Energy Development and US Infrastructure

November 9, 2016
Today’s Presenters

• **Moderator**
  Seri Park, Assistant Professor, Villanova University

• **Energy Development and Our Nation’s Infrastructure**
  Leslie McCarthy, Associate Professor, Villanova University

• **Energy Sector Use of Rural Low Volume Roads**
  Mark J. Nahra, County Engineer, Woodbury County, IA

• **Impact of Energy Development on Texas Highways**
  Jon Epps, Executive Associate Director, Texas Transportation Institute
NCHRP is...

A state-driven national program

- The state DOTs, through AASHTO’s Standing Committee on Research...
  - Are core sponsors of NCHRP
  - Suggest research topics and select final projects
  - Help select investigators and guide their work through oversight panels
NCHRP delivers... Practical, ready-to-use results

• Applied research aimed at state DOT practitioners

• Often become AASHTO standards, specifications, guides, manuals

• Can be directly applied across the spectrum of highway concerns: planning, design, construction, operation, maintenance, safety
A range of approaches and products

- Traditional NCHRP reports
- Syntheses of highway practice
- IDEA Program
- Domestic Scan Program
- Quick-Response Research for AASHTO
- Other products to foster implementation:
  - Research Results Digests
  - Legal Research Digests
  - Web-Only Documents and CD-ROMs
NCHRP Webinar Series

• Part of TRB’s larger webinar program
• Opportunity to interact with investigators and apply research findings.
Today’s First Presenter

- Energy Development and Our Nation’s Infrastructure

Leslie McCarthy, Associate Professor, Villanova University
Energy Development and Our Nation’s Infrastructure

Leslie Myers McCarthy, Ph.D., P.E.
Assoc. Professor, Villanova University
NCHRP Synthesis Project 469

- Principal Investigators: Leslie McCarthy, Anthony Giancola, & Seri Park
- Project Duration: October 2013 – September 2014
- TRB Program Officer: Jo Allen Gause
- Expert Panel: FHWA, ND DOT, Texas DOT, PennDOT, Oregon DOT, Scott County MN, Penn State Univ., Woodbury County, Iowa
- Final Report: NCHRP Synthesis 469

Courtesy: TxDOT
NCHRP Synthesis 469 Objectives

**Goals:**

- Document impacts of the energy sector on roads and bridges
- Identify state-of-the-practice strategies used by DOTs and local agencies to minimize and mitigate those impacts
- Help transportation managers understand and communicate energy development impacts on roads and bridges, and choose strategies for managing them
Project Approach

**Major Tasks:**

1. Review current practices by all states re: maintenance and planning in areas affected by energy development.
2. Survey all state DOTs & identify 5 states for further study.
3. Interview DOT staff, local agencies, and industry for input in the 5 case example states.
4. Conduct detailed phone interviews to obtain specific details.
Data Collection

Assess costs & damages to infra

Safety and Geometry

Engineering methods used for heavy loads

Photo: DVRPC Freight Planning
Agencies Interviewed

- DOTs, Counties, TTAP, and...
- Geographic distribution to include diversity in terms of climate, energy types, and development level
- Significant Impacts observed from survey responses
### Energy Sectors by Number of States

<table>
<thead>
<tr>
<th>Energy Sector</th>
<th>Number of States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biofuels</td>
<td>47</td>
</tr>
<tr>
<td>Coal</td>
<td>25</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>33</td>
</tr>
<tr>
<td>Nuclear</td>
<td>31</td>
</tr>
<tr>
<td>Oil</td>
<td>31</td>
</tr>
<tr>
<td>Solar</td>
<td>23</td>
</tr>
<tr>
<td>Wind</td>
<td>39</td>
</tr>
</tbody>
</table>

Adapted from U.S. Energy Mapping System
Synthesis Survey Responses

41 DOTs gave survey responses (rate of 80%)
Publications

More detailed information can be found in:

FHWA Public Roads Magazine
(Sept/Oct 2015 issue)

NCHRP Synthesis Report 469
(2015)

Rating of energy development impact level by facility type

<table>
<thead>
<tr>
<th>Facility Type</th>
<th>No Impact</th>
<th>Minimally Impacted</th>
<th>Moderately Impacted</th>
<th>Significantly Impacted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interstates or freeways</td>
<td>10</td>
<td>16</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Primary (National Highway System or state highway system)</td>
<td>4</td>
<td>13</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Secondary (minor arterials or collectors/distributors)</td>
<td>2</td>
<td>8</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Secondary (local roads)</td>
<td>2</td>
<td>9</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Damage or performance-related issues on infrastructure due to energy development activities

<table>
<thead>
<tr>
<th>Issue</th>
<th>DOTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noticeable increase in maintenance funds expended by DOT districts</td>
<td>7</td>
</tr>
<tr>
<td>for improvements to public roads and bridges near energy development sites</td>
<td></td>
</tr>
<tr>
<td>Noticeable increase in funding requests from local agencies for</td>
<td>5</td>
</tr>
<tr>
<td>capital improvement or resurfacing projects</td>
<td></td>
</tr>
<tr>
<td>Reports from local agency public works, law enforcement, or</td>
<td>12</td>
</tr>
<tr>
<td>engineering departments</td>
<td></td>
</tr>
<tr>
<td>Complaints logged from the public, commercial business owners, or</td>
<td>15</td>
</tr>
<tr>
<td>the energy sector industry</td>
<td></td>
</tr>
<tr>
<td>Change in recorded bridge rating or adequacy data from detailed</td>
<td>9</td>
</tr>
<tr>
<td>inspections</td>
<td></td>
</tr>
<tr>
<td>Change in recorded road condition (ride quality or distress levels)</td>
<td>14</td>
</tr>
<tr>
<td>survey data from detailed inspections</td>
<td></td>
</tr>
<tr>
<td>Windshield inspections or visual observations</td>
<td>18</td>
</tr>
</tbody>
</table>
Roadway Exposure Conditions and Amount of Damage Reported

- Roadway exposed to freeze/thaw or heave conditions
  - NE, NV, SD
  - UT
  - PA, ND, OH
  - IA, MI

Increase or acceleration in damage on roadways as being more pronounced during freeze/thaw conditions associated with energy developments.

Regulations in place to limit the amount of loading (e.g., weight restrictions, issuance of overweight permits) on roadways during freeze/thaw periods.
### Methods Reported to Assess Costs

<table>
<thead>
<tr>
<th>State</th>
<th>Practices for Assessing Infrastructure Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>Permit cost quantification (<a href="#">Cost Data</a>)</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Web-based road wear cost calculator (<a href="#">Tool</a>)</td>
</tr>
<tr>
<td>Montana</td>
<td>Continuous monitoring of population and traffic growth (<a href="#">Planning</a>)</td>
</tr>
<tr>
<td>Texas</td>
<td>Task force of state agency, local government, &amp; energy industry representatives (<a href="#">Coordination</a>)</td>
</tr>
<tr>
<td>Utah</td>
<td>Asset management and maintenance system (<a href="#">Database</a>)</td>
</tr>
</tbody>
</table>
Level of Cost Sharing between DOTs and Energy Companies

The chart shows the distribution of cost sharing for different states:

- **Alabama**: DOT Share and Energy Company Share.
- **Arkansas**: DOT Share and Energy Company Share.
- **Iowa**: Energy Company Share.
- **Pennsylvania**: Energy Company Share.
- **Utah**: DOT Share and Energy Company Share.
- **West Virginia**: DOT Share and Energy Company Share.

The distribution of cost sharing is indicated on a percentage scale from 0% to 100%.
<table>
<thead>
<tr>
<th>Measures Reported</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforcement of roads (e.g., use of geotextiles, stabilization of aggregates or subgrade)</td>
<td>Measure Rated as <strong>Very Effective</strong></td>
</tr>
<tr>
<td></td>
<td>West Virginia</td>
</tr>
<tr>
<td></td>
<td>Iowa, Nebraska, Pennsylvania, Utah</td>
</tr>
<tr>
<td>Roadway geometric feature modifications (e.g., widening paved shoulder, horizontal curve re-alignment, etc.)</td>
<td>Arkansas, Colorado, Iowa, Kansas, Texas</td>
</tr>
<tr>
<td></td>
<td>Alabama, Montana, North Dakota, Pennsylvania, Utah</td>
</tr>
<tr>
<td>More frequent use of law enforcement (e.g., limit the traffic especially during the periodic heavy rainfall)</td>
<td>Colorado</td>
</tr>
<tr>
<td></td>
<td>Arkansas, Montana, Pennsylvania, Texas, Utah</td>
</tr>
<tr>
<td>Encourage or require the <strong>use of detours</strong> and alternate routing for heavy trucks</td>
<td>Colorado, Iowa, West Virginia</td>
</tr>
<tr>
<td></td>
<td>South Carolina, Minnesota, Nebraska, Pennsylvania, Utah</td>
</tr>
<tr>
<td>Install additional signage to warn motorists of heavy truck traffic volumes in the area</td>
<td>West Virginia</td>
</tr>
<tr>
<td></td>
<td>Alabama, Pennsylvania, Utah</td>
</tr>
<tr>
<td>Lower the posted speed limit</td>
<td>Colorado</td>
</tr>
<tr>
<td></td>
<td>Alabama, Pennsylvania</td>
</tr>
<tr>
<td>Specific state or local legislation or regulations that apply to specific energy development industries (e.g., adequate public facilities ordinances, specific road and bridges design standards, etc.).</td>
<td>Colorado</td>
</tr>
<tr>
<td></td>
<td>Alabama, Pennsylvania</td>
</tr>
<tr>
<td>Temporary measures such as roadway embankments</td>
<td>Kansas</td>
</tr>
<tr>
<td></td>
<td>Pennsylvania</td>
</tr>
<tr>
<td>Campaigning and public outreach (e.g., ProgressZone in state of North Dakota)</td>
<td>North Dakota</td>
</tr>
<tr>
<td></td>
<td>Colorado, Pennsylvania, Texas, Utah</td>
</tr>
<tr>
<td><strong>Use of intelligent transportation systems (e.g., advance warning systems)</strong></td>
<td>Alabama, Colorado</td>
</tr>
<tr>
<td></td>
<td>Pennsylvania, Utah</td>
</tr>
</tbody>
</table>
### Traffic Operation Strategies Used and Rated Effectiveness

<table>
<thead>
<tr>
<th>Measures</th>
<th>States</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Encourage use of detours or alternate routing for heavy trucks</strong></td>
<td>Iowa, Pennsylvania, South Carolina</td>
</tr>
<tr>
<td><strong>Install increased signage to warn motorists of heavy truck traffic volumes</strong></td>
<td>Utah, Alabama, Pennsylvania, Texas</td>
</tr>
<tr>
<td><strong>Use of intelligent transportation systems (e.g., advance warning systems)</strong></td>
<td>Utah, Alabama, Colorado, Pennsylvania</td>
</tr>
<tr>
<td><strong>Collaborate with energy development companies to adjust the timing and logistics of the truck movements (e.g., staged truck routing schedule)</strong></td>
<td>Iowa, West Virginia, Colorado, Pennsylvania, South Carolina</td>
</tr>
</tbody>
</table>
Defining Challenges

- Coordination/Collaboration among agencies: 2 DOTs
- Routing of heavy vehicle traffic: 2 DOTs
- Road improvements to address geometric design issues: 3 DOTs
- Enforcement: 3 DOTs
- Accurate assessment of the impacts: 4 DOTs
- Land Permit, Lease; Other Load permits: 6 DOTs
- Adhere to specifications: 1 DOT
- Safety: 4 DOTs
- Traffic Increase: 4 DOTs
- Maintenance: 5 DOTs
- Operation/Monitor: 2 DOTs
- Accelerated degradation: 6 DOTs
- Lack of resources (e.g., difficulty in staff retention): 2 DOTs
- Lack of funding: 3 DOTs
## Tools to Address Challenges

<table>
<thead>
<tr>
<th>State</th>
<th>Tools Reported To Address Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Colorado</strong></td>
<td>Local agencies are developing fees to address issues with infrastructure damage.</td>
</tr>
<tr>
<td><strong>Missouri</strong></td>
<td>An approach where the <em>permit fee applied is commensurate</em> with the number of permits issued in order to address funding issues.</td>
</tr>
<tr>
<td><strong>Nebraska</strong></td>
<td>The cost is being extracted from the corresponding annual budget, as the amount is not significant.</td>
</tr>
<tr>
<td><strong>North Dakota</strong></td>
<td>The state legislature has provided <em>general fund money from the oil extraction fund to the DOT and local jurisdictions for road and bridge improvements</em>.</td>
</tr>
<tr>
<td><strong>Pennsylvania</strong></td>
<td>The <em>energy development sector</em> is responsible for the excess maintenance costs, inspection fees, and roadway condition survey costs.</td>
</tr>
<tr>
<td><strong>Texas</strong></td>
<td>A <em>unique relationship</em> between the current/future energy sectors and railroad commission has been developed.</td>
</tr>
<tr>
<td></td>
<td>Standard lease agreement with an associated fee.</td>
</tr>
<tr>
<td></td>
<td>Temporary use of water lines to reduce roadway truck volumes.</td>
</tr>
</tbody>
</table>
Steps in the process for maintaining roads bonded by unconventional energy industries in PA

If roads are posted with weight restrictions, an Excess Maintenance Agreement, security bond, and permit is required for hauling. The Excess Maintenance Agreement requires permitted haulers to leave roads in pre-hauling condition. As part of the Excess Maintenance Agreements, PennDOT requires a Maintenance Plan.

- Maintenance Plans are submitted to PennDOT's District Posting and Bonding Coordinator.
- The Maintenance Plans are circulated within PennDOT for comment and/or approval.
- Comments are provided to the hauler and a revised plan is submitted to PennDOT for approval.
- The hauler maintains and upgrades the posted roadway in accordance with the Excess Maintenance Agreement.
Conclusions

- **Strong correlation** between increase in negative impacts on safety and infrastructure deterioration.

- Increase in the issuance of Oversize and/or Overweight (OS/OW) permits.

Photo: Texas Dept of Transportation
Conclusions

- **Engineering approaches:**
  - increase the lane widths (and adding a pave shoulder)
  - increasing pavement thickness
  - stabilization of unpaved roadway surface layers

- **Repair funds:**
  - Combination of local and state funding

- **Compensation to state and local damaged roads:**
  - Various mechanisms
    - Development impact fees; user fee-based; energy-related permit fees; donation agreements

- **Most common type of contractual agreement:**
  - Use of state or local permits
Future Research Opportunities

Lack of...

1. Quantitative info on specific economic & social impacts
2. Safety and crash statistic data, especially for low volume roads
3. Info on existing low volume road pavement designs
4. Consistent, accurate approach for estimating damage & predicting pavement remaining service life
5. Investigation into detour routing
6. Info on extent of damage on high-type roadways
Moving Forward

Must balance competing outcomes of energy development & transportation

Data Collection
- Adequate staff resources
- Efficient methods for comprehensive crash data
- Use of available electronic databases

Periodic review of effectiveness of practices

Identify Performance Metrics

Engage freight planning divisions at DOTs, MPOs and RPOs

Photo: C. Barkan

Photo: Alaska Pipeline
Potential Mitigation Techniques

- Long-life flexible, rigid, or composite pavement designs.
- Asphalt or concrete mixture designs that resist heavy loads.
- Predetermined alternate routing for trucks based on structural condition ratings or inspection data.
- Temporary structural monitoring (sensors) on the most vulnerable bridges, culverts, or other structures.
- Use of ITS for advance warning systems, such as curve warning, real-time traffic congestion, and traffic incidents.
- Tagging of energy developer transport vehicles with GPS transponders.
- Increase signage to warn motorists of heavy truck traffic volumes.
- Media safety campaigns and increased enforcement.
- Collaboration with energy development companies.
Social Impacts of Fracking
A Pennsylvania Case Study

- **Fracking associated with More Heavy Truck Crashes**
  - Heavy Truck crashes rose 7.2% in heavily-fracked rural PA counties

- **Fracking associated with More Social Disorder**
  - Disorderly conduct arrests increased by 17.1% compared to 12.7% in unfracked rural counties

- **Fracking associated with More Cases of Sexually transmitted infections**
  - After fracking, average increase in chlamydia & gonorrhea increased 62% greater in heavily fracked compared to unfracked rural counties

*Food & Water Watch Report Sept 2013 report*
Questions / Comments?

- **Contact Info**
  - Leslie McCarthy: leslie.mccarthy@villanova.edu
  - Seri Park: seri.park@villanova.edu
  - Anthony Giancola: tonygiancola@rcn.com

Photo: Texas Dept of Transportation
Energy Sector Use of Rural Low Volume Roads

NCHRP 469: Impacts of Energy Developments of U.S. Roads and Bridges

Mark J. Nahra P.E.
Woodbury County Engineer (Iowa)
November 9, 2016
Iowa's Energy Sector

- **Rural Product**
  - Grain Crops
  - Biomass/Corn Stover
  - Wind

- **Energy Produced**
  - Ethanol and Biodiesel
  - Cellulosic Ethanol
  - Electricity
Energy issues in other states

- Local officials in other states have dealt with other parts of the energy sector.
  - Oil and Natural Gas development
  - Fracking – water and material transport
  - Logging
Energy Industry Effects on LVR

- **Change in traffic patterns**
  - Hauls to grain elevators, rail terminals, and river access changed as plants have located in new areas.
  - Ethanol plants located close to production – centroid location

- **Increased loads**
  - Construction traffic to wind generation sites
  - Corn yields increased over 100% in past 25 years
    - Corn hauled to farm storage or new plant sights that may not be along developed roads.
Iowa’s Current County Road System

- 89,000 miles of county roads
  - 17,775 miles of HMA and PCC paved roads
  - 69,000 miles of gravel roads
    - Most graded before 1960
    - Minimal gravel base
- Most are on 66 foot wide rights of way
- Intersections have inadequate turning radii for long loads.
Wind Farm Construction

- Construction loads are severe.
- Road Damage has occurred.
- Up to 450 Cubic Yards of Concrete per wind turbine base
- 45-50 loaded of concrete trucks per base.
Paying for road improvements/repairs

- Are we just asking for it? Do our economic development efforts and competing for new industry set us up for extra costs?
  - Counties sometimes encourage energy development with property tax credits
  - Valuation of energy production facilities can be a property tax windfall
  - Cities “steal” county developments by annexation
City Annexation
Energy Industry Effects on LVR

- Large loads delivering components
  - Turning radius on many rural intersections too tight for long loads
  - Temporary road embankments built to accommodate machinery movement

- Pavement life consumed
  - Construction loads: concrete, aggregate and steel for wind farms consume pavement life
Megaloads on County Highways

Courtesy of Mitchell County Engineers Office
Long Loads
Extremely long loads
Iowa BioFuel Production

- Iowa tops the nation in production of ethanol for fuel
  - Iowa produces 3.534 billion gallons per year
  - Number 1 in the nation, Nebraska no. 2 @ 1.6 billion gallons per year

- Iowa is now number 2 for wind generation of electricity (trailing only Texas)
Woodbury County

A recent research study (IHRB TR-608) calculates the amount of money needed to hold roads at their current condition level

- Paved Roads $24,000 per mile per year
- Gravel Roads $ 8,000 per mile per year
- Dirt Roads $ 1,000 per mile per year

Based on this, Woodbury County should budget $16,200,000 per year

Current FY 2017 Budget is $12,600,000

Paying for development is not easy when you already have a shortfall for meeting basic needs.
The search for answers

- What research has been conducted on the effects of the energy industry on our roads, and what are the results?
- What other indicators do we have on the effects of the energy industry on low volume roads?
- How can we address the impacts of significant increases in low volume road traffic from developments in the energy industry?
Research done in Iowa

- TR-593: Iowa's Renewable Energy and Infrastructure Impacts
- HR-1073: Heavy Agricultural Loads on Pavements and Bridges
- TR-548: Investigation of the Impact of Rural Development on the Secondary Road System

- These studies helped identify and quantify the problems.
New Attempts to Capture Funds for Road Repairs/Restoration

- Tax Increment Financing
- Adjacent property designated as an “Urban Renewal District” to allow funds raised to be targeted to development.
- Roads can be designated as the “urban renewal district”
- Funds used to repair and regrade roads
Woodbury County Urban Renewal District

Plant site
County Zoning

- Counties are beginning to use zoning to assist with managing wind farm development
- Areas targeted for wind farm development are accounted for as a permitted land use in zoning ordinance.
- Awareness of this potential use allows planning.
- County can be ready when the industry knocks on the door.
- Zoning doesn’t prohibit or encourage wind farm development, but it assures that there is a conversation before the ready mix starts rolling.
Zoning for Energy Sector Impacts

SPECIAL USE APPLICATION, REVIEW AND APPROVAL CRITERIA FOR A COMMERCIAL WIND ENERGY PROJECT (CWEP) FOR THE ZONING REGULATIONS OF COFFEY COUNTY, KANSAS.

Note: See Section 4-1013B.1 in the A-1 Agricultural District for Wind Energy Projects, Commercial as a Special Use.

A. Purpose.

The purpose of this statement is to outline required information for application of a Special Use and review and approval criteria for a Commercial Wind Energy Project (CWEP). A Development Plan is to be submitted with the application. These criteria are written to:

- Assist the Applicant and relevant authorities;
- Provide details of the CWEP;
- Provide information so individuals may gain an understanding of the CWEP;
- Provide a basis for public discussion and informed comment on the CWEP;
- Provide information regarding significant environmental, social, cultural and economic effects related to the CWEP, and;
- Provide a background on which decision makers will consider the project.

Information in the Application and Development Plan shall be as current as possible at the time of submission. Where information is unavailable or not yet finalized, estimates such as alternative options shall be provided and noted as estimates or alternatives. Not all matters in the criteria are relevant to all aspects of the project. Only those matters relevant to the particular project need be addressed.

B. Intended.

These criteria are intended to:

- Address major issues associated with the project; however, they are not all inclusive. Issues not listed may be deemed significant and issues may emerge as significant (studies, public input) during the course of review.
- These criteria are not intended to regulate the installation of the smaller individual/private wind energy conversion systems. (See Section 6-300814 and Section 2.102 for definition of Height, Maximum.)

Courtesy of Coffey County, KS
In addition to zoning, counties have made wind farm developer liable for road improvement costs.

Preconstruction agreements are put into place.

De-mobilization of wind farm is also an issue.

Wind generators have a finite life span of 10-20 years on components.

Plans need to be made for de-construction or component replacement at some time in the future.
Agreements prior to construction

• Courtesy of Coffey County, KS
Counties are becoming more proactive

• Talk to your neighbors and other states
• As wind farms grow in other areas of the country, lessons learned by counties can help everyone.
• Use groups like NACE and other statewide associations to assist in preparing for industry expansion.
• The need for new energy sources will not go away, use your opportunity to prepare for potential development if you have resource potential in your area.
Questions?
Impact of Energy Development on Texas Highways

TRB Webinar: Energy Development & US Infrastructure

November 9, 2016

Jon Epps
Texas A&M Transportation Institute
**Purpose**
- Support for districts
- Administrative/management information

**TxDOT**
- Special unit (pavement asset management)

**TTI**
- Interdisciplinary Research/support team
• Current repair strategies
• Factors involved in selecting strategies
• Determination of condition of existing pavement
• Define traffic (oil/gas development & production)
• Pavement thickness requirements
• Performance of repair strategies
Documents

- Energy Sector Briefs (ESB)
- Implementation Reports (IR)
- Technical Memorandum (TM)
- Research Reports (RR)
• Well development
  – 1,000 to 4,000 loaded trucks

• Well operation
  – Crude oil haul
  – Salt water haul
  – Re-stimulation (2,000 plus or minus)
  – Service equipment
• Oil/Gas permits issued/year-10,000 to 24,000
• Well development
  – Site preparation
  – Drilling
  – Completion
  – Operating Infrastructure
• Well operation
  – Crude haul
  – Salt water haul
  – Re-stimulation
  – Service equipment
Background

Economic Impact

• West Texas
  – $14.5 billion in 2012
  – 21,450 jobs
  – $1 billion in wages
  – $475 million in state revenue
Economic Impact

- South Texas
  - $46 billion in 2012
  - 89,000 jobs
Road Impacts

• Impacts
  – FM roadways
  – SH and US highways
  – IH highways

• Estimated damage per year
  – $1 billion to TxDOT system
  – $1 billion to local government system
Roadway Impacts

• **Maintenance costs**
  – From $500 to $1,500 per year
  – To $35,000 to $45,000 per year

• **Cost to industry (no repair)**
  – $1.5 to $3.5 billion per year
  • Equipment damage
  • Lower operating speeds

• **TxDOT expenditures annually**
  – TxDOT-$500 million
  – Local gov’t-$200 million
Drilling Activity, No. of Wells per Year vs. Price of Crude, $/Barrel

- Drilling Activity:
  - 10,000
  - 20,000

- Price of Crude:
  - 50
  - 100
Amount of Information Gathered

$$
\begin{array}{c}
\text{Large} \\
\text{Small}
\end{array}
$$

Repair Strategy

$$
\begin{array}{c}
\text{Routine Maintenance} \\
\text{Minor Rehabilitation} \\
\text{Major Rehabilitation}
\end{array}
$$
**Step 2 - Pavement Condition**

<table>
<thead>
<tr>
<th>Anticipated Maintenance/Rehabilitation</th>
<th>Pavement Condition Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
</tr>
<tr>
<td>Routine Maintenance</td>
<td>1</td>
</tr>
<tr>
<td>Preventive Maintenance</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>1, 2 &amp; 3</td>
</tr>
</tbody>
</table>
Step 1 - Geometrics/Pavement Characteristics

- Most important considerations
  - Quantity of existing materials
  - Width of lanes
  - Width of paved shoulder
  - Vertical controls
Step 2- Pavement Condition

- Level 1-Visual Condition Survey
  - Type of Distress
  - Severity of Distress
  - Extend of Distress
Step 2 – Pavement Condition
GPR
Step 2 – Pavement Condition FWD
Step 2
Pavement Condition

Dynamic Cone Penetrometer
Step 2
Pavement Condition
Step 2 – Pavement Condition Lab Testing
Open the layer panel
Expand/collapse a folder
Turn layer on/off

Completed in 2014

Completed in 2015

Permitted as of 12/2015
Axle Load Distribution: Tandem Axles
5-Axle (or more) Possible Energy Development Related Trucks

Frequency (Thousands)

Axle Group Weights, lbs (Thousands)
## Number of Trucks per Phase

<table>
<thead>
<tr>
<th>Well Development</th>
<th>Number of Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Barnett Shale</td>
</tr>
<tr>
<td>Drilling pad and construction equipment</td>
<td>70</td>
</tr>
<tr>
<td>Drilling rig</td>
<td>4</td>
</tr>
<tr>
<td>Drilling fluid and materials</td>
<td>59</td>
</tr>
<tr>
<td>Drilling equipment: casing, drilling pipe</td>
<td>54</td>
</tr>
<tr>
<td>Fracking equipment: pump trucks, tanks</td>
<td>74</td>
</tr>
<tr>
<td>Fracking water:</td>
<td></td>
</tr>
<tr>
<td>Fracking water (steel tank)</td>
<td>373</td>
</tr>
<tr>
<td>Fracking water (aluminum tank)</td>
<td>160</td>
</tr>
<tr>
<td>Fracking sand:</td>
<td></td>
</tr>
<tr>
<td>Fracking sand (steel tank)</td>
<td>40</td>
</tr>
<tr>
<td>Fracking sand (aluminum tank)</td>
<td>17</td>
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<tr>
<td>Other additives and fluids</td>
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</tr>
<tr>
<td>Flowback water removal</td>
<td>133</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>988</strong></td>
</tr>
<tr>
<td>Traffic, ESAL</td>
<td>&lt;0.5 Million</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>EF #Wells</td>
<td>&lt;10</td>
</tr>
<tr>
<td>PB #Wells</td>
<td>&lt;20</td>
</tr>
<tr>
<td>BS #Wells</td>
<td>&lt;40</td>
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</tbody>
</table>
Step 4 – Thickness Design

- Hot Mix Asphalt /Surface Treatment(s)
- Flexible Base
- Cold In-place Recycling
- Subgrade
- Full Depth
- Partial Depth:
  - Cement
  - Asphalt
  - No stabilizer
Step 4 – Thickness Design

Hot Mix Asphalt /Surface Treatment(s)

Cold In-place Recycling
+ Full Depth
+ Partial Depth:

Material Properties

Cement
Asphalt
No stabilizer
<table>
<thead>
<tr>
<th>Traffic, ESAL</th>
<th>&lt;0.5 Million</th>
<th>0.5-1.5 Million</th>
<th>1.5-3.0 Million</th>
<th>3.0-4.0 Million</th>
<th>4.0-5.0 Million</th>
<th>&gt;5.0 Million</th>
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<tbody>
<tr>
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<td>10-90</td>
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<td>200-270</td>
<td>270-340</td>
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<tr>
<td>PB #Wells</td>
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<td>250-340</td>
<td>340-440</td>
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<td>BS #Wells</td>
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<td>40-210</td>
<td>210-470</td>
<td>470-640</td>
<td>640-810</td>
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</tbody>
</table>

**Eagle Ford (Subgrade Modulus < 7ksi)**

<table>
<thead>
<tr>
<th>Surface</th>
<th>2 CST HMA</th>
<th>4” HMA</th>
<th>6” HMA</th>
<th>2 CST HMA</th>
<th>4” HMA</th>
<th>6” HMA</th>
<th>2 CST HMA</th>
<th>4” HMA</th>
<th>6” HMA</th>
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</thead>
<tbody>
<tr>
<td>CM 6”</td>
<td>11</td>
<td>7</td>
<td>6</td>
<td>12</td>
<td>8</td>
<td>6</td>
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<td>CM 8”</td>
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<td>6</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>12</td>
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<td>7</td>
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<tr>
<td>AE/NS 8”</td>
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<td>7</td>
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<td>12</td>
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</table>

**Medium Subgrade (Subgrade Modulus < 7 – 15 ksi)**

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<th>2 CST HMA</th>
<th>4” HMA</th>
<th>6” HMA</th>
<th>2 CST HMA</th>
<th>4” HMA</th>
<th>6” HMA</th>
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</thead>
<tbody>
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<td>CM 6”</td>
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<tr>
<td>CM 8”</td>
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<tr>
<td>AE/NS 6”</td>
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<td>12</td>
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</tr>
<tr>
<td>AE/NS 8”</td>
<td>12</td>
<td>6</td>
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</table>

**Permian Basin (Subgrade Modulus > 15 ksi)**

<table>
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<tr>
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<th>6” HMA</th>
<th>2 CST HMA</th>
<th>4” HMA</th>
<th>6” HMA</th>
<th>2 CST HMA</th>
<th>4” HMA</th>
<th>6” HMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 6”</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
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<tr>
<td>CM 8”</td>
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<td>6</td>
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<td>6</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>AE/NS 6”</td>
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<td>9</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>AE/NS 8”</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>6</td>
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</tr>
</tbody>
</table>

**BS # Wells:** Number of wells serviced by road in Barnett Shale; PB = Permian Basin; EF = Eagle Ford Shale

- CM 6” = Cement Modified FDR, 6 in. thick
- CM 8” = Cement Modified FDR, 8 in. thick
- AE/NS 6” = Asphalt Emulsion FDR or Non-Stabilized FDR, 6 in. thick
- AE/NS 8” = Asphalt Emulsion FDR or Non-Stabilized FDR, 8 in. thick

Not Recommended – Premature Failure Expected
TxDOT-TTI Joint Effort - Repair Guidelines

- Geometrics
- Pavement Condition
- Traffic
- Thickness Design

Constraints
- Financial
- Workforce
- Materials
- Weather/Scheduling
- Traffic Control

Routine Maintenance

Select Method

Economics

Rehabilitation
## Structural Design Considerations

<table>
<thead>
<tr>
<th>Subgrade</th>
<th>Shoulder Widths, Ft</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recommended</td>
<td>Minimum</td>
</tr>
<tr>
<td>Soft</td>
<td>6</td>
<td>4</td>
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<tr>
<td>Stiff</td>
<td>4</td>
<td>2</td>
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</tbody>
</table>
Repair Strategies

Routine Maintenance
- Shallow Patch
- Deep Patch
- Level-up
- Shoulder/Edge Repair

Preventive Maintenance
- Fog Seal
- Seal Coat (Chip Seal)
- Slurry/Micro Seal
- Hot Mix Asphalt

Rehabilitation/Strengthening
- Subgrade Stabilization
- FDR
- Flex Base
- Surface Treatment
- Hot Mix Asphalt
Expected Outcomes

• Select Repair Strategies that will
  – Improve opportunities for correct decisions
  – Reduce risk of incorrect decisions

• Reduce repair cost
  – First cost
  – Life cycle cost

• Reduce traffic disruption

• Improve safety
Step 8 - Rehabilitation

Lubbock
• Energy Sector Briefs (ESB)
• Implementation Reports (IR)
• Technical Memorandum (TM)
• Research Reports (RR)