Additional Road Investments Needed to Support Oil & Gas Production and Distribution in North Dakota

Upper Great Plains Transportation Institute
North Dakota State University

Presentation Topics

- Overview of study and results
- Details of Analysis
- Details of paved road analysis
  - Types of improvements, costs, and effects
- Details of unpaved road analysis
  - Types of improvements and analysis methods
- Conclusions and discussion

Study Overview

- Purpose:
  - Forecast road investment needs in oil and gas producing counties of North Dakota over the next 20 years
- Objective:
  - Quantify the additional investments necessary for efficient year-round transportation for the oil industry while providing travelers with acceptable roadway service

Study Overview

- Scope: The focus is on roads owned or maintained by local governments – e.g. counties and townships.
- Study Area: 17 oil and gas producing counties
  - Counties include: Billings, Bottineau, Bowman, Burke, Divide, Dunn, Golden Valley, McHenry, McKenzie, Mclean, Mercer, Mountrail, Renville, Slope, Stark, Ward, and Williams

Primary Data Sources

- Analysis based on: oil production forecasts, traffic data, county road surveys
- Types of roads analyzed: paved, graveled, and graded & drained
- 2010 survey→ information on impacted routes and conditions
- 2008 survey→ information on typical road characteristics

Production Forecasting

- Oil &Gas Division of North Dakota Industrial Commission
  - Existing and near-term drilling locations
  - Based upon current rig activity and permit applications through end of 2010
- Future locations of rigs estimated from lease data from North Dakota Land Department

Drilling Phases

- Initial phase: lease expirations 2010-2015
  - Assume drilling begins in final year of lease
- Fill-in phase: 3-5 additional wells placed
- Private leases will occur in same areas as public leases
- 21,250 wells drilled in next 10-20 years
- Assume 1,500/year→14 years to drill 21,250 wells

Traffic Prediction Model

- Forecasted output of wells is routed over road network using detailed GIS model
- Oil movements converted to equivalent truck trips following least-cost routes
- Projected inputs (e.g., sand and water) and outbound movements (salt water) similarly routed
- Movements of specialized equipment (such as workover rigs) included

Road Investment Analysis

- Predicted inbound and outbound movements accumulated for each impacted segment
- Oil-related trips combined with baseline (non-oil) traffic to estimate total traffic load on each road
- Economic/engineering methods used to estimate additional investment needs

Field Data: Traffic Counts

- Counters deployed at 100 locations
- Raw data adjusted
  - To represent traffic for 24-hour period
  - Monthly variation
- ADT=145; Trucks=61 (26 multi-units)
- Paved roads ≈ 100 trucks/day
- Data used to calibrate trip model and estimate baseline traffic loads

Estimated Investment Needs 2012-2013 -- 2030-2031 (Millions)

Unpaved Roads	$567.00
Paved Roads	$340.10
All Roads	$907.10
3% Inflation	$1,099.30
5% Inflation	$1,266.57

Investment Needs by Biennium (Millions)

Biennium	Unpaved	Paved	Total
2012-2013	$114.90	$118.20	$233.10
2014-2015	$114.90	$149.90	$264.80
2016-2017	$75.90	$17.00	$92.90
2018-2019	$36.90	$20.70	$57.60

Details of Analysis

- Data Collection
- Network Flow Modeling
- Unpaved Analysis
- Paved Analysis

Data Collection

- Roadway Data
  - Traffic Classification
  - Traffic Counts
  - Condition Data
- Cost and Practices Data
- Oil Development Data
  - Number and Locations of Wells
  - Inputs to Production
    - Origins and Destinations
  - Production Output
    - Origins and Destinations

Roadway Data

- Traffic Classification
  - Maps sent to county point person with instructions to classify roadways by traffic levels
  - Used to identify potential sample traffic count sites
- Traffic Counts
  - Selected using the classification data provided by the county point people
  - Used to calibrate the GIS network routing model and to verify vehicle classification
  - Photos were taken of many of the road segments where counters were placed, and used to verify surface type and condition data

Cost and Practices Data

- Survey of County Contacts
  - Component costs - Unpaved
    - Gravel
    - Blading
    - Location
    - Delivery
    - Placement
    - Dust suppressant
    - Paving costs

Cost and Practices Data

- Survey of County Contacts
  - Maintenance Practices
    - Gravel Overlay Interval
    - Gravel Overlay Thickness
    - Blading Interval
    - Dust Suppressant Usage

Cost and Practices Data

- County Level Cost Calculations
  - Due to the variations in reported costs and practices, unpaved costs were calculated at the county level
  - Reflects actual practices and actual costs at the time of the analysis

Roadway Data

- Condition Data
  - Maps were sent to the county point person with instructions to classify roadways by surface condition
  - Specific classification instructions were given, per the *South Dakota Pavement Condition Survey Guide*
  - 692 miles listed as either poor or very poor condition

Oil Development Data

- Numbers and Locations of Wells
  - Initial rig and well locations obtained from NDIC Oil & Gas Division website
  - Forecasted locations estimated from ND Land Department GIS shapefiles of public land leases
    - Leases for public lands only
    - Private land development assumed to be in the same geographic region as the public leases
    - Buffer public lands to estimate development areas on private land

Oil Development Data

- Forecasted locations estimated from ND Land Department GIS shapefiles of public land leases
  - ND Land Department data has lease expiration dates
  - Assumption that drilling will occur in the final year of the lease, and is a single well
  - Oil & Gas estimates 1,450-2,940 wells/year – 2,140 expected, 21,250 in 10 to 20 years
  - Lease expirations available through 2015
  - Post 2015 – filling in phase of drilling
    - 4-6 additional wells on the site

Oil Development Data

- Inputs
  - Data collected from Oil & Gas, NDDOT, and industry representatives
  - The goal was to quantify the number and type of truck trips that the well drilling process generates
  - The major trip generators were water, equipment and sand

Bakken Well Inputs

Table 1. Rig Related Movements Per Well		
Item	Number of Trucks	Inbound or Outbound
Sand	80	Inbound
Water (Fresh)	400	Inbound
Water (Waste)	200	Outbound
Frac Tanks	100	Both
Rig Equipment	50	Both
Drilling Mud	50	Inbound
Chemical	4	Inbound
Cement	15	Inbound
Pipe	10	Inbound
Scoria/Gravel	80	Inbound
Fuel trucks	7	Inbound
Frac/cement pumper trucks	15	Both
Workover rigs	1	Both
Total - One Direction	1,012	
Total Trucks	2,024	

Oil Development Data

- Outputs
  - Production (Oil & Gas)
    - County average IP rates
    - Production curve and pipeline access
    - Saltwater production
  - Oil collection/transload sites (Oil & Gas)
    - Current list of operating oil collection points
  - Saltwater Disposal Sites (Oil & Gas)
    - Current list of operating SWD sites

Network Flow Modeling

- Origins and Destinations
  - OD Pairs
    - Sand – Rig
    - Freshwater –Rig
    - Rig – Rig (Equipment)
    - Supplies (chemical, pipe, cement, fuel, etc.) – Rig
    - Rig - SWD
    - Rig – Collection Point
  - Assignment of Pairs
    - Closest destination chosen
    - Routing is based on the least cost path between origin and destination

Network Flow Modeling

- Scenarios
  - Baseline – Summer 2010
    - June Oil Sales
    - Existing Well and Rig Locations
    - Network Development and Refinement

Network Flow Modeling

- Forecast Flows
  - 2011, 2012, 2013, 2014, 2015, 2016-2020, 2021-2025, 2026-2030
    - Associated Volumes
      - Inputs (Water, Sand, Equipment, etc.)
      - Output (Oil and SWD)
  - Model Forecasted Traffic Movements
    - Generate Volume Estimates for Individual Roadway Segments

Unpaved Road Analysis

- Estimation of the additional maintenance and improvement activities due to oil development
- Impacted Miles: 11,834 gravel, 884 graded & drained

Table 23. Miles of Unpaved Road Impacted by Oil-Related Traffic		
County	Gravel*	Graded & Drained
Billings	560	28
Bottineau	924	113
Bowman	230	42
Burke	912	106
Divide	1,076	63
Dunn	968	105
Golden Valley	413	40
McHenry	335	24
McKenzie	1,046	69
McLean	451	34
Mercer	36	1
Mountrail	1,294	71
Renville	677	21
Slope	97	5
Stark	737	48
Ward	633	48
Williams	1,444	65
Total	11,834	884

Unpaved Roads

- Impacted means that at least one oil related truck was routed over the section in the network flow model
  - Impacts and needs vary by traffic levels
- Impact Classification
  - Low: 0-25 (10,930 miles)
  - Elevated: 25-50 (1,094 miles)
  - Moderate: 50-100 (409 miles)
  - High: 100+ (284 miles)

Unpaved Roads

- Improvement Types
  - Graded and Drained
    - Low: No additional improvements
    - Elevated: Maintenance increase
    - Moderate: Upgrade to gravel roadway (reconstruct)
    - High: Upgrade to gravel roadway (reconstruct)
  - Roadway Width
    - Initial condition of graded and drained roads are often deficient with respect to roadway width
    - Reconstruction includes regrading the road, and addition of width to a minimum of 24 feet with gravel overlay

Unpaved Roads

- Improvement Types
  - Gravel
    - Low: Decrease blading interval
    - Elevated: Decrease gravel interval by 33% (3-4 years)
    - Moderate: Decrease gravel interval by 50% (2-3 years)
    - High: Upgrade to double chip seal surface
  - Additional Enhancements/Improvements
    - Dust Suppressant
    - Reconstruction to eliminate deficiencies – roadway width and structural deficiencies

Unpaved Roads

- Chip Seal Improvement
  - Single Chip Seal
    - Constructed from a single application of binder followed by a single application of uniformly graded aggregate
    - Selected for normal situations where no special considerations would indicate that a special type of chip seal is warranted

FIGURE 11 Single chip seal.

Source: TRB: Chip Seal Best Practices

Unpaved Roads

- Chip Seal Improvement
  - Double Chip Seal
    - Constructed from two consecutive applications of both the bituminous binder followed by a single application of uniformly graded aggregate
    - Double chip seals have less noise from traffic, provide additional waterproofing, and a more robust seal in comparison with a single chip seal
    - Used in high stress situations, such as areas that have a high percentage of truck traffic or steep grades

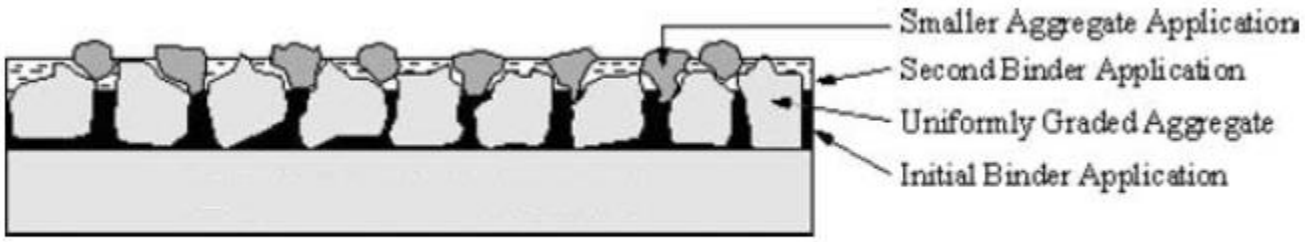

FIGURE 12 Double chip seal.

Source: TRB: Chip Seal Best Practices

Table 23. Projected Additional Needs by County ($2010 million)		
County	Gravel	Graded & Drained
Billings	$18.30	$0.30
Bottineau	$6.60	$0.00
Bowman	$2.10	$0.00
Burke	$17.10	$0.80
Divide	$47.90	$0.40
Dunn	$75.60	$5.40
Golden Valley	$22.70	$0.30
McHenry	$3.30	$0.10
McKenzie	$81.70	$4.40
McLean	$21.10	$1.10
Mercer	$0.80	$0.00
Mountrail	$76.10	$0.90
Renville	$11.10	$0.60
Slope	$2.50	$0.30
Stark	$35.70	$0.90
Ward	$29.30	$0.70
Williams	$97.20	$1.90
Total	$548.90	$18.10

Table S.3 Additional Unpaved Road Costs by County: 2012-2015 ($ 2010 Million)

County	2012-2013	2014-2015	2012-2013 Reconstruction	2014-2015 Reconstruction
Billings	$3.9	$3.9	$2.5	$2.5
Bottineau	$0.8	$0.8	$0.3	$0.3
Bowman	$0.5	$0.5	$0.3	$0.3
Burke	$3.2	$3.2	$1.8	$1.8
Divide	$9.4	$9.4	$6.0	$6.0
Dunn	$17.3	$17.3	$11.8	$11.8
Golden Valley	$4.3	$4.3	$2.9	$2.9
McHenry	$0.1	$0.1	$0.0	$0.0
McKenzie	$18.2	$18.2	$11.6	$11.6
McLean	$4.0	$4.0	$2.9	$2.9
Mercer	$0.2	$0.2	$0.1	$0.1
Mountrail	$15.9	$15.9	$10.1	$10.1
Renville	$1.9	$1.9	$1.1	$1.1
Slope	$0.6	$0.6	$0.5	$0.5
Stark	$8.1	$8.1	$5.7	$5.7
Ward	$6.2	$6.2	$5.0	$5.0
Williams	$20.2	$20.2	$13.6	$13.6
Total	$114.9	$114.9	$76.3	$76.3

Key Factors: Paved Road Analysis

- Thickness of aggregate base and asphalt surface layers
- Condition (extent of deterioration)
- Graded width
- Soil support (spring load restrictions)
- Truck weights and axle configurations
- Volume of oil-related traffic and other trucks

Paved Road Thickness (Inches)

	Layers	Mean	Minimum
CMC	Base	5.3	2.0
	Surface	4.4	2.5
Local	Base	4.5	2.0
	Surface	3.5	1.5

Medium-design: 4" AC, 8" Aggregate Base, 8" Subbase

Paved Road Conditions

- 68 miles in poor or very poor condition
  - Experiencing heavy oil-related traffic
  - Cannot be cost-effectively resurfaced
  - Must be reconstructed
- 334 miles in fair condition
  - Expected to deteriorate rapidly under heavy truck traffic
  - Reduced service lives

Spring Load Restrictions

- Relative damage from load may increase by 400%
- > 80% of miles are subject to 6- or 7-ton load restrictions or 65,000-lb gross weight
  - Reduced payloads for trucks
- Ideally, the most heavily traveled oil routes should be free from seasonal restrictions
- Reconstruction only guaranteed solution

Graded Roadway Width

- Determines if thick overlays are feasible without narrowing lanes and shoulders
- ≈ 50% of county roads ≤ 28 ft wide
- Narrower roads affect roadway capacity (e.g., vehicles per hour) as well as safety
  - Predicted crash rate for a two-lane road with 11-ft lanes and 2-ft shoulders is 1.38 x crash rate with 12-ft lanes and 6-ft shoulders

Reduced Road Service Lives

- Using AASHTO design equations, the service life of each impacted road is projected with and without oil traffic
- The average reduction in life is five years
- Williams, McKenzie, and Mountrail Counties have the most predicted miles with reduced service lives

Type of Road Improvements

- Reconstruction: $1.25 million per mile
  - Eliminate spring restrictions
  - Standard lanes with shoulders
  - Improved base-surface thickness ratio
- Structural overlay: $300,000 per mile
- Base-case: thin overlay
- Renewal costs: $8.90 per front-haul truck mile

Annual Road Maintenance

- Maintenance includes two optimally-timed seal coats, crack sealing, patching, striping, etc.
- Increases by 50% when traffic increases from low to medium levels
- Increases by 35% when traffic increases from medium to high levels
- Excludes administrative overhead

Additional Paved Road Funding Needs (Million $2010)

Improvement Type	Miles	Needs
Maintenance	958.4	$41.60
Overlay	249.4	$39.80
Reconstruction	225.6	$256.10
Renewal	483.4	$1.30
All Types	.	$338.90

Estimated Investment Needs 2012-2013 -- 2030-2031 (Millions)

Unpaved Roads	$567.00
Paved Roads	$340.10
All Roads	$907.10
3% Inflation	$1,099.30
5% Inflation	$1,266.57

Conclusion and Discussion

- Estimates for oil-impacted roads only
- Needs in addition to other road needs
- Investments will provide improved service for all road users; benefits include:
  - Year-round legal loads on key paved roads
  - Wider safer roads with more capacity
  - Reduced transportation cost
  - Lower life-cycle costs (incl. road user cost)