



TEXAS DEPARTMENT OF TRANSPORTATION



REOB'S AND OTHER ADDITIVES IN ASPHALT

WASHTO 2015 Subcommittee on Materials & Construction
Conference

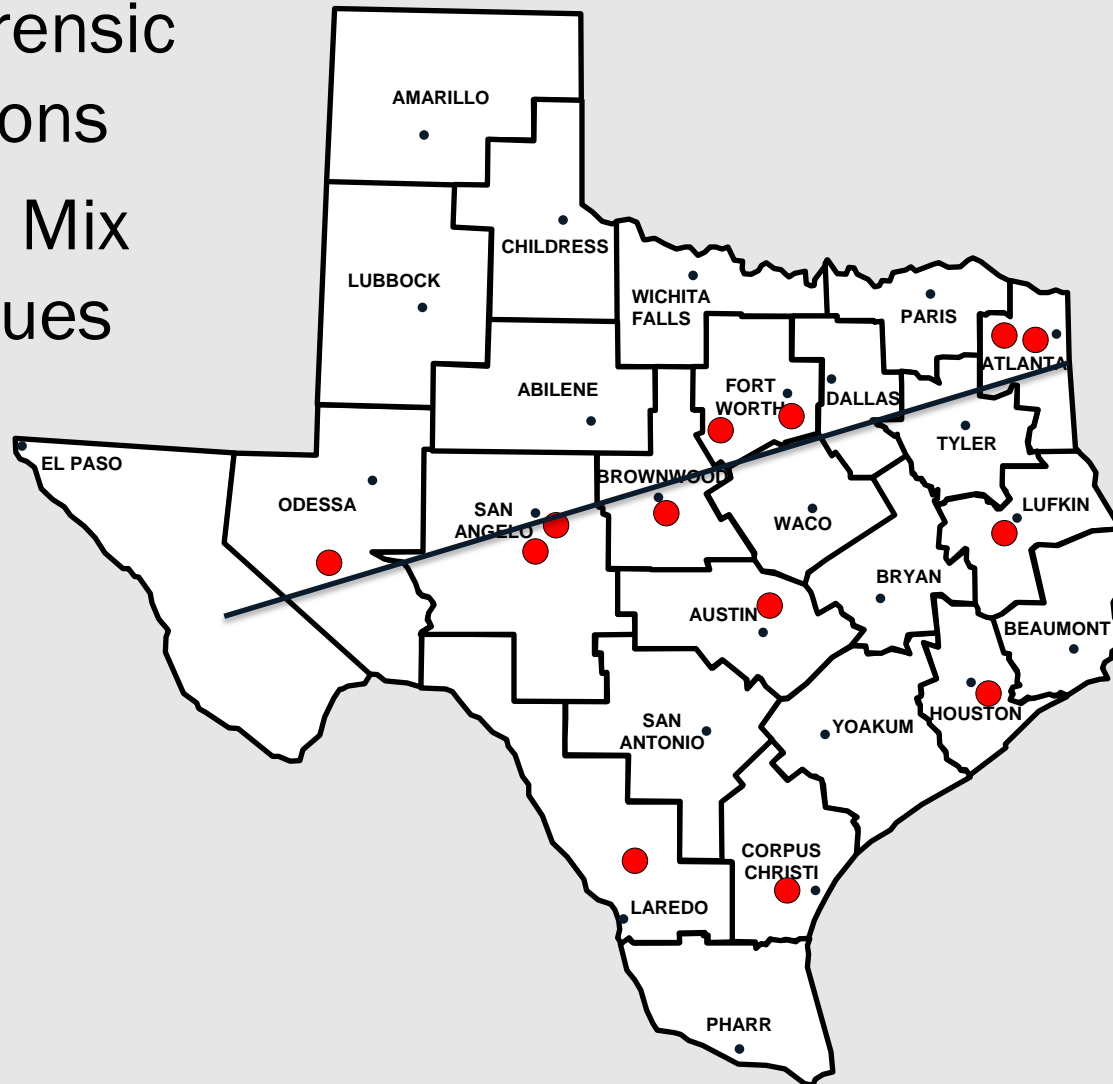
Outline

- Recent Forensic Investigations
- Background on Asphalt Additives
- Use at a National Level and Current Issues
- Detection of PPA, REOBS, GTR, and H₂S Scavengers
- TxDOT Approach and Current Work
- Research and Plan Moving Forward



Forensic Investigations - 2014

- 13 Full Forensic Investigations
- Numerous Mix Design Issues



Forensic Investigations

- Issues seemed to be related to binder quality
- Binder rheology did not pick up the problems
- Chemical composition may help diagnose the problems

Photo taken
July 28, 2014



Photo taken
Aug. 26, 2014



■ PPA (1)

- First patent filed in 1973
- Pennsylvania DOT 2002 and 2008
- Ontario Ministry of Transportation 2007
 - 12 states no restrictions
 - 15 states have banned the use of PPA
 - 14 have restrictions
 - 7 remain neutral

■ REOBs (2)

- REOBs used since the 1980s
- In 2014 state DOTs in New England banned the use of REOBs

PPA & REOBs (GTR and H₂S Scavengers)

- Polyphosphoric Acid (PPA)
 - Modifies the high temperature property of the binder
- Re-refined Engine Oil Bottoms (REOBs)
 - Modifies the low temperature property of the binder
- Ground Tire Rubber (GTR)
 - Recycled material
- H₂S Scavengers
 - Reduces hydrogen sulfide in asphalt
- HCl Scavengers
 - Used in trichloroethylene solvent

Detection of REOBs, GTR, and H₂S Scavengers

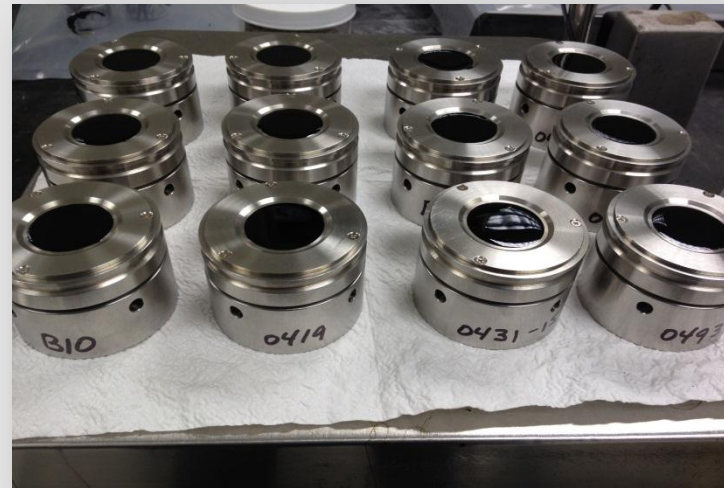
■ X-Ray Fluorescence Spectroscopy

– Heavy Metal Analysis

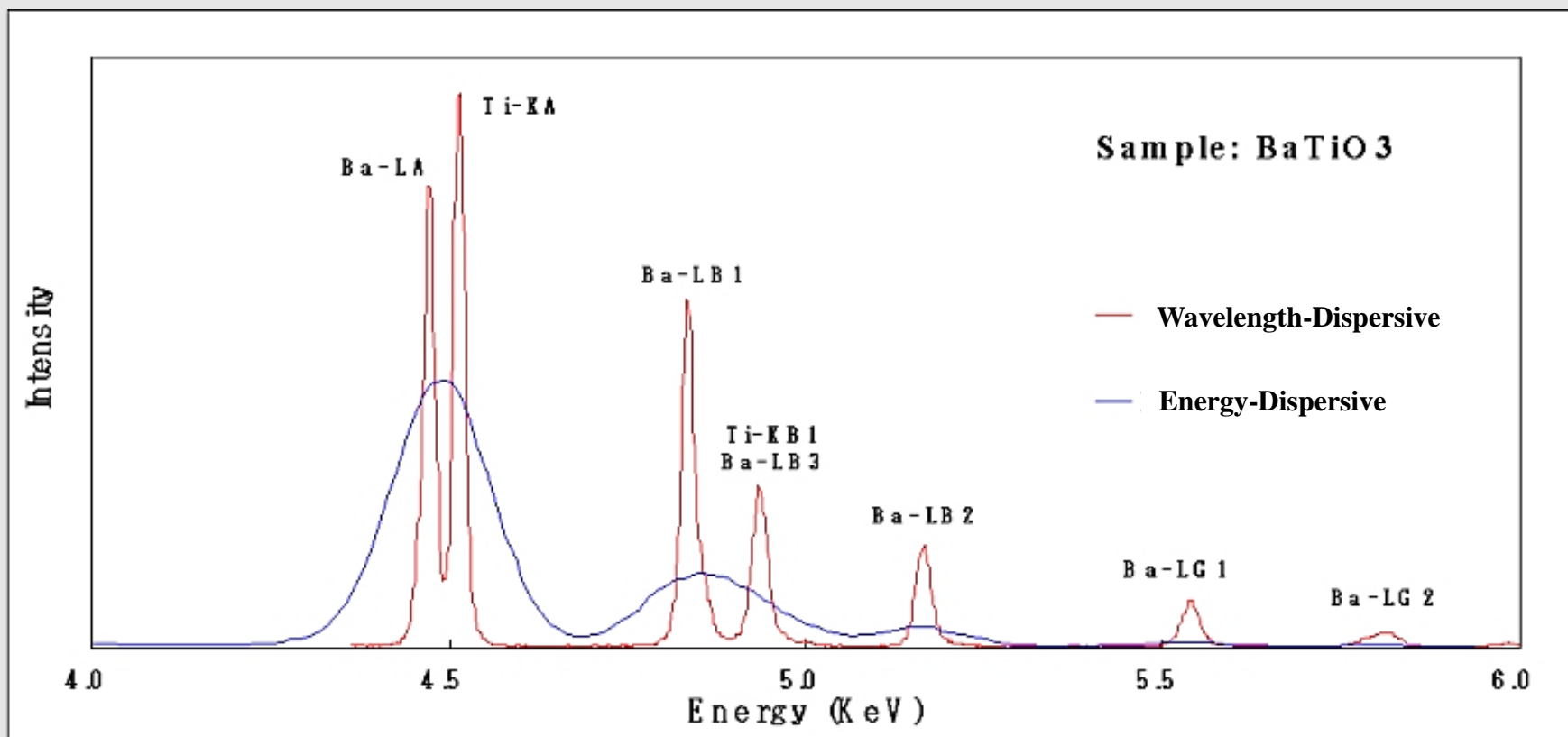
- Zinc (Zn)
- Copper (Cu)
- Molybdenum (Mo)

– Other elements

- Silicon (Si)
- Phosphorous (P)
- Calcium (Ca)



Wavelength Vs. Energy Dispersive



XRF Data

- Intensity is related to concentration
 - Standards were created for both PPA and REOBs
 - Allows amount of PPA and REOBs to be determined

Sample ID	Intensity Counts						
	P	S	Mo	Zn	Cu	Ca	Si
2599	9.776	1222.6	21.077	86.321	2.3068	20.321	0.8179
2603	0.4662	1316.1	3.9607	22.032	0	1.424	0.4257
2629	0	1240.4	0	3.2583	0	0.5229	0.2655
2631	0.3615	1248	0	3.183	0	0.9632	0.4649
2632	0.2468	1247	0	3.7485	0	0.5614	0.3392
2634	0.3316	1092.4	0	101.12	1.0553	2.2732	2.4654
2637	0.6185	1066.1	0	27.133	0	1.4169	0.7146
2684	0.2004	1374.1	0	20.839	0	0.8712	0.3063
2695	9.0276	1191.6	23.056	74.818	2.191	20.253	0.4434
2881	0.2794	1372.1	0	0	0	0.657	0.3841
2601	0.4621	1269.8	3.4972	15.152	0	1.4489	0.4813
2612	0.4874	1365.9	0	23.008	0	1.0561	0.2926
2615	19.597	1244.1	36.855	149.16	4.1268	41.567	0.8471
2624	0.2677	512.77	0	2.751	0	1.5569	0.458
2636	0.5176	1084.1	0	24.861	0	1.3648	0.6984
2693	59.188	902.9	0	1.3448	1.266	0.7155	0.3471
2740	0	1417.8	0	0	0	0	0.2021
2743	0	1467.1	0	0	0	0	0.1996
2768	0.1651	1174.5	0	24.055	0	0.6872	0.3646
2820	15.862	327.36	27.818	154.51	6.1997	46.195	1.3054
2606	0	860.69	0	0	0	0.5388	0.422
2609	47.608	852.04	0	6.9038	0	1.0104	0.3965
2628	0.515	1219.6	0	3.7584	0	0.7789	0.3356
2683	1.7294	1265.3	2.9167	36.772	0.8414	3.5375	0.3365
2685	1.7938	1280.2	0	35.851	0	3.7163	0.4597

What Does It All Mean?

- Determine what metals and other elements are in REOB's, PPA and other asphalt additives.
 - Standards were created for both PPA and REOBs
- Convert intensities into amounts – ppm or percentages
 - Amounts were determined from intensities for PPA and REOBs
- Develop a methodology for determining when multiple additives are used in an asphalt binder



Detection of REOBs, GTR, and H₂S Scavengers

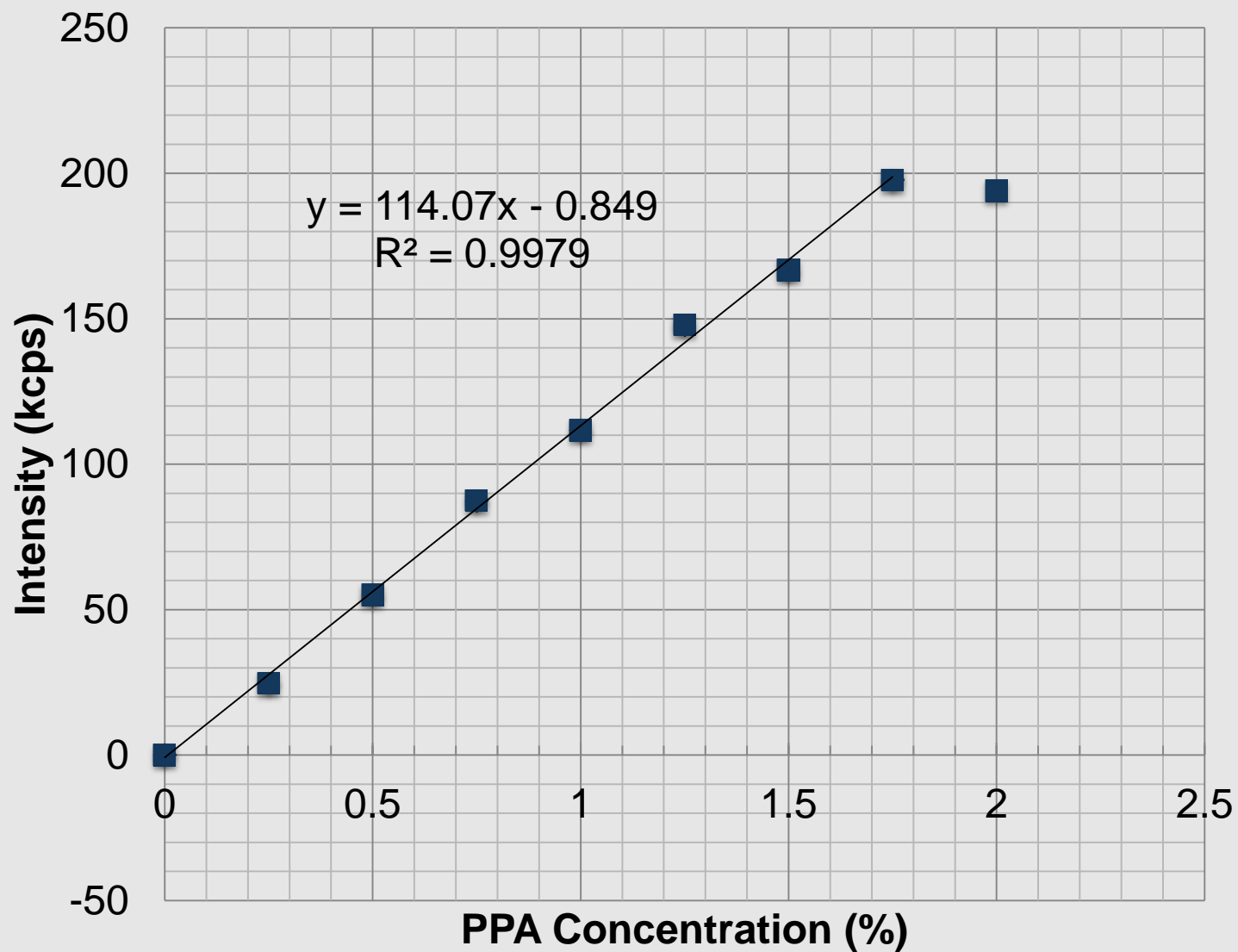
XRF Analysis of REOB and GTR (ppm)

Element	REOB	GTR	Asphalt
Phosphorous	12,000	0	0
Sulfur	16,000	33,000	30-30,000
Calcium	9,000	1,600	0
Iron	1,200	2,800	8-115
Copper	900	1,000	0
Zinc	5,500	16,000	0
Molybdenum	600	0	0
Silica	-	21,000	0

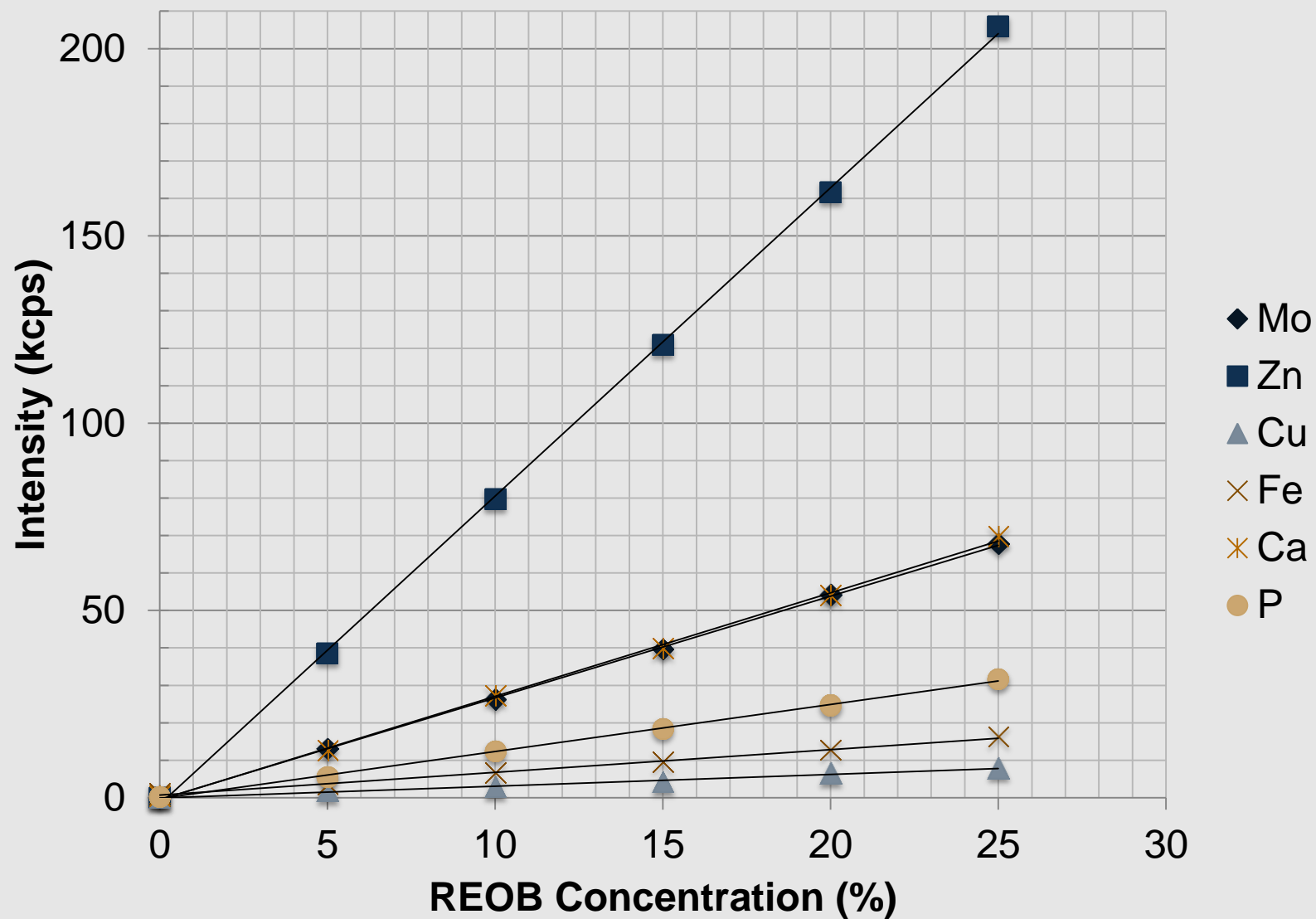
Hydrogen Sulfide Scavengers Contain Zinc
PPA Contains Phosphorous

Source: USDOT and FHWA (3)

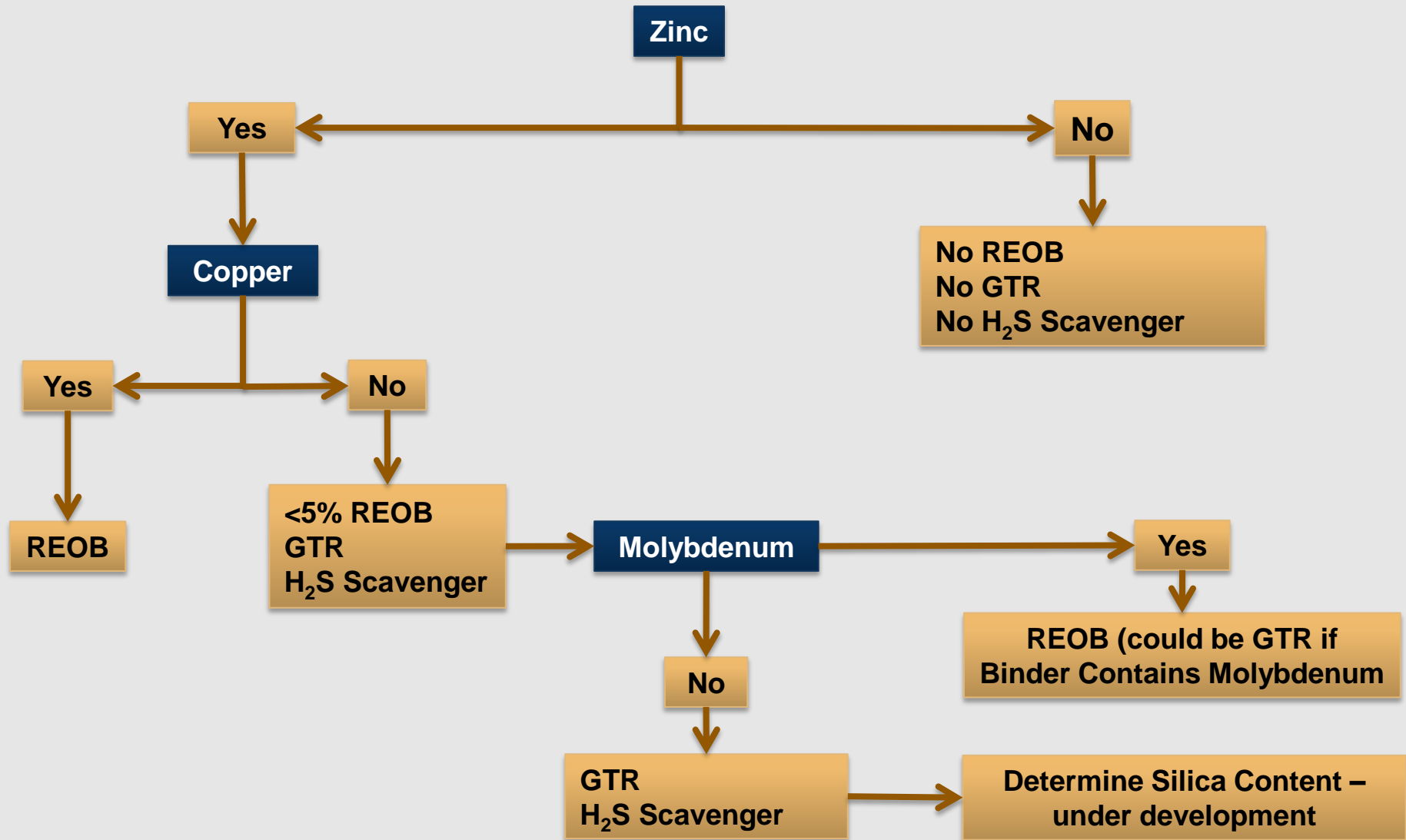
PPA Calibration Standards



REOBs Calibration Standards



Current Methodology



Current and Future Testing

- Testing original binder samples from projects that have performance issues
- Testing all PG and AC binders in the state as part of our Quality Monitoring Program
- Addressing the variability of REOBs
- Exploring alternative methods of binder extraction
 - The Abson recovery process seems to effect the heavy metal intensities
- Evaluating the performance properties of mixes containing REOBs and PPA
- LIBS – Laser Induced Balanced Spectroscopy

- Center for Transportation Research
 - Look at non-standard binder tests
 - Help determine limits for PPA and REOBs
 - Help identify bad performers

Test Method	Remarks
MSCR (at multiple temperatures)	Previous tests have shown that certain binders that contain PPA also have an abnormally a high true grade based on the non-recoverable compliance criterion of 4.0 1/MPa.
BBR (at low temperatures for stiffness and m-value)	Anomalies in the low temperature properties can serve as indicators of modifications that may result in a non-durable binder.
Spot Test (T209)	A separation test and compatibility indicator for binder components.
Poker Chip Test	A simple binder fracture test that measures a materials resistance to fracture.
Mortar Test	Measures the fatigue cracking resistance of the asphalt binders in an asphalt mortar. The test was implemented as a diagnostic tool by TxDOT in 2008.
SARA / Corbett fraction (ASTM D4124)	Indicates the relative proportions of different polar fractions in the asphalt binder. Binders with relatively high fractions of extreme polar fractions are very likely to be unstable in field performance.
Fluorescence Microscopy	Used to assess compatibility and distribution of polymers and other fractions within the asphalt binder.

References

- (1) USDOT and FHWA
<http://www.fhwa.dot.gov/pavement/asphalt/pubs/hif12030.pdf>
- (2) The Association of Modified Asphalt Producers
<http://modifiedasphalt.org/news-bulletin-reob/>
- (3) Turner-Fairbank Highway Research Center, USDOT and FHWA, North East Asphalt User Producer Group Meeting, Framingham MA, October 22-23, 2014.
- (4) Rigaku <http://www.rigaku.com/en/products/xrf/primini/app004>

Many thanks to: Carmen Iglehart,
Ryan Barborak and Cliff Coward

QUESTIONS

