Establishing a Framework for Analyzing Asphalt Pavements Sustainability

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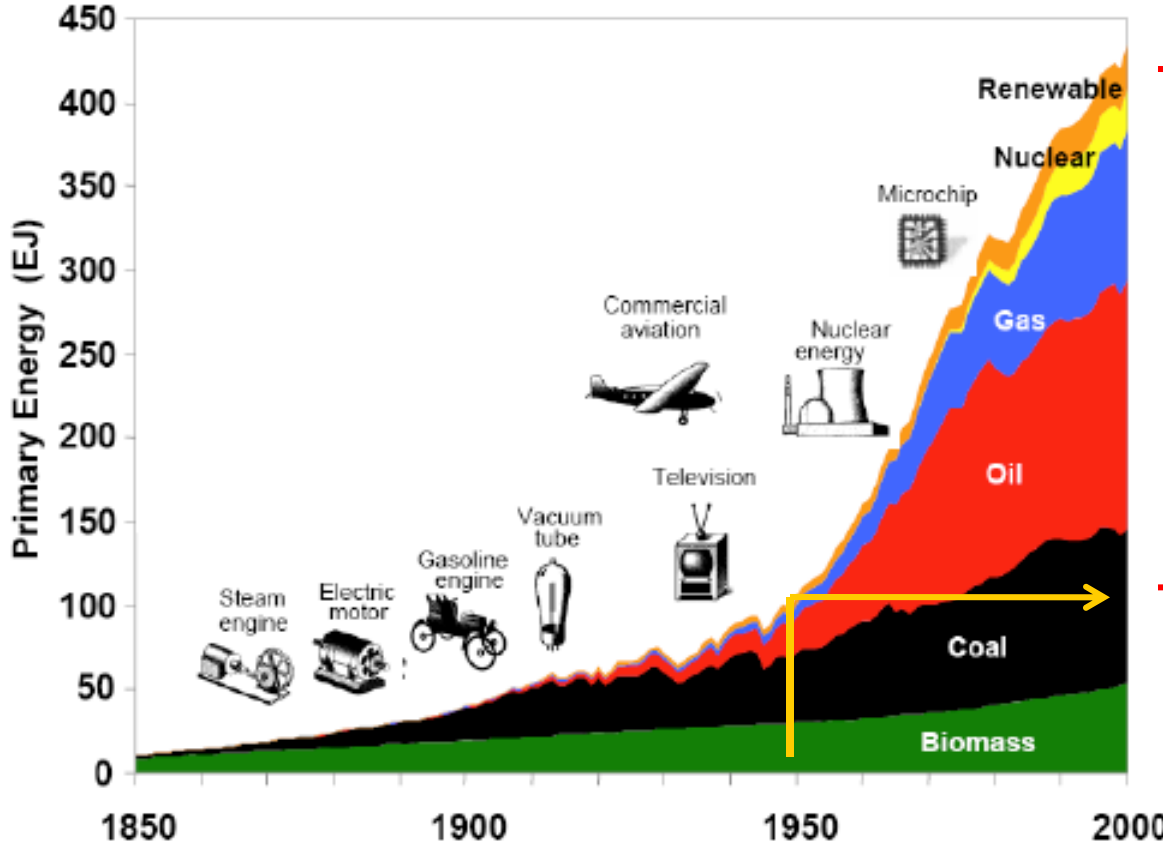
Presentation Overview

- Background:
  - Energy and Emissions
- Objectives of Study:
  - The Challenges
- Tools available for estimation
  - Energy/emissions
- Next Steps Proposed

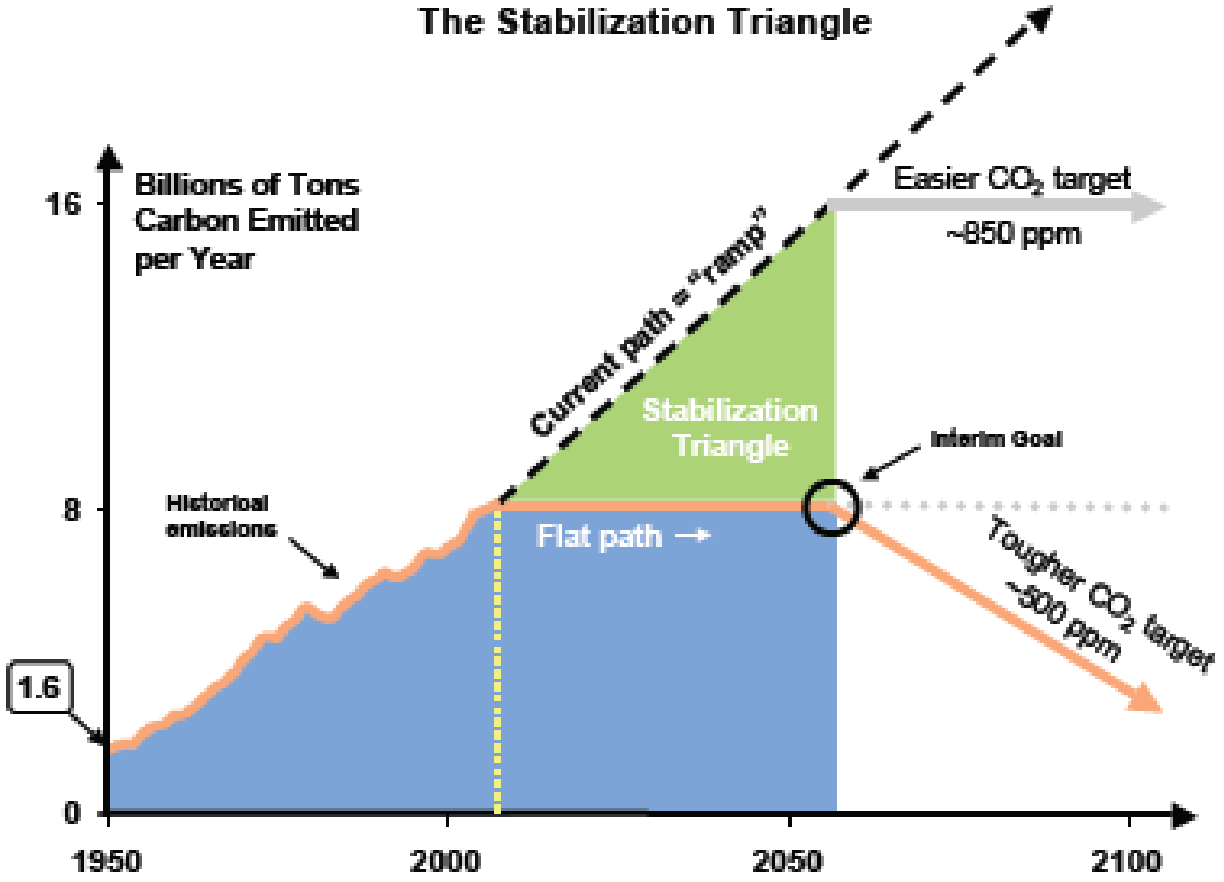
World Primary Energy Supply
Is this sustainable ?



> 4 X In 50 Yrs

Source: Nakicenovic

Projected Global Emissions
How much more can we tolerate ?



Source: Pacala and Socolow

Can road engineers make a difference? .... YES

Current Estimates (U.S. Only)

- 500+ million tons of HMA produced annually
- Average HMA plant emits ~2,500 tons CO_2 annually *(2,500 tons = 0.0023 Tg (megatonnes)*
- Over 3500 HMA production facilities in U.S.(EPA)
  - 8.75 megatonnes of CO_2 (USA only)
  - ~ 0.5 % of total emissions
  - Over 1 billion gallons of fuel
  - 90% of total life cycle energy is spent in production

The main challenges

1. Reaching consensus on what is important for making asphalt roads more sustainable
2. Enhancing data collection
3. Setting system boundaries

Literature Review Results

- Lack of detailed, reliable, and scientific data
- Lack of monitoring tools
- Simplistic and inconsistent analysis tools
- Lack of sensible sustainability regulations

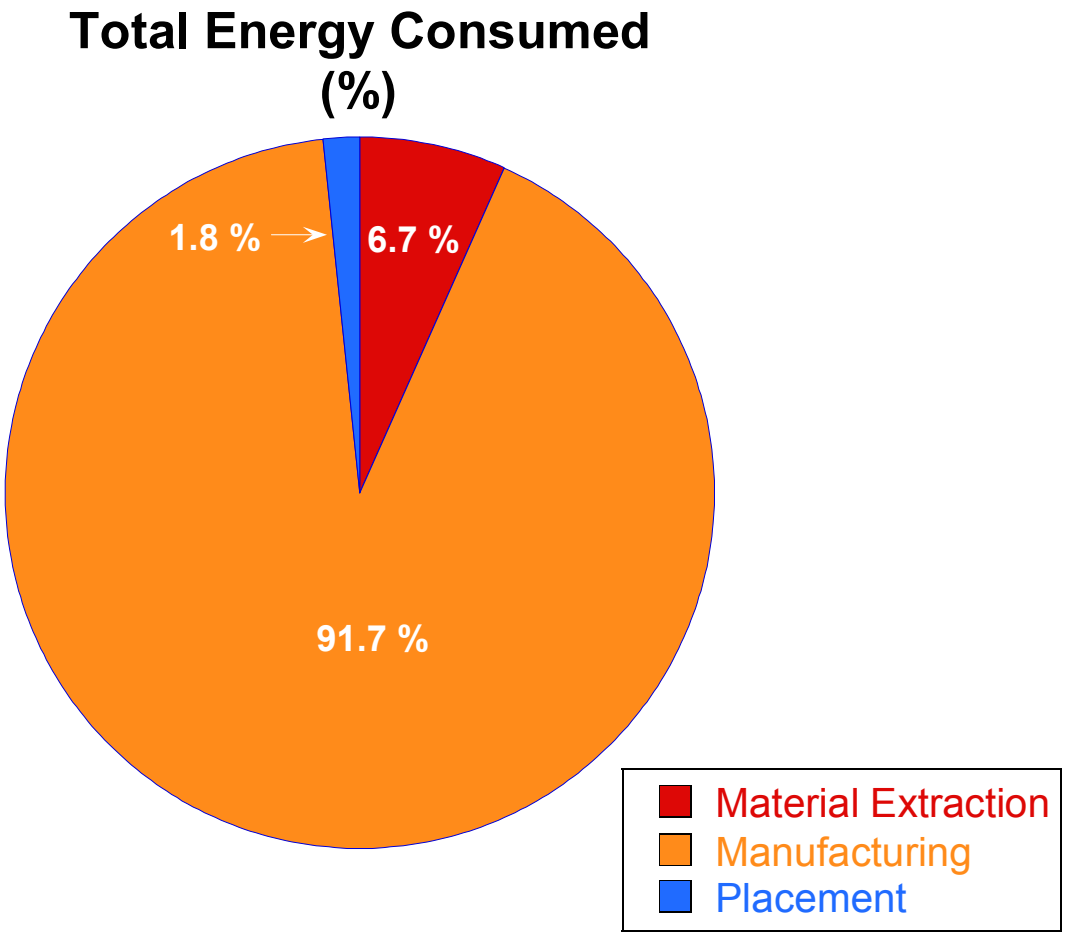
- There are good ideas and good intentions

The pavement life cycle

- Key processes
  - Materials extraction
  - Bitumen & HMA production
  - Construction

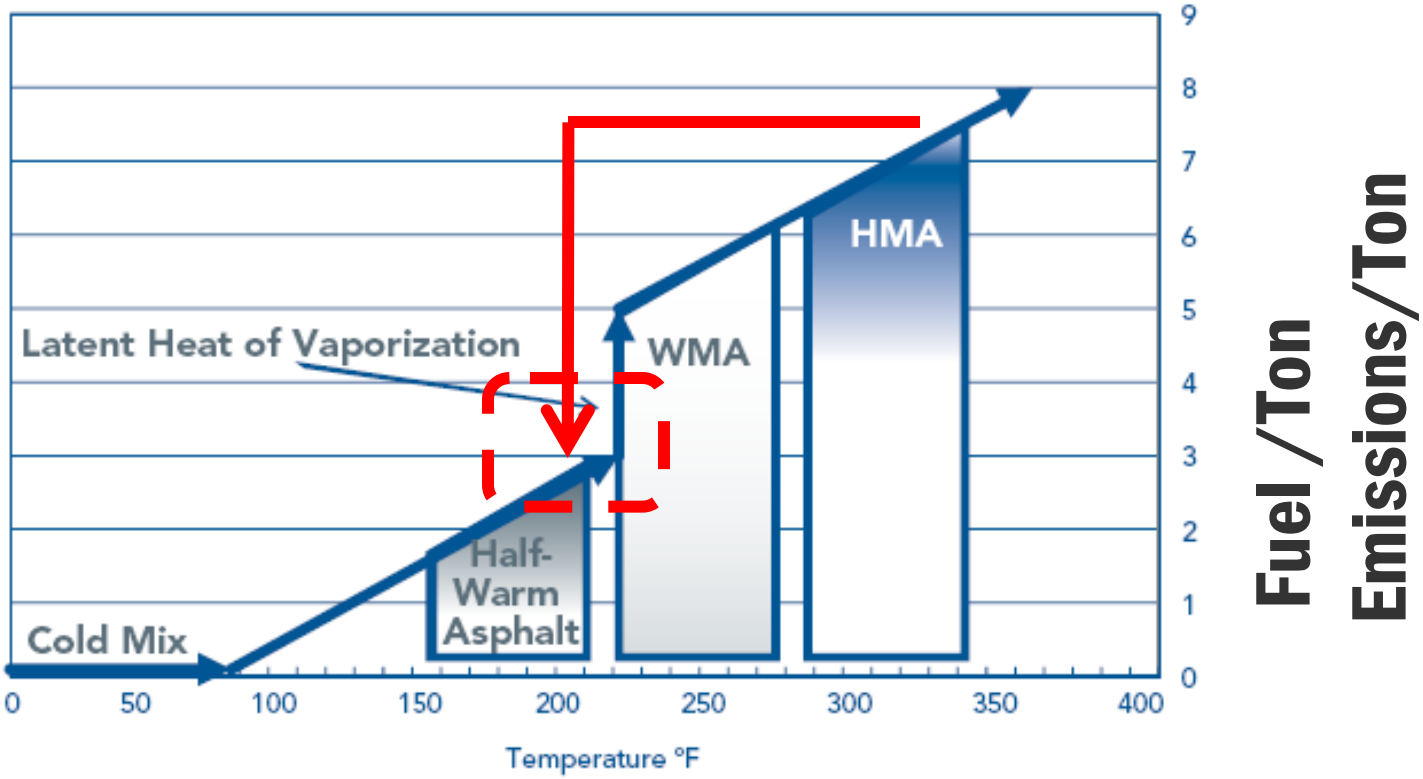
  - Maintenance
  - Rehabilitation and recycling

Distribution of Energy Consumption Asphalt Roads



The Promise: Production Impact

Less Energy + Less Impact on Environment



Source: FHWA

Current Practice: Focus on materials initial cost

Source: Image used courtesy of Payne & Dolan

Source: Image used courtesy of Payne & Dolan

Need to focus– Set System Boundaries

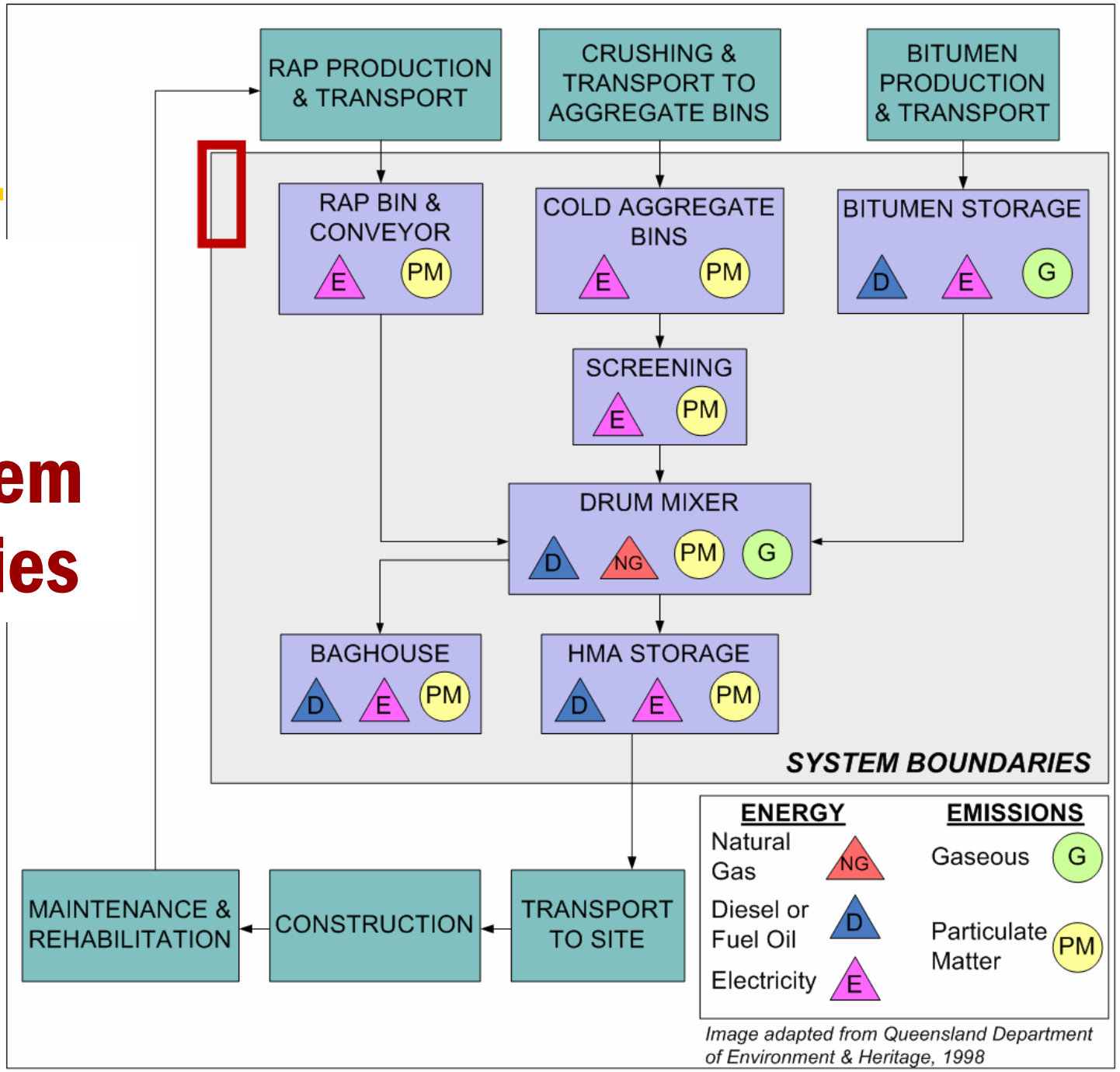
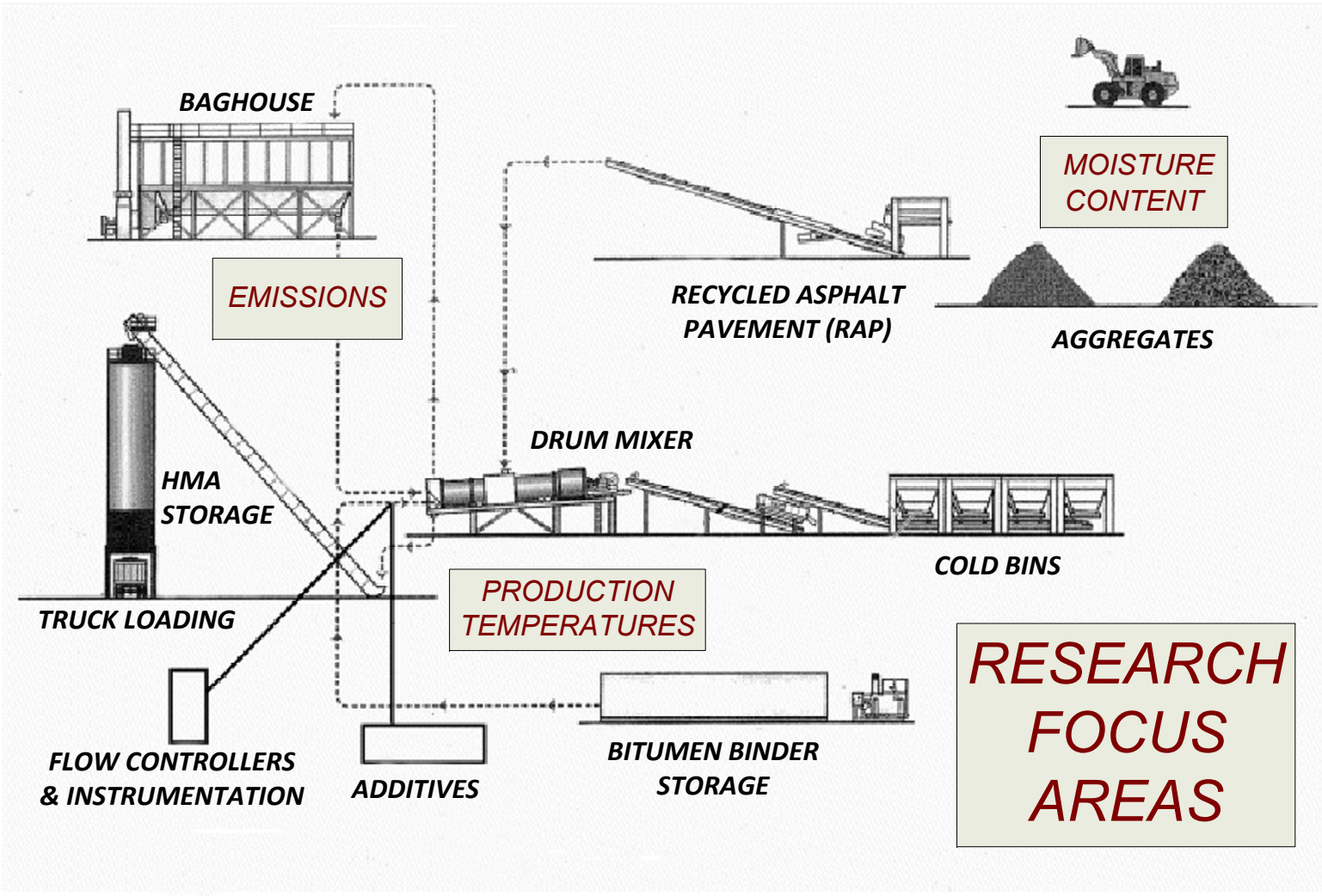


Image adapted from Queensland Department of Environment & Heritage, 1998

Key Plant Parameters

- Energy sources
  - Electricity
  - Fuel oil, diesel, natural gas
- Aggregate gradation
  - Moisture content
  - Surface area
- RAP contribution (less heat needed)

HMA Production (Fuel & Electricity)



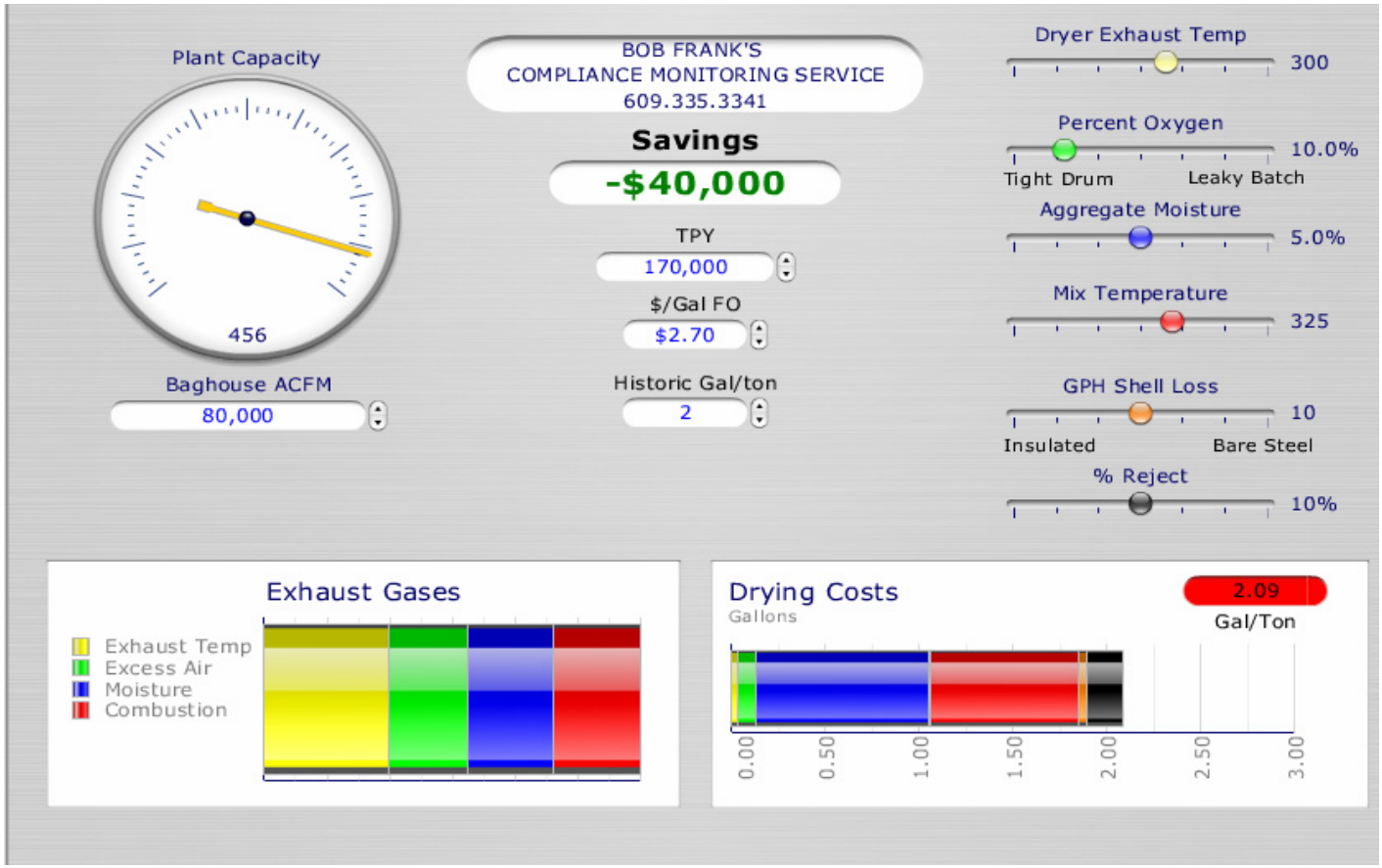
Enhance Data Collection
What Can/Should Be Measured?

- Measuring plant variables requires…
  - Instrumentation
  - Capital investment
  - Contractor willingness for cooperation
  - Structure for data analysis

Existing Estimation /Analysis Tools

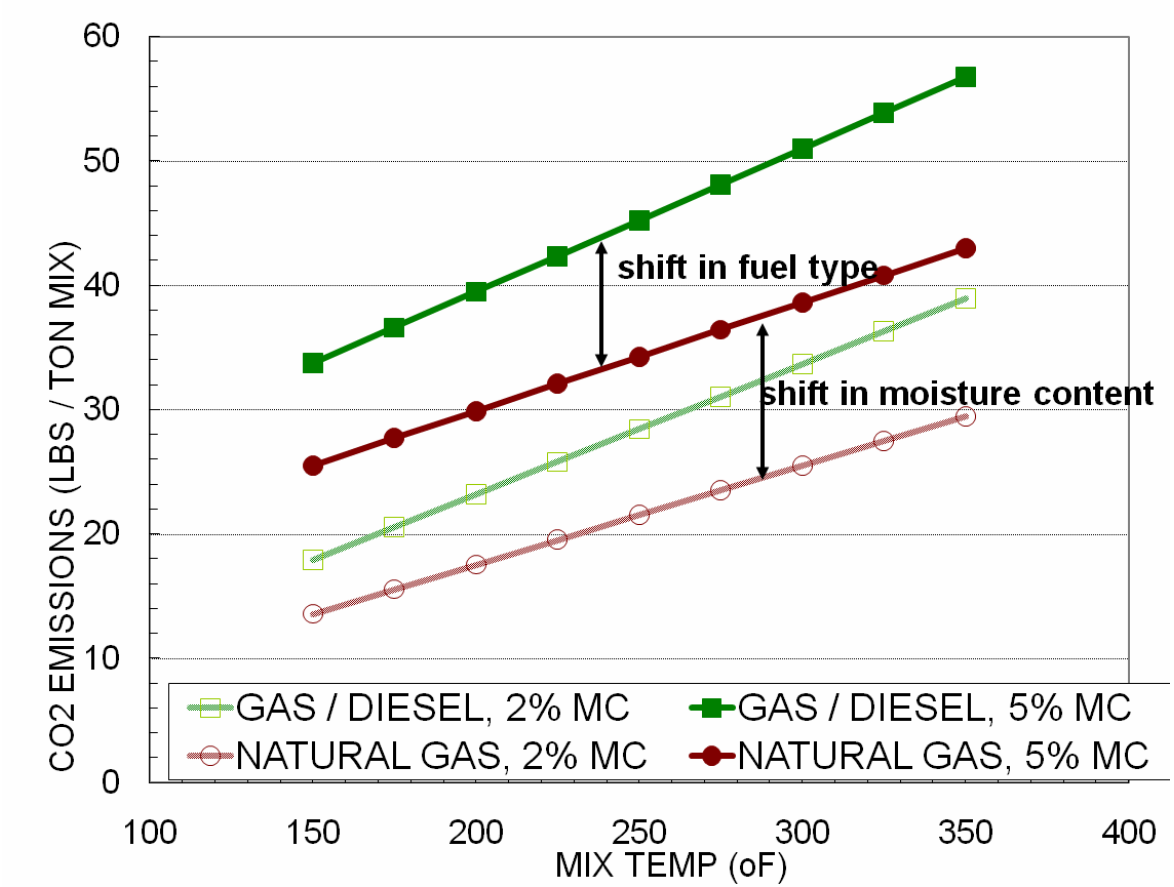
- Plant Diagnostic Tool
  - Pennsylvania Asphalt Pavement Association (PAPA)
- Spreadsheet models
  - World Bank
  - Land Transport New Zealand
  - Pavement Life-cycle Assessment Test for Environment and Economic Effects (PaLATE)

Existing Tools: Plant Diagnostic Tool

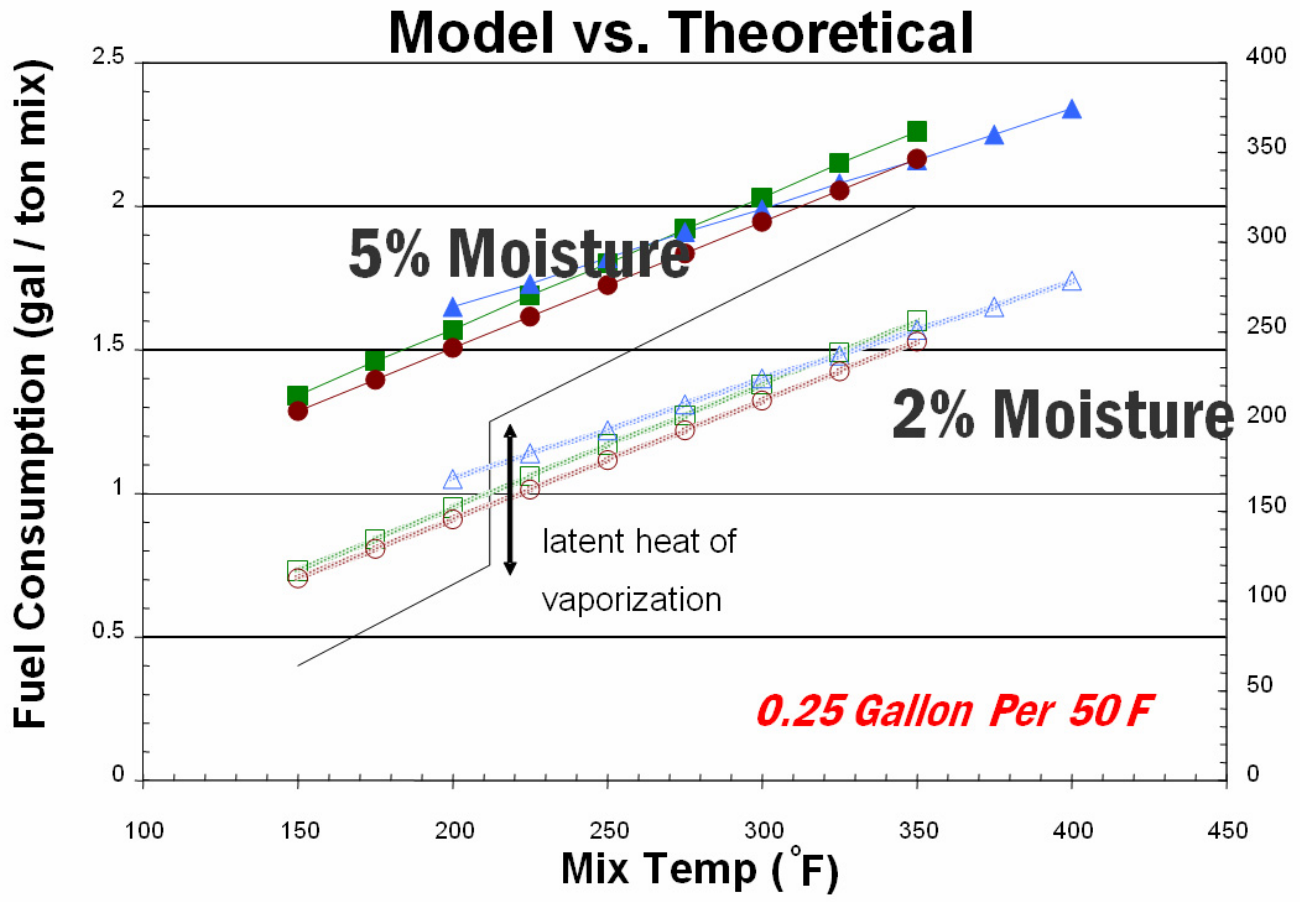


Source: Pennsylvania Asphalt Pavement Association

Model: Emissions



Models: Fuel Consumption Not Consistent with Theory



Tools for Emissions Estimates

GHG Emissions Calculation Methodology for Green Pavement Production

Units:	x T CO2 / 1 Joule	*	x Joules / Ton Mix	*	x Tons Mix / Ton Asphalt	= T CO2 / Ton Asphalt
Data Source:	*IPCC* *(varies by fuel)*		*Heat Capacity for 1 Ton material (Worksheet)*		*Manufacturer*	*Result*

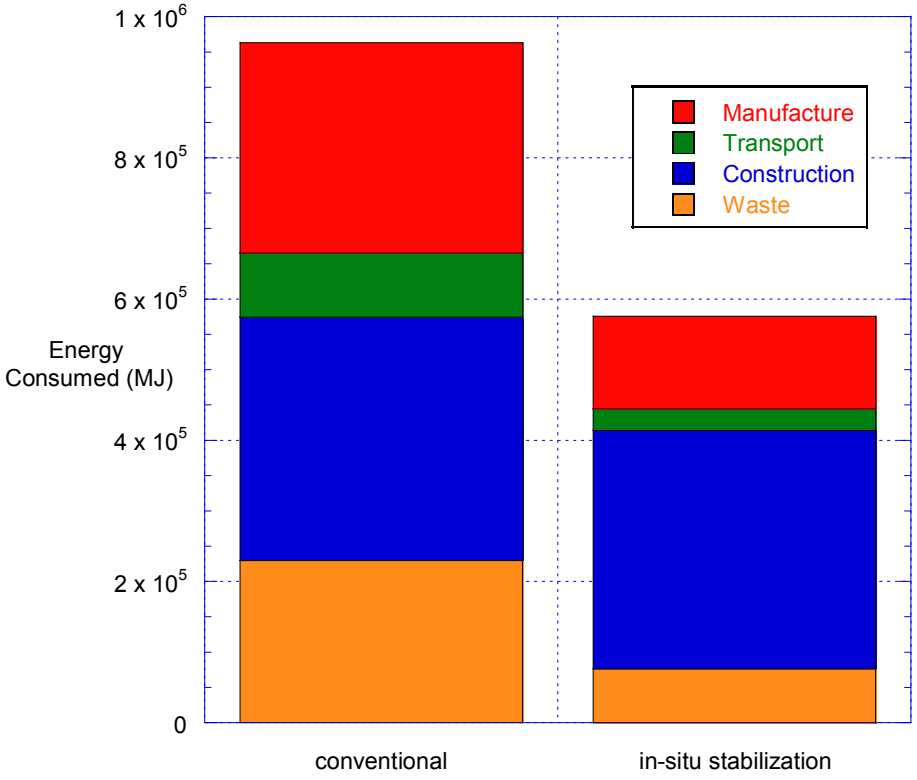
Model Test

Fuel Type	(3) Gas / Diesel Oil	
Aggregate Specific Heat Capacity	0.92	Cg
Ambient Temperature	15.56	Degrees Celsius
Moisture Content	3.00%	% Aggregate Mix
Minimum Mix Heat Temperature	176.67	Degrees Celsius
Tons Mix per Ton Asphalt	1.03	Tons
Efficiency of Heating Element	0.88	% Efficiency
Energy Loss from Drum	0.10	& Energy Loss

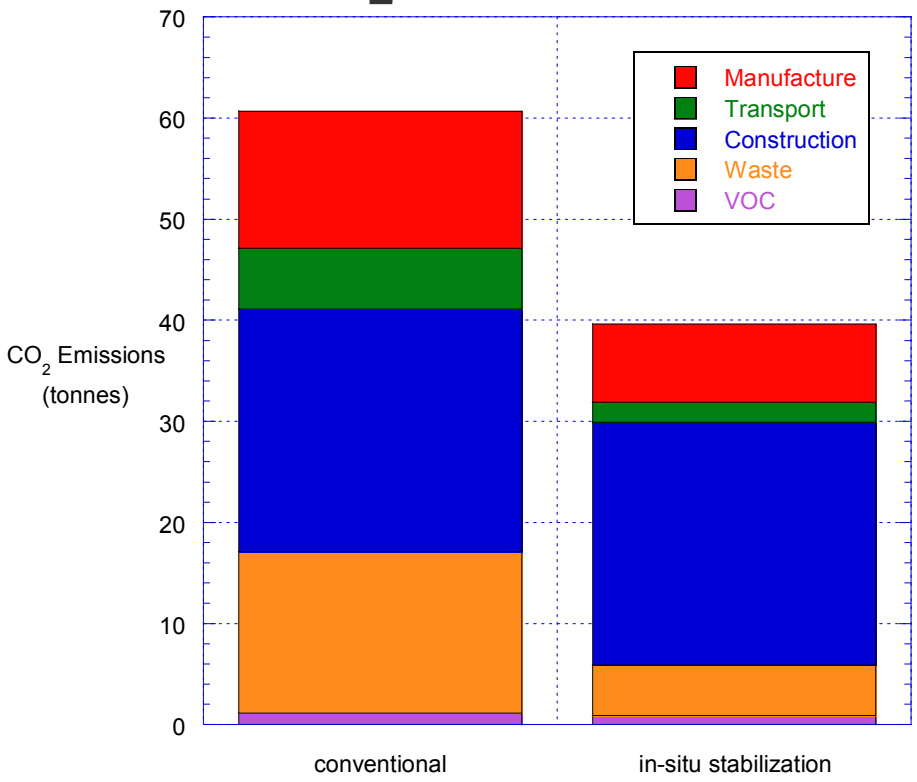
Average Road Width	14.4	m
Road Length	100	km
Average Depth	38	cm

Existing Tools:
Land Transport New Zealand

Energy Consumed



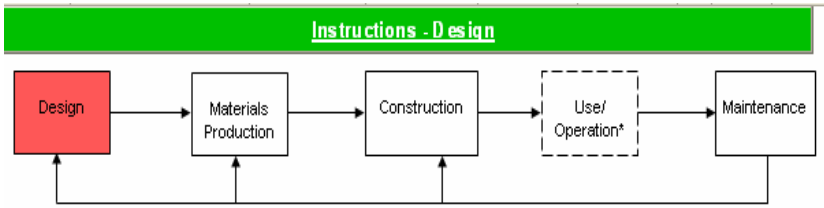
CO_2 Emissions



Existing Tools: PaLATE

Consortium on Green Design and Manufacturing
University of California, Berkeley

PaLATE
Pavement Life-cycle Assessment Tool for Environmental and Economic Effects

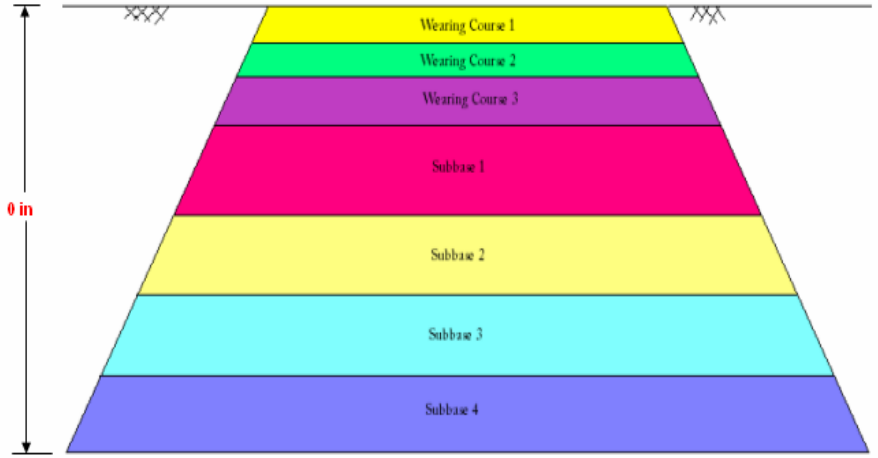


Only fill in the appropriate cells

Layer Specifications				
Layer	Width [ft]	Length [miles]	Depth [inches]	Volume [yd^3]
Wearing Course 1				0
Wearing Course 2				0
Wearing Course 3				0
Subbase 1				0
Subbase 2				0
Subbase 3				0
Subbase 4				0
Total			0	0

Embankment and Shoulder Volume [yd^3]:	

Period of Analysis [yrs] (40 yrs or less)	**40**



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Model Inadequacies

- Severe discrepancies exist between estimation models.
- Full analysis of *real* data needed to determine *actual* plant fuel consumption and emissions.
- Estimates are no longer sufficient.

Next Steps Proposed- 1

- Re-focus Research on Warm Mix Asphalt
  - Clarify the specific needs for drying aggregates and fines removal.
  - Define mechanism of Warm Mix Additives.
  - Investigate performance against conventional HMA.
- Enhance information database:
  - Construct and manage a comprehensive, open source energy and emissions database. Enable contractors to add pertinent data.
  - Define a baseline for where the industry currently stands in key sustainability indicators.

Next Steps Proposed - 2

- Advance cold asphalt application specifications and test methods to mirror the Superpave development for hot binders.
  - Science of asphalt emulsification should be the focus of significance research and development efforts.
- Develop a point system (similar to the LEED program):
  - Incentivize contractors and road agencies to recognize cost and resource savings in using sustainable methods.
- Advance existing models for life cycle assessments (such as WRAP or PaLATE) into an eco-efficiency model.

Acknowledgments - Collaborators

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  - AIChE - Institute for Sustainability
  - Other at MARC of the UW-Madison