Determination of Lime in Hot Mix Asphalt

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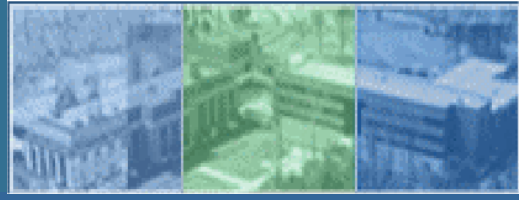
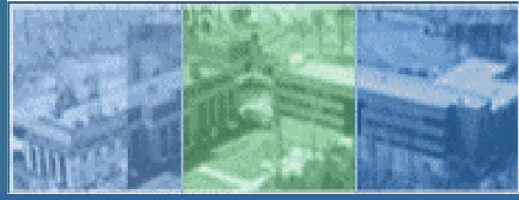
Given at AMAP 02/14/07



Existing Methods

- ASTM C-25-99 “Standard Test Method for Chemical Analysis of Limestone, Quicklime and Hydrated Lime”
- No Standard Test for Determining the Lime Content of HMA was found



Experimental Approach

Rapid Qualitative or Semi-quantitative Analysis

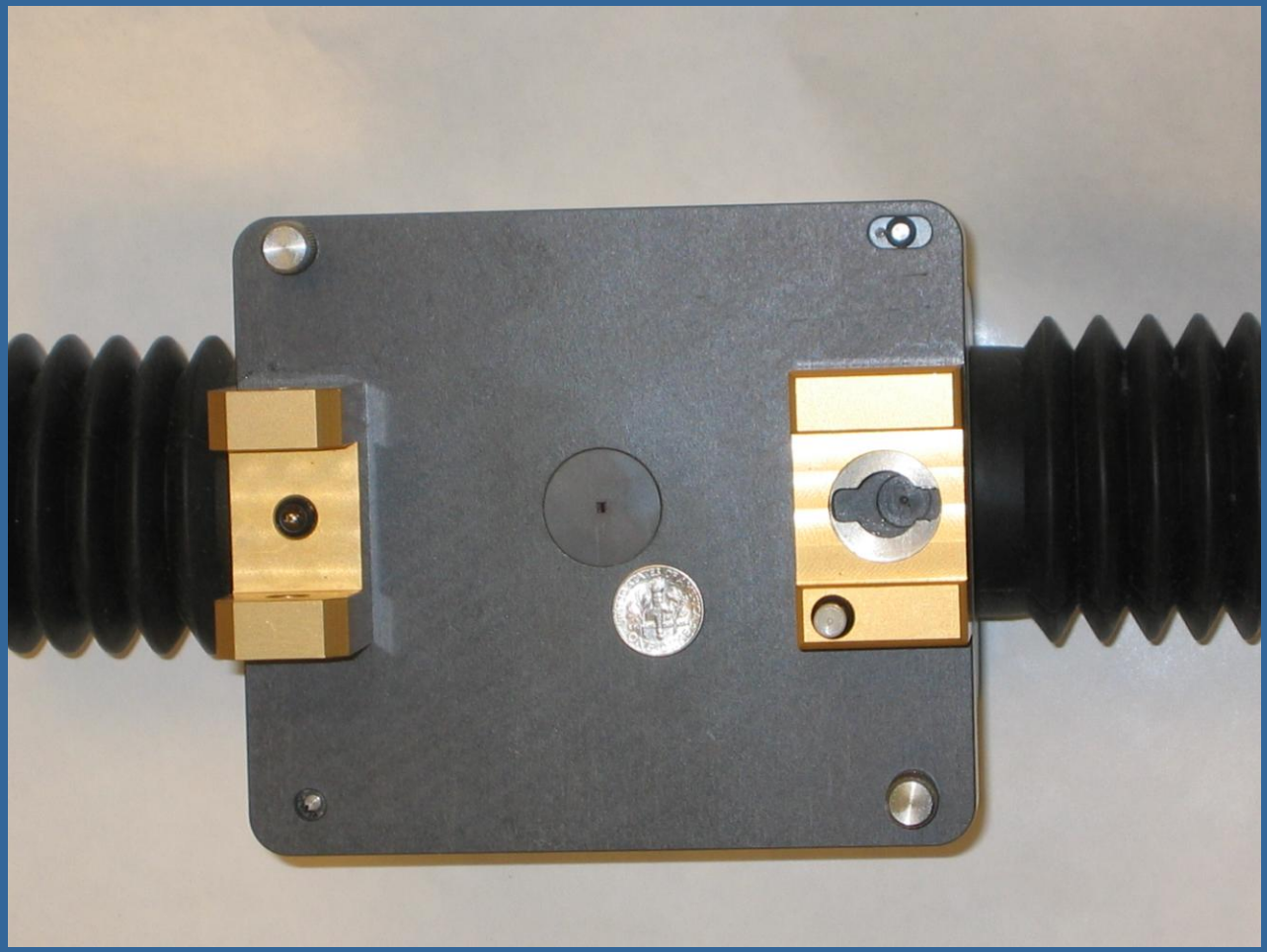
- Fourier Transform Infrared Spectroscopy

Accurate Quantitative Analysis

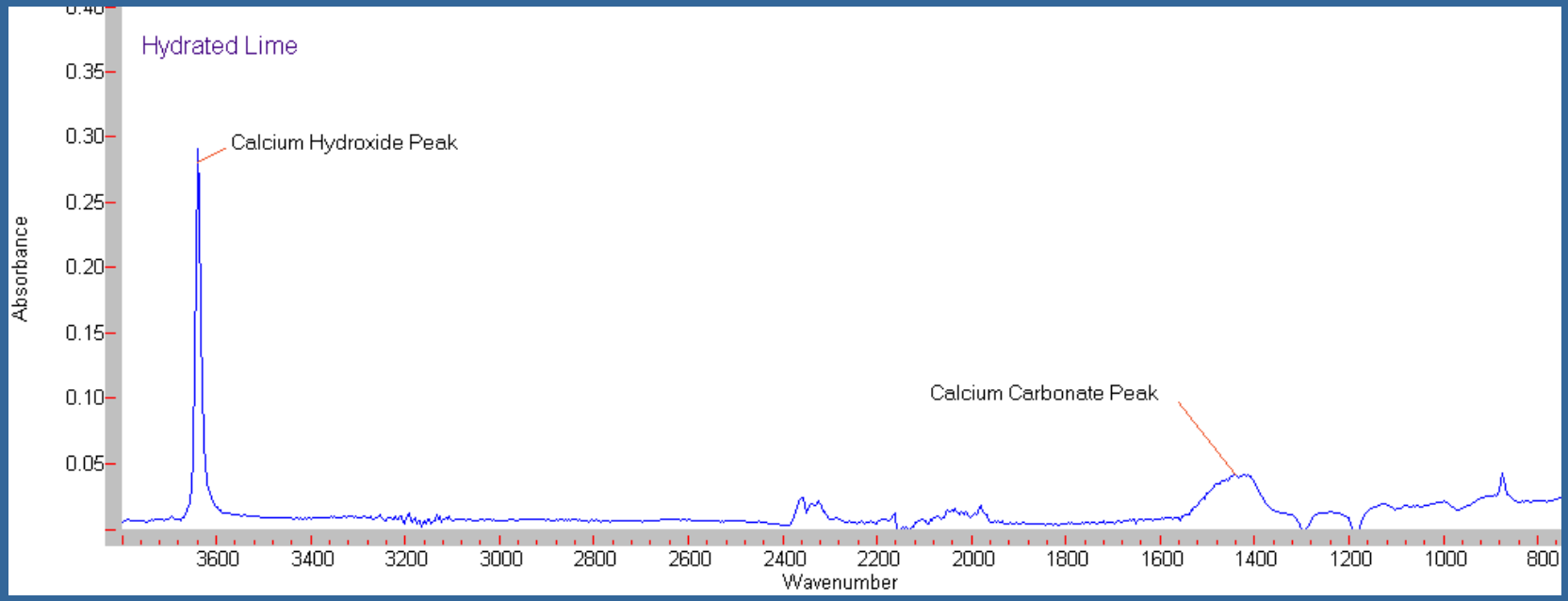
- Chemical Extraction of Calcium

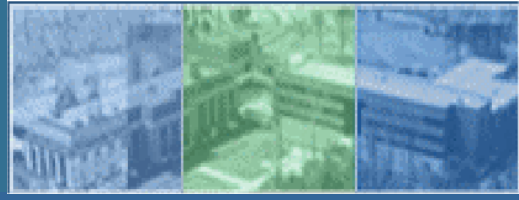
FTIR Spectroscopy

ATR Bridge



FTIR Spectrum of Hydrated Lime

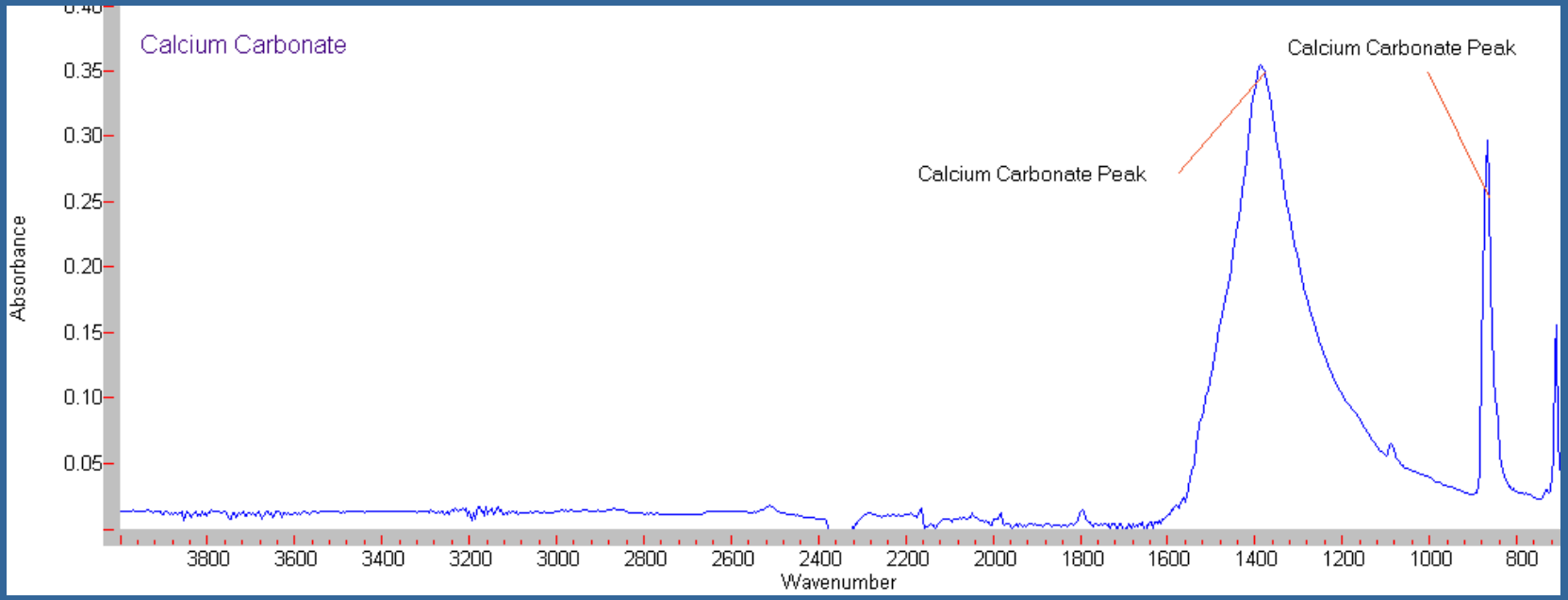




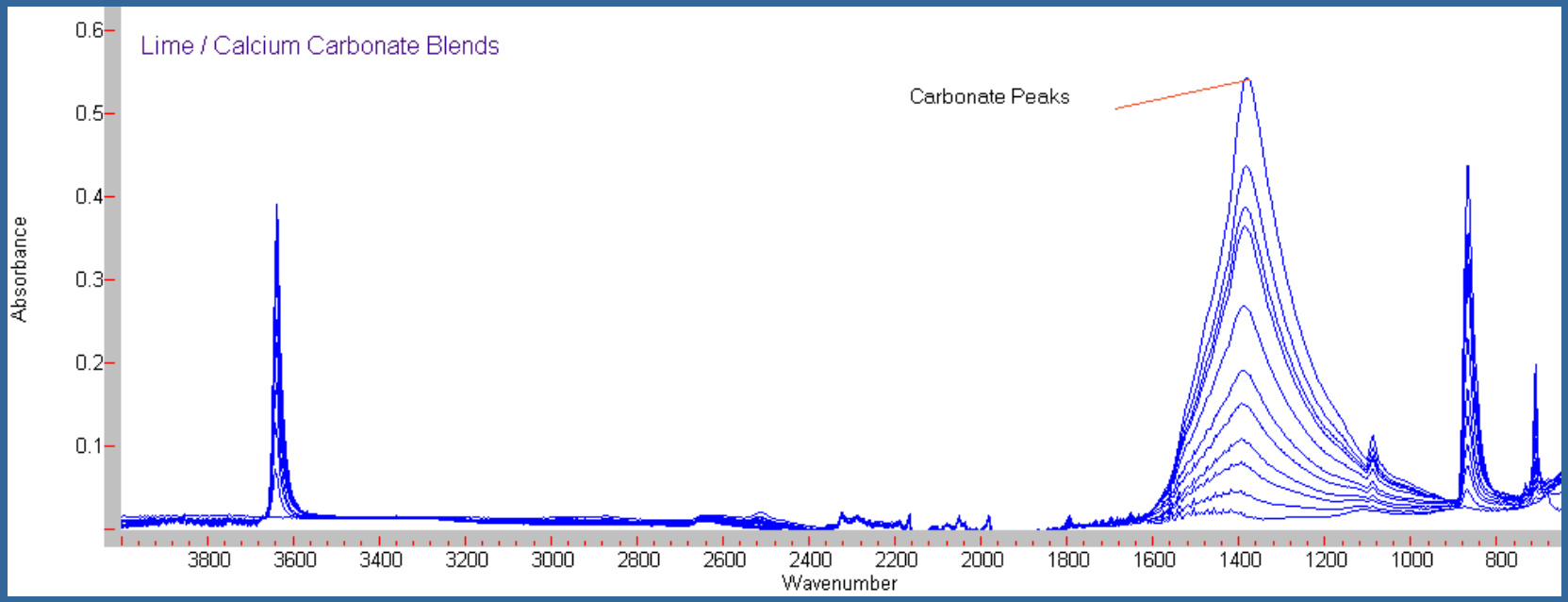
Lime Absorbs Carbon Dioxide

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_20$$

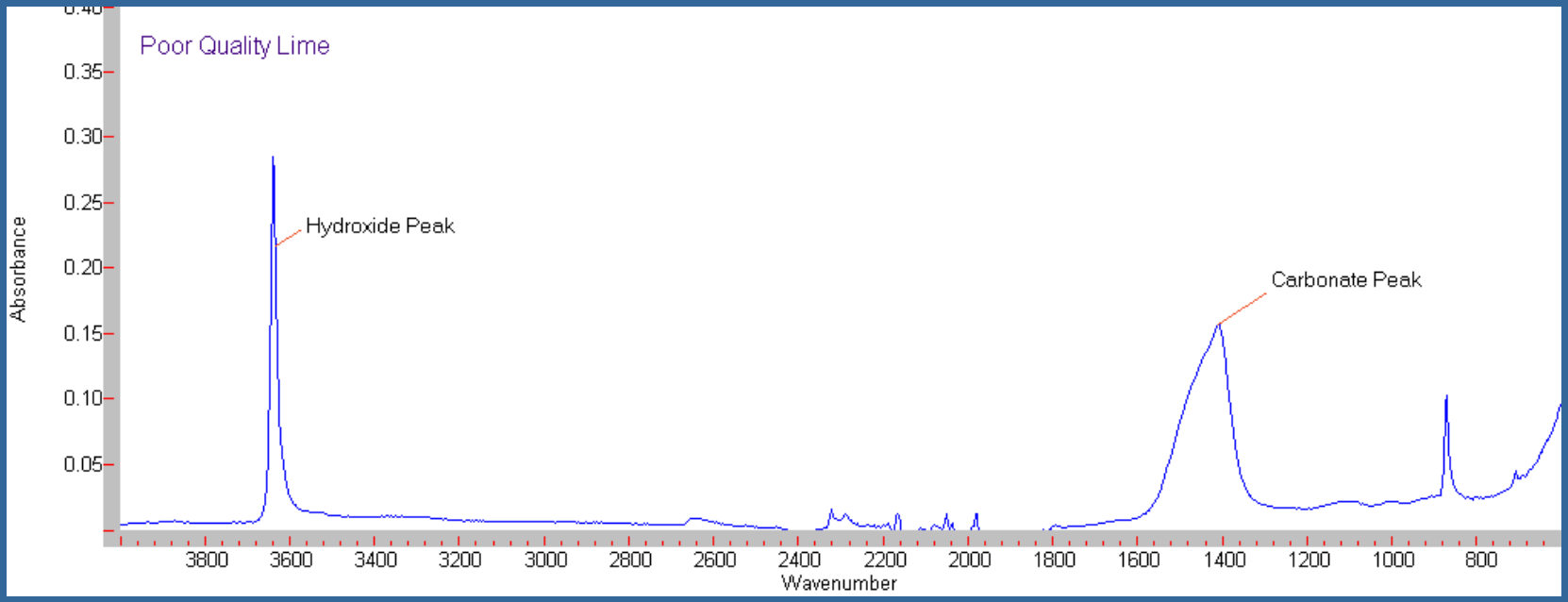
FTIR Spectrum of Calcium Carbonate



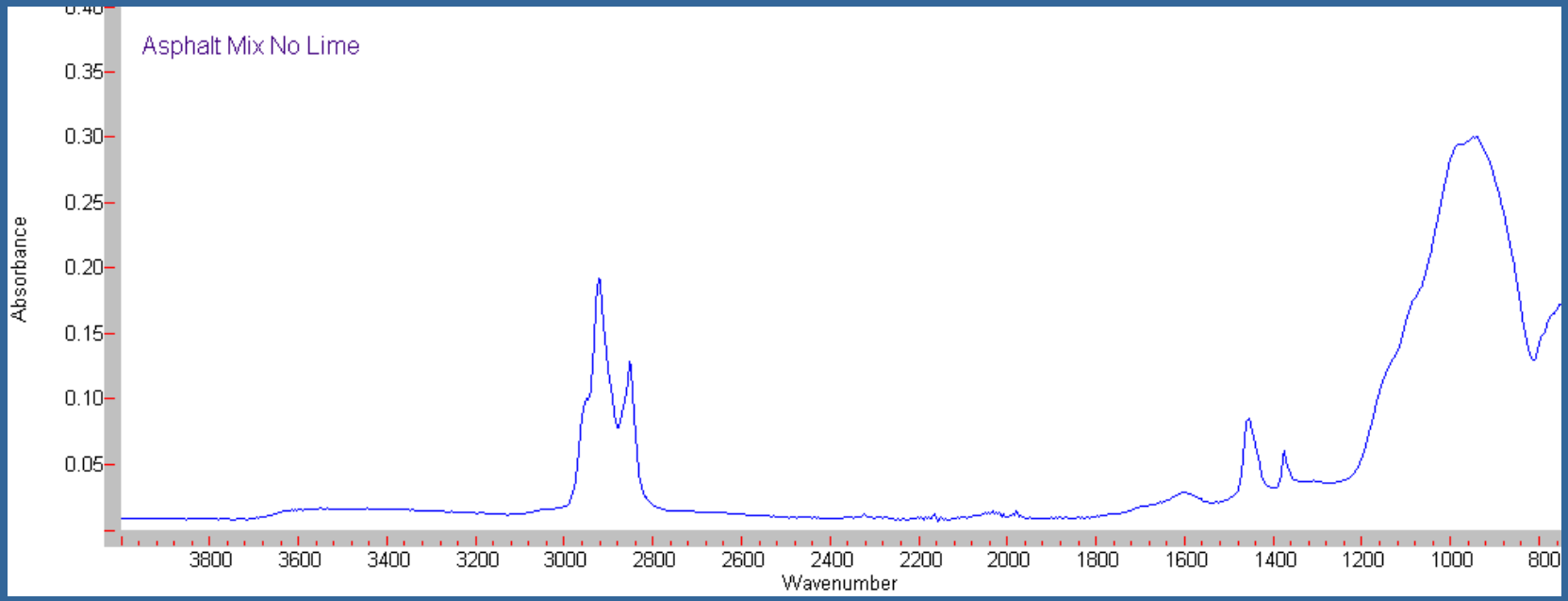
FTIR Spectra of Lime/Calcium Carbonate Mixtures



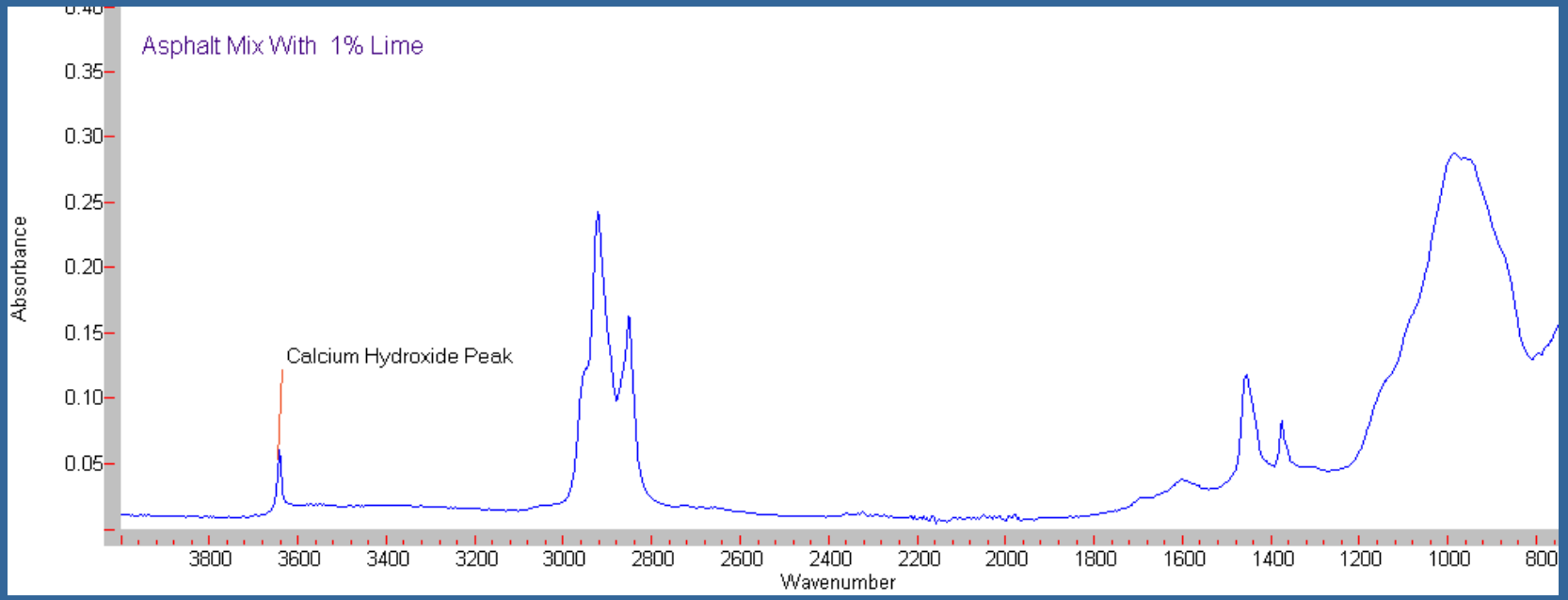
FTIR Spectrum of Poor Quality Lime

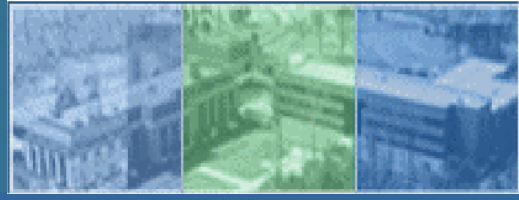


FTIR Spectrum of Asphalt Scraped from Hot Mix



FTIR Spectrum of Asphalt Scraped from a Lime Treated Hot Mix

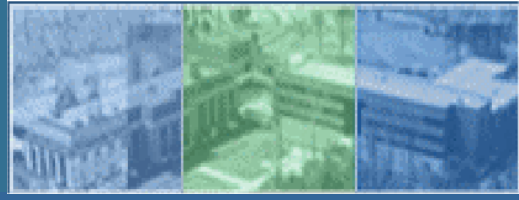




Accurate Quantitative Analysis

Chemical Extraction of Calcium

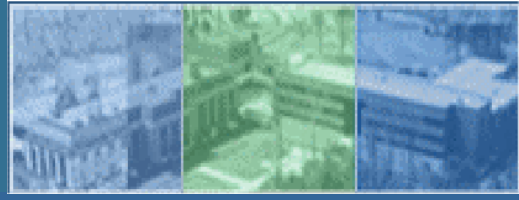
- Binder Removal
- Calcium Analysis



Extraction and Detection of Calcium

$$Ca(OH)_2 + 2HCl = CaCl_2 + 2H_20$$

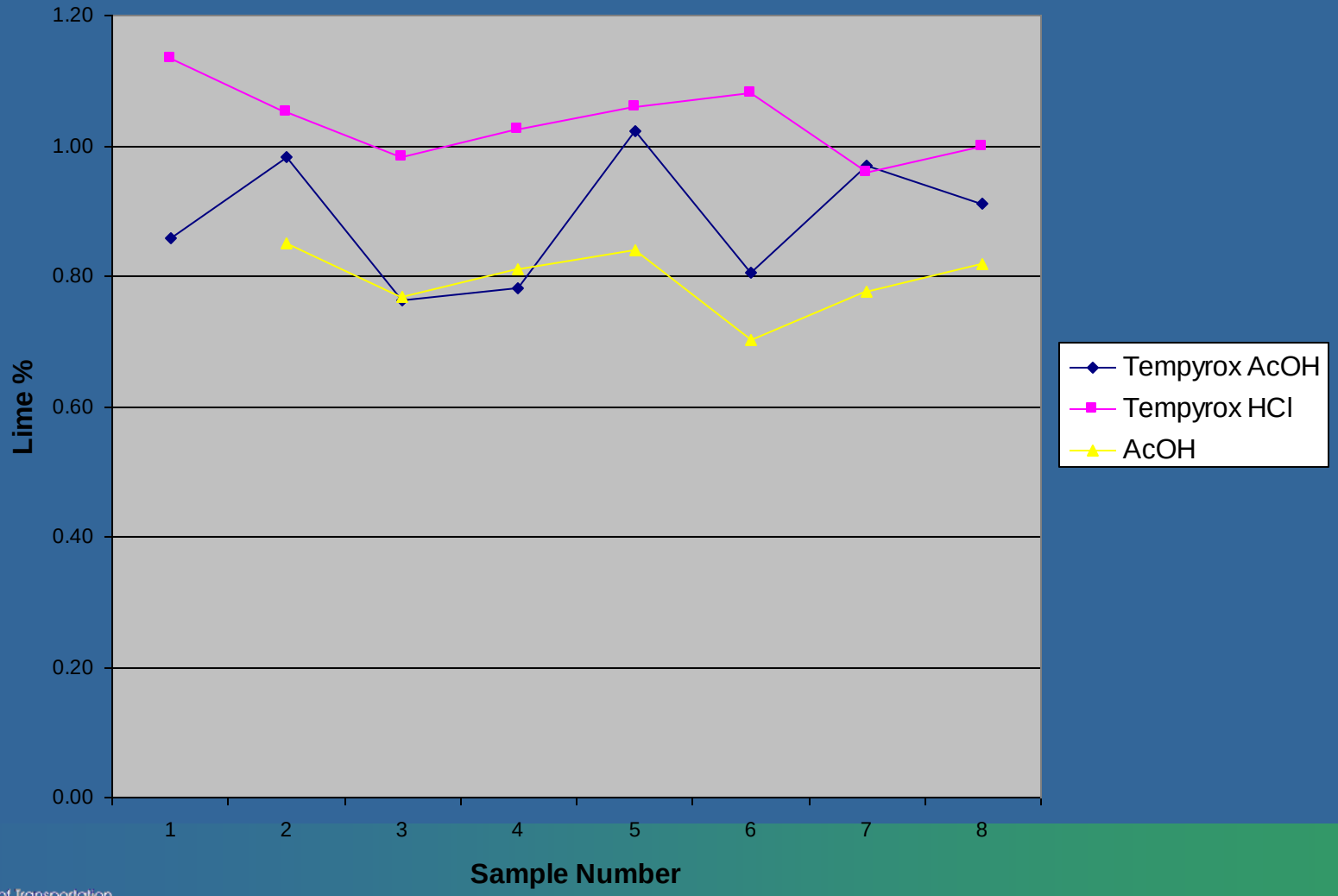
$$CaCO_3 + 2HCl = CaCl_2 + CO_2 + H_20$$



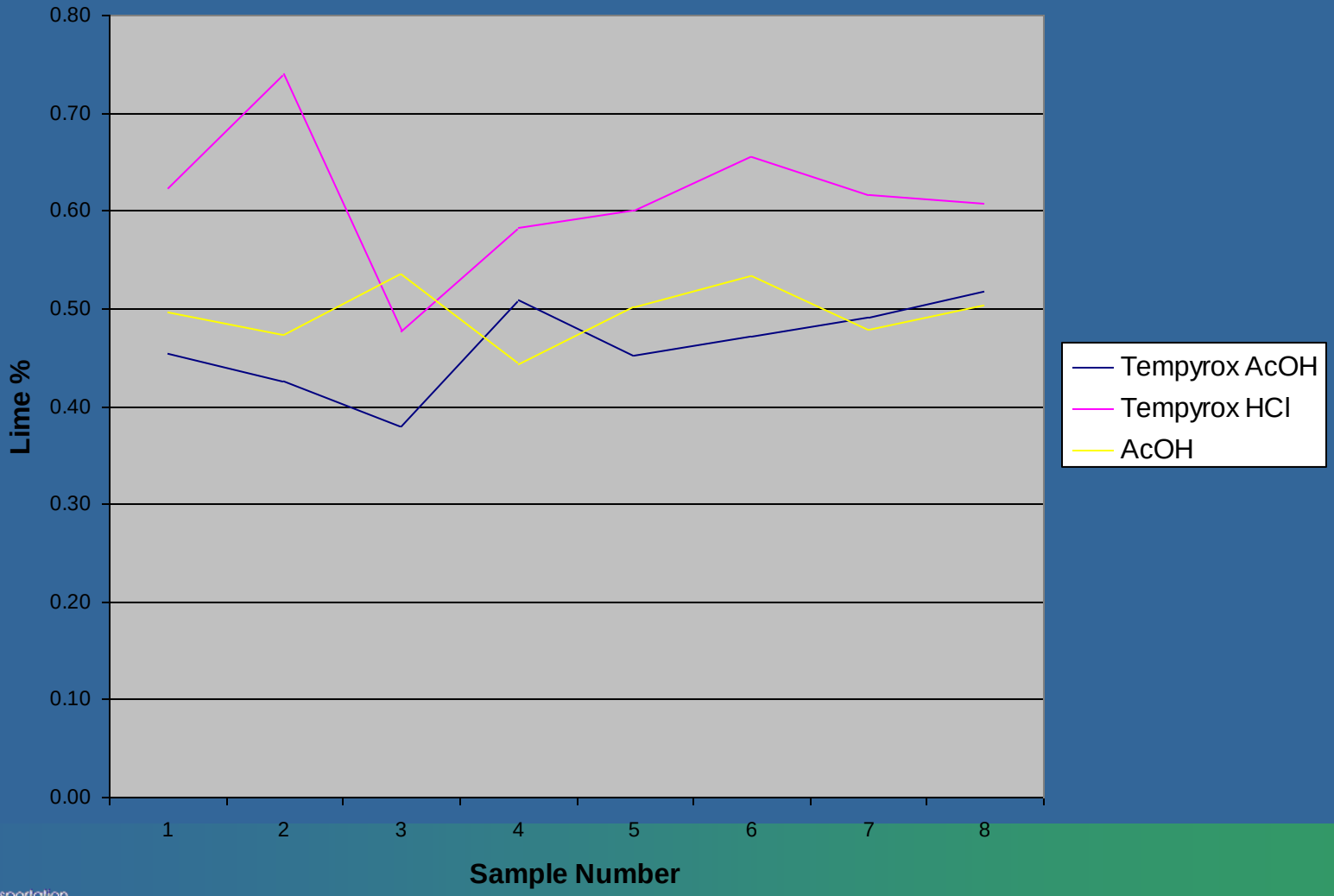
Extracting Calcium From Drilling Dusts

- Burning Plus Acetic Acid
- Burning Plus Hydrochloric Acid
- Boiling with 4% Acetic Acid - Binder Still Present

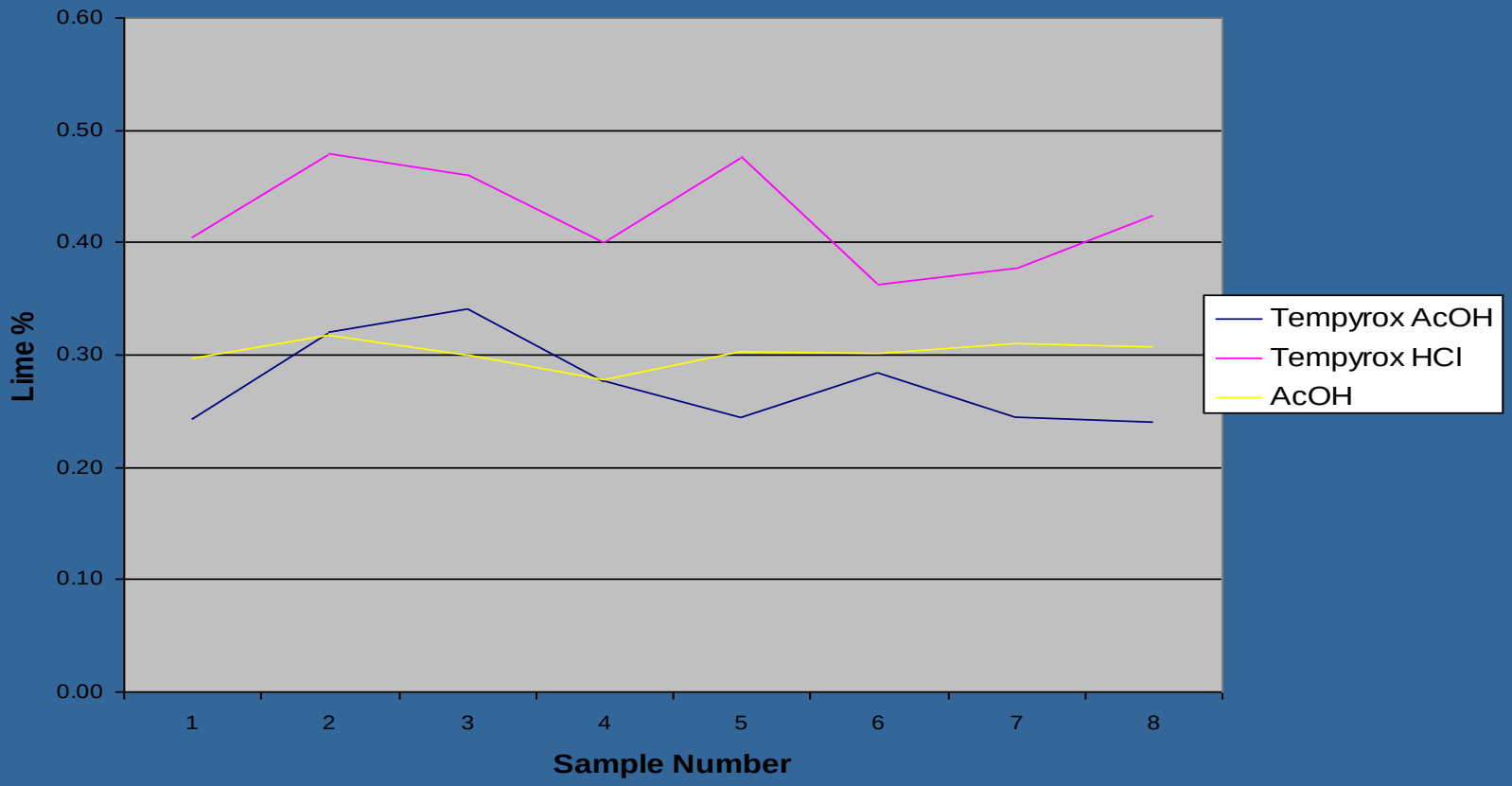
Analysis of Core Containing 1% Lime

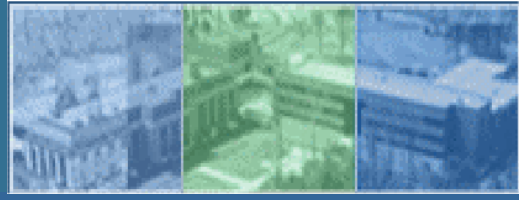


Analysis of Core Containing 0.5% Lime



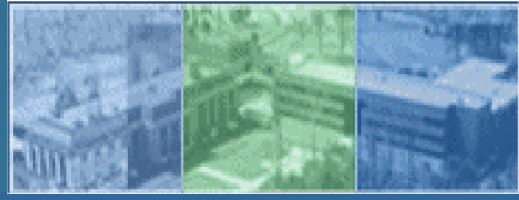
Analysis of Core Containing 0.25% Lime





Comparison of Extraction Methods

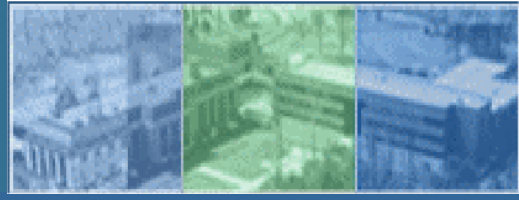
- Removal of the binder is not necessary
- Hydrochloric acid gives slightly high results
- Acetic acid gives slightly low results at 1% lime level
- Acetic acid gives accurate results at 0.5 and 0.25% lime levels



Summary

- Fourier Transform Infrared Spectroscopy is a very simple and rapid method for determining the asphalt content of Hot Mix Asphalt

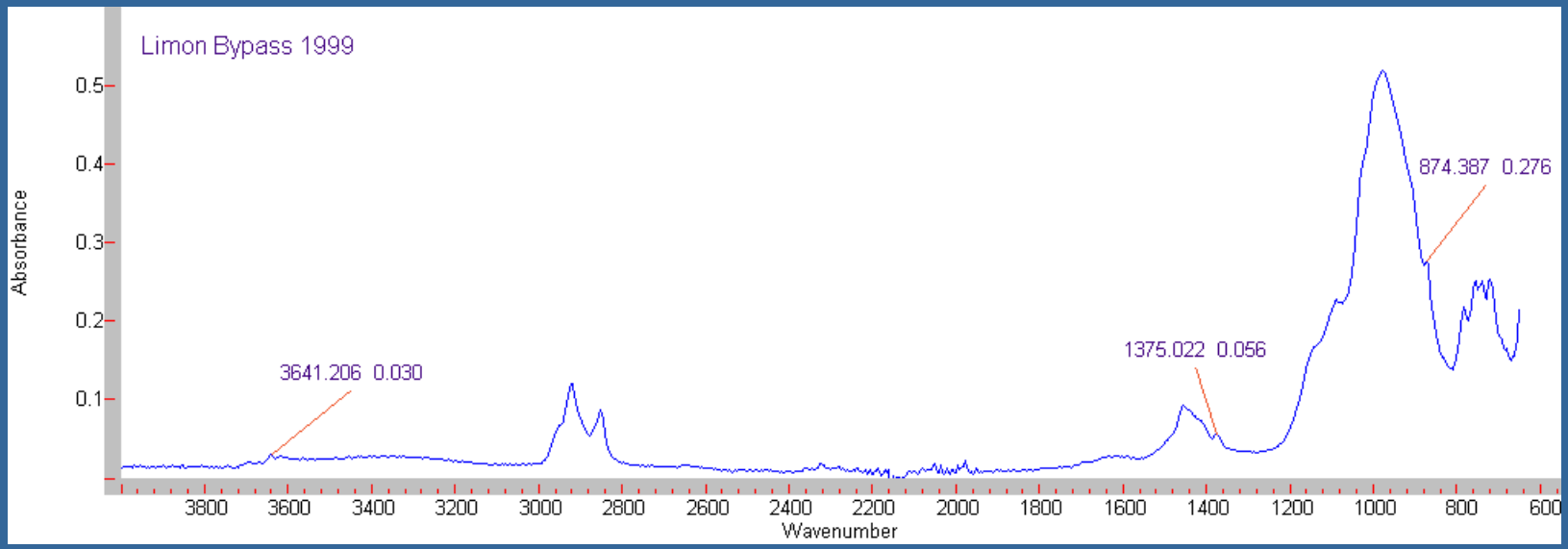
- More accurate quantitative results can be obtained by drilling the pavement, boiling the drilling dust with 4% acetic acid and measuring the lime content by either Atomic Absorption spectroscopy or Ion Exchange Chromatography



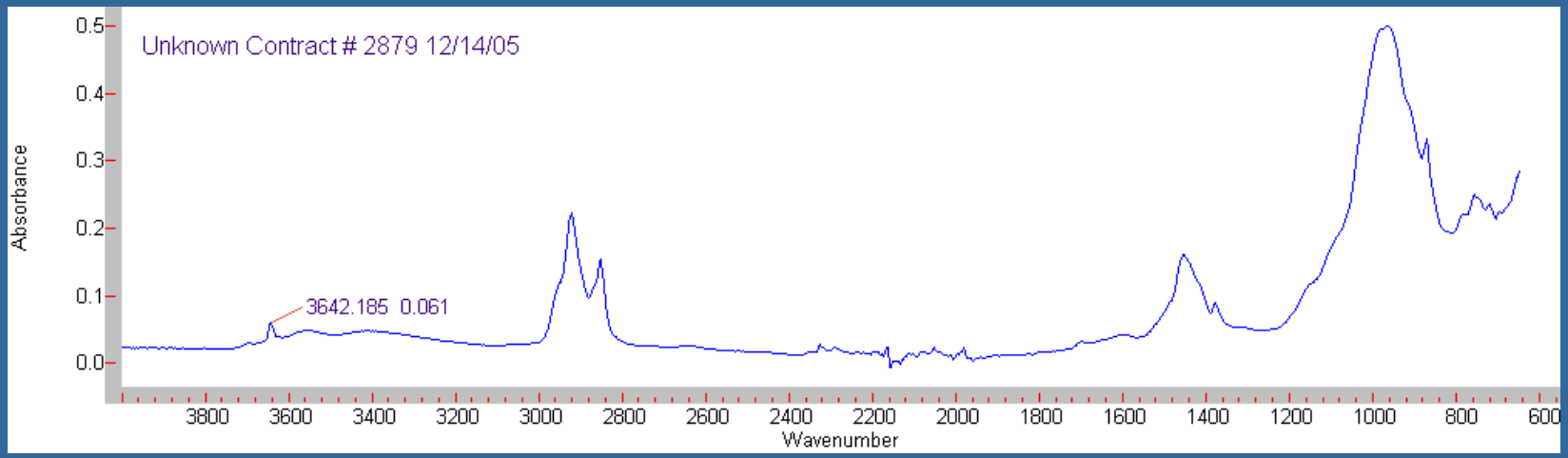
Forensic Analysis of Cores from Nevada and Colorado DOT

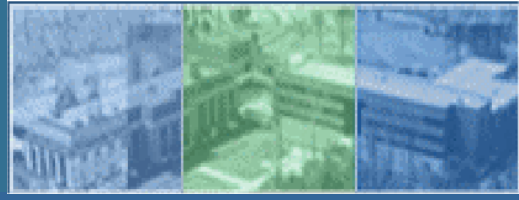
- Lab made gyratory samples
- Lab compacted field samples
- Samples containing limestone aggregate
- Cores cut from old paving projects

FTIR Spectrum of Asphalt Scraped from a Core taken from Limon Bypass CO paved in 1999



FTIR Spectrum of Asphalt Scraped from a Core taken from NV Road Paved in 1995





Results from Colorado and Nevada Samples

State	Core	Age Years	Aggregate	Lime % by Acid Extraction	Lime % By FTIR
CO	SH40 A	2	Some Limestone	6.65	0.51
CO	SH40 B	2	Some Limestone	7.33	0.51
CO	SH40 C	2	Some Limestone	6.29	0.29
CO	Limon A	6	Unknown	1.91	0.53
CO	Limon B	6	Unknown	1.62	1.40
NV	BF05-33	<1	Some Limestone	1.59	1.33
NV	BF-05-29	<1	Limestone	17.12	1.74
NV	BF-04-88	<2	No Limestone	1.58	0.32
NV	BF05-31	<1	Limestone	34.85	0.96
NV	Unknown	Unknown	Unknown	3.01	0.97
NV	BF95-167	10	Limestone	31.18	1.1


Questions?