

Caltrans Research: Chain Wear

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Chain Requirements & Accelerated Pavement Wear

- Heavy snowfall in mountain corridors triggers frequent tire chain-control requirements
 - Most frequent in high-elevation routes with high truck traffic volumes
- Tire chains cause accelerated wheel-path wear on concrete pavements and reduced pavement service life
- Impacts:
 - Increased maintenance frequency
 - Increased lane closures/traffic disruptions
 - Higher maintenance and rehabilitation costs



Caltrans' Approach Before 2015

- On concrete pavements, wheel path deterioration due to chain wear is primarily surface issue and Caltrans' mitigation strategies focuses on:
 - Surface restoration
 - Ride quality
 - Skid resistance
- Common Caltrans Surface Restoration Strategies Includes
 - Diamond grinding and grooving
 - Partial – depth repair
 - Joint Resealing and Crack Sealing
- Limitations on the surface restoration strategies
 - Does not eliminate chain wear (only manages it)
 - Increased maintenance and preservation needs
 - Higher lifecycle costs
 - Frequent traffic disruptions for the traveling public



Diamond saw blade



Diamond ground surface



Caltrans' Approach After 2015

- Most of the common maintenance strategies were not properly addressing chain wear in wheel path in mountain areas
- In 2015 on I-80, near Truckee in Nevada County, Caltrans placed different types of Polyester Polymer Concrete (PPC).
- Materials in addition to PPC have been tried, including surface hardeners in 2015 and experimental materials in 2023.

What is PPC?

It is a rapid-setting, high-strength composite material made from polyester resin, aggregates, and catalysts, designed to provide durable, long-lasting repairs on concrete pavement surfaces.

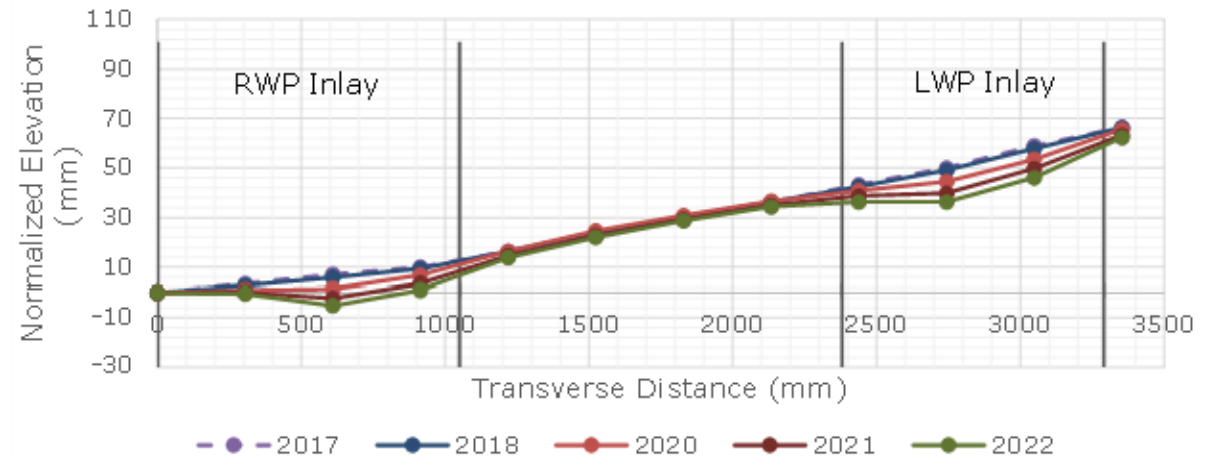
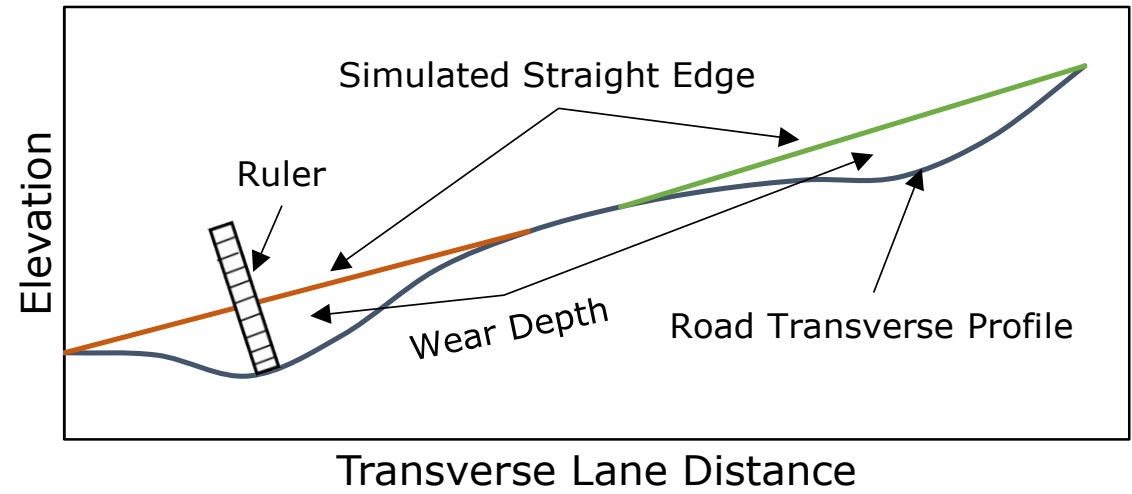
- Caltrans has been monitoring PPC Inlay projects and experimental materials through an NCE contract.



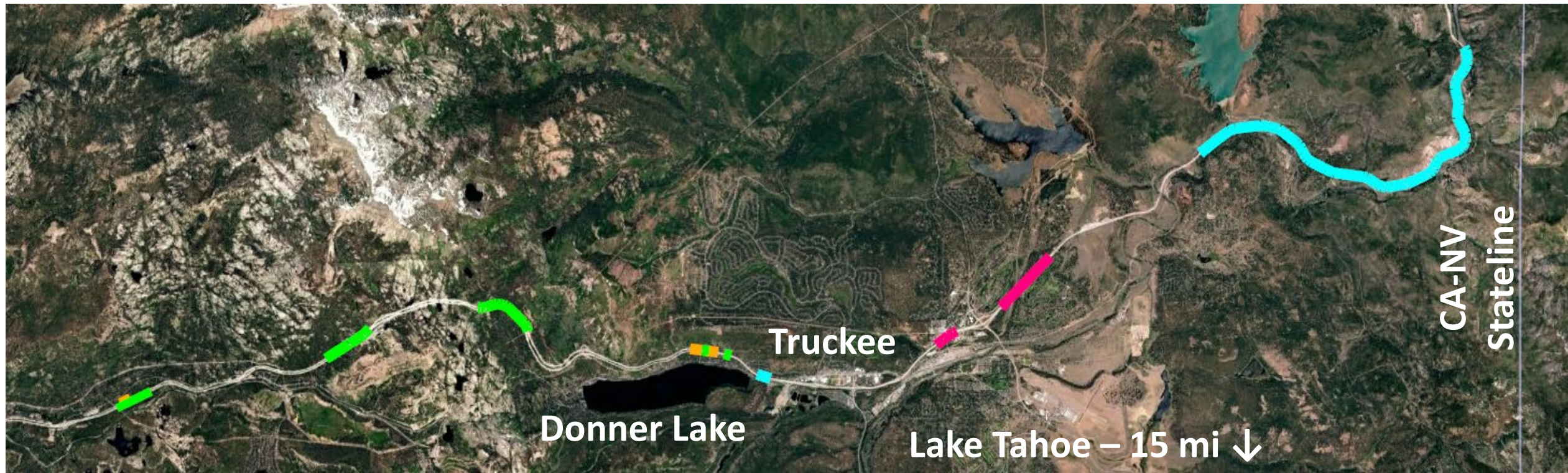
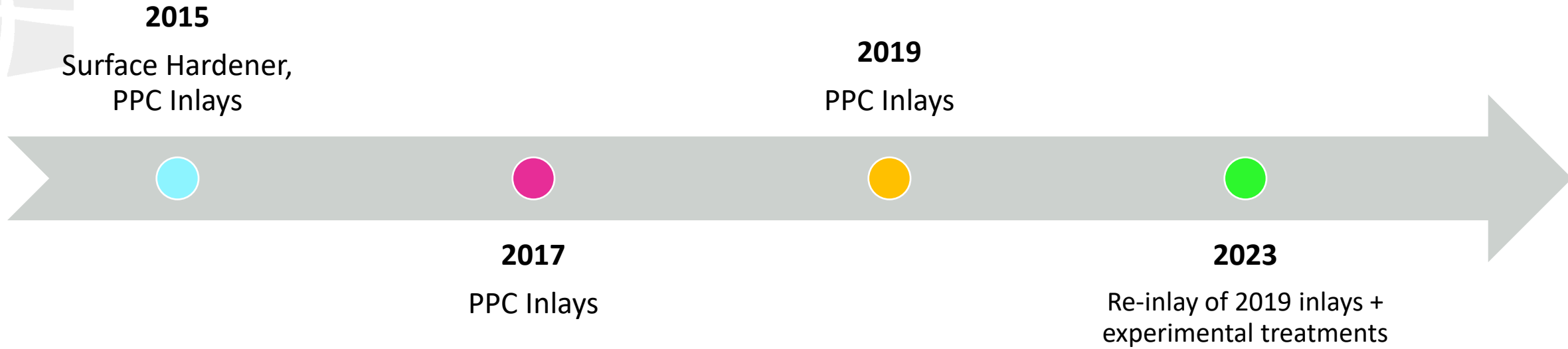
Monitoring & Analysis



Face Dipstick Profiler – Transverse Profile Measurements



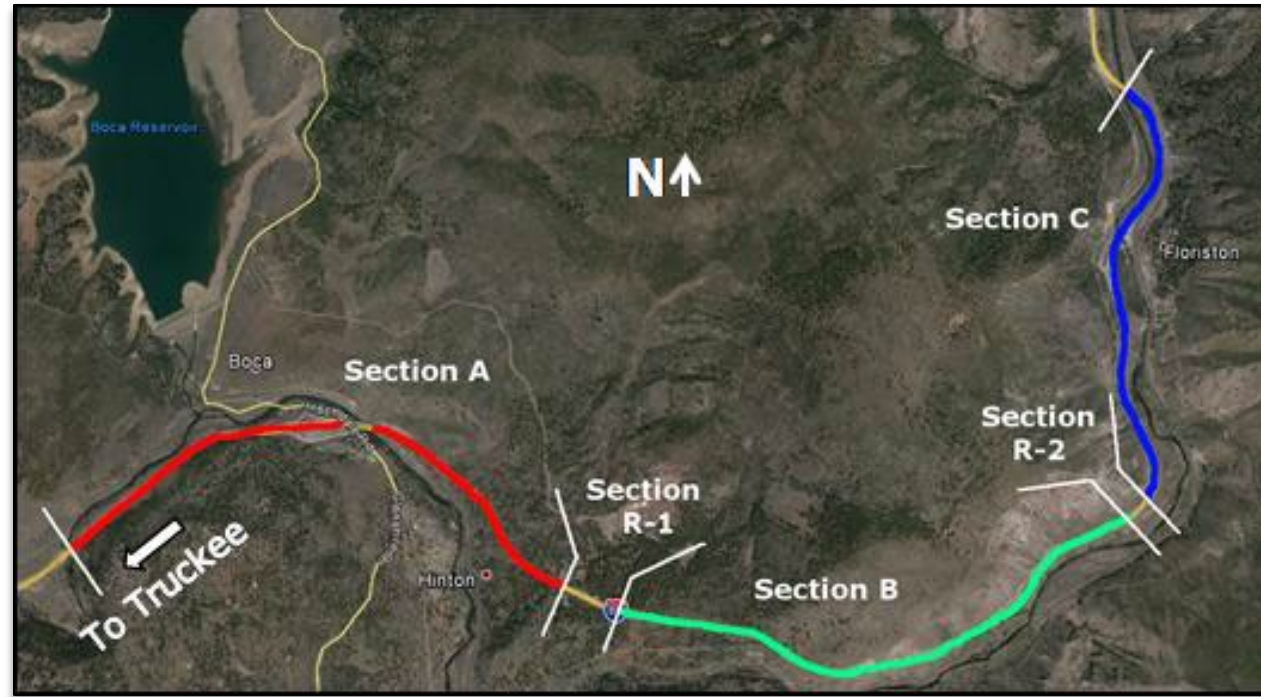
Experiment Timeline



Surface Hardeners 2015

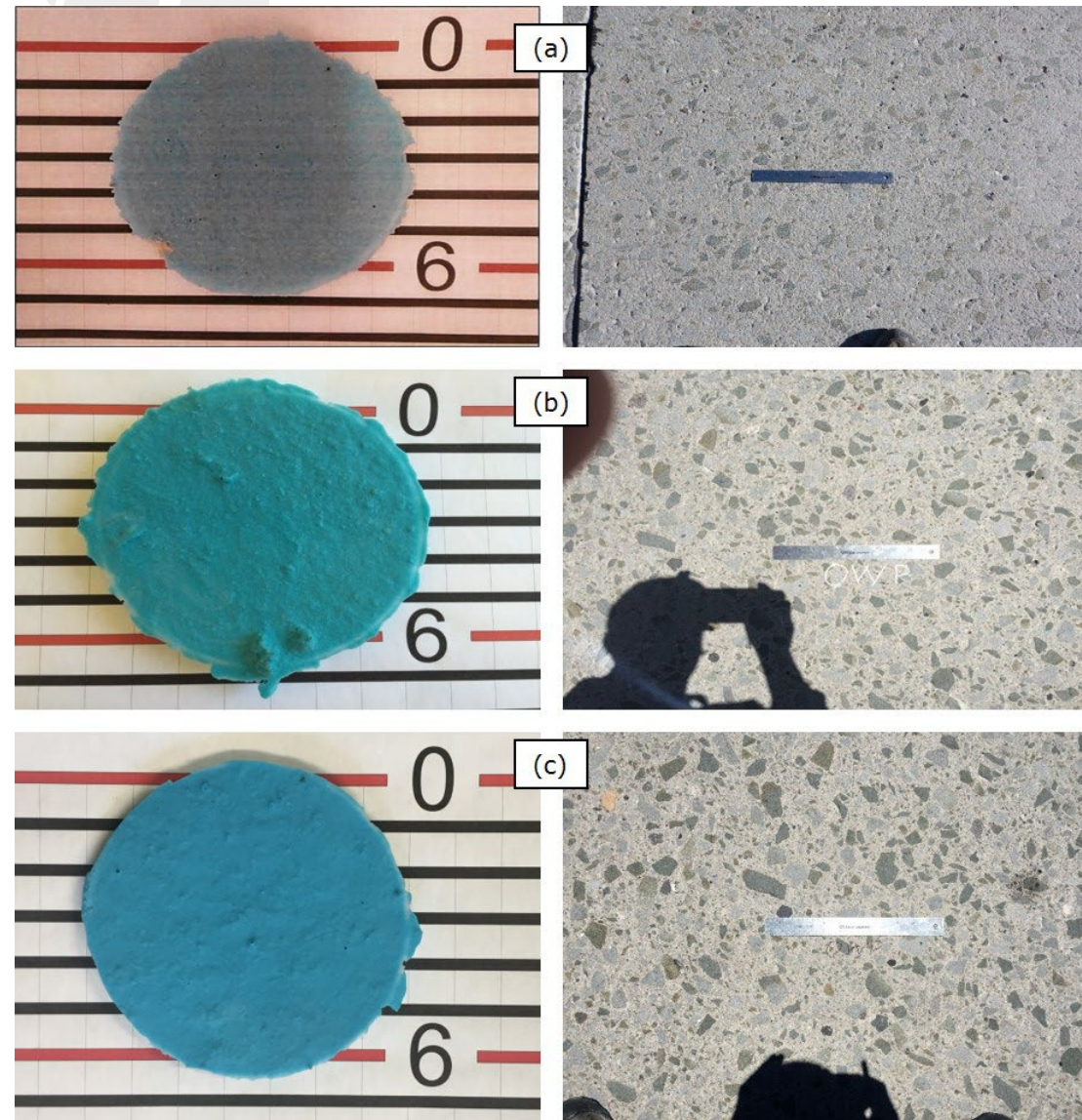


Surface Hardener Experiment (Lithium Silicates)



Section	Description	Surface Texturing
A	23% Solids	Grind
Control R1	no treatment	Groove & Grind
B	10% Solids (Reapplication 2016)	Half Grind/Half Groove & Grind
Control R2	no treatment	Grind
C	11-12% Solids	Grind

Qualitative Observations of Surface Texture

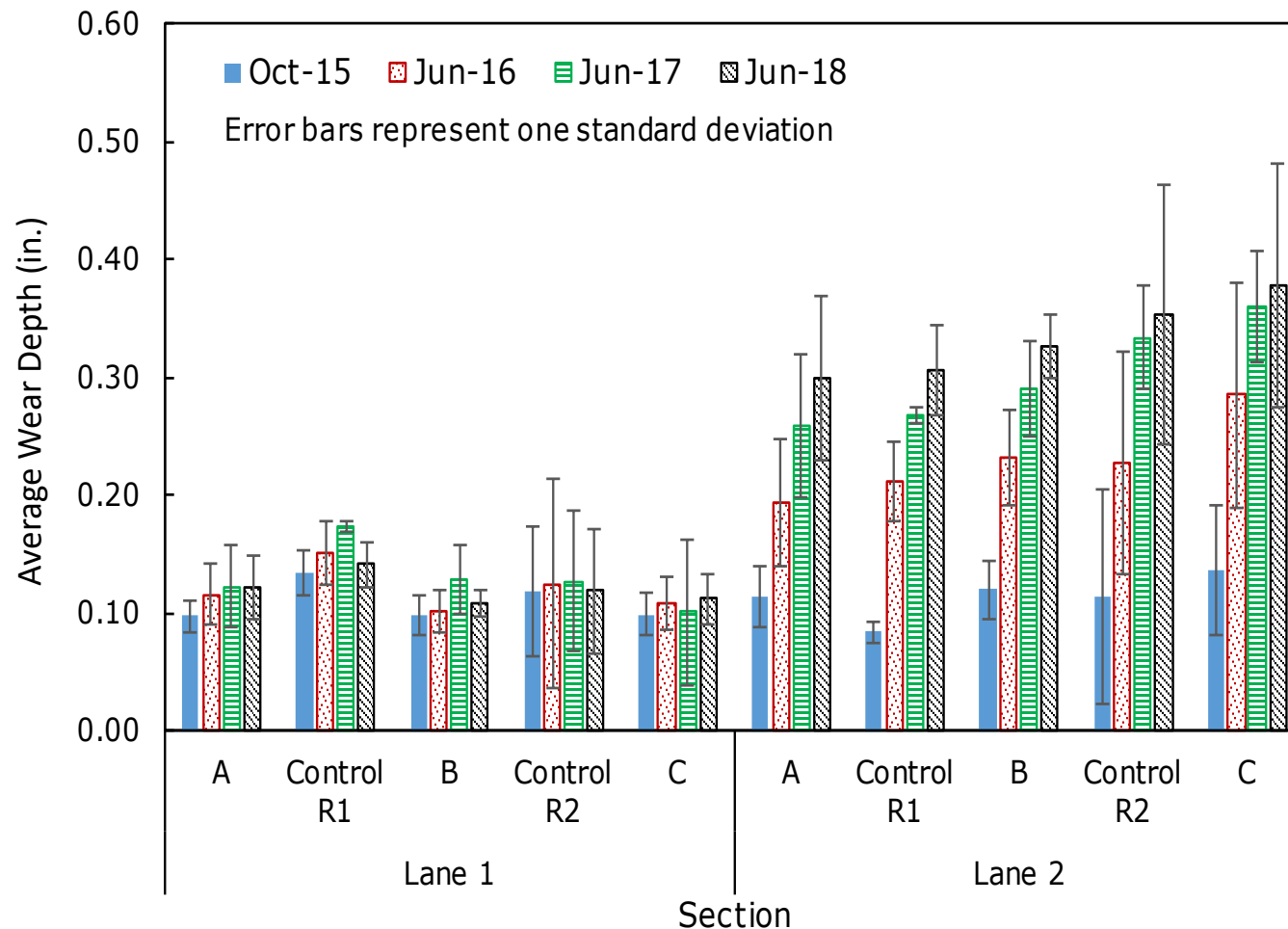


Section A: (a) 2015, (b) 2016, (c) 2017

Section	2015	2016	2017
A	Macrotexture from grinding observed	Exposed aggregate & smooth, polished surface	Missing cement paste & exposed aggregate
Control R1	Grooves clearly observed	Grooves showed evidence of wear	Missing cement paste & exposed aggregate
B	Grooves or grinding observed	Sections with no grooves (only grinding) showed exposed aggregate & smooth, polished surface	Missing cement paste & exposed aggregate
Control R2	Macrotexture from grinding was observed	Exposed aggregate & smooth, polished surface	Missing cement paste & exposed aggregate
C	Macrotexture from grinding was observed	Exposed aggregate & smooth, polished surface	Missing cement paste & exposed aggregate


Surface Hardener Performance

- Similar change in Lane 2 wear depths across sections
- Annual surface elevation measurements confirm findings



Key Takeaways – Surface Hardeners

- Surface hardeners were ineffective in reducing surface wear.
 - After three winter seasons, experimental sections exhibited similar wear to the control sections.
- No conclusions regarding the effectiveness of a re-application of lithium silicate after one winter.
- Grooves (in ground and grooved locations) remained after the first winter but were worn away after the second winter.



Leads us to
2015 Inlay Experiment

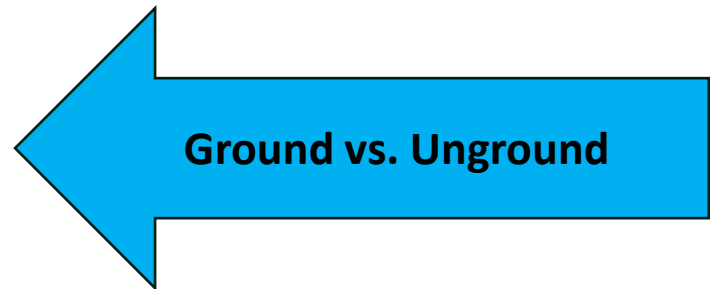
Polyester Polymer Concrete (PPC) Inlays

2015, 2017,
2019

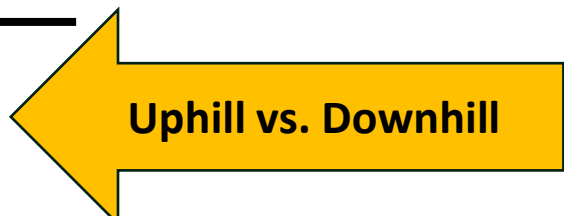




Year	Section	Description
2015	Control R3	no treatment
	D	Polyester concrete fill inlay
	E	Polyester concrete inlay to fill ground wheel path
	Control R4	no treatment



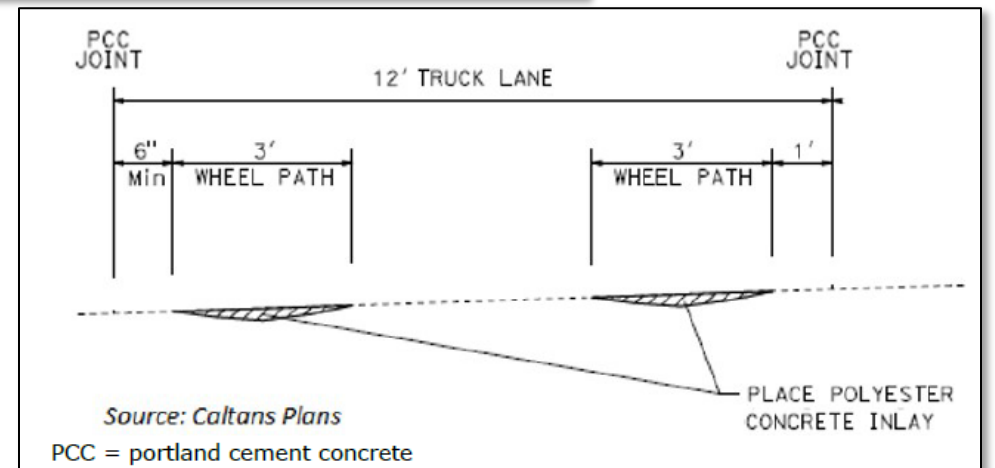
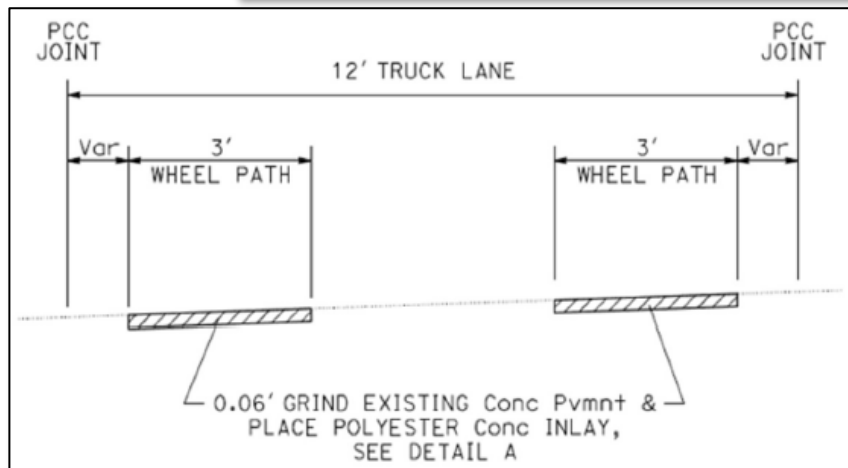
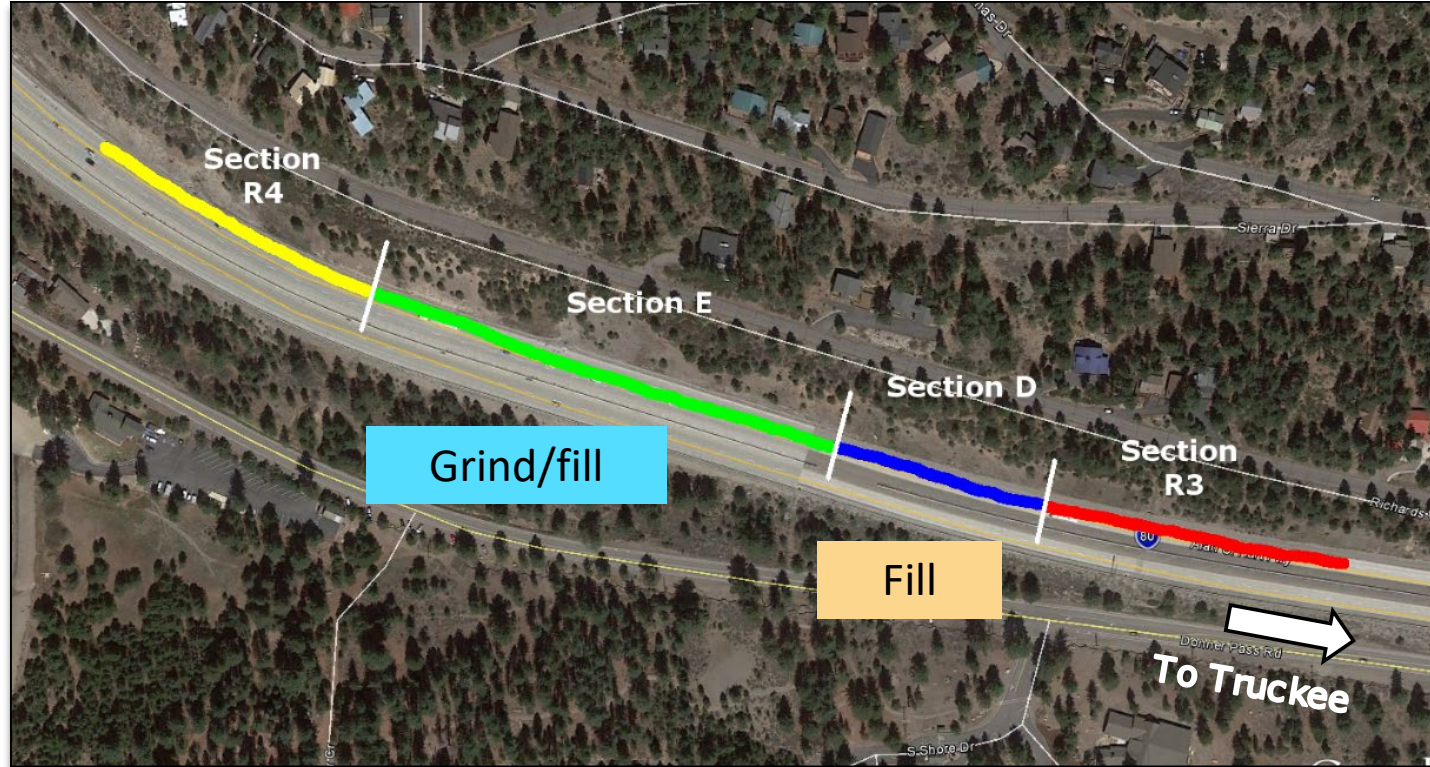
Year	Section	Polyester Resin Binder	Aggregate Gradation	Aggregate Type
2017	G1	Type 1 (9800)	Coarse (3/8")	Granite
	M1	Type 1 (9800)	No. 4	Sand
	M2	Type 2 (1121)	No. 4	Sand
	G2	Type 2 (1121)	Coarse (3/8")	Granite
2019	L1	Type 1 (9800)	Coarse (3/8")	Granite
	L3A	Type 1 (9800)	Coarse (3/8")	Granite
	L3B	Type 1 (9800)	Coarse (3/8")	Granite



Will grinding the wheel path before filling make a difference?



2015 Polyester Concrete Inlays





2015 Polyester Concrete Inlay Performance

Condition in 2017

Fill

Grind/fill

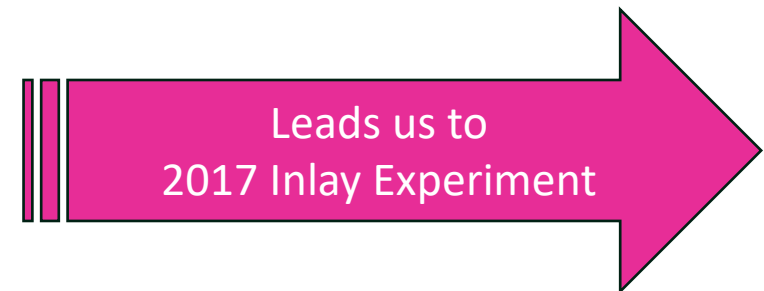


Example surface wear after two winters



Key Takeaways – 2015 PPC Inlays

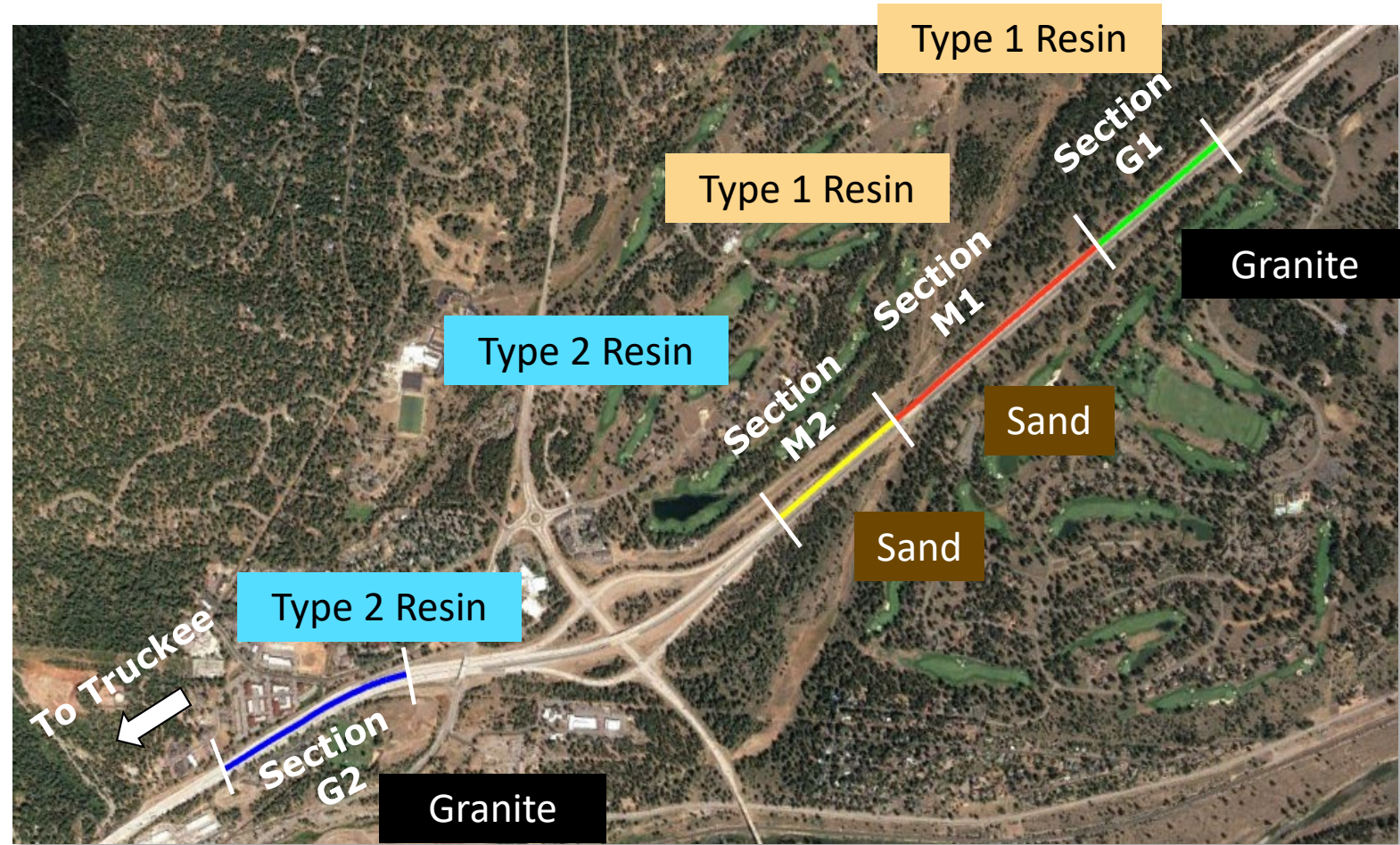
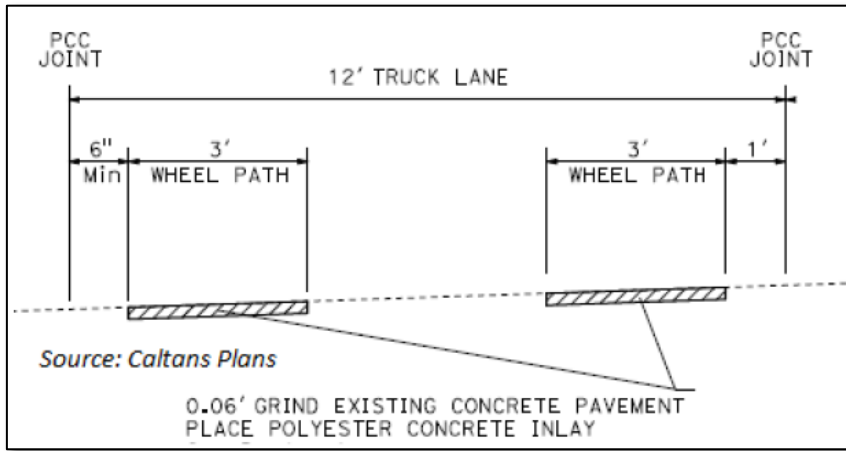
- The 2015 polyester concrete inlays (“fill” or “grind/fill”) were essentially worn away after two winters in service (by 2017).
- It is important to note that sections were exposed to approximately 1.8 times more chained trucks than the surface hardener sections.



What is the best
combination of resin and
aggregate?



2017 Polyester Concrete Inlays



2017 PPC Inlay Performance

- Example surface wear progression (Section G1)

Type 1 Resin

Granite



2017 PPC Inlay Performance

- Inlay conditions in 2022

Type 1 Resin

Granite



M1



Type 1 Resin

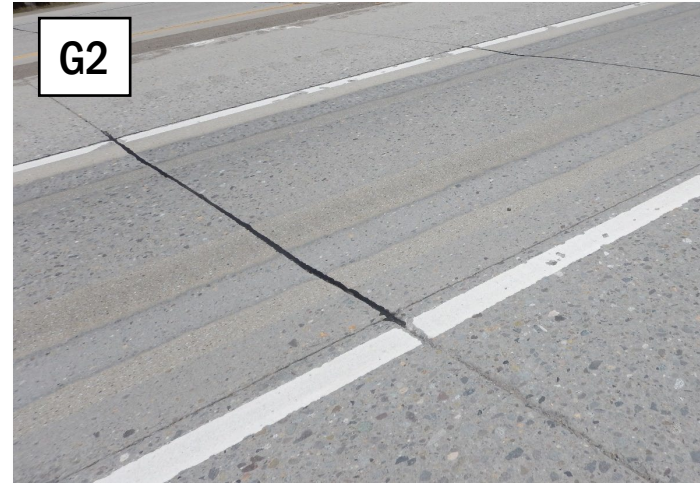
Sand

Type 2 Resin

Sand



G2

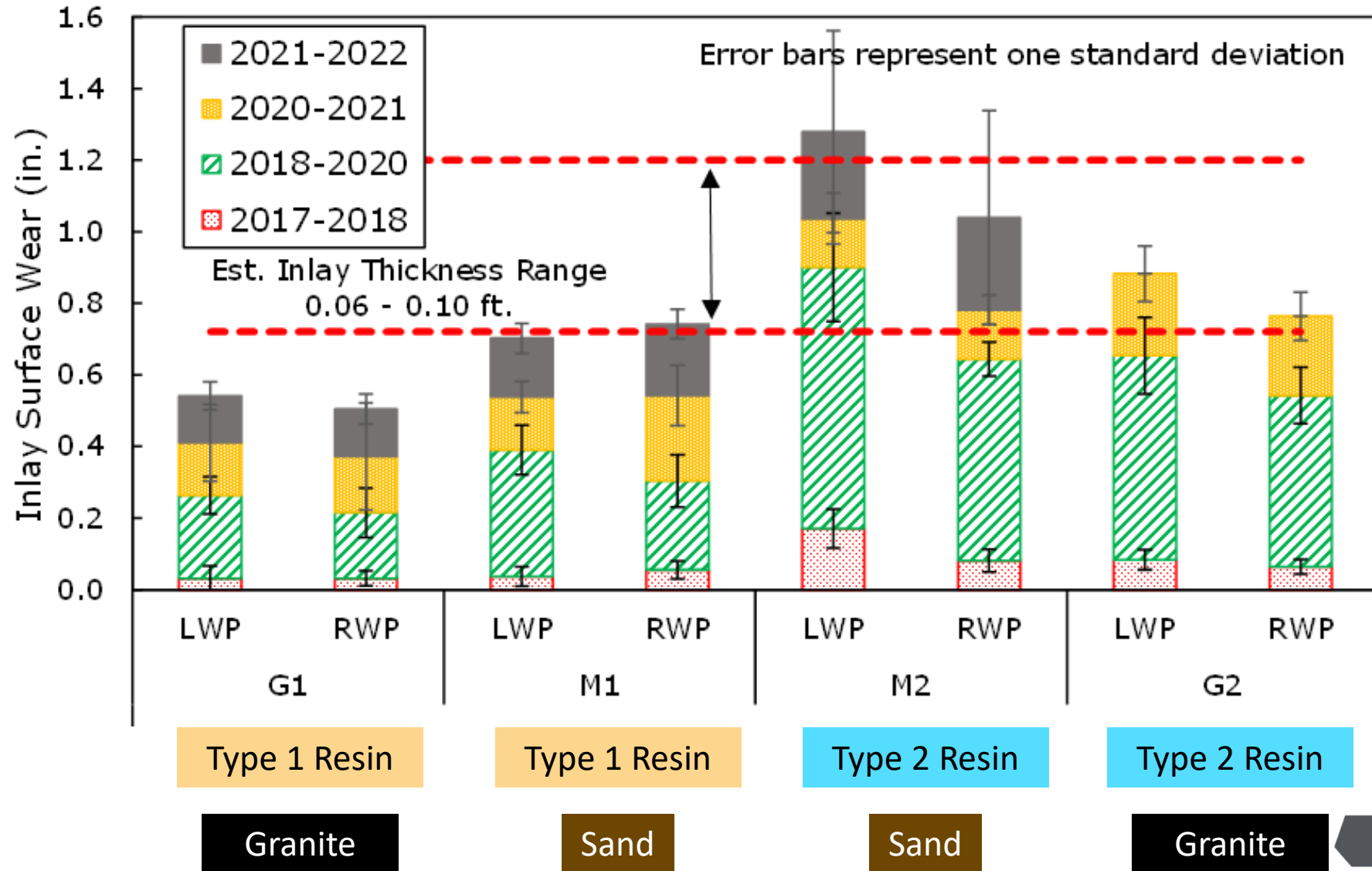


Type 2 Resin

Granite



Inlay Surface Wear from Dipstick Measuring



Key Takeaways – 2017 PPC Inlays

- Data confirmed **Resin 1** outperforms Resin 2 and **granite** performs better than sand (with Resin 1).
- Materials carried forward into next experiment.



Leads us to
2019 Inlay Experiment

What about uphill vs.
downhill?





2019 PPC Inlays

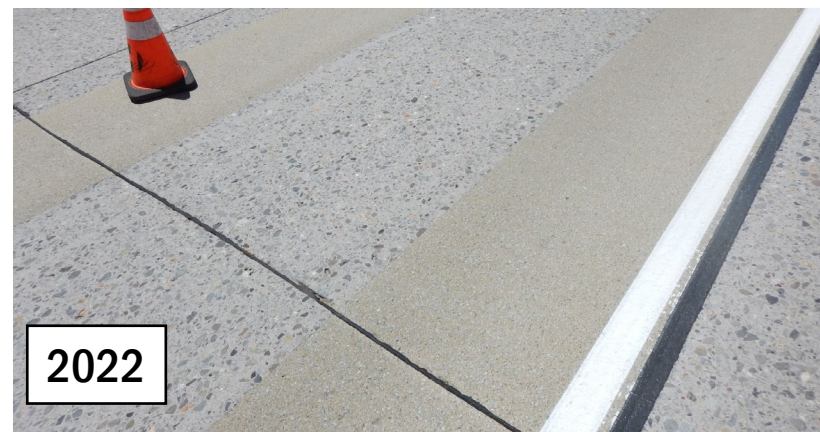


All 2019 Inlays use Type 1 resin binder + Granite



2019 PPC Inlay Performance

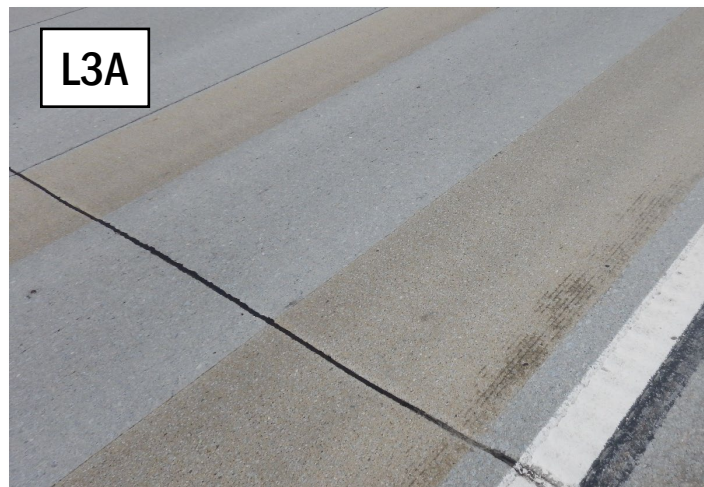
- Example surface wear progression (Section L1 – Downhill)





2019 PPC Inlay Performance

- Inlay conditions in 2022



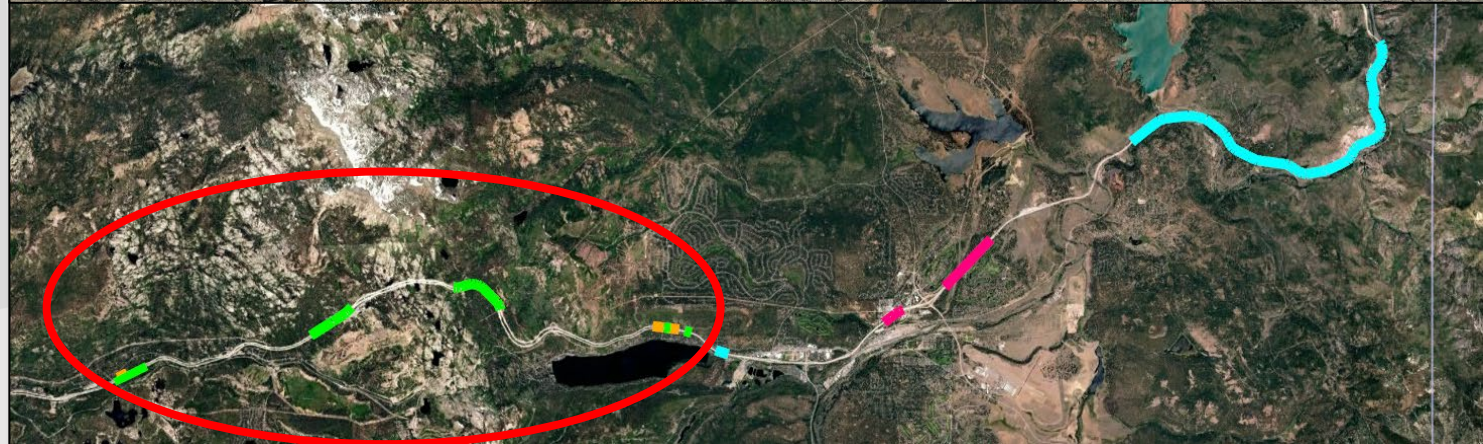


Key Takeaways – 2019 PPC Inlays

- The average inlay wear was 0.34 in. (L1), 0.36 in. (L3A), and 0.50 in. (L3B).
- Data suggest tire chains cause more wear in uphill segments than downhill segments
 - L1 had similar or less wear than L3A and L3B
 - L1 exposed to ~1.6 times more chained trucks
- After 3rd winter, underlying concrete was visible in isolated areas



Experimental Inlays 2023

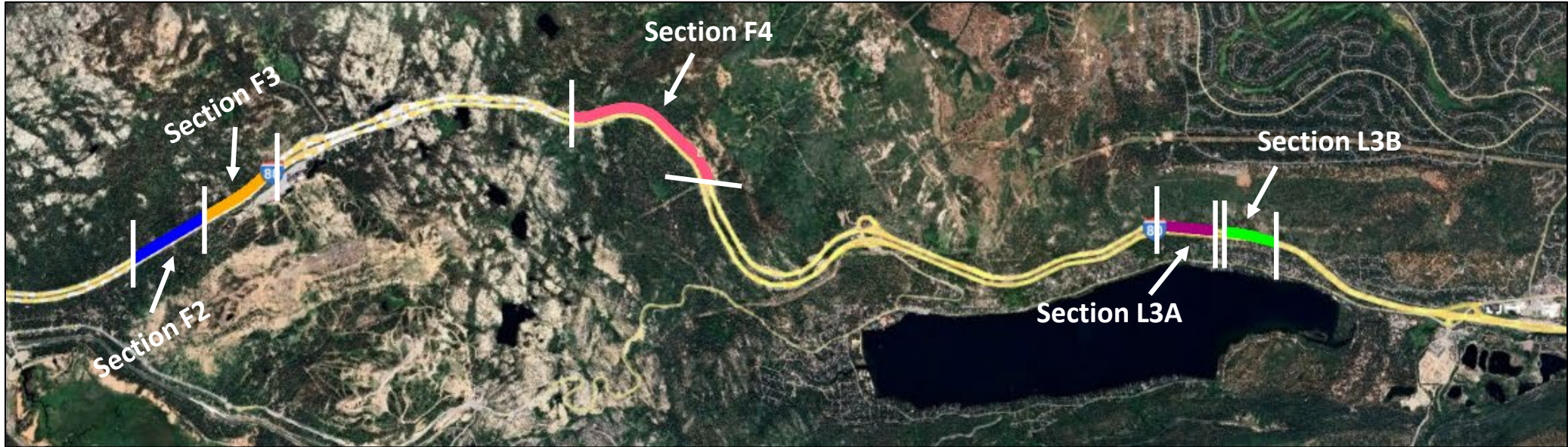


How do conventional PPC
Inlays compare with
more “experimental”
materials?



**Re-Inlayed 2019
Standard PPC Inlays**

Section	Binder Materials	Aggregate	Grind/fill or Fill?
L3A	Polyester Resin	Granite	Grind/fill
L3B	Polyester Resin	Granite	Grind/fill



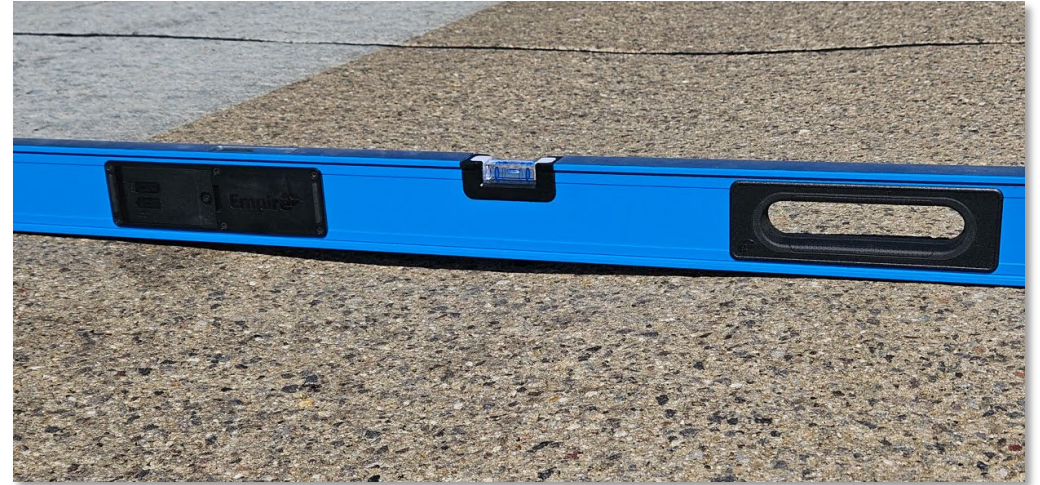
**2023
Experimental
Inlays**

Section	Description	Binder Material	Aggregate	Grind/fill or Fill?
F2	Control	Polyester Resin	Granite	Grind/fill
F3	Polyester Resin + Bauxite	Polyester Resin	Fine Grained Bauxite	Fill
F4	Epoxy + Sand	Epoxy Binder	Sand	Grind/fill

2023 PPC Inlay Wear Condition (pictured in 2025)



L3A



L3B

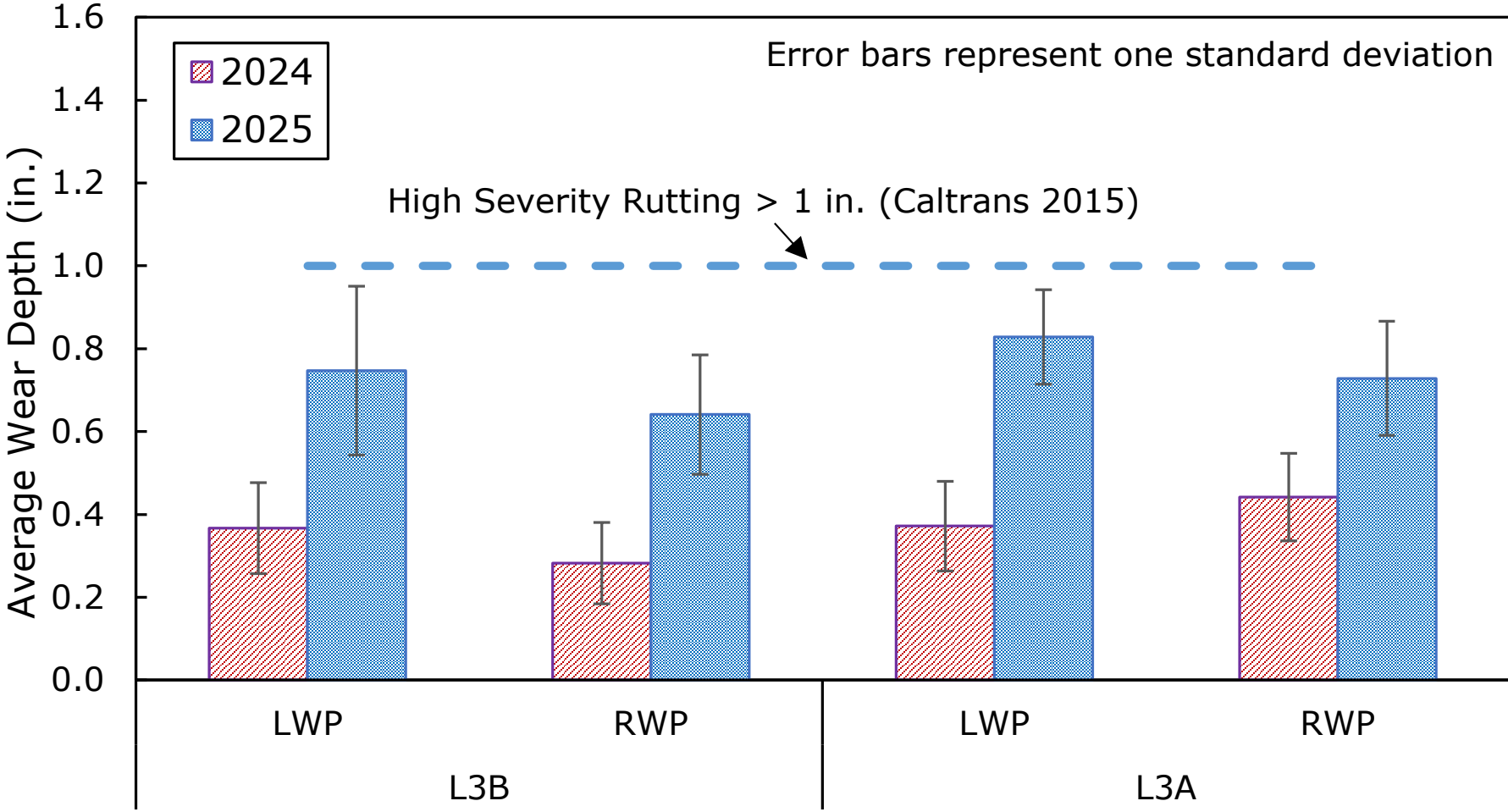


F3 (Polyester + Bauxite)

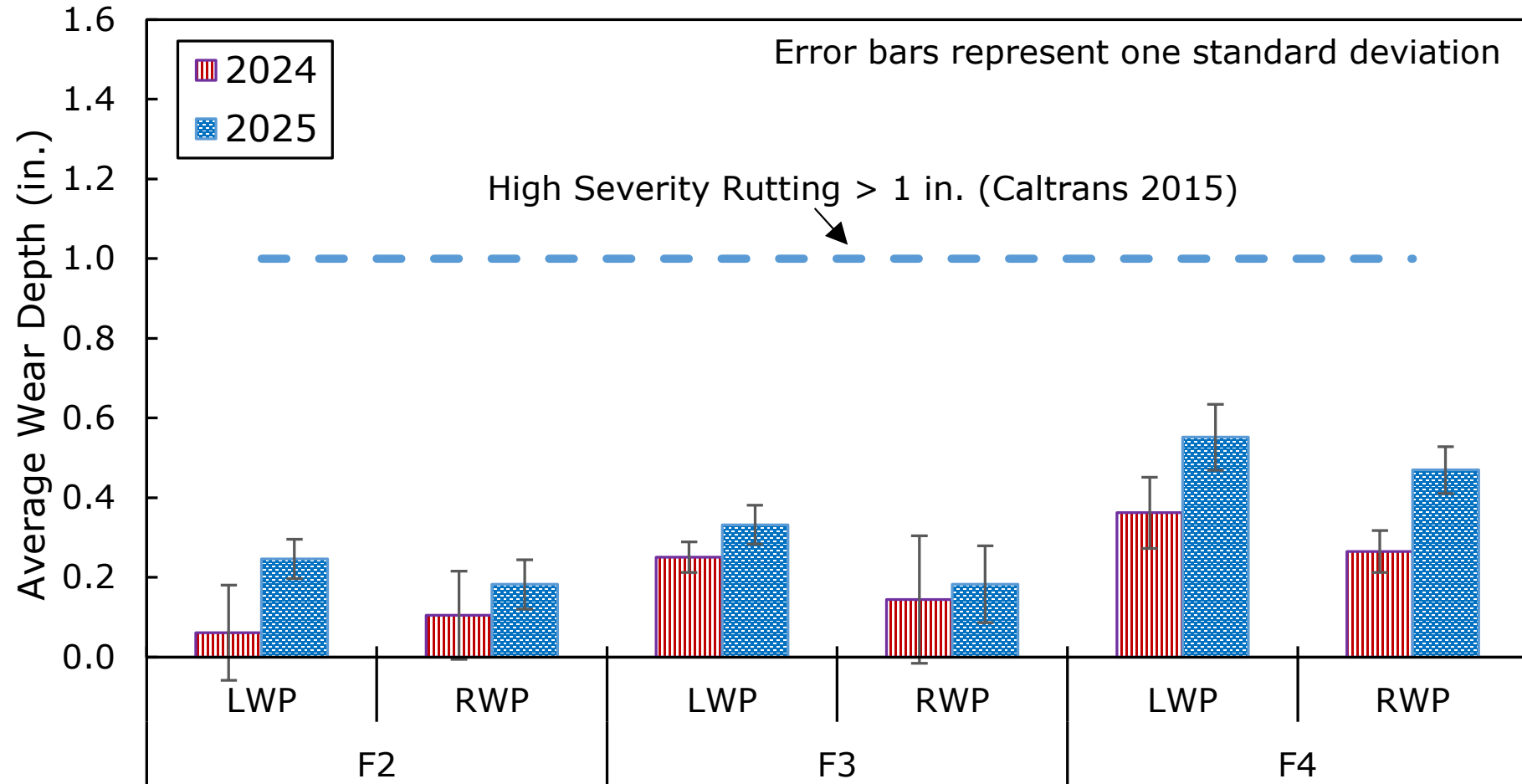


F4 (Epoxy + Sand)

2023 PPC Inlays



2023 Experimental Inlays



Key Takeaways – Experimental Inlays

2023 Experimental Inlays:

- **Section F2 (Control):** Showed less wear (0.22 in. avg. cumulative). However, construction (grind/fill vs. fill) technique and materials appeared different between wheel paths.
- **Section F3 (Polyester + Bauxite):** Averaged 0.26 in. cumulative wear. The left wheel path showed more advanced wear. Some right wheel path areas appear to have been re-inlaid.
- **Section F4 (Epoxy + Sand):** highest experimental wear (0.51 in. avg. cumulative). Defined wear channels were present, but no underlying concrete was exposed. Uphill grade and exposed to highest chain truck traffic of all 2023 sections.
- **Experimental vs. PPC Inlays**
 - Standard Inlays (L3A, L3B) had significantly higher wearing rates compared to Experimental Inlays (F2, F3, F4) and experienced significantly less chained truck traffic
 - **However:** F2 also used standard materials as L3A and L3B but less wear
 - Appears to be less wear in downhill grades (consistent with previous study)

2015 -2025 Recap

- **2015 Surface Hardeners**

- Ineffective – no conclusions about reapplication.
- Grooving present after 1st winter, worn away after 2nd .

- **2015 PPC Inlays (Fill vs. Grind/Fill)**

- Same materials (Resin 2 + granite).
- Both worn away after two winters.

- **2017 PPC Inlays (Resin & Aggregate)**

- Resin 1 + Granite outperformed other combinations.
- Carried this resin/aggregate combination into 2019 study.

- **2019 PPC Inlays (Uphill vs. Downhill)**

- Data suggests higher rate of chain wear on uphill sections.

- **2023 Experimental Inlays (Polyester + Bauxite, Epoxy + Sand)**

- Polyester + bauxite inlays had more wear than control section (downhill).
- Epoxy + sand inlays had less wear than PPC inlays (uphill).



Where do we go from here?



Wrapping up this study. . .

- Final round of performance monitoring – this summer
- Final report (2023-2026) later this year



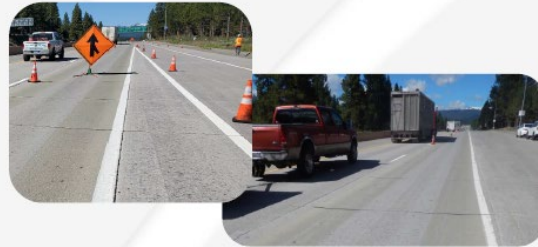
Final Report

56A0418-001 FIELD EVALUATION OF PCC SURFACE HARDENERS AND POLYESTER INLAYS FOR 03-NEV-80

October 2018



State of California
Department of Transportation,
Division of Maintenance, Pavement Program



Final Report

56A0623 PERFORMANCE EVALUATION OF POLYESTER POLYMER CONCRETE (PPC) INLAYS ON I-80 NEV NEAR TRUCKEE

November 2022



State of California
Department of Transportation,
Division of Maintenance, Pavement Program

Questions?

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