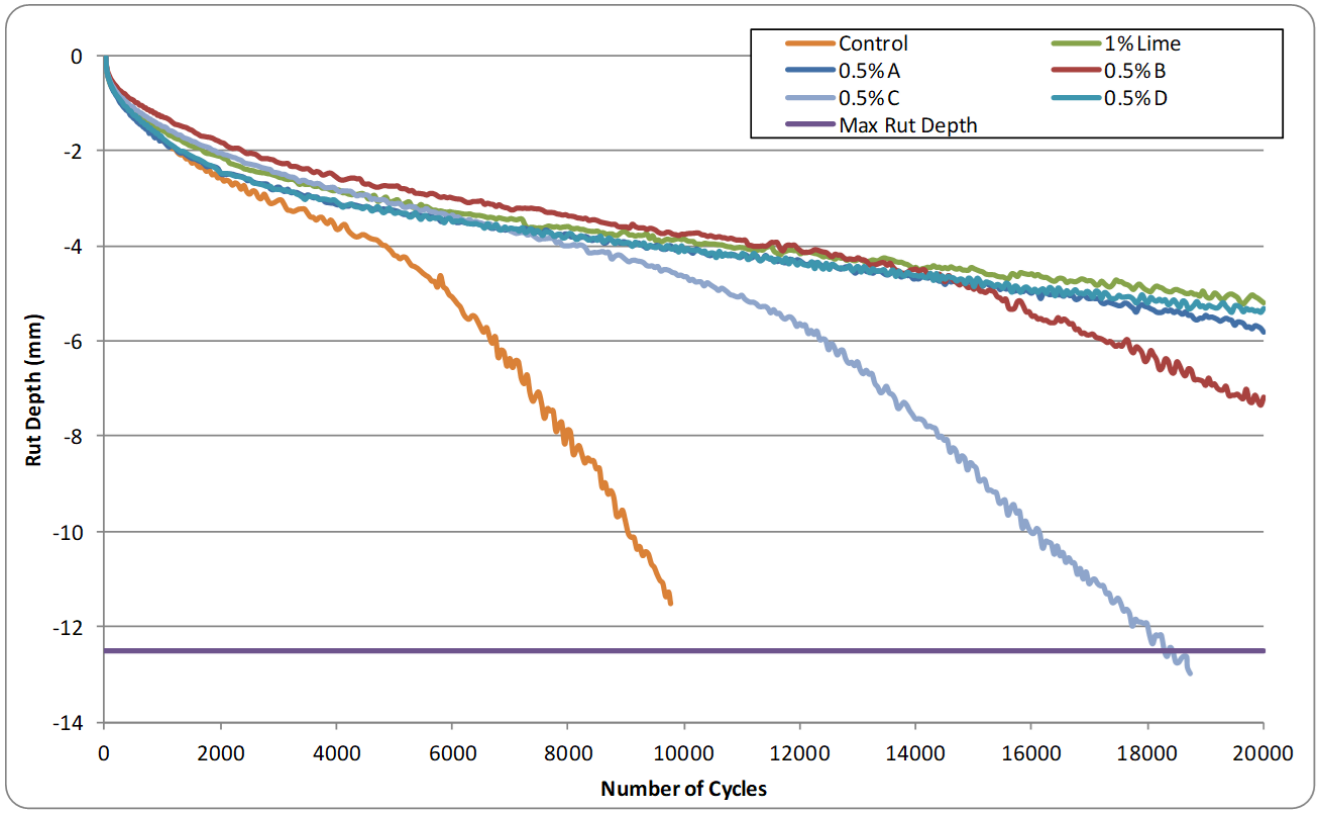


Test Results – Wet Strength



Hamburg Wheel Track

- Different LAS have varying performance in the HWT
- LAS performance can be equal to that of Lime based on performance testing
- Demonstrates the importance of testing materials in the mix



Lime Supply

- Source
- Logistics
- Material Handling

Lime Source

Logistics & Material Handling

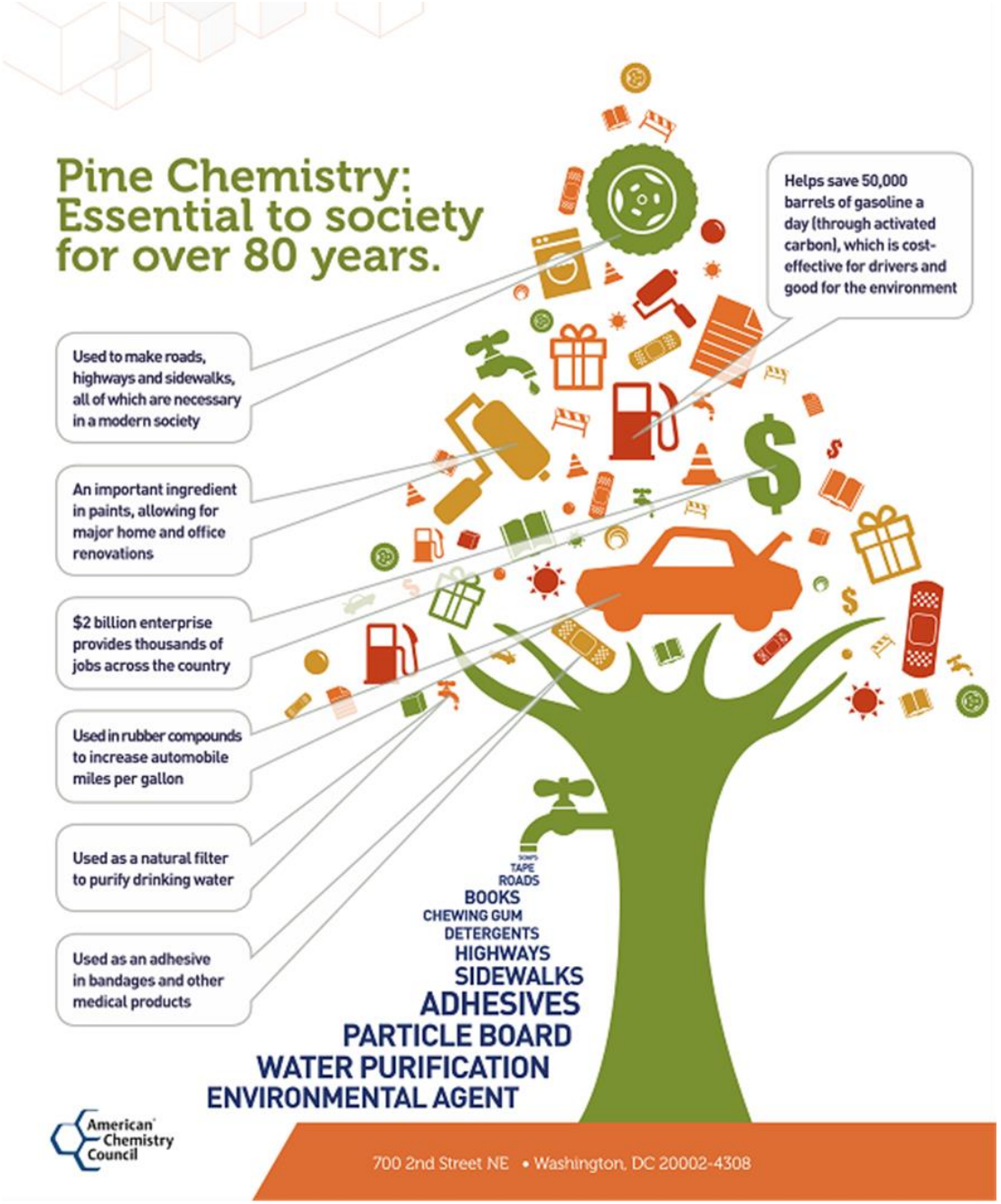
- There are various ways of adding hydrated lime to HMA at the plant
  - a lime solution is sprayed on the aggregate
  - Some plants “marinate” aggregate stockpiles in a lime slurry
  - The hydrated lime can be added to the aggregate on the cold feed belt
- *Cost Benefit Analysis of Anti-Strip Additives in Hot Mix Asphalt with Various Aggregates, Christensen, et.al, PENNDOT, May 2015*
- *The Benefits of Hydrated Lime in HMA, Little, et.al, National Lime Association, 2001*

LAS/WMA Supply

- Source
  - Renewable
  - Sustainable
  - Green
- Logistics
- Material Handling

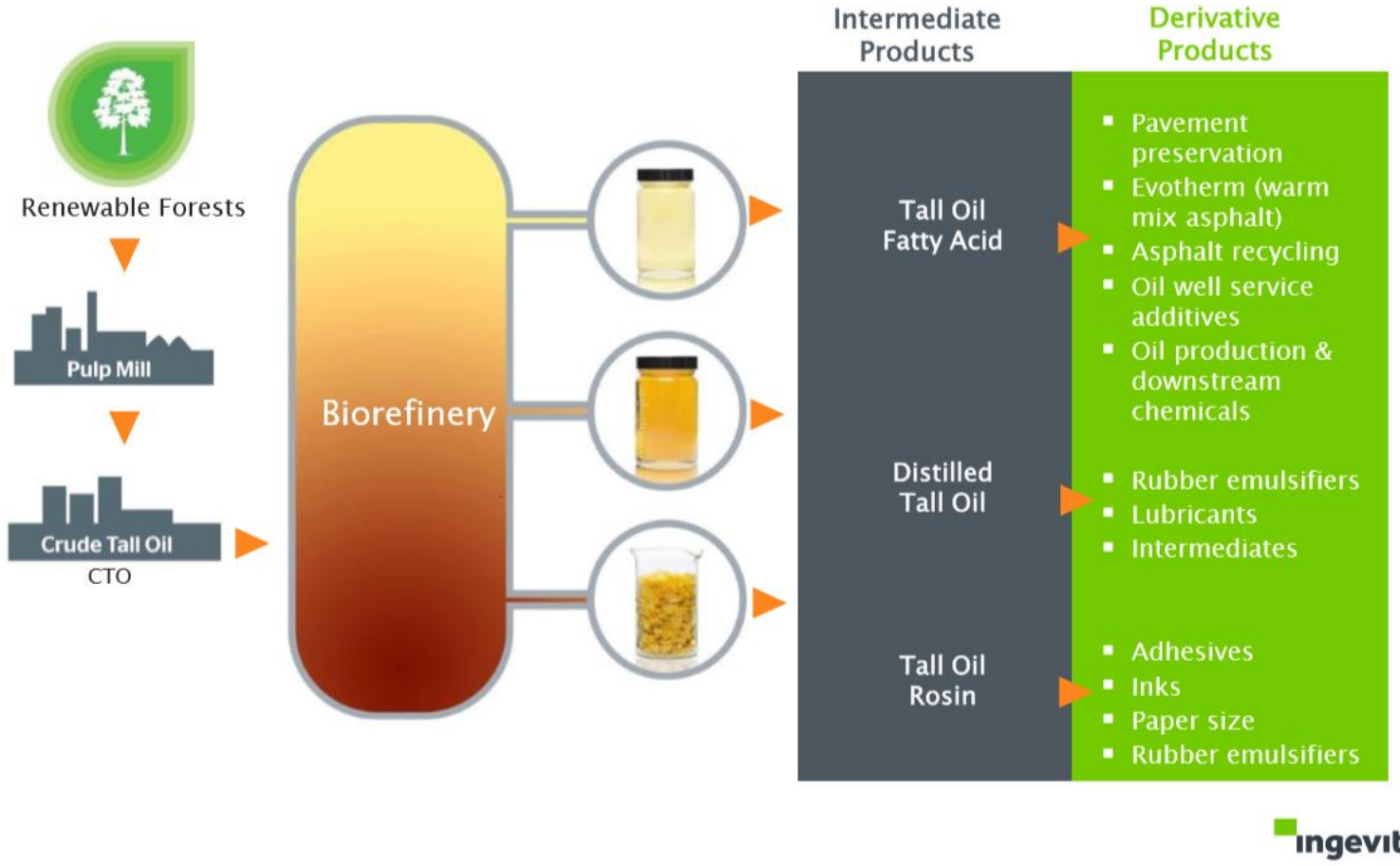
What comes from the Pine Tree?

- Chemicals for
  - Adhesives for tape
  - Roads/Highways
  - Books
  - Chewing gum
  - Detergents
  - Concrete Sidewalks
  - Water Purification Filters – Activated Carbon
  - Filters for Fuel Recovery



LAS Supply

- Crude Tall Oil
  - by product from paper making process
  - Looks like dark, molten caramel - is made up of rosins, fatty acids and other natural materials
  - Sap of pine trees
- Refining Process
  - Tall Oil Fatty Acids
  - Tall Oil Rosins
  - Distilled Tall Oil
  - Tall Oil Pitch



LAS Pump Tank
Telemetry Units
Totes/Pumps

Logistics

Material Handling

- 6,000 or 10,000 gallon Pump Tanks
  - Remote Telemetry
  - Supplier maintains tank and monitors supply
  - Used as needed
- 275 gallon tote
  - 40” x 48” x 46”
  - Durable steel frame
  - Stackable 2 high when full and stationary
  - Free pick-up service for disposal of empty totes

Cost Analysis

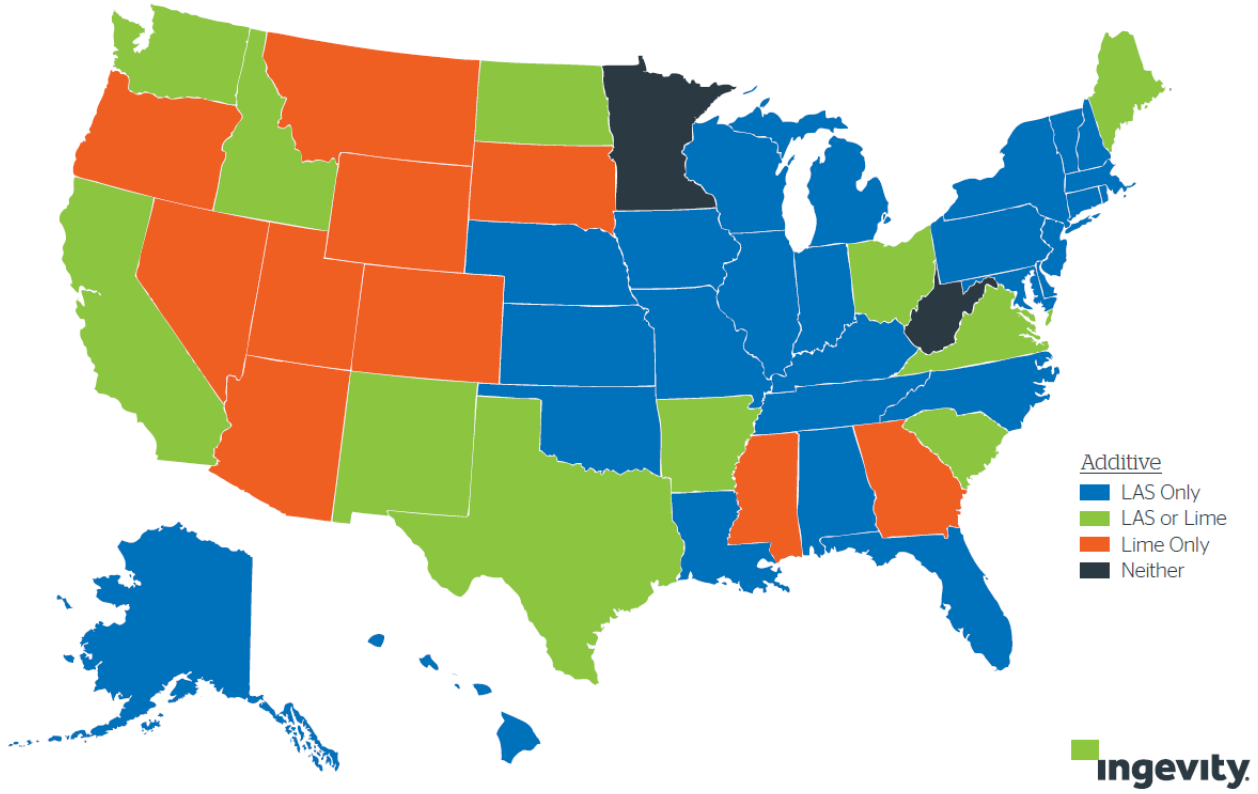
- Lime: $200/ton
  - 1% w/w Aggregate
  - $2.00/mix ton
  - Not including storage & handling costs
  - Approx. $2-5/mix ton
- LAS/WMA: $1.20 - $2.80/lbs.
  - 0.5% w/w Asphalt
  - $0.70 – $1.60/mix ton

Environmental Costs - Green Effects

- Hydrated Lime: 1100 - 1200 lbs. of CO_2 emissions per ton of hydrated lime manufactured
- LAS/WMA: 100 lbs. of CO_2 emissions per ton of LAS manufactured
- The carbon emissions from Hydrated Lime are likely an order of magnitude higher than those for the LAS/WMA

Lime and LAS/WMA Use by State

- Survey of Ingevity Sales personnel
- October 2018



Summary

- Stripping
  - Adhesion/Cohesion Theories
- Performance Test Data Comparison
  - HWT
  - TSR
- Supply
  - Source
  - Logistics
  - Materials Handling
- Costs
  - $
  - Environmental
- Where Materials Are Used

Conclusions

- Performance-based specifications: Advances in materials testing opens doors to more material choices
- Agencies should use the performance related test(s) that are most predictive
- LAS/WMA can have advantages in performance, cost, handling and supply when compared to Lime
- Some materials may react better to Lime; Some materials may react better to LAS/WMA
- Let the performance test results drive the decision

Questions?

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