NORTH DAKOTA STRATEGIC FREIGHT ANALYSIS

Item IV. Heavier Loading Rail Cars

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Disclaimer

ABSTRACT

North Dakota's grain producers rely on an efficient rail system to move their products to export and domestic markets. In the 1999-2000 crop year, approximately 69 percent of all North Dakota grains and oilseeds transported to export and domestic markets were transported by rail.

A recent shift to larger grain hopper cars may threaten the viability of the state's light-density branch line network. The old industry standard of 263,000-pound cars capable of hauling 100 tons of grain is being replaced with 286,000-pound cars capable of hauling 111 tons of grain. Many light-density branch lines can not handle these larger cars, as they have light rail in place, shallow or poor ballast, and/or deferred tie maintenance. Although it is possible to load the larger rail cars at lighter weights or operate at lower speeds on such lines, railroads operating over such lines eventually will face a decision between upgrading and abandoning lines that cannot handle the 286,000 pound cars at full weight.

This study simulates the impacts of handling larger rail cars on many types of rail lines, models the decision process used by railroads in deciding whether to upgrade such lines or abandon them, estimates the costs of upgrading rail lines that are unlikely to be upgraded, and estimates generalized highway impacts that could result from the abandonment of non-upgraded lines.

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EXECUTIVE SUMMARY

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A recent shift to larger grain hopper cars may threaten the viability of the state's light-density branch line network. The old industry standard of 263,000-pound cars capable of hauling 100 tons of grain is being replaced with 286,000-pound cars capable of hauling 111 tons of grain. Many light-density branch lines can not handle these larger cars, as they have light rail in place, shallow or poor ballast, and/or deferred tie maintenance. Although it is possible to load the larger rail cars at lighter weights or operate at lower speeds on such lines, railroads operating over such lines eventually will face a decision between upgrading and abandoning lines that cannot handle the 286,000 pound cars at full weight.

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In simulating the impacts of handling larger rail cars on different types of rail lines, the study estimates that rail lines that have rail in place that is less than 90 pounds per yard are likely to need some form of upgrading to handle the larger rail cars. More than 1,200 miles of rail line in North Dakota have rail that is less than 90 pounds per yard. The costs of upgrading all of these lines are estimated to range between $258 million and $324 million, excluding the costs of bridge upgrading.

In modeling the railroad decision process on whether to upgrade lines with light rail to handle the larger cars, it was shown that railroads are likely to rank investment alternatives based on their internal rates of return. In estimating the internal rate of return to an upgrading investment, railroads are likely to use a maximum of an eight-year time frame for evaluating the benefits to upgrading. Moreover, the internal rate of return to the upgrading investment will depend on the proximity of the rail line to competitors' rail lines, the actions taken by competitors in terms of upgrading their rail lines, the ability of trucks to serve destination markets directly, the location of new shuttle train facilities, operational cost savings resulting from the upgrade, service improvements from the upgrade, and the cost of upgrading.

A numerical illustration of originating traffic levels where railroads are more likely to upgrade lines shows that at current revenue splits, short lines are unlikely to make the investment to upgrade in most cases, while Class I railroads may find it beneficial to upgrade at traffic levels as low as 35 to 40 cars per mile.[1] The illustration shows that a larger revenue share for short lines or a loan guarantee program that extends the length of loan terms available to short lines could increase the likelihood of upgrading lines with light rail on Short Line systems.

Finally, the study estimates the generalized highway impacts that would result from eliminating rail lines with various traffic thresholds. The study shows that the generalized

[1]This is only the case when the Class I has competition in close proximity. In cases where the Class I railroad does not have competition in close proximity, the railroad is unlikely to upgrade the branch line at any traffic levels, since the railroad can maintain its traffic without serving the branch line.

highway impacts resulting from eliminating rail lines are small in comparison to the rail upgrading costs. If all rail lines with less than 35 cars per mile originated and less than 90 pound per yard rail are eliminated (895.5 miles) and if highway impacts are realized in perpetuity, the total highway impacts may exceed $41 million, but the cost of upgrading these lines would exceed $191 million. Similarly, if all lines with less than 150 cars per mile originated and less than 90 pound per yard rail are eliminated (1,202.3 miles) and highway impacts are realized in perpetuity, the total highway impacts may exceed $73 million, but the cost of upgrading these lines would exceed $257 million.[2] Thus, a state-funded subsidy to upgrade all such potentially abandoned lines does not appear to be warranted. However, some subsidy may be justified on specific lines.

[2]These upgrading costs do not consider the costs of upgrading bridges. The need for upgrading bridges to handle heavy rail cars is very case specific. Thus, it is beyond the scope of this study to estimate bridge upgrading costs.

INTRODUCTION

North Dakota's grain producers rely on an efficient rail system to move their products to export and domestic markets. Because of the low-valued, bulky nature of grain products, and because of the long distances of North Dakota grain producers from points of consumption, rail is the least costly mode for transporting grain products to the market. In the 1999-2000 crop year approximately 69 percent of all North Dakota grains and oilseeds transported to export and domestic markets were transported by rail.

A large component of the North Dakota rail system is light-density branch lines. Currently, nearly two-thirds of all North Dakota route mileage is comprised of light-density branch lines. This branch-line mileage accounts for all of the state's Short Line mileage (1,287 miles) and nearly half of the state's Class I mileage (1,268 miles).

A recent shift to larger grain hopper cars may threaten viability of the state's light-density branch line network. The old industry standard of 263,000-pound cars that are capable of hauling 100 tons of grain is being replaced with 286,000-pound cars capable of hauling 111 tons of grain. Many light-density branch lines can not handle these larger cars, as they have light rail in place, shallow or poor ballast, and/or deferred tie maintenance. Although it is possible to load the larger rail cars at lighter weights or operate at lower speeds on such lines, railroads operating over such lines eventually will face a decision between upgrading and abandoning lines that cannot handle the 286,000 pound cars at full weight.

It is estimated that nearly one-third of U.S. grain currently is being hauled by these larger hopper cars.[3] While the shift to larger hopper cars provides benefits in the form of improvements

[3]Source: U.S. Public Use Waybill Sample, 1998.

in efficiency for railroads hauling on mainline track and in the form of potential rate incentives to shippers that are able to use such cars, it also may result in increased costs to shippers located on lines that can not handle such cars. Such shippers may be forced to transload at an alternative rail facility via higher-cost truck transportation – a shift that may cause accelerated highway deterioration and secondary economic impacts to affected communities.

This study examines the shift to 286,000-pound cars in the hauling of railroad grain and the potential impacts on the state of North Dakota. Specifically, the study:

- examines the economics of larger cars for railroads, and their historical share of railroad activity;
- reviews studies examining the rail infrastructure needed to handle 286,000 pound cars;
- provides simulations of hauling 286,000-pound cars on lines with different rail weights, tie conditions, and ballast depths;
- estimates the costs of upgrading North Dakota lines where such upgrading is likely;
- provides a description of the North Dakota light-density network, including traffic levels, rail conditions, and competitive conditions, providing a preliminary assessment of lines that will likely need upgrading, and those that are likely to be abandoned;
- presents a theoretical model of the railroad upgrading decision, making use of information provided in interviews of railroads serving North Dakota;

- develops estimates of traffic densities where railroads are more likely to upgrade rail lines;
- and discusses the types of impacts that the upgrading decision could have for North Dakota communities.

The next section of the report examines economics of the heavier loading rail cars.

THE ECONOMICS OF HEAVY HOPPER CARS

Larger rail cars can create several efficiencies for railroads, including: (1) reduced car and locomotive ownership costs, (2) reduced labor costs, (3) reduced fuel costs, (4) reduced car and locomotive maintenance costs, and (5) increased system capacity. At the same time, the larger cars also cause accelerated deterioration of track and its components, and potential line upgrading costs. The following paragraphs discuss the potential efficiency benefits and the accelerated deterioration of track and upgrading needs, and review studies that have examined the magnitude of the efficiency gains from switching to larger rail cars for large railroads.

Many of the cost savings offered by larger rail cars on railroad main lines are the result of an ability to carry more commodity weight with only a small increase in the weight of the equipment needed to haul the commodity. The gain in commodity weight capacity relative to the weight of the equipment needed to haul that commodity weight is referred to as an increase in the net-to-tare ratio. A higher net-to-tare ratio means that a given commodity weight can be hauled with fewer locomotives, meaning a savings in fuel costs, labor costs, and locomotive ownership and repair costs.

Additional cost savings are offered by large rail cars simply from their ability to carry more tons of the commodity. This results in a reduction in car ownership and repair costs, and an increase in system capacity due to an ability to handle more payload at side track locations.

However, hauling heavy rail cars also can result in increased deterioration of rail, ties, ballast, turnouts, and bridges. This may cause the need for increased routine maintenance and/or cause the need for upgrading of facilities.

One recent study examined the impacts of heavy rail cars on the efficiency of mainline operations.[4] In simulating operating and maintenance cost changes for larger cars in comparison to using 263,000-pound rail cars on a generic western coal route, the authors found 10 to 15 percent savings in crew costs, 10 to 2 percent savings in locomotive ownership costs, 10 to 1 percent savings in locomotive maintenance costs, 8 to 3 percent savings in car ownership costs, 3 to 12 percent savings in car maintenance costs, and 7 to 4 percent savings in fuel costs for 286,000-pound and 315,000-pound cars, respectively. They also found a 6 to 21 percent increase in track and bridge costs resulting from 286,000-pound and 315,000-pound cars, respectively. However, the overall effect of the larger rail cars was a net decrease in costs of between 7 and 2 percent for the 286,000-pound and the 315,000-pound cars, respectively. (See Figure 1). Studies by Zeta-Tech Associates performed for the Burlington Northern, and studies by the Association of American Railroads (AAR) have found similar results.[5]

Given these large potential cost savings, it is not surprising that there has been a shift to using the larger hopper cars in recent years. As railroads have started to replace portions of their grain car fleet, they have invested in 286,000 pound rail cars rather than the 263,000 pound rail cars used previously. Figure 2 shows the average payload capacity of the U.S. covered hopper car fleet from 1988 through 1997. As the figure shows, the average payload capacity of the covered hopper car has increased by three tons per car since 1991.

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[4]Kalay, Semih and Tom Guins, "Heavy Axle Loads: The Dollars and Sense Case" *Railway Age*, March 1998, pp 59-63.

[5]See "BN: Big-Car Economics," *Railway Age*, April 1990, pp 43-45.

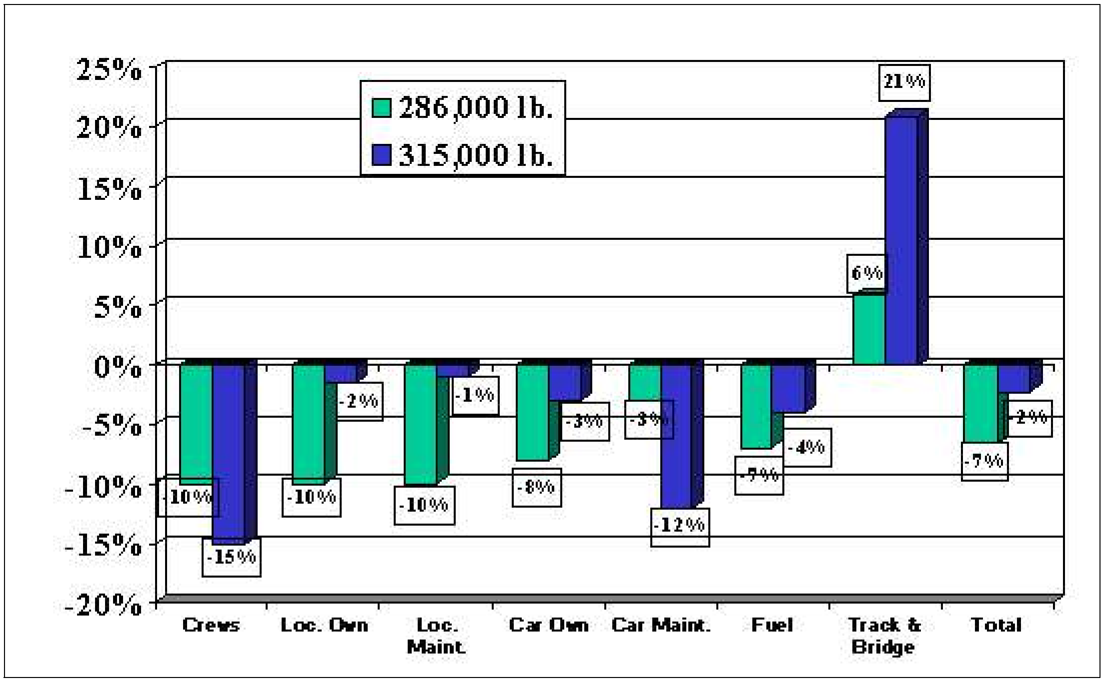

Figure 1: **Simulated HAL Savings on a Western Coal Route - Comparison to 263,000-Pound Cars**

Source: Kalay, Semih and Tom Guins, "Heavy Axle Loads: The Dollars and Sense Case," *Railway Age*, March 1998, pp. 59-63.

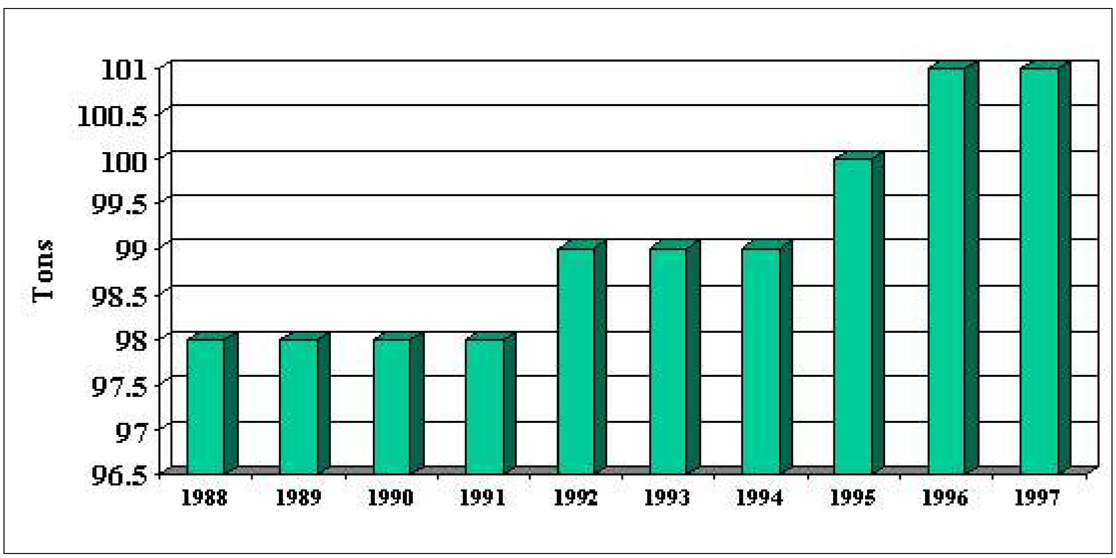

Figure 2: **Average Capacity of the U.S. Covered Hopper Car Fleet: 1988-1997.**

The shift in the use of the larger cars is even more dramatic, as shown by the proportion of railcars hauling grain that moved by the 286,000-pound cars in 1998. Figure 3 shows that the percentage of all U.S. rail grain hopper car loadings occurring in 286,000-pound configurations has increased from less than 1 percent of all covered hopper cars in 1993 to more than 27 percent of all covered hopper cars in 1998. This represents more than 28 percent of the tonnage of rail grain moved in hopper cars.

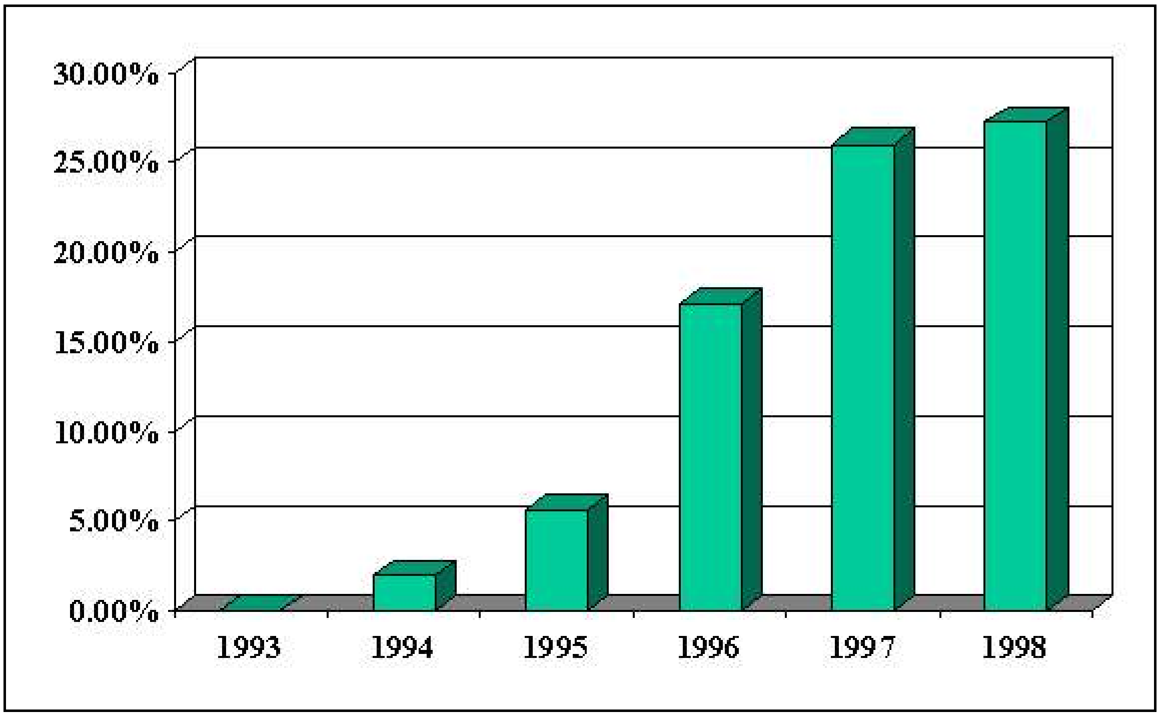

Figure 3: Percentage of Grain Hopper Cars Originating in 286,000 Pound Cars - U.S.

Source: U.S. Public Use Waybill Sample – 286 kip cars are estimated as those that have a nominal capacity of more than 109 tons.

Similarly, as Figure 4 shows, the percentage of all covered hopper car loadings of grain in North Dakota using the 286 kip[6] configuration has increased from 0 percent in 1993 to nearly 34 percent in 1999. For 1999, the 286 kip carloads loaded in the state of North Dakota amounted to nearly 38,000.

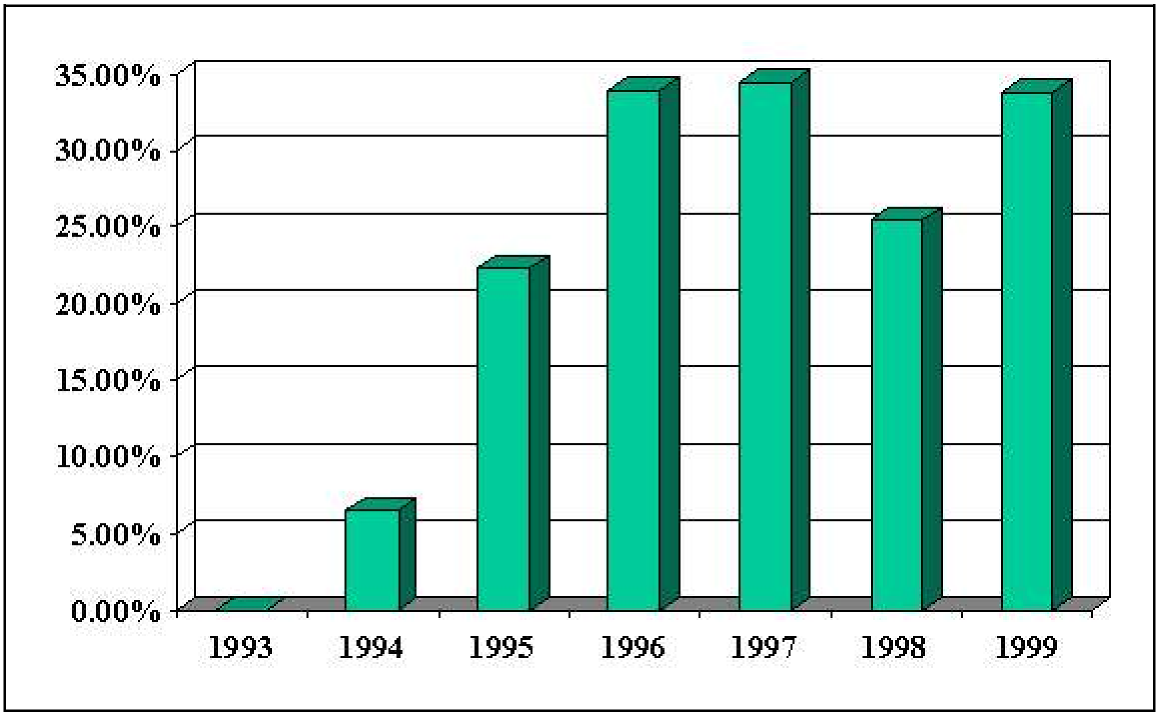

Figure 4: Percentage of Grain Hopper Cars Originating in 286,000-pound Cars - North Dakota
Source: North Dakota Master Waybill Sample – 286 kip cars are those identified as having a maximum allowable weight on rail of 286,000 pounds

This shift to larger cars in North Dakota and nationwide reflects the rate incentives put in place by railroad carriers. Shippers located on lines equipped to handle 286 kip cars have benefitted through lower rates. Table 1 shows the per bushel wheat rate savings at various North

[6] One kip is equal to 1,000 pounds.

Dakota locations resulting from fully loading 286 kip cars in comparison to fully loading 263 kip cars. As the table shows, North Dakota shippers save about three cents per bushel from fully loading the heavier rail cars in comparison to fully loading the 263 kip cars.

Table 1: Rail Rates for Shipping Wheat to the Pacific Northwest in Fully Loaded Rail Cars (52 car rate)

City	268 kip Rate (per bushel)	286 kip Rate (per bushel)	Savings (per bushel)	Percent Savings
Casselton	$1.21	$1.18	$0.03	2.48%
Dickinson	$1.15	$1.12	$0.03	2.61%
Williston	$1.16	$1.13	$0.03	2.59%

Problem for Light-Density Branch Lines

While the economics of larger hopper cars are positive for Class I mainlines, several factors suggest that the larger hopper cars may present a problem for Short Line railroads and for light-density Class I branch lines. Many of these light-density lines are built to lower standards than Class I main lines, and many have experienced deferred maintenance. Characteristics of light-density branch lines that may suggest a problem for hauling heavy hopper cars over those lines include:

- light rail (e.g., rail weighing 90 pounds per yard or less)
- thin ballast sections (e.g. less than one foot of ballast under ties)
- poor tie conditions (e.g. less than 10 good ties per 39 ft. section – almost four feet between good ties)
- old bridges

These characteristics suggest a problem because increased hopper car capacity places an increasing stress level on the track and its substructure. While the gross weight of the covered hopper car fleet and the gross weight of the covered hopper cars being used has been increasing over time, the basic axle design has remained the same. Most freight cars still have the same number of axles (four) and wheels (eight).[7] Consequently, axle and wheel loads have been increasing with gross car weights.

Table 2 shows that the wheel loads placed on rail track increased by nearly 20 percent when the 1970s standard of 220,000-pound rail cars was replaced by the 263,000-pound standard. The wheel loads placed on rail track will increase by nearly another 9 percent when the 286,000-pound standard is put in place.[8] For purposes of this study, the term used to describe cars with loads of more than the current standard (263,000 or 268,000 lb. gross weight) is heavy axle load (HAL) cars.

Table 2: Typical Freight Car Weights and Wheel Loads

Common Net Car Loads (Tons)	Gross Car Weights (Pounds)	Wheel Loads (Pounds)
80	220,000	27,500
100	263,000	32,875
101	268,000	33,500
111	286,000	35,750
125	315,000	39,375

[7]The 1999 North Dakota Waybill Sample shows that all covered hopper grain car shipments originating in the state had four-axle configurations.

[8]The percentage increase in wheel loads will be somewhat smaller on the BNSF and CPR 268,000-pound cars (approximately 7 percent).

This increase in wheel loads has important implications for the rail infrastructure needed to accommodate future grain hopper car shipments. The weight of the car is transmitted to the rails and the underlying track structure through these wheel loads. As wheel loads increase, track maintenance expenses increase and the ability of a given rail weight, ballast depth, and tie configuration to handle prolonged rail traffic decreases. Moreover, the ability of a given bridge to handle prolonged rail traffic also decreases as wheel loads increase.

On light-density branch lines that in many cases were built decades ago in an era of relatively light car weights, the increased wheel loads will likely require some form of upgrading. This is particularly true for branch lines with old bridges.

Because the negative impacts of heavier wheel loads on the track structure increase with increased speed, some Short Line railroads are trying to offset the negative impacts of heavier loads on their track by operating at slow speeds (e.g. 5 mph or less). However, it is doubtful that Short Line railroads can make the transition to HAL cars simply by operating at slow speeds. The opportunity cost of the freight cars, crews, and other productive assets is too great for these types of operations to work as a long term solution to the HAL problem. The next section of the study examines the literature that has made an assessment of the impact that HAL cars may have on track and bridge structures.

REVIEW OF LITERATURE

This review of literature examines studies performed in the early 1980s aimed at examining the potential impacts of the switch from 80-ton cars to 100-ton cars, and the more recent literature examining the impacts of a switch to the 111-ton cars. All of the studies provide insight into the types of impacts that heavier cars may have on rail sections and the potential magnitude of such impacts.

The review of literature covers two general areas of research regarding the shift to heavier loading cars. One area focuses primarily on the physical impacts of heavy cars on various track structures, while another focuses on current infrastructure needs and costs given the switch to heavier cars. The first area of research covered is that focusing on the physical impacts of heavier cars on track structures.

Part 1 - The Impact of Heavy Cars on Track Structures

Findings of the AAR Panel on 100-ton cars

In 1981, an AAR panel of distinguished railroad engineers compared the expected impacts of 220,000-pound cars (80-ton loading cars) on well-maintained tangent track with 132-pound continuous welded rail to the expected impacts of 263,000-pound cars (100-ton loading cars) on the same track. The panel concluded that rail life would be 1.5 to 2.1 times greater using the 220,000-pound cars, while tie and ballast lives would be 1.0 to 1.4 times greater under the lighter loads. The panel's report also noted that the impacts of heavier 100-ton cars would be much greater on light rail and poorly-maintained track. However, these effects were not quantified.

Findings of the Ahlf Study of 100-Ton Cars

Robert Ahlf (1980) developed an economic-engineering model of maintenance of way and structure (MW&S) costs using reported Class I railroad maintenance expenses and work load measures (such as gross ton miles).[9] He classified each MW&S cost element into one of three categories: 1) fixed costs; 2) costs that vary in relation to the mechanical actions of the track under load; and 3) costs that vary with rail life. The costs of ballast, ties, and track surfacing events were included in Category 2 (costs that vary with track mechanical action). Rail deflection was used as an indicator of the mechanical actions of the track under different axle loads and track support conditions.

Ahlf concluded that: (1) 39 percent of MW&S costs vary with track mechanical action, (2) 17 percent of MW&S costs vary with rail life, and (3) Industry deployment of 100-ton cars will reduce rail service life by about 50 percent (a finding that is consistent with the maximum impact projected by the AAR panel).[10] Ahlf's estimates of incremental MW&S costs are summarized in Table 3.

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[9]Ahlf, Robert E. "The Implications of the 100-Ton Car," *Modern Railroads*, February, 1980.

[10]His reasoning, in part, was that deployment of 100-ton cars changed the limiting factor in rail life from wear to fatigue-related defects, as discussed in the following passage: *Rail head contact stresses, previously of minor importance in determining rail life, are now the dominant factor. These stresses, beyond the elastic limit, are resulting in rapid propagation of fatigue-related defects which are becoming the primary limitation on rail life in tangent track. Depending upon the defect rate which a railroad is willing to live with, tangent rail life is being reduced to less than one-half of what it would otherwise be with lighter cars.*

Table 3:	Estimates of the Incremental Maintenance of Way Costs From 100-Ton vs. 80-Ton Cars	
Track Quality	**Incremental Cost per Ton-Mile (1980 Dollars)**	**Percentage Increase in Ton-Mile Cost**
Poor	$0.135	31.80%
Average	$0.107	39.20%
Good	$0.091	48.30%
Source: Ahlf, 1980		

Alf also compared the incremental track cost to the potential operational cost savings of 100-ton cars. He used data from nine unit train movements to estimate locomotive fuel, maintenance, and ownership costs savings. He also used freight car prices and expected service lives to develop annualized car ownership cost estimates. His overall conclusion was that railroads would incur a net economic penalty of .061 cents per ton-mile from the use of 100-ton versus 80-ton cars.[11]

AAR Studies of HAL Forces and Track Dynamics

The AAR has conducted a series of heavy axle load tests during the last 15 years. These tests have focused on rail/wheel interactions, the effects of heavy axle loads on track structure, and the effects of freight car suspension systems on vertical and lateral forces and dynamic loads.

In general, the AAR's tests have shown that freight cars experience dynamic loads in excess of 1.8 times the static load at high speeds due to a wide variety of track irregularities. The most damaging loads are produced by "harmonically excited vehicles," especially when "excited

[11]This net cost assumes that the freight cars averaged 200 miles per day.

by periodic, parallel 39' low joints."[12] In those cases, the AAR found that the peak vertical wheel load can be as high as 3 to 5 times the static wheel load.[13]

The AAR's findings on dynamic wheel loads are especially relevant to this study. Many branch lines are built with jointed 39-foot rails. In this track design, the wheel loads are transferred from one rail to another via joint bars. After years of use, the rail ends may become battered and areas of relatively low track support may develop under the joints. Even usable light rail sections may need to be welded into longer sections to dampen the peak dynamic wheel loads generated from HAL cars.

The next area of research reviewed is that focusing on current infrastructure needs and costs given the switch to heavier loading rail cars.

Part 2 - Current Infrastructure Needs and Costs

Findings of Iowa Department of Transportation

In 1998, the Iowa Department of Transportation (IDOT) analyzed the potential impacts of 286,000-pound cars on the state's branch-line network. IDOT made several assumptions regarding the track structure necessary for long-term performance:

- Replace all rail weighing less than 112-pounds per yard.
- Replace all turnouts whenever rail is replaced.

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[12]Kalay, Semih and Albert Reinschmidt. "An Overview of the Wheel/Rail Load Environment Caused by Freight Car Suspension Dynamics," A Paper Presented at the 68th Annual Meeting of the Transportation Research Board, Washington, D.C., January 1989.

[13]Kalay, Semih and Albert Reinschmidt. "An Overview of the Wheel/Rail Load Environment Caused by Freight Car Suspension Dynamics," A Paper Presented at the 68th Annual Meeting of the Transportation Research Board, Washington, D.C., January 1989.

- Replace enough crossties so that 75 percent of the ties in a rail section are non-defective.
- Add enough ballast so that at least six inches of clean ballast underlies the crossties.

Using these minimum standards, IDOT concluded that approximately 1,400 miles of rail line needed rehabilitation work in Iowa. The unit costs used in the Iowa analysis are shown in Table 4. As the table shows, IDOT estimates that it will cost $169,000 per mile to replace rails and turnouts, and approximately $262,000 per mile to completely upgrade a track section. The overall cost estimate includes the costs of crossties, ballast, tie plates, and other track materials.

Table 4: Track Upgrading Costs Used in the Iowa Department of Transportation Study

Cost Item	Cost per Mile
Rails and Turnouts	$169,156
Ties	$58,657
Ballast	$24,604
Miscellaneous	$9,968
Total	$262,385

None of the 1,400 miles of branch line identified in the Iowa study require complete rehabilitation. Thus, the average rehabilitation cost per mile is approximately $177,000. For the entire state, IDOT estimates that $250 million in rehabilitation costs are needed to accommodate 286,000-pound cars. Bridge rehabilitation costs are not reflected in this estimate.

Findings of Grain Short Line Railroad Study

Martens (1999) conducted a survey of "grain" Short Line railroads in the United States. He found that:

- 38 percent of the route miles of the responding railroads will not be able to adequately handle 286,000-pound cars even at slow speeds
- 18 percent of the grain shippers served by the responding railroads will be affected by track closings due to 286,000-pound cars
- approximately $119,000 per mile in track upgrading costs will be necessary to keep all route miles open
- another $52,000 per mile will be needed in bridge upgrading costs

On average, Martens estimates that it will cost approximately $267,000 to rehabilitate a bridge. His total upgrading cost estimate for grain Short Line railroads is $170,000 per mile, including bridge rehabilitation costs.

Findings of American Short Line and Regional Railroad Association Study

In 2000, the American Short Line and Regional Railroad Association (ASLRRA) commissioned a HAL study by ZETA-TECH. In this study, ZETA-TECH surveyed 46 Short Line and regional railroads. Collectively, these 46 railroads operate more than 4,700 miles of track and comprise approximately 10 percent of the industry's track miles.

In the survey, ZETA-TECH collected detailed information on track and bridge conditions, annual traffic volumes, and operating speeds. They also developed a series of "logic matrices" to determine when various combinations of rail weights, tie conditions, and ballast depths and qualities are adequate to handle 286,000-lb cars. Using the survey information in conjunction with the logic matrices, ZETA-TECH estimated the rails, ties, ballast, and bridges that need to be repaired or replaced for the sample of railroads. Then, they expanded the results of the survey to the Short Line industry.

The rehabilitation costs used in the American Short Line and Regional Railroad Association study are shown in Table 5.[14] As shown in the table, the cost to completely upgrade a mile of track, including turnouts, is estimated at approximately $516,000.

Table 5: Track Upgrading Unit Costs per Mile Used in American Short Line and Regional Railroad Association Study

Component	Unit	Cost
Rail	Track-mile	$345,966
Ties	Tie	39
Ballast (2")	Track-mile	2,000
Surfacing	Track-mile	5,636
Turnout	Turnout	41,605
Complete replacement	**Track-mile**	**$516,066**

Not all of the 4,700 miles analyzed in the ALSRRA study require complete rehabilitation. The average rehabilitation cost per mile is approximately $137,000, exclusive of bridge costs (Table 6). Expanding their results to the industry, ZETA-TECH estimates that approximately $6.86 billion in improvements are needed for Short Line railroads to accommodate HAL cars.

[14]*An Estimation of the Investment In Track and Structures Needed to Handle 286,000 lb. Rail Cars*, prepared for the American Short Line and Regional Railroad Association, ZETA-TECH Associates, 2000.

Table 6: Average Rehabilitation Cost per Mile used in the American Short Line and Regional Railroad Association Study

Component	Required Investment per Mile
Rail	$75,106
Ties	16,372
Ballast/Surfacing	2,657
Turnouts	7,882
Bridges	35,236
Total	**$137,253**

The studies reviewed in this section make important contributions to our collective understanding of HAL effects. Many of the same studies will be referred to again later in the chapter. Although important, these studies don't answer all of the questions regarding long-term use of HAL cars on branch lines. Nor, do they address the specific research objectives of this study.

In summary, the limitations of previous studies are:

- they don't describe conditions in North Dakota or provide information that can be used directly in policy evaluation; and
- they don't model track performance explicitly; therefore important conclusions are grounded in engineering judgment or proprietary models, which are not easily transferable to other states or circumstances.

In this study, the performance of track under heavy axle loads is analyzed using publicly-available models. As a result, the findings can be verified or replicated by others. The next section of the report provides a theoretical model of the impacts of HAL cars on various rail configurations.

Impact of HAL on Track Components

As shown previously, the static wheel load of a 286,000-pound car is 35,750 pounds. This represents a static wheel load to the rail that is nearly 9 percent greater than the 263,000-pound car, and 30 percent greater than the 220,000-pound car.

The impact that such an increase in wheel load can have on a particular section of track depends on the combination of rails, ties, tie plates, and ballast in place. In terms of load distribution, the rails, ties, tie plates, and ballast function as a system. The rail functions as a continuous beam (or at least continuous over a section) and spreads a wheel load longitudinally to several crossties via the tie plates. The crossties help distribute the load laterally and provide for a more uniform vertical distribution to the ballast section below. The ballast further distributes the load to the subgrade resulting in lower and more uniform pressure on underlying (natural) roadbed soils.

If the steel wheel and rail are relatively new, the contact area is about one-quarter of an inch. In this case, the static load on the rail resulting from a 263 kip car is 131,500 pounds per square inch (psi). Ideally, the track structure must distribute this wheel load to the subgrade so the maximum stress does not exceed 20 psi.[15] To complicate matters, dynamic loads from a freight car in motion are much greater than static wheel loads.

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[15]Stress is defined by a load (or force) divided by the area over which it is applied. It can be measured in pounds per square inch (psi). The bending or vertical stress applied at the rail is related to the wheel load and the contact area. The maximum allowable stress in the subgrade varies with soil characteristics and environmental factors. The 20 psi value is a generalization. The actual subgrade bearing capacity at which significant permanent deformation occurs varies with local conditions.

To assess the performance of track, a characteristic known as track resilience or elasticity is considered. Resilience or elasticity is the ability of a material to return to its original shape or position after an applied load has been removed.[16]

One of the most important factors in determining the ability of track to return to its original shape and position after the applied load is removed is the amount of elastic compression and rebound of a track structure, referred to as deflection. Vertical deflection (measured in inches) is the best single indicator of track strength, life, and quality.[17]

Obviously, some track deflection is unavoidable and necessary to provide a smooth ride and to prevent breaking of various railcar components.[18] However, excessive deflection results in differential movement and wear of track components. Tie and ballast actions can result in ballast abrasion, which leads to many additional problems, including poor drainage. Excessive deflection also can result in permanent deformation of subgrade soils. As noted by Hay (1982), the "up-and-down pumping action of the track as wheel loads are repetitively applied and released is a prime source of track deterioration."[19]

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[16]In the case of railroad track, elasticity is the ability of the track structure to return to its original *surface* condition (e.g., smoothness or vertical evenness over distance) and *alignment* (the position of the track in the horizontal plane). However, even with proper elastic responses under ideal conditions, some small permanent deformation typically occurs in track materials from applied heavy car loads. Consequently, over time (and under heavy loads) the subgrade and even the ballast gradually will compress or consolidate.

[17]Hay (1982).

[18]Hay (1982).

[19]Ibid.

Over the years, several agencies and individuals have developed guidelines for maximum deflection including the American Railway Engineering and Maintenance Association (AREMA, 1974)[20] and Lundgren (1970).[21] These guidelines are summarized in Table 7. The AREMA guidelines recommend a maximum deflection of 0.25 inches for heavy track with reasonably firm subgrade. The limit of desirable deflection for track of light construction is .36 inches. According to the guidelines, track that deflects .40 inches or more will deteriorate quickly under heavy axle loads.

Table 7: Vertical Track Deflection Ranges and Expected Track Behavior

Maximum Deflection (Inches)	**Track Behavior**
0.00 to 0.13	Deflection range for track that will last indefinitely
0.13 to 0.25	Normal maximum desirable deflection for heavy track to give requisite combination of flexibility and stiffness
0.36	Limit of desirable deflection for track of light construction ($\leq$ 100 lb)
0.40 or greater	Weak or poorly maintained track that will deteriorate quickly

[20] At the time these guidelines were developed, AREMA was the American Railway Engineering Association. In this study, all references to this association use the current name. A key reference for the deflection guideline of 0.25 inches is: Report of the Committee on Economics and Construction Maintenance, *Proceedings of the American Railway Engineering Association*, 1974.

[21] The source of the deflection guidelines shown Table 7 is: J.R. Lungdren, et al., *A simulation Model of Ballast Support and the Modulus of Track Elasticity*, Transportation Series Report 14, University of Illinois, 1970. The criteria are shown in Figure 15.8 of: William W. Hay. *Railroad Engineering*, 2nd Edition, John Wiley & Sons, 1982.

The performance of a given section of track under dynamic wheel loadings is a function of the weight of the rail in place, the quality of the subgrade, the quality and depth of the ballast underneath the rail, and the spacing and condition of the crossties in place. This section will highlight the role played by each of these characteristics.

The most obvious track characteristic affecting the performance of a section of track is the rail weight. Rail weight is measured pounds per yard. Heavier rail increases the stiffness of the track structure and reduces deflection. Moreover, heavier rail contributes to overall track stability and acts as a "bridge" over areas of weak track support (e.g., sections of failed cross ties or poor ballast and subgrade). Because of its greater bending resistance, heavier rail increases the lives of crossties.

Rail stiffness or bending resistance increases with the *moment of inertia* (I). In steel beams of similar cross section (such as T rails), the moment of inertia is proportional to the cross-section area and varies with the square of the weight (Hay, 1982).[22] Intuitively, its importance is as an indicator of rail stiffness.

Figure 5 shows an approximate relationship between rail weight and stiffness for common rail sections. As the figure shows, replacing 85-lb rail with 115-pound rail doubles rail stiffness. Replacing 70-lb rail with 115-lb rail increases rail stiffness 3.7 times.

HAL cars cannot be accommodated simply by laying heavier rails. The support beneath the rails is a critical factor. William Hay, author of a classic text in railroad engineering, writes:

> *A common correction for poor track has been to lay new and heavier rail. The money might often be better spent in increasing the strength and stiffness of the*

[22]Moment of inertia is measured in inches to the fourth power.

rail support. One might as well try to stabilize a sinking building by adding another story to it.

The track structure truly is a system. The quality of one component affects overall performance, as well as the life expectancies of other components. Simply increasing the weight of rail, which creates greater stiffness or bending resistance, will not necessarily compensate for other poor components (e.g., ties or ballast).

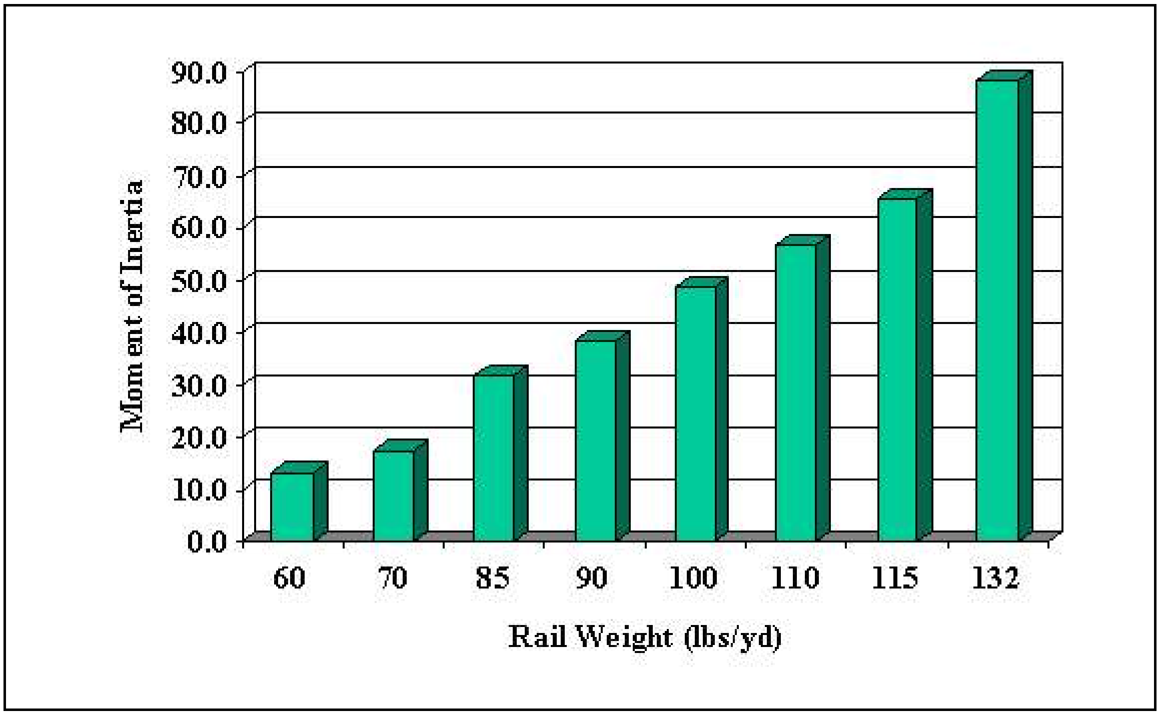

Figure 5: Relationship Between Rail Weight and Rail Stiffness

A measure of track quality that captures the important role played by the support underneath the rail is called *modulus*. Modulus can be defined as "the amount of load in pounds on a one-inch length of rail required to compress the track by one inch."[23] Modulus simultaneously reflects track stiffness and flexibility. Just as it is not desirable to have a track structure that is too flexible, it also is not desirable to have a track structure that is too stiff.

[23]Hay (1982).

Track modulus is affected by ballast depth and quality and by subgrade characteristics. However, modulus also is impacted by crosstie characteristics and conditions. Generalized track modulus values are shown in Table 8.

Table 8:	**Generalized Track Modulus Values**
Very Low	500 psi
Poor	1,000 psi
Average	2,000 psi
Good	3,000 psi
Very Hard	5,000 psi
Source: Ahlf (1988)	

Modulus and moment of inertia are important components in determining the track deflection resulting from a given wheel load. As shown in Figure 5, replacing 100-pound rail with 132-pound rail will increase moment of inertia by about 80 percent. However, the impact of this replacement on overall track deflection resulting from a given wheel load will only be a 14 percent decrease, if the replacement is on a track with average support (e.g., modulus of 2,000 psi). In comparison, changing the track support itself has a much greater impact on the overall deflection. For example, an 80 percent increase in modulus— from 2,000 to 3,600 psi—will decrease deflection by about 36 percent.

Track modulus is affected by ballast depth and quality, subgrade characteristics, and crosstie conditions and spacings. The following paragraphs discuss the effects of tie spacing and condition on modulus.

A wheel load may be distributed to more than seven crossties in a conventional track structure, with the center tie carrying between 15 percent and 40 percent of the load (Zarembski, 1992). The dimensions and qualities of the crossties and the effective tie spacing affect the load distribution per tie in a section of track.

In general, tie spacing refers to the center-to-center distance between adjacent ties. Design spacings may range from 19.5 inches on high-traffic main lines to 24 inches on low-traffic branch lines. However, *effective* tie spacing means the center-to-center distance between non-defective ("good") ties. Broken, split, rotting, or otherwise damaged crossties may not qualify as "effective ties" since their load distribution capabilities are diminished.

Fewer effective ties under a section of rail (and/or greater spacing between ties) means that each good tie must assume a higher unit load. For example, each tie in a track section with an effective spacing of 19.5 inches would bear approximately 40 percent of the axle load distribution. In comparison, the same type of tie located in a track section with an effective spacing of 28" would bear approximately 60 percent of the load distribution. Figure 6 illustrates the relationship between track modulus and effective tie spacing for an otherwise "average track."

An effective tie spacing of 19.5 inches (a mainline standard) results in approximately 24 non-defective ties per 39-foot rail section, or 3,200 ties per mile. An effective tie spacing of 29 inches corresponds to approximately two-thirds non-defective ties per rail section. An effective tie spacing of 39 inches corresponds to approximately half non-defective ties. Finally, an effective spacing of 59 inches results in only one-third of the non-defective ties typically found in a mainline section.

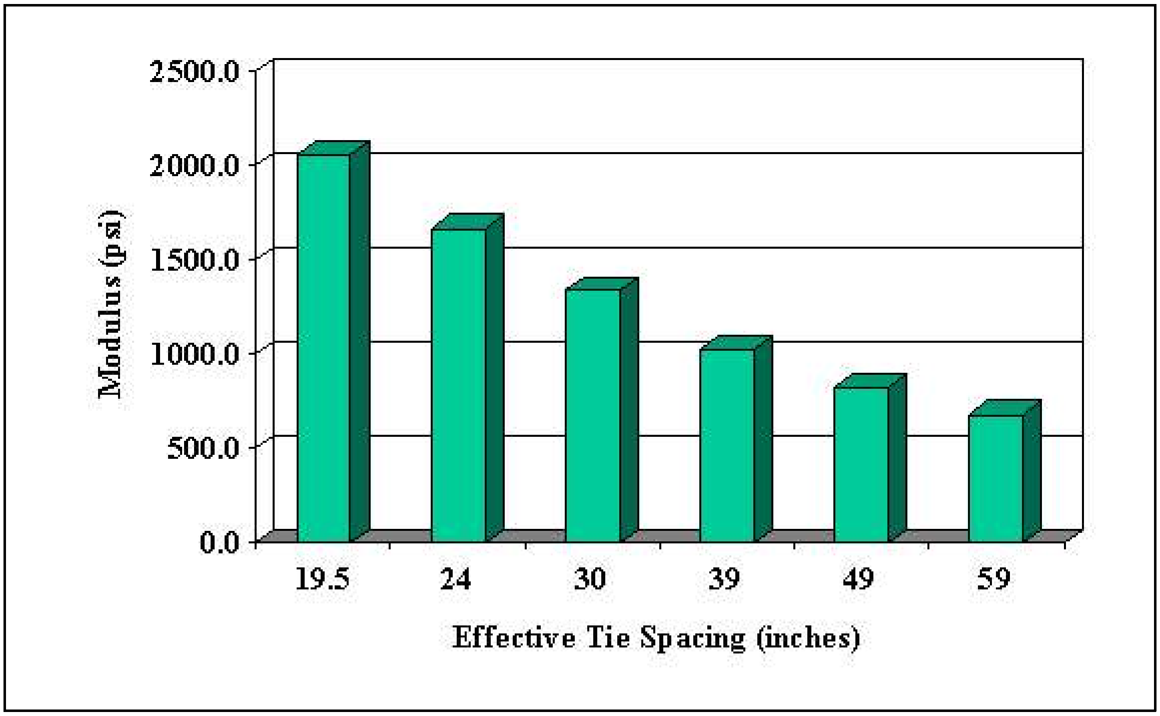

Figure 6: Effect of Tie Spacing on Track Support

Ballast depth also has an important impact on track support. As Hay notes, "it is evident that a major portion of track deflection occurs in the support system beneath the ties."

As noted previously, the dynamic wheel loads from a freight car in motion are much greater than the static wheel loads. Thus, speed plays an important role in the effects of heavy axle loads on a given track section.

The impact of speed on deflection is shown through a dynamic factor. The dynamic factor is a multiplier that increases the stress of a static wheel load to account for the effects of roll, slip, vibration, unequal load distribution, and related forces of motion.

Figure 7 illustrates dynamic factors for train speeds of 40 mph or less on average track.[24] As the figure shows, the dynamic factor increases from 1.09 at 10 mph to 1.35 at 40 mph.

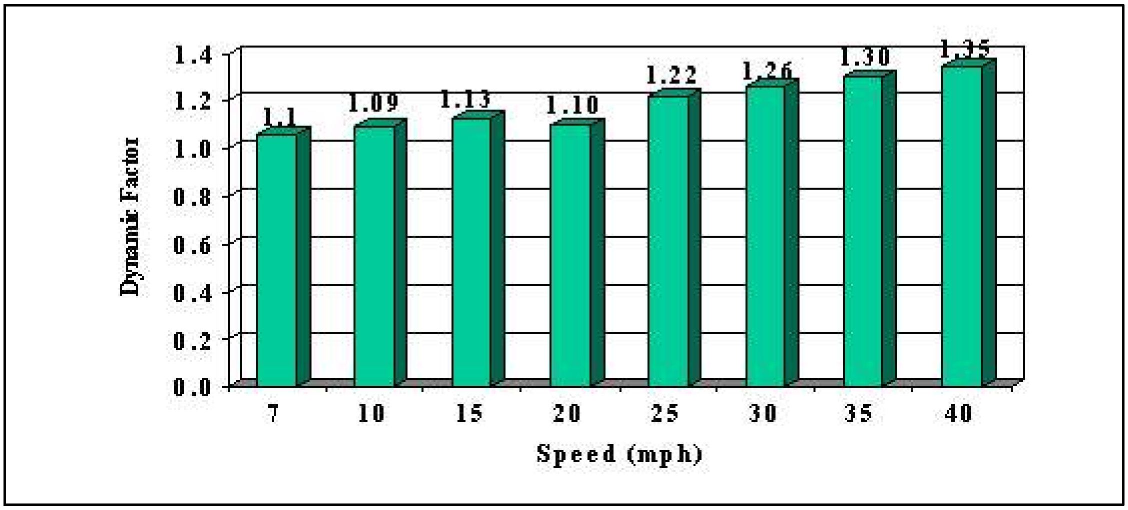

Figure 7: General Effects of Speed on Dynamic Load Factor
Source: Authors' calculations using 38" wheels representative of most 286 kip cars – the AREA equation for dynamic wheel loads is used.

Although the factors shown in Figure 7 are useful, they don't distinguish among types of track. The AAR has concluded that freight cars sometimes experience dynamic loads in excess of 1.8 times the static load at 40 mph due to a wide variety of track irregularities. Figure 8 shows other dynamic factors frequently used in track analysis. These factors are a function of speed and track quality. As the chart shows, the dynamic factor ranges from 1.28 on good track at speeds of less than 40 mph to 2.37 on poor track at speeds of 80 mph. As the chart also illustrates, the "poor track" dynamic factor is 1.5 times greater than the "good track" dynamic

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[24]Calculated from the following AREA equation:

Dyn. Factor = (33*Speed)/(wheel diameter*100).

factor at speeds of less than 40 mph. The next section of the report simulates the impacts of 286 kip cars on different track configurations.

HAL Simulation Methodology

In this study, track performance is simulated using a track deflection equation originally developed by the American Railway Engineering Association Committee on Track Stresses, based on the work of A. N. Talbot. The Talbot equations have been widely used in track analysis. They are documented in Hay (1982).[25] According to Hay, Talbot=s equations are

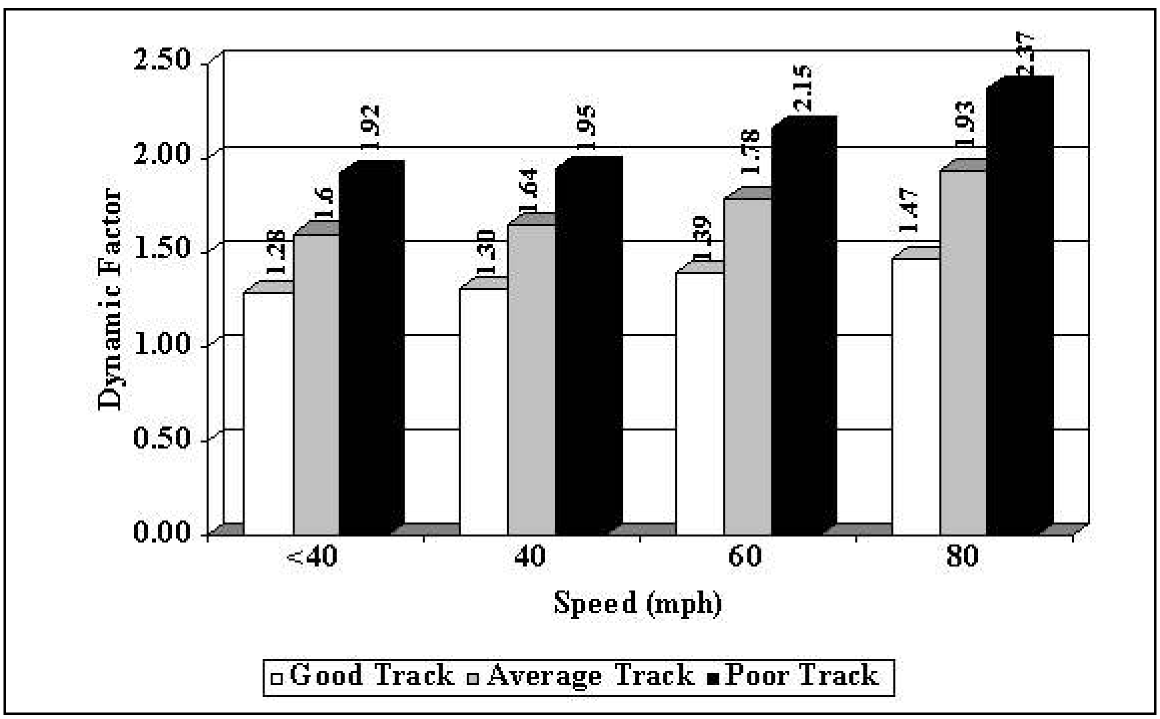

Figure 8: Dynamic Wheel Load Factors as a Function of Speed and Track Quality
Source: Alf, 1988.

[25] Ahlf (1988) illustrates the use of a similar stress model in track analysis.

Acomprehensive@ and Aproduce results very close to those observed in the field.@ The primary track deflection equation used in this study is shown in Equation 1.

Equation 1

$$Y_0 = \frac{P}{\sqrt[4]{64\,EIu^3}}$$

Where: Y_O = Vertical deflection (in inches)
P = Dynamic wheel load (in pounds)
E = Elasticity of rail steel (30,000,000 psi)
I = Moment of inertia of a steel rail (Figure 5)
u = track modulus (psi)

As shown in Equation 1, deflection (Y_o) is directly related to the dynamic wheel load (*P*) and inversely related to track support. Specifically, deflection is inversely related to the three-quarters power of track modulus (*u*). Furthermore, deflection is inversely related to the 4th root of rail stiffness as measured by moment of inertia (*I*) and the modulus of elasticity of rail steel (*E*).

Light-Rail Simulations

In this study, simulations are performed on 90-, 70-, and 60-pound rail using Equation 1. These simulations are done to make an assessment of the impacts that 286 kip cars are likely to have on many North Dakota branch lines. As shown in a subsequent section, lines that are 90 pounds or less make up more than 1,700 miles of track and account for more than 75 percent of all branch line mileage in the state.

Most simulations are performed using a ballast depth of six inches with various amounts of ties in good condition.[26] Specifically, the simulations are run under a scenario where one out

[26]Conversations with Short Line operators suggest that six-inch ballast depth represents the high end for most North Dakota branch lines. To the extent that ballast is deeper (more

of every 14 ties is bad (21 inch spacing), a scenario where one out of every three ties is bad (29 inch spacing), a scenario where one out of every two ties are bad (39 inch spacing), and a scenario where two out of every three ties are bad (59 inch spacing).[27] Different North Dakota rail lines may have ties in any of these conditions. They also may have different ballast depths and conditions, and subgrade conditions from those simulated. Thus, the ability of a particular rail weight to accommodate 286 kip cars can not be estimated precisely. Nonetheless, these simulations will provide insight into areas where long-term accommodation of 286 kip cars is less likely.

The first simulation is for a 90-pound rail section, with rail traffic moving at 35 mph. The simulation is done for six inches of ballast and for 12 inches of ballast. Figure 9 shows the simulation results.[28] Although the track deflections exceed recommended maximums in all cases, deflections are less than one-half inch with good tie maintenance (i.e. an effective tie spacing of 21 inches).

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shallow) on a particular line, the simulations could overstate (understate) the likely deflection.

[27]A bad tie is defined as one with little or no weight-bearing support.

[28]A beginning track modulus of 1,500 is used for 6" ballast (a modulus of 1,500 is right on the borderline between average and poor) and a beginning modulus of 2,056 is used for 12" ballast, with modulus deteriorating as more bad ties are introduced. The simulation assumes a dynamic factor of 1.6 (average track) for 21-inch tie spacing and 1.92 (poor track) for 29 - 59-inch tie spacing.

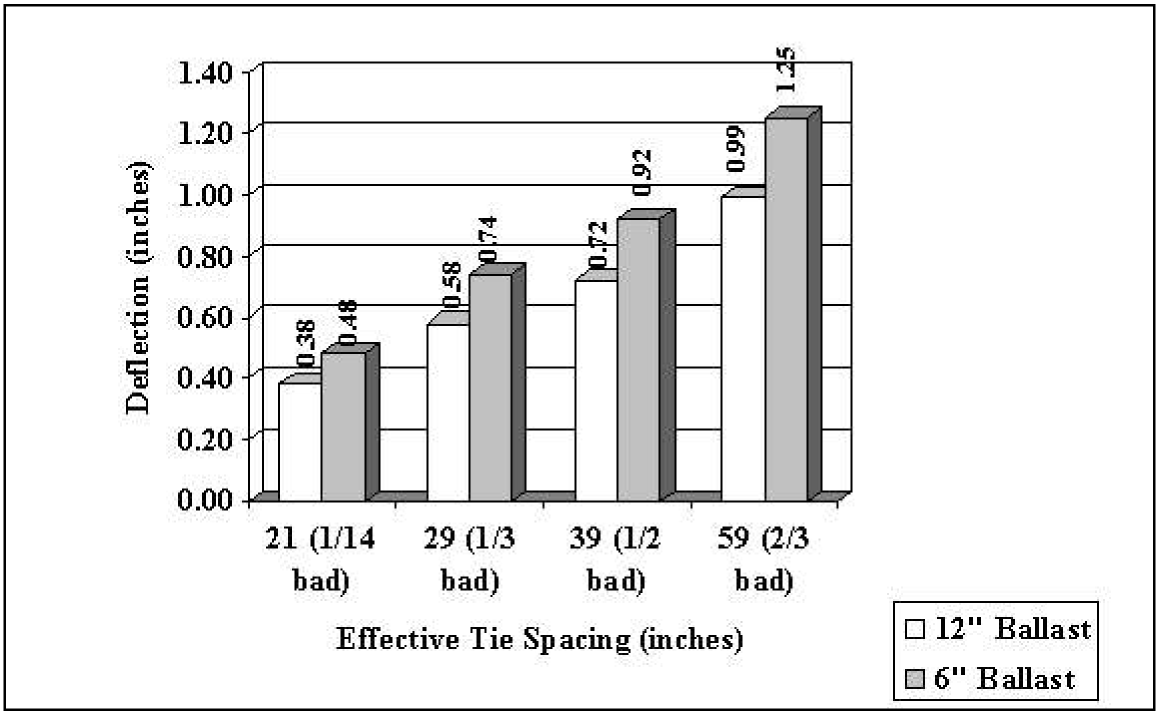

Figure 9: Simulation of Impacts of 286-kip cars on 90-Pound Rail – 35 MPH

However, with one-third defective ties and six inches of ballast, the hypothetical track section experiences deflection of nearly three-fourths of an inch. A 90-pound rail section with two-thirds defective ties and six inches of ballast can deflect as much as 1.25 inches.[29]

Again, it must be emphasized that the ability of a particular rail section to handle 286 kip cars over the long run will depend on the ballast and tie conditions specific to that line. Thus, 90-pound lines that have good tie maintenance and adequate ballast may be able to run 286 kip cars at 35 mph over the long run.

[29]It should be noted that these simulations do not take into account the strength differences between bolted rail and continuous welded rail.

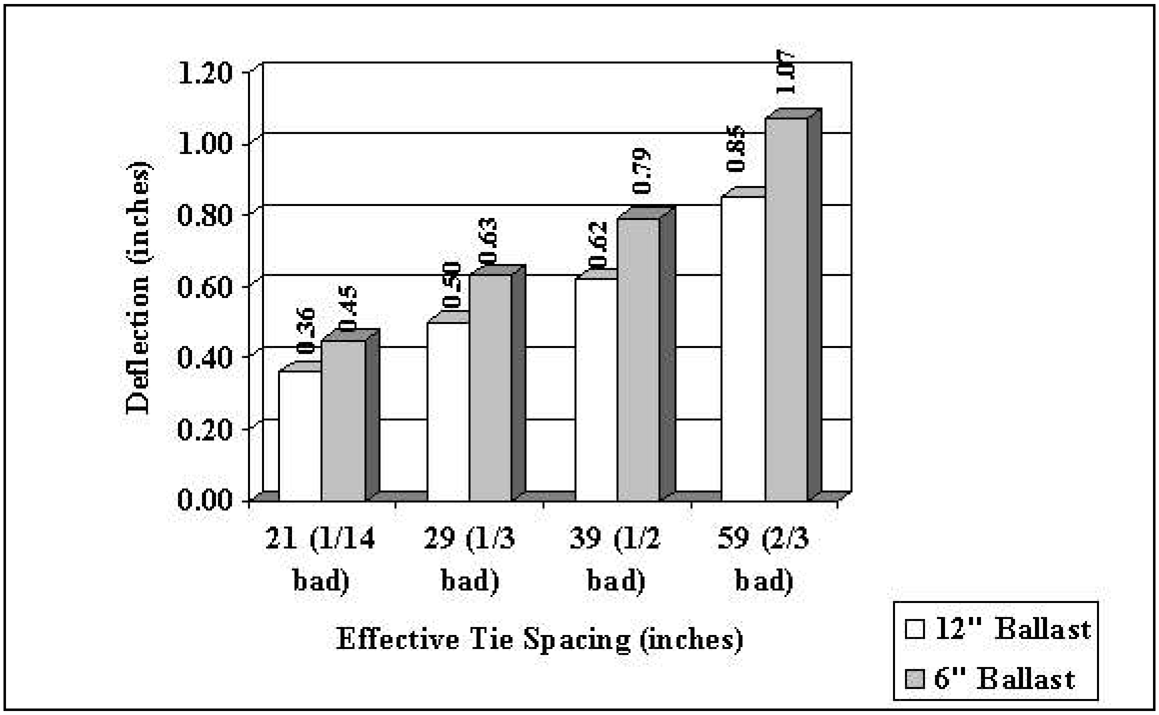

Figure 10: Simulation Impacts of 286 kip cars on 90-Pound Rail – 25 MPH

Figure 10 shows simulations over a 90-pound rail section with six-inch and 12-inch ballast depths, when speeds are 25 mph. The results are similar to the 35 mph scenario. However, in this case a 90-pound rail line with good tie-maintenance and 12 inches of ballast can handle 286 kip cars in the limits of desirable deflection for light tracks.

Figure 11 shows deflections for track with 70-pound rail and six inches of ballast, with operating speeds of 25 mph. As the figure shows, high deflections of .55 inches could occur on this track even with good tie maintenance. Excessive deflection of .77 inches occurs with one-third defective ties. With 50 percent bad ties and six inches of ballast, this track structure could defect as much as .96 inches. Finally, with two-thirds bad ties, the simulated deflections exceed 1.3 inches.

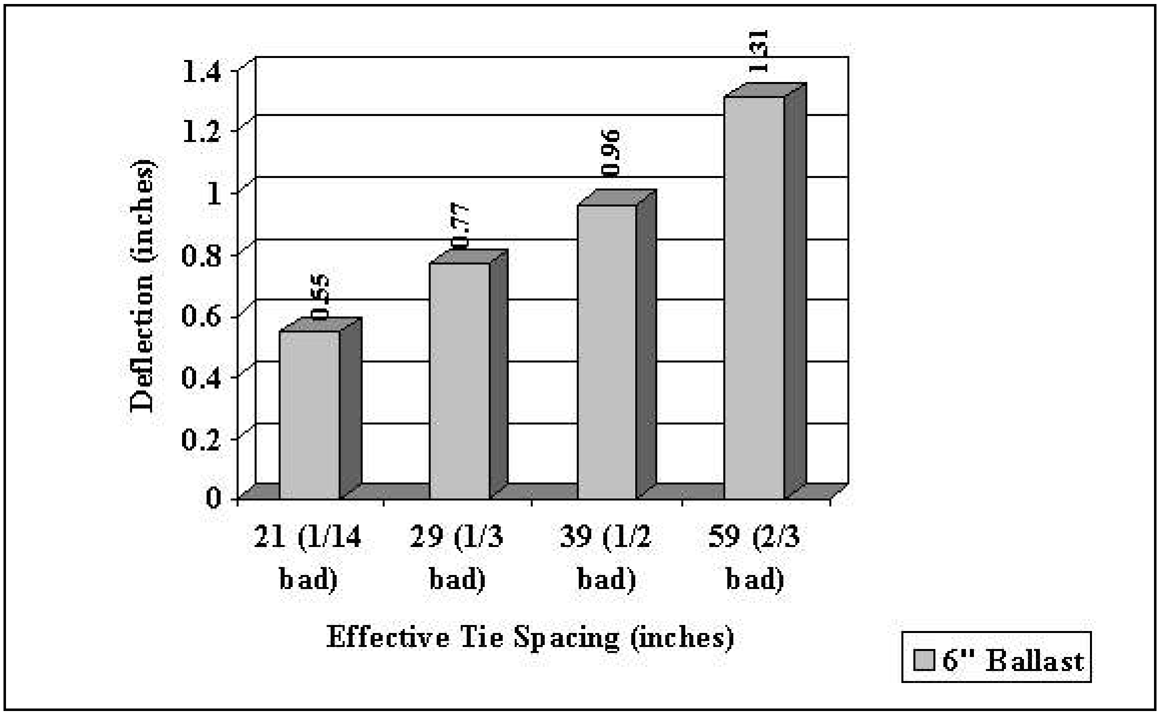

Figure 11: Simulation Impacts of 286 kip cars on 70-Pound Rail – 25 MPH

As previously mentioned, one option that railroads might consider on these light-rail lines is to operate at slow speeds. Simulations were run on 70-pound rail at speeds of 5 and 10 mph to account for this possibility.[30] Figure 12 shows such simulations with an assumed six inches of ballast. As the simulations show, railroads may be able to operate at low speeds in the short run with good tie maintenance. However, these deflection factors suggest that rapid deterioration of 70-pound rail will occur even at low speeds.

[30]As noted previously, this is not likely a long-term solution to the 286 kip car problem, because the opportunity cost of rail cars and locomotives is high.

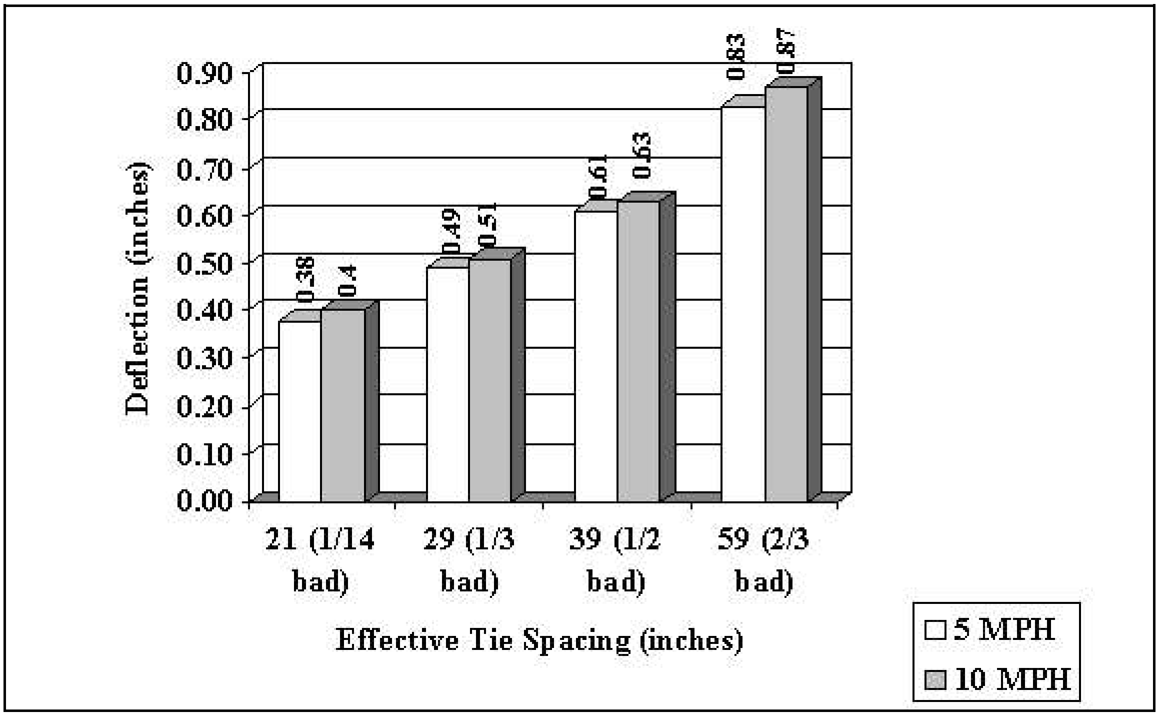

Figure 12: Simulation Impacts of 286 kip cars on 70-Pound Rail (6" Ballast)

Finally, these slow speed simulations also are performed on 60-pound rail. The simulations (Figure 13) show slightly higher deflections than for 70-pound rail, and suggest that some form of upgrading is likely to be necessary to operate the larger cars even at slow speeds over the long run.

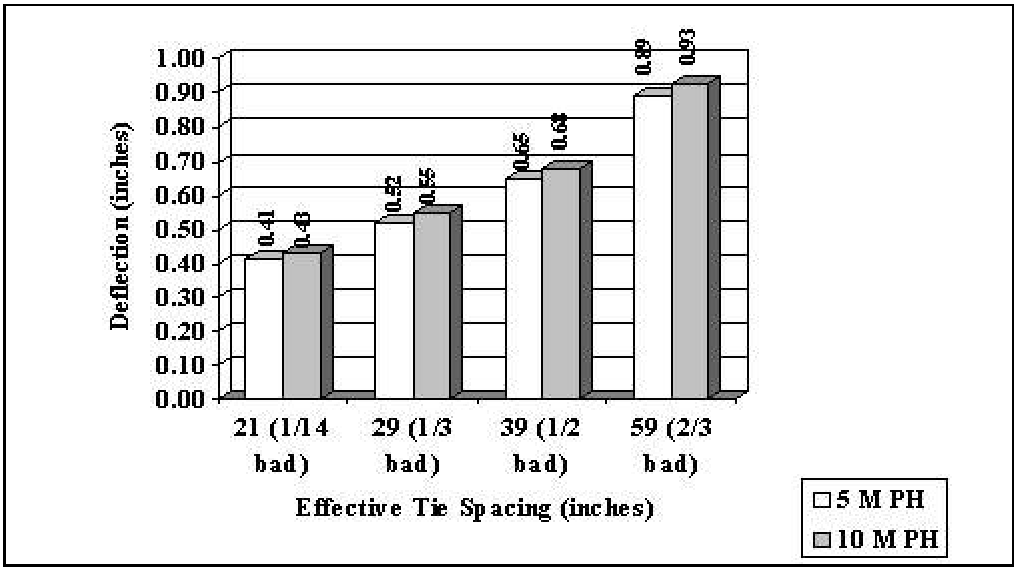

Figure 13: Simulation Impacts of 286 kip cars on 60-Pound Rail (6" Ballast)

Heavier Rail Simulations

Three heavy rail scenarios are analyzed using generalized track parameters: 132-pound rail with good track support, 112-pound rail with good track support, and 112-pound rail with average track support.[31] In each case, the effects of 286,000 pound cars moving at 40 mph are simulated. As Figure 14 shows, the expected track deflections are less than .25 inches for the first and second scenarios, and about one-third inch for the third scenario, which reflects 112-pound rail with one-third bad ties.

[31]The first scenario reflects 22" of ballast, while the second and third reflect 16 inches. Effective tie spacings are 21 inches for scenarios 1 and 2, and 29 inches for scenario 3.

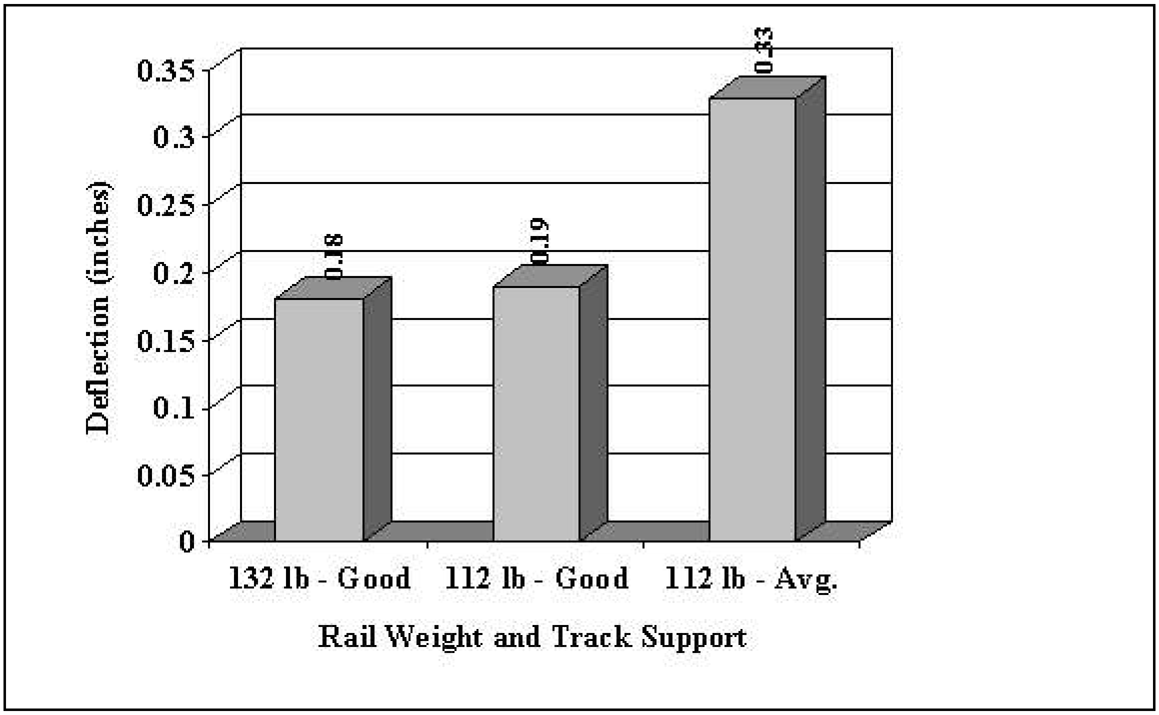

Figure 14: Simulation Impacts of 286 kip cars on Heavier Rail Sections – 40 MPH

Inferences of Simulations

The deflection analysis has shown that overall track support and speed are important factors in examining the potential impacts of HAL cars, in addition to rail weight. With good tie maintenance, good ballast, and slower speed operations, 90-pound rail *may* perform satisfactorily under 286,000 pound car loads. However, deferred maintenance or higher speed operations will increase deflection to unacceptable levels. The simulations show that lighter rail (e.g. 60 pounds per yard or 70 pounds per yard) is not likely to perform satisfactory under HAL traffic, even at slow speeds.

In comparison, 112-pound rail exhibits good track performance with average track support. These simulations suggest it is desirable for railroads to upgrade track built with lighter rail (i.e., less than 90 pounds per yard), if they wish to accommodate long term 286 kip car operations. When upgrading track, it also is desirable to use heavier rail (e.g., 112-pound or 115-pound rail) instead of relaying track with used 90-pound rail.

These simulations show similar results to those of other studies. Iowa DOT concluded that light-rail sections with less than 112-pound rail should be upgraded. As shown in Tables 9 and 10, ZETA-TECH concluded that 90-pound rail is marginal, at best.[32] For example, ZETA-TECH recommends that 90-pound rail be replaced if the railroad desires to operate at speeds greater than 25 mph. Moreover, 90-pound rail should be replaced when traffic densities exceed 5 million gross tons. Finally, ZETA-TECH says that 90-pound rail is marginal for operating speeds of 25 mph or less, even at the lightest traffic densities. This is exactly what our 25 mph simulation shows, as deflection reaches .36 with 12 inches of ballast and good tie maintenance.

Table 9: ZETA-TECH Evaluation of Rail Sections, by Traffic Density Ranges, for Operating Speed > 10 mph and ≤ 25 mph

	Traffic Density in Million Gross Tons		
Rail Weight	**< 1**	**1 – 5**	**5 – 10**
≥ 115 lb.	OK	OK	OK
100 – 114	OK	OK	Marginal
90 – 99	Marginal	Marginal	Replace
< 90 lb.	Replace	Replace	Replace

[32] *An Estimation of the Investment In Track and Structures Needed to Handle 286,000 lb. Rail Cars*, Prepared for the American Short Line and Regional Railroad Association, ZETA-TECH Associates, 2000.

Table 10: ZETA-TECH Evaluation of Rail Sections, by Traffic Density Ranges, for Operating Speed > 25 mph

	Traffic Density in Million Gross Tons		
Rail Weight	**< 1**	**1 – 5**	**5 – 10**
≥ 115 lb.	OK	OK	OK
100 – 114	OK	Marginal	Marginal
90 – 99	Replace	Replace	Replace
< 90 lb.	Replace	Replace	Replace

Costs of Rehabilitating Rail Track

As mentioned in the analysis above, the impact of a HAL rail car on a track of a given rail weight will depend on the specific conditions of that particular line, including the amount and quality of ballast, the quality of the subgrade, and the tie maintenance. Thus, it is not possible to identify with certainty those lines that are in need of upgrading without an on site line-by-line evaluation.

Nonetheless, the simulations suggest that long-term operation of 286,000 pound cars on lines that have track that is less than 90 pounds per yard is not likely to be viable. These lines perform poorly even at low speeds. Moreover, a slow speed operation is not likely to be a viable long-run alternative since the opportunity costs associated with locomotives and cars are high.

Tables 11 through 15 show the miles of track in each weight class by railroad in the state of North Dakota. As the tables show, more than 75 percent of all branch line mileage in the state is 90 pounds per yard or less.

Table 11: Miles of BNSF Branch Line by Weight Class in the State of North Dakota

Weight (pounds per yard)	Bolted or Welded	Miles
66	B	7.5
68	B	24.6
70	B	0.7
72	B	2.2
75	B	21.0
77	B	29.3
80	B	39.0
85	B	146.8
90	B	339.6
90	W	30.1
100	B	19.7
110	B	76.5
110	W	21.3
112	B	30.8
112	W	43.7
115	B	15.3
115	W	90.6
130	B	3.6
131	B	1.9
131	W	12.1
132	B	1.6
132	W	19.9

Table 12: Miles of CP Rail Branch Line by Weight Class in the State of North Dakota

Weight (pounds per yard)	Bolted or Welded	Miles
80	B	29.7
85	B	11.8
85	W	77.6

Table 13: Miles of DMVW Branch Line by Weight Class in the State of North Dakota

Weight (pounds per yard)	Bolted or Welded	Miles
60	B	88.2
72	B	11.9
80	B	165.3
85	B	76.2
85	W	0.3

Table 14: Miles of NP Branch Line by Weight Class in the State of North Dakota

Weight (pounds per yard)	Bolted or Welded	Miles
80	B	330.7
85	B	1.8
100	W	2.0

Table 15: Miles of RRVW Branch Line by Weight Class in the State of North Dakota

Weight (pounds per yard)	Bolted or Welded	Miles
60	B	6.8
66	B	11.5
72	B	78.1
85	B	43.0
85	W	12.0
90	B	59.5
90	W	71.8
100	B	8.5
100	W	35.3
110	B	11.9
112	B	47.6
112	W	32.5
115	B	40.5
115	W	20.5
131	B	6.5

Table 16 provides a summary of branch lines in the state that are less than or equal to 90 pounds per yard. As the table shows, to the extent that operation continues on each of the North Dakota branch lines currently in place, between 1,200 and 1,700 miles of rail line may have to be replaced.[33]

[33]Not all of these lines are likely to be replaced. The following section describes the factors that railroads consider in making the upgrading decision. It also looks at traffic densities and the location of shuttle facilities, and their impact on the likelihood of upgrading various North Dakota rail lines.

Table 16:	Miles of Light Rail Branch Line in the State of North Dakota	
Railroad	**< 90 lbs. per yard**	**≤ 90 lbs. per yard**
BNSF	276.3	640.8
CP RAIL	119.1	119.1
DMVW	323.0	323.0
NP	332.5	332.5
RRVW	151.4	282.7
TOTAL	**1,202.3**	**1,698.1**

Although not all of these lines are likely to be replaced, this section develops a cost estimate of replacing these lines under a scenario where continued operation occurs on all of the lines. The following section will make some revisions to the estimates based on the likelihood of upgrading various lines.

The first step in developing a cost estimate of upgrading the lines is to estimate the types of components needed and their costs.[34] The estimates presented here are based on conversations with vendors (suppliers) and Short Line railroads. The cost estimates reflect 4th quarter 2000 price quotes.

New heavy continuously-welded rail generally costs more than $500 per ton plus $150 in welding cost. Two types of used tangent rail are widely available on the market. Number 1 rail has one-eighth inch of head wear or less. Number 2 rail has one-quarter inch of head wear or less.

The price of used Number 2, 115-pound rail ranges from $450 to $500 per ton. This estimate doesn't include shop welding cost, which is approximately $150 per ton. The price of used Number 1, 115-pound rail ranges from $475 to $525 a ton. Again, this figure doesn't include shop welding cost, which is approximately $150 per ton. The price of used Number 2,

[34]The cost to upgrade a rail line is dependent upon its unique circumstances. Without detailed field studies, only generalized cost estimates can be developed.

112-pound rail ranges from approximately $400 to $425 a ton. This price doesn't include shop welding cost, which is approximately $150 per ton. Finally, the cost of used Number 1, 112-pound rail ranges from $425 to $450 a ton. Again, this figure doesn't include shop welding cost, which is approximately $150 per ton.

Conceivably, these rails could be laid as jointed rail, which would require 270 joints per mile, at a cost of about $4,000 per mile. This figure includes the cost of two angle bars per joint, valued at $15 each. However, jointed rail may not provide the long-term performance needed under heavy axle loads. Therefore, this option isn't considered in the remainder of the analysis.

Although purchasing new rail is an option, used rail is probably more cost-effective for the levels of traffic on these branch lines. The lowest rail price quote was for curve-worn 132-pound rail. This rail already is continuously-welded. It can be transposed and placed in tangent track. The estimated cost for this type of rail is $325 per ton.

These prices have been used to construct Tables 17 and 18, which show generalized rehabilitation cost estimates per mile. In Table 17, it is assumed that the line will be upgraded to 115-pound rail. In Table 18, it is assumed that the line will be upgraded using 132-pound curve-worn rails.

Table 17: Minimal Cost per Mile to Upgrade to 115-Pound Rail

Cost Item	Quantities	Unit Price	Cost per Mile
Used 115# No. 1 rail	202.4	$ 625	$ 126,500
Tie Plates - 6,000 per mile	6,000.0	4	24,000
Rail Anchors - 6,000 per mile	6,000.0	1	6,000
Ties: 500 per mile	500.0	41	20,500
5/8 x 6 Truck Spikes - 50 kegs per mile	50.0	65	3,250
Labor - Rail relay @ $7.5 per foot	5,280.0	7.50	39,600
Field Welds - 8 per mile	8.0	350	2,800
Replace Crossings - 1 per mile	1.0	3,000	3,000
Ballast - 400 tons per mile	400.0	16	6,400
Surfacing per foot	5,280.0	0.75	3,960
Reclaim & reload rail and OTM - per mile	1.0	3,000	3,000
Labor & locomotive to distribute material	1.0	2,000	2,000
Subtotal: Direct Cost			241,010
Contingencies: 10%			24,101
Total per Mile			**$265,111**

Table 18: Minimal Cost per Mile to Upgrade to 132-Pound Curve-Worn Rail

Cost Item	Quantities	Unit Price	Cost per Mile
Curve-worn 132-lb rail	232.3	$ 325	$ 75,504
Tie Plates - 6,000 per mile	6,000.0	4	24,000
Rail Anchors - 6,000 per mile	6,000.0	1	6,000
Ties: 500 per mile	500.0	41	20,500
5/8 x 6 Truck Spikes - 50 kegs per mile	50.0	65	3,250
Labor - Rail relay @ $7.5 per foot	5,280.0	7.50	39,600
Field Welds - 8 per mile	8.0	350	2,800
Replace Crossings - 1 per mile	1.0	3,000	3,000
Ballast - 400 tons per mile	400.0	16	6,400
Surfacing per foot	5,280.0	0.75	3,960
Reclaim & reload rail and OTM - per mile	1.0	3,000	3,000
Labor & locomotive to distribute material	1.0	2,000	2,000
Subtotal: Direct Cost			190,014
Contingencies: 10%			19,001
Total per Mile			**$209,015**

Without detailed field studies, it is not possible to develop accurate estimates of the salvage value of in-place branch-line assets. Typical salvage values range from $3,500 per mile to $12,000 per mile. A median value range of $4,000-$5,000 per mile is assumed for this study. These salvage values assume that the rails removed from branch lines are not suitable as relay rail for use in other rail lines.

In conclusion, the minimal cost to upgrade to115-pound rail is $265,000 per mile. After the salvage value of in-place assets is considered, the cost drops to $260,000 per mile. A lower upgrading cost may be possible by using curve-worn rail, in which case the estimated cost is about $205,000 per mile. Neither figure includes the costs of turnouts or bridges.

As shown in the literature review, Iowa Department of Transportation estimated that it would cost $262,000 per mile to upgrade branch lines in Iowa. The Iowa estimate includes the cost of turnouts. The ZETA-TECH study identified unit costs for turnouts for three Class I railroads. The lowest of these was estimated at approximately $29,000 per turnout.

Although there is uncertainty in these numbers, they provide some indication of the minimum costs needed to upgrade inadequate branch-line sections. If the costs per mile are applied to all North Dakota branch lines that are less than 90 pounds per yard, the total upgrading costs in the state would range from $258 million to $324 million, excluding the costs of bridge upgrading.[35] If the costs per mile are applied to all North Dakota branch lines that are 90 pounds per yard or less, the total upgrading costs in the state would range from $364 million to $458

[35]This includes an estimated 391 turnouts that would need to be replaced at a cost of $29,000 per turnout.

million, excluding bridge upgrading costs.[36] Figure 15 shows the North Dakota rail lines that have light rail.

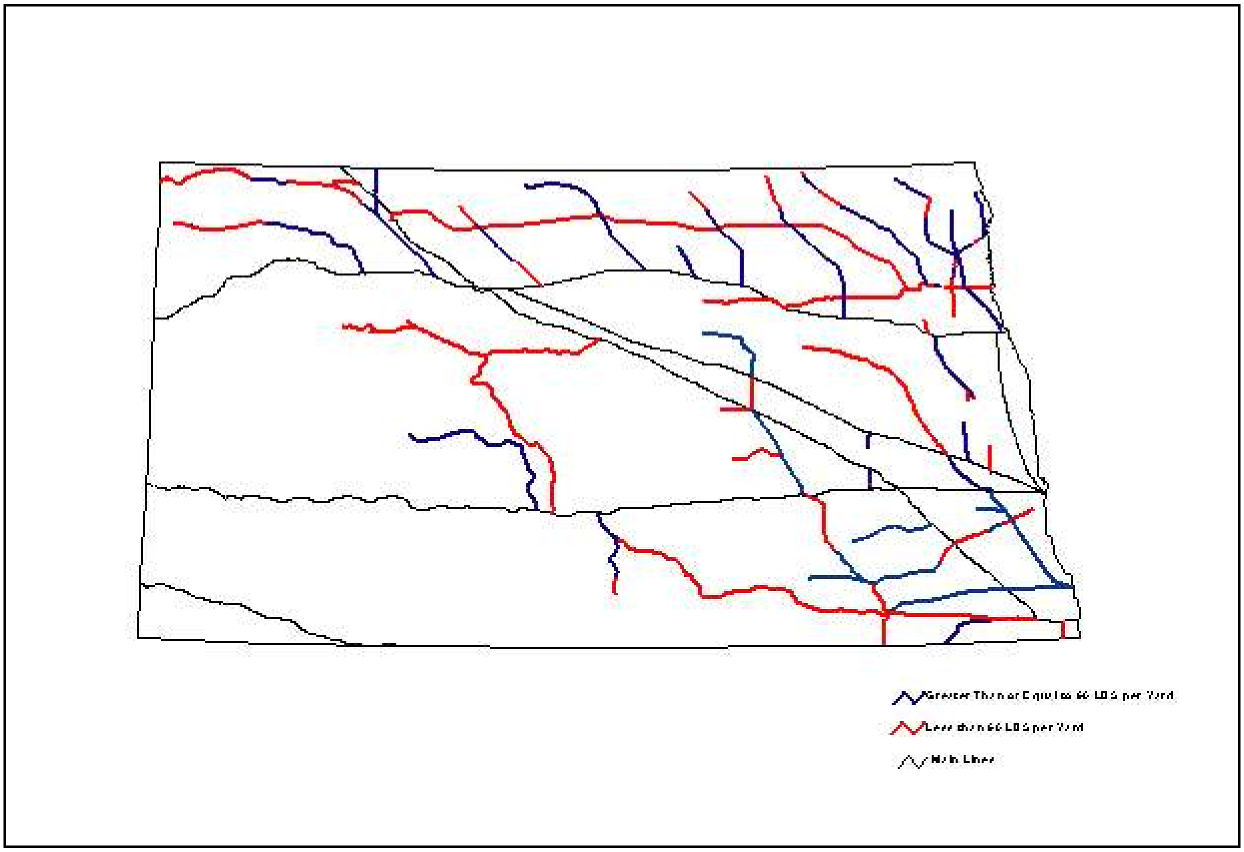

Figure 15: North Dakota Lines with Light Rail

As mentioned previously, it is not likely that all of these lines with light rail will be upgraded to handle 286,000-pound cars. The next section of the report presents a theoretical model to describe the railroad's upgrading decision, and provides a numerical example to give insight into the minimum traffic levels needed to justify an upgrading investment.

[36]This includes an estimated 564 turnouts that would need to be replaced at a cost of $29,000 per turnout.

Theoretical Model of the Railroad's Upgrading Decision

As highlighted in the previous section, many railroad branch lines do not appear to be capable of handling the 286,000-pound rail cars without some kind of upgrading expenditure, under normal operating conditions. Although it may be possible for railroads to operate at lower speeds or to haul lighter loads in the 286,000-pound cars on these lines, these do not appear to be long term solutions for adjusting to an eventual system-wide switch to the larger cars. Economic incentives provided to shippers for loading the larger rail cars and car hire charges that depend on the time that a rail car is in the service of a particular railroad will likely make full loading of the 286,000-pound cars under current operating speeds the predominant mode of operation in the future. In cases where a portion of a particular railroad's lines are not capable of handling fully-loaded 286,000-pound cars at current operating speeds, the railroad will face a decision between upgrading the rail line and abandoning the line. This section of the report highlights the process used by railroads in making the upgrading/abandonment decision.[37]

A better understanding of this process will provide insight into areas where abandonment might occur, enabling state and local public decision makers to make more informed decisions regarding infrastructure expenditures.

The railroad's decision process for upgrading a rail line to accommodate the carriage of 286,000-pound hopper cars can be characterized as an investment decision similar to the investment decision facing any firm that is considering the purchase of physical capital. In

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[37]Throughout the process of developing a theoretical model of the railroad decision process, information obtained from discussions with the railroads serving the state (Class Is and short lines) was used. The general framework and the factors considered have been verified through these discussions.

general, a firm will invest in physical capital as long as the internal rate of return from such an investment exceeds the rate of return available from alternative investments, and as long as the firm is able to obtain the necessary capital to make such an investment. For the railroad, this means that the firm will invest in upgrading a rail line as long as the internal rate of return to upgrading exceeds the rate of return the railroad could obtain from investing in other rail lines or any other railroad property, and as long as the railroad is able to obtain capital to make the investment. The internal rate of return for a railroad investment in upgrading a branch line can be obtained from solving for ρ in the following equation (ρ is the internal rate of return).

$$C_{UPGRADE} = \sum_{i=0}^{N} \frac{R_i}{(1+\rho)^i} \qquad (1)$$

$$\begin{aligned} where:\quad & C_{UPGRADE} = Upgrading\ Cost \\ & R_i = Incremental\ Profits\ in\ period\ i\ resulting\ from\ upgrade \\ & \rho = Internal\ Rate\ of\ Return \\ & N = number\ of\ periods\ over\ which\ the\ upgrade\ is\ expected \\ & \quad to\ yield\ benefits \end{aligned}$$

The investment criterion of making an investment in upgrading as long as the internal rate of return exceeds the rate of return obtainable from alternative investments is equivalent to the net present value criterion, which says to invest in a project as long as the net present value of the project exceeds its costs. This criterion can be illustrated by the following equation:

$$NPV = \sum_{i=0}^{N} \frac{R_i}{(1+r)^i} \qquad (2)$$

$$\begin{aligned} where:\quad & r = the\ rate\ of\ return\ to\ the\ best\ alternative\ investment \\ & NPV = Net\ Present\ Value \end{aligned}$$

As long as ρ in equation 1 (the internal rate of return) exceeds r in equation 2 (the rate of return to the best alternative), then the net present value of the investment must be greater than the cost of the upgrade. Thus, the two criteria are equal to each other. For describing the railroad's upgrading decision, we will consider the internal rate of return criterion, since it provides a useful framework for ranking investment alternatives.

In theory, the railroad firm should be able to obtain financing to make the necessary improvements in rail lines to handle 286,000-pound cars as long as the internal rate of return associated with the upgrade exceeds the rate of return that investors can obtain from alternative investments. However, it also is important to consider the role that credit market imperfections may have on the investment behavior of rail firms.

Fazzari, Hubbard, and Petersen (1988) show that there is a potential for firms to suffer from a "lemons" problem in credit markets.[38] Some firms have good investment opportunities and others have bad investment opportunities. Each firm knows if its own investment opportunity is good or bad, but creditors do not. Because the firm knows more about its investment opportunities than creditors do and because all firms have an incentive to say that their investment opportunities are good, firms with good opportunities will have a tough time obtaining finances at a reasonable price. This occurs because potential creditors have no way of distinguishing good borrowers from bad borrowers, so they offer all borrowers a price reflective of bad borrowers.

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[38]The "lemons" problem considered by Fazzari, Hubbard, and Petersen is similar to the asymetric information problem first considered in Akerlof, George A. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism," *Quarterly Journal of Economics*, vol. 84 (August 1970), pp. 488-500. Akerlof showed that in a market with asymetric information where two types of used cars exist - nice cars and lemons - the price always will be equal to the lemon price.

Stiglitz and Weiss (1981) have shown that this type of phenomenon also can lead to credit rationing.[39] When the demand for loanable funds increases, the interest rate charged on loans by banks also should increase. However, as the interest rate rises, the average riskiness of the firms willing to accept a loan increases. Because the bank cannot distinguish risky from good borrowers, credit is rationed to good borrowers.

In many cases, this problem of asymmetric information can have a significant impact on the amount of investment made by smaller firms. This is especially likely for the smaller Short Line railroads that have financial and operational information that is largely unavailable to the public. Thus, it is likely that rail firms will not have the necessary capital to invest in all of the projects that would yield an internal rate of return exceeding the market rate of return. Rather, firms must prioritize investments based on a ranking of rates of return.

Given the general process of ranking investment alternatives, given the internal rate of return, it is useful to understand the factors that influence the internal rate of return, and therefore the upgrading decision. These factors include: (1) the number of periods over which the upgrade is expected to yield benefits, (2) the incremental traffic expected as a result of the upgrade, (3) incremental revenues and costs as result of the incremental traffic from the upgrade, (4) service improvements as a result of the upgrade that increase revenues, and (5) the upgrading cost. The following paragraphs will discuss each of these factors, in turn.

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[39]Stiglitz, Joseph and Andrew Weiss, "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, 71(3), June 1981.

Useful Life of the Upgrade

Railroad assets are known to have long physical lives. At the low traffic levels typical of North Dakota branch lines, crossties can last for more than 40 years.[40] With good maintenance practices, rail can carry more than 600 million gross tons over its life.[41] For North Dakota branch lines carrying less than one million gross tons per mile, this means that rail can last almost indefinitely. Similarly, bridges and other track components also have long physical lives.

Although the physical life of railroad assets is long, railroads consider a short time frame when evaluating the potential benefits of a railroad investment because of uncertainty regarding the future of traffic and the difficulty in transferring railroad assets within a railroad system or between systems. A great deal of uncertainty exists regarding the future of railroad traffic on a particular line. A rail line may be in physically good condition in 20 years as a result of an upgrading investment, but the traffic only may last for 10 years. This problem is exacerbated by the fact that assets in railway lines and structures are immobile. Thus, if a rail line loses traffic, the physical capital used to improve the line can not easily be put to a productive use on another part of the railroad's system or by another railroad. Moreover, the inability to liquidate or move railroad assets increases the risks to banks in providing loans over a long time period, even when future traffic levels are known with some degree of certainty. The bank is not only concerned with the uncertainty of traffic over a particular line in the future, but also with the uncertainty of the financial viability of the railroad in the future.

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[40]Based on information provided in a railway track maintenance seminar by Robert Alf, "The Behavior of Railroad Track, and the Economical Practices of its Maintenance and Rehabilitation," March 2001.

[41]Ibid.

The appropriate time horizon used to consider the benefits of upgrading a rail line depends on risk perceptions of the railroads making the upgrading decision and the banks financing such upgrades. Thus, the only way to choose an appropriate time horizon for modeling the railroad's upgrading decision is to interview railroads and banks to see what time frame they actually use in making such a decision. According to Short Line operators in the state, the longest time period considered for the benefits of an upgrade would be seven years. This is consistent with information provided by two banks specializing in providing loans to Short Line railroads, who stated that the maximum term they would grant for a railroad loan would be seven to eight years. In modeling the railroad's upgrading decision in this study, an eight-year time horizon is used. The following section discusses the role of traffic in the upgrading decision.

Incremental Traffic

Obviously, the increase in traffic is an important determinant of the rate of return that an upgrading investment is expected to create. The incremental profits from an upgrading investment to handle 286,000-pound cars are obtained as a result of revenues obtained from incremental traffic. Incremental traffic as a result of upgrading is the traffic gained in comparison to a scenario where the line would be abandoned. This consists of traffic maintained due to continued service, traffic gained due to improved service, and traffic gained due to continued service where competitors' lines are abandoned.

Several factors will affect the level of incremental traffic resulting from an upgrading investment. These include the proximity of the rail line to rail competitors, the reaction of rival rail firms to the upgrading decision, the ability of trucks to serve destination markets directly, the location of new shuttle train facilities, and service level changes resulting from the investment. These factors are discussed in the following paragraphs.

One important factor affecting the incremental traffic from an upgrading decision is the proximity of the rail line to rail competitors. Shippers are likely to move their grain by the closest rail alternative. If a railroad decides not to upgrade a rail line and instead abandons the line, the railroad may lose traffic to a nearby competitor. Alternatively, if the closest rail line to the line where the upgrading decision is being made is owned by the railroad making the decision, then the traffic is likely to be maintained by the railroad even if it abandons the line. In this case, the incremental traffic from an upgrade may be zero. Thus, railroads facing a potential decision between upgrading and abandoning a line are much more likely to choose upgrading when competitors are in close proximity than in cases where they own the nearest alternative line.

In considering the role played by the proximity of competitors in the upgrading decision, it also is useful to understand the nature of Short Line relationships with Class I railroads. In the state of North Dakota, the three Short Line railroads act as feeders into the Class I railroads. The RRVW is a feeder into the BNSF, while the NP and DMVW feed into the CP. Thus, the RRVW and the BNSF do not compete with each other and the CP feeders do not compete with the CP.

Although neither the Short Line railroads nor their Class I partners view each other as competitors, the proximity of a partner to the line under consideration will likely play a different role for each. From the perspective of the short lines, although they don’t compete with their Class I partners, a loss in traffic to their Class I partner still constitutes a loss in their core traffic, which could threaten their viability. From the perspective of the Class I railroad, a loss in traffic to their Short Line partner means a small loss in revenue, but an even larger reduction in costs in many cases. The appeal of a Short Line partnership to the Class I railroads is an ability to maintain traffic that would otherwise be lost to a competitor without the need to operate over many light-density branch lines. Because of these differences in perspectives, a Short Line railroad faced with a decision to upgrade will likely be equally influenced by the proximity to its partner and its competitors, while the Class I railroad faced with a similar decision will likely be influenced only by its proximity to competitors.

Figure 16 shows current North Dakota rail lines and their ownership. As the figure shows, there are many lines where competitors are in close proximity to each other. In such cases, the amount of incremental traffic from an upgrade is higher, holding all other factors constant.

Another closely related factor that will affect the level of incremental traffic resulting from an upgrading investment is the action taken by rivals in upgrading branch lines. As discussed in the previous paragraph, there are some cases where the branch lines of competing firms are in close proximity to each other. The incremental traffic available to a railroad from upgrading depends on whether the competitor upgrades its line or abandons it. For example if the BNSF and the CP have branch lines in close proximity to each other, BNSF's incremental traffic from upgrading may encompass all current traffic in the case where CP also upgrades, or it may encompass current traffic plus a portion of CP's current traffic where CP decides not to upgrade. Thus, the perceptions of rival railroads regarding the actions taken by their competitors play a crucial role in each firm's estimate of an internal rate of return from an upgrading investment.

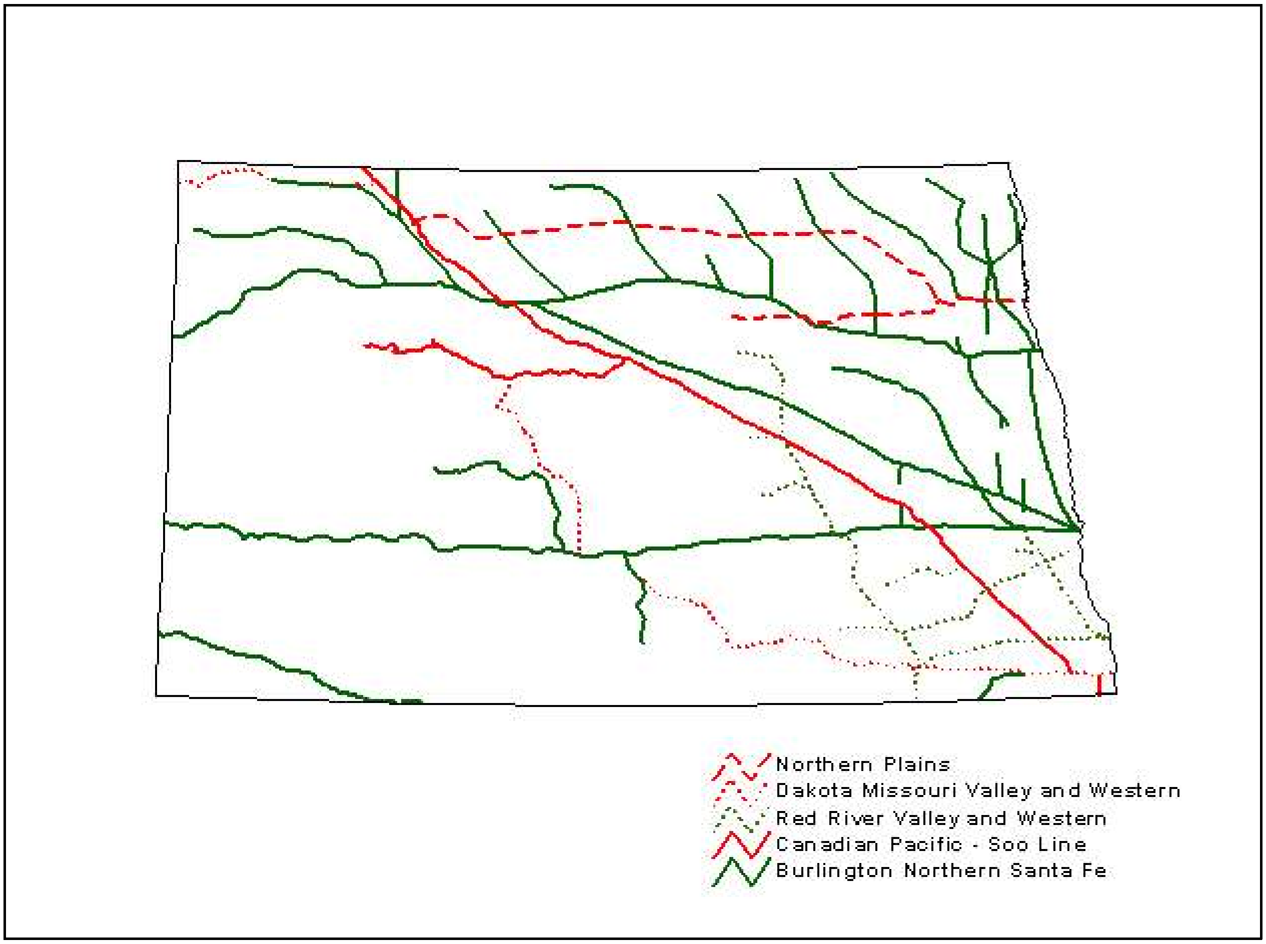

Figure 16: North Dakota Rail Lines and Their Ownership

The tools of game theory could be used to make an assessment of the incentives for rival firms in making upgrading investments and the resulting perceptions of rail firms of competitor actions. However, in this case it is not necessary to draw on the tools of game theory. Because railroad firms are risk averse and because upgrading branch lines involves a heavy and immobile investment, it is unlikely that a railroad would make an investment relying on the assumption of gaining traffic from a rival's abandonment of a rail line.[42] Thus, in modeling the railroad's

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[42]An exception might be a case where a railroad has such lines slated for abandonment on its system diagram map.

upgrading decision, it is assumed that railroads estimate the internal rate of return of an upgrading investment under the expectation that their rivals will upgrade their lines in question.

A third factor affecting the amount of incremental traffic resulting from an upgrading decision is the ability of trucks to serve destination markets directly. Even if a rail branch line's closest rail alternative is on the same railroad's system, the traffic still could be lost to trucks if the decision to abandon the line is made. If trucks can be competitive with rail in transporting to final destinations, shippers losing service may transport directly to markets by truck rather than transporting by truck to a transloading facility that may be located on the same railroad's system.

Tolliver and Bitzan (1997) estimate that trucks can be cost-competitive with single-car rail shipments when the distance to the destination market is less than 164 miles, and possibly up to 280 miles.[43] Most North Dakota shippers are farther than 280 miles from any market, while a few shippers in the far eastern portion of the state are within this distance of Duluth and Minneapolis. Thus, in most of North Dakota the cost-competitiveness of trucks will only play a minor role in affecting the level of incremental traffic available from an upgrade. In the far eastern portion of the state, however, even when the closest rail alternative to the line in question is owned by the same railroad, much of the traffic transported to Minneapolis and Duluth may be considered incremental traffic to an upgrade since such traffic likely will be lost to truck in the event of an abandonment.

A fourth factor that will affect the amount of incremental traffic available from an upgrade is the location of new shuttle train facilities that routinely handle shipments of more than 100 rail

[43]This assumes that 100 percent of truck miles are fully loaded, and equates truck costs to variable rail costs and fully allocated costs, respectively.

cars. Such facilities likely will realize lower transportation rates. Consequently, they are likely to offer higher grain prices to farmers, and draw grain away from elevators that are in close proximity but that can't take advantage of shuttle train rates. In Item 3 of this analysis, Vachal identifies 10 potential shuttle train facility locations in the state, along with potential draw areas for different commodities. The 10 potential draw areas for wheat, and rail lines with less than 90 pound per yard rail in these draw areas are shown in Figure 17. The incremental traffic from an upgrade will likely be smaller for rail lines located near shuttle train facilities, but without their own shuttle train facilities.

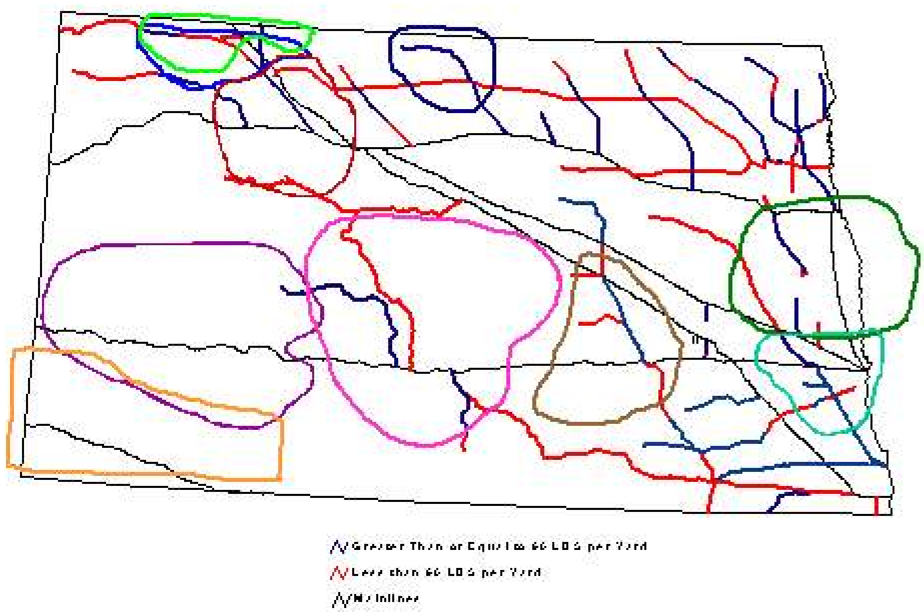

Figure 17: Shuttle Train Draw Areas for Wheat

A final factor affecting the amount of incremental traffic available from an upgrading investment is service level changes resulting from the upgrade. An upgrade may improve the speed of service, result in an increased frequency of service, decrease the probability of derailment, and result in reduced rates to shippers. To the extent that such improvements occur, and to the extent that this results in more traffic being shipped by this railroad, such improvements will increase the amount of incremental traffic available from an upgrade. For the railroad calculation of internal rate of return on upgrading investments, the service level change is not expected to have much of an impact on the incremental traffic available. This is because trucks are not cost competitive to final markets for most of the state, and the expectation is for competitors to upgrade their lines as well.

Incremental Revenues and Costs

The previous section highlighted the incremental traffic resulting from the upgrading investment. This traffic is important in estimating the internal rate of return due to its impacts on revenues and costs. The incremental revenues attributable to the upgrade are the revenues on incremental traffic for the entire time that the traffic travels on the railroad's system. In many cases, this may encompass the entire rail movement for Class I railroads. The incremental costs attributable to the upgrade, in addition to the upgrading cost itself, are the routine maintenance costs associated with the roadway and the transportation costs associated with the incremental traffic for the entire move on the railroad's system.

However, as previously noted, the operating costs associated with transporting the 286,000-pound cars will be somewhat lower than those experienced by the railroad before the upgrade. Using larger rail cars results in a reduction in car and locomotive ownership costs, a reduction in labor costs, a reduction in fuel costs, a reduction in car and locomotive maintenance costs, an increase in system capacity, and a reduced probability of derailment.

The review of simulations of the efficiencies of using heavy axle loads on a Class I mainline provided a useful illustration of the types of efficiencies resulting from using the larger cars. For Short Line railroads and Class I branch lines though, the cost savings resulting from using larger rail cars are not likely to be as large as those realized on a Class I mainline. Nonetheless, the cost savings are still significant and represent an important component in estimating the internal rate of return of an upgrading investment.

Martens (1999) introduces a Short Line railroad costing model that can be used to make an assessment of the efficiency gains resulting from using the larger rail cars on small railroads and Class I branch lines.[44] His model is used to simulate operating costs on Short Line and Class I branch lines before and after the upgrading investment in a subsequent section of the report. The model will take into account savings in fuel costs, car and locomotive ownership costs, car and locomotive maintenance costs, and labor costs resulting from the shift to larger cars.[45]

Service Improvements Generating Incremental Revenue

In addition to the incremental revenues obtained from maintaining traffic that would otherwise be lost, the upgrade also may result in service improvements that allow railroads to

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[44]The model is a spreadsheet based model that uses inputs obtained from interviews with Short Line railroad operators.

[45]An additional benefit to upgrading would be reduced spot maintenance. This is not considered in our cost model.

increase the prices they charge.[46] That is, shippers may be willing to pay more to receive more frequent and timely service.

However, it is unlikely that major service changes would result from an upgrade of a rail line to handle 286,000-pound cars. For the most part, the upgrade will allow continued service on lines at current service levels. For purposes of this study, incremental revenues obtained from service improvements are not considered. The next section of the report presents a numerical illustration of the upgrading decision, providing a generalized assessment of where lines are likely to be upgraded in the state of North Dakota.

Numerical Illustration of the Upgrading Decision

The previous section of the report described the general process that railroads are likely to follow when making decisions on whether to upgrade lines that do not have the infrastructure necessary to handle 286,000-pound cars. This section uses the Short Line cost model developed by Martens (1999), the Uniform Rail Costing System (URCS), estimates of rail shipment revenues, and estimates of upgrading costs to estimate the internal rate of return available to Short Line and Class I railroads at various traffic levels. These estimates of the internal rate of return to the upgrading investments can be used in combination with estimates of incremental traffic levels on North Dakota lines and current line conditions to provide a generalized assessment of the lines that are most likely to be abandoned. The following paragraphs describe the estimation of the internal rate of return to upgrading in detail.

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[46]This could occur in cases where short lines are allowed to individually price their services. However, in practice Class I railroads charge similar rates for an entire region.

Short Line Internal Rate of Return

A description of the methodology used to estimate the internal rate of return for Short Line railroads is presented first. As shown in a previous section of the report, the internal rate of return to an upgrading investment depends on the incremental annual profits resulting from upgrading a rail line and the upgrading cost. The incremental profits from the upgrade for Short Line railroads are estimated from data obtained from the American Short Line and Regional Railroad Association's (ASLRRA's) Annual Data Profile, and from a modified version of the Short Line cost model presented by Martens (1999).

Incremental annual revenues are estimated by taking the average revenue per car and multiplying it by the assumed number of cars per mile and by the average number of miles owned.[47] This is done for a variety of carload per mile traffic densities.

Incremental annual costs are estimated by using a modified version of the spreadsheet based Short Line cost model presented by Martens (1999). The spreadsheet based model is an economic-engineering model that estimates the equipment and transportation costs associated with carrying a given amount of grain traffic in 263,000-pound and 286,000-pound cars.[48]

The incremental profits in a given period resulting from the upgrading investment are estimated as the incremental revenues less the incremental equipment, transportation, and maintenance of way costs from Short Line operation. Incremental maintenance of way costs only

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[47]Average revenue per car and average number of miles owned are obtained from the ASLRRA's Annual Data Profile (1998). Average revenue per car for local line-haul railroads is $288, and the average number of miles owned is 111.

[48]All Short Line costs are based on an assumed average length of haul of 44 miles (Average for local line-haul railroads in the ASLRRA's Annual Data Profile, 1998).

include those encompassed by routine activities such as vegitation control, snow removal, and signal maintenance. Investment types of maintenance of way costs are not considered since they are encompassed by the upgrading investment. For example, tie replacement, rail replacement, and ballast replacement all are included in the upgrading cost.

Table 19 presents a modified version of the spreadsheet based Short Line cost model used by Martens (1999). As the table shows, the costs per car for shipping at a density of 50 cars per mile is estimated at $179 per car for 263,000-pound cars and $197 per car for 286,000-pound cars. The transportation and equipment costs per car are $119 and $130 for the 263,000-pound and 286,000-pound cars, respectively. These estimates are similar to the estimated average transportation and equipment costs of $127 per car for local line-haul railroads reporting to the American Short Line and Regional Railroad Association's (ASLRRA's) Annual Data Profile in 1996.[49]

Table 19 also includes an estimate of the incremental profit per ton and the total annual incremental profit from line operation (excluding administrative costs). This total incremental annual profit of $617,861 for 286,000-pound car shipment can be used as an estimate of the annual incremental benefit to a short line of upgrading the rail line, when traffic density is 50 cars per mile.[50] Similar estimates of incremental benefits from upgrading are developed for other traffic densities, as well.

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[49]These data were not available in subsequent versions of the ASLRRA's Annual Data Profile.

[50]Different incremental benefits are obtained for different traffic densities.

Table 19:	**Spreadsheet Based Short Line Cost Model (Modified Version of the Model Presented by Martens, 1999)**		
	263,000 Pound Car	**286,000 Pound Car**	
1. Tons Shipped	527,250	527,250	50 Cars per Mile with 263 K
2. Carloads	5,550	4,974	#1 / Tons per car
3. Average Haul	44	44	Average for Local Line-Haul RRs from ASLRRA Database
4. Avg. Service Frequency (per week)	4.11	3.68	#2 / (#6 * 52)
5. Shipments per Year	213	191	#4 * 52
6. Avg. Cars per Train	26.00	26.00	Assumed
7. Tons per Car	95	106	Assumed
8. Tons per Train	2,470	2,756	#6 * #7
9. Ton-Miles	108,680	121,264	#8 * #3
10. Speed	25	25	Assumed
11. Total Running Time (Hours) - per shipment	3.52	3.52	(#3 * 2) / #10
12. Switch Time per Car (Min)	9.3	9.3	From Martens (1999)
13. Total Switch Time (Hours) - per shipment	8.06	8.06	(#12 * #6 * 2) / 60
14. Total Hours (per shipment)	**11.58**	**11.58**	**#11 + #13**
15. Total Hours (per Year)	**2,472**	**2,215**	#14 * #5
Crew Costs			
16. Crew Size	2	2	Assumed
17. Wages per Hour	$16.00	$16.00	Discussions with Industry Personnel
18. Payroll Tax	25%	25%	Discussions with Industry Personnel
19. Benefits	20%	20%	Discussions with Industry Personnel
20. Compensation per Crew Person	$57,347.72	$51,396.54	#17 * (1 + #18 + #19) * #15
21. Total Crew Cost (per year)	**$114,695**	**$102,793**	#20 * #16
Locomotive Ownership Costs			
22. Replacement	$200,000	$200,000	Discussions with Industry Personnel
23. Useful Life	15	15	Discussions with Industry Personnel
24. Salvage Value	$50,000	$50,000	Discussions with Industry Personnel
25. Dep. Cost per Year	$10,000	$10,000	(#22 - #24) / #23

26. Average Locomotive Value	$125,000	$125,000	(#22 + #24) / 2
27. ROI	11%	11%	Martens (1999)
28. ROI Cost Per Loc. Per Year - per Loc.	$13,750	$13,750	#27 * #26
29. Total Cost per Year - per Loc.	$23,750	$23,750	#25 + #28
30. Locomotives	1	1	Martens (1999)
31. Locomotive Ownership Cost (per year)	**$23,750.00**	**$23,750.00**	#29 * #30
Fuel Cost			
32. Total Shipment Weight Loaded (Tons)	3,419	3,718	#6 * (131.5 or 143 Tons per Car)
33. Gallon / Freight Mile	4.39	4.77	4.39 from Martens, 4.77 est. based on weight difference
34. Cost per Gallon	$0.98	$0.98	Discussions with Industry Personnel
35. Cost per Mile	$4.30	$4.68	#34 * #33
36. Total Fuel Cost (per shipment)	$378.59	$411.70	#35 * #3 * 2
37. Total Fuel Cost (per year)	**$80,815**	**$78,763**	#36 * #5
Locomotive Repair			
38. Cost per Locomotive per Day	$120	$120	Discussions with Industry Personnel
39. Total Locomotive Repair Cost (per year)	**$43,800**	**$43,800**	#38 * 365
Car Ownership Costs			
40. Car Replacement Cost	$55,000	$63,000	Trinity Industries (From Martens, 1999)
41. Useful Life - Years	35	35	Trinity Industries (From Martens, 1999)
42. Salvage Value	$4000	$4580	Discussions with Industry Personnel
43. Deprec. Per Year	$1,457	$1,669	(#40 - #42) / #41
44. Average Value	$29,500	$33,790	(#40 + #42) / 2
45. ROI	11%	11%	Martens (1999)
46. ROI per Car per Year	$3,245	$3,717	#45 * #44
47. Cost per Year (per car)	$4,702	$5,386	#43 + #46
48. Cost per Day	$12.88	$14.76	#47 / 365
49. Average Car Days per Car per shipment	4.5	4.5	Martens (1999)
50. Car Days per Train	117	117	#49 * #6
51. Car Days in Service on SL - Year	24,975	22,383	#50 * #5

52. Total Car Ownership Cost (per Year)	**$321,743**	**$330,294**	**#51 * #48**
Car Repair Costs 53. Cost per Car Mile	$0.043	$0.043	Avg. for SOO Line (2000)
54. Car Miles	488,400	437,717	#3 * #5 * #6 * 2
55. Total Car Repair Costs	**$21,001**	**$18,822**	#54 * #53
Other Transportation Costs***** 56. Other Transportation Costs per Train Mile	$2.88	$2.88	Discussions with Industry Personnel
57. Total Other Transportation Costs	**$54,099.69**	**$48,485.57**	**#56 * #3 * #5 * 2**
58. Total Transportation Cost	**$659,904**	**$646,708**	**#57 + #55 + #52 + #39 + #37 + #31 + #21**
59. Maint.of Way - Non Capitalized (per mile)	$3,000.00	$3,000.00	Discussions with Industry Personnel
60. Total MOW - Non Capitalized	**$333,000**	**$333,000**	**#59 * 111**
61. Total Cost	**$992,904**	**$979,708**	**#60 + #58**
62. Cost Per Ton	$1.88	$1.86	#61 / #1
63. Cost Per Car	$179	$197	#61 / #2
64. Revenue per Car	$288	$321	Average for Local Line-Haul RRs from ASLRRA Database (assumes current revenue per ton remains the same with 286 K)
65. Revenue per Ton	$3.03	$3.03	#64 / 95 (assumes current rev per ton remains the same with 286 K)
66. Profit per Ton - Short Line	**$1.15**	**$1.17**	**#65 - #62**
67. Total Profits - Short Line (excluding Admin. Cost)	**$604,664**	**$617,860**	**#66 * #1**

*Derail Costs, Vehicles for Deadheading Crews, Utilities and Communications, Crew Supplies, Property and Liability Insurance

In addition to the annual incremental profit, the other important piece of information needed to estimate the internal rate of return to an upgrading investment is the amount of the upgrading investment. A previous section of the report estimated that the minimum upgrading cost needed for lines that have less than 90 pound per yard rail is $205,000 per mile (after subtracting salvage value of materials). The total upgrading cost is estimated by multiplying the $205,000 per mile by the number of miles (111).

Table 20 provides estimates of the internal rate of return to upgrading a hypothetical Short Line railroad at various traffic levels, and with various time frames for considering the benefits of an upgrade. Although the internal rate of return to upgrading will vary somewhat by individual railroad based on cost characteristics and revenue splits, the internal rates of return shown in the table are likely to approximate those for North Dakota short lines.

Table 20: Estimates of the Internal Rate of Return to Upgrading for a Hypothetical Short Line Railroad

Years for Considering Benefits	50 Cars per Mile	75 Cars per Mile	100 Cars per Mile	150 Cars per Mile	200 Cars per Mile
8	-29.5%	-20.3%	-13.3%	-1.9%	8.1%
15	-10.6%	-4.0%	1.1%	9.5%	17.2%
20	-5.7%	-0.1%	4.2%	11.6%	18.5%
25	-3.0%	1.9%	5.7%	12.4%	19.0%

As the table shows, under current revenue splits, it appears unlikely that Short Line railroads would upgrade lines with less than 200 cars per mile.[51] However, if some government agency were to provide a mechanism that allowed longer term financing, it is possible that such upgrades would be considered at lower traffic levels (e.g. 150 cars per mile). One example of such a mechanism may be a loan guarantee program that eliminated risk to lenders from making such long-term loans.

[51]Recall that seven to eight years is the longest time frame banks would consider for financing such improvements.

Another factor that may increase the likelihood that short lines would upgrade lines to handle larger hopper cars would be an increase in the revenue split provided to short line railroads from Class I railroads. In cases where the Class I railroad perceives that traffic lost by their feeding short line results in traffic lost to a competitor, the Class I may be willing to increase the revenue paid to its Short Line partner in an attempt to maintain profitable traffic. The following section estimates the internal rate of return available to Class I railroads from upgrading rail lines to handle larger hopper cars. Because of the possibility of Class I railroads providing revenue incentives to short lines for upgrading lines, the internal rates of return available to Class I railroads at various traffic levels may have important implications for the viability of Short Line rail lines that need upgrading. Thus, when making a generalized assessment of rail lines that may be abandoned, a range of traffic levels will be used – i.e. between those where Class I's would upgrade and those where Short Lines would upgrade at current revenue levels.

Class I Internal Rate of Return

The incremental profits from upgrading a Class I branch line are estimated from the 1999 North Dakota Waybill Sample. In an earlier section of the report, we showed that where a competitor's rail line is in close proximity to the line in question, a loss in branch line traffic as a result of a line abandonment represents the loss of an entire movement on the Class I system. Thus, the incremental profit is estimated as the entire profit obtained by the originating Class I railroad on a particular move.

Incremental profits are estimated as the product of the average profit per car and the traffic density in cars per mile. Average profit per car is estimated by taking the weighted average revenue per car and subtracting the weighted average variable cost per car for all farm products rail shipments originating in North Dakota in 1999.[52] The average profit per car obtained from the 1999 waybill is $927 per car.

When the incremental profits attributable to a line with various traffic densities (over an eight-year period) is compared to the upgrading costs, it is apparent that the rate of return to upgrading is much higher for Class I railroads than for Short Line railroads, holding all other factors constant (See table 21).[53] As Table 21 shows, it is estimated that upgrading may be beneficial to Class I railroads on branch lines with traffic densities of as little as 35 to 40 cars per mile.

Table 21: Estimates of the Internal Rate of Return to Upgrading for a Hypothetical Class I Branch Line

Years for Considering Benefits	30 Cars per Mile	35 Cars per Mile	40 Cars per Mile	50 Cars per Mile	75 Cars per Mile
8	2.1%	7.1%	11.9%	21.5%	47.2%

In cases where a Class I railroad faces the possibility of losing traffic fed from its short line to a competitor because of a Short Line abandonment, the Class I railroad may increase the revenue it pays to its short line. Thus, the smaller traffic densities needed to justify upgrading a

[52]The number of carloads is used as the weighting factor.

[53]It is important to note that in cases where the Class I railroad does not have competition in close proximity, the railroad is unlikely to upgrade the branch line at any traffic levels. In such cases, the Class I railroad can maintain its traffic without serving the branch line.

Class I branch line also may apply to short lines, in some cases. Figure 18 shows the rail lines that have less than 35 cars originated per mile and light rail.[54] These lines are likely to be abandoned even if the Class I standard applies to short lines.[55]

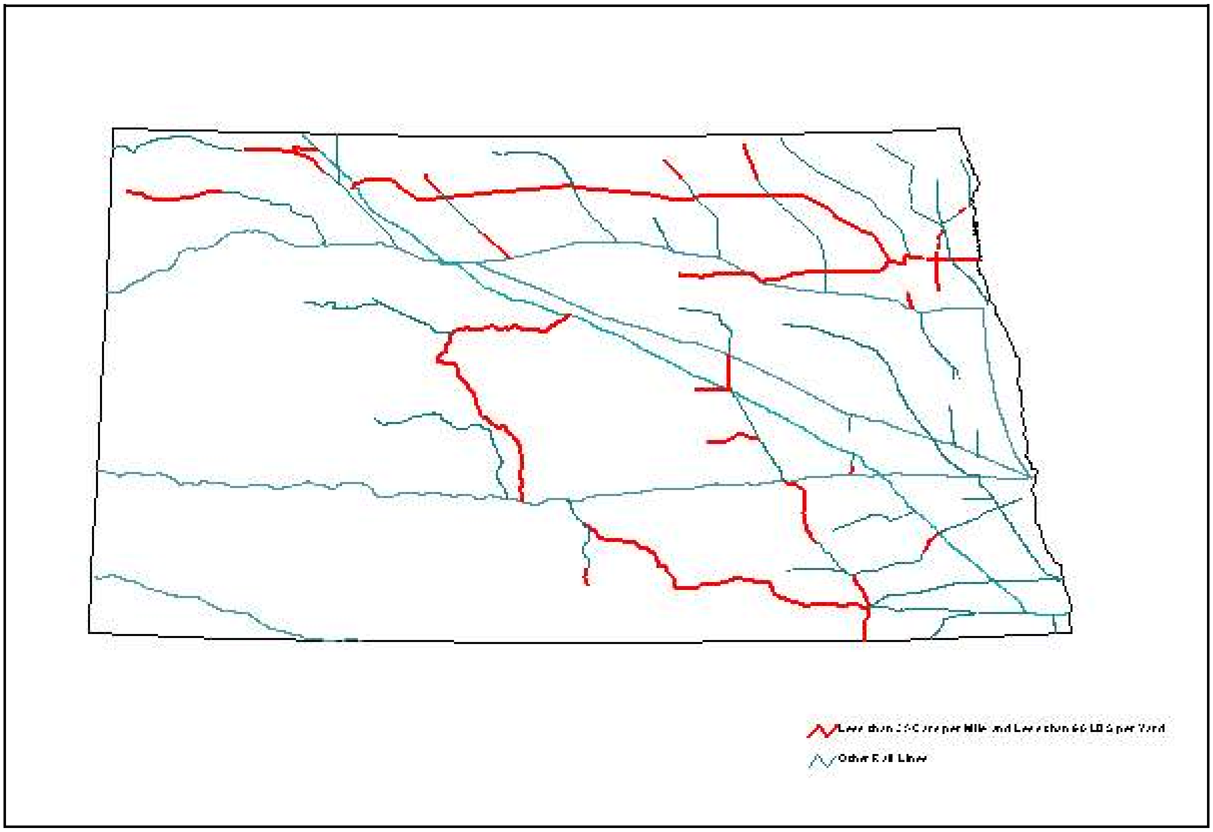

Figure 18: North Dakota Rail Lines with Less than 35 Cars per Mile and Light Rail

[54]The number of miles by railroad are shown in Table 22. Traffic estimates are the annual averages between 1995 and 1997 from the North Dakota Grain Movement Database.

[55]It should be recognized that this traffic density measure does not account for overhead traffic. Thus, it is possible that some of these lines have more traffic than indicated by this measure. Some line segments may also be needed to maintain a continuous rail network.

Table 22: Miles of Rail Line with Less than 35 Cars per Mile Originated and with Light Rail

Railroad	Miles
Burlington Northern-Sante Fe	159.4
Canadian Pacific	49.4
Dakota Missouri Valley & Western	225.3
Northern Plains	332.5
Red River Valley & Western	128.9
Total	**895.5**

Figures 19, 20, and 21 show rail lines that have less than 40, 100, and 150 (200) cars per mile, respectively, and have light rail.[56] The lines identified in these figures give a general range of the potential line abandonments that could occur as a result of a switch to larger hopper cars.[57] At a traffic density of 40 cars originated per mile, the internal rate of return is estimated at nearly 12 percent for a Class I railroad. If the Class I railroad gives an increased share of revenues to its Short Line partner, Short Line segments with more than 40 cars per mile originated could justify upgrading. At a traffic density of 100 to150 cars per mile, short lines may be able to justify upgrading if a mechanism to allow longer-term financing were available (e.g. 15 to 25 year loans). Finally, at a traffic density of 200 cars per mile, Short Line railroads may be able to justify upgrading under currently available financing terms.

[56]The lines that have less than 150 cars per mile are the same lines that have less than 200 cars per mile. The miles in each category by railroad are shown in Tables 23, 24, and 25.

[57]The figures only consider current originating traffic volumes, and do not consider the likelihood of losing traffic to rivals.

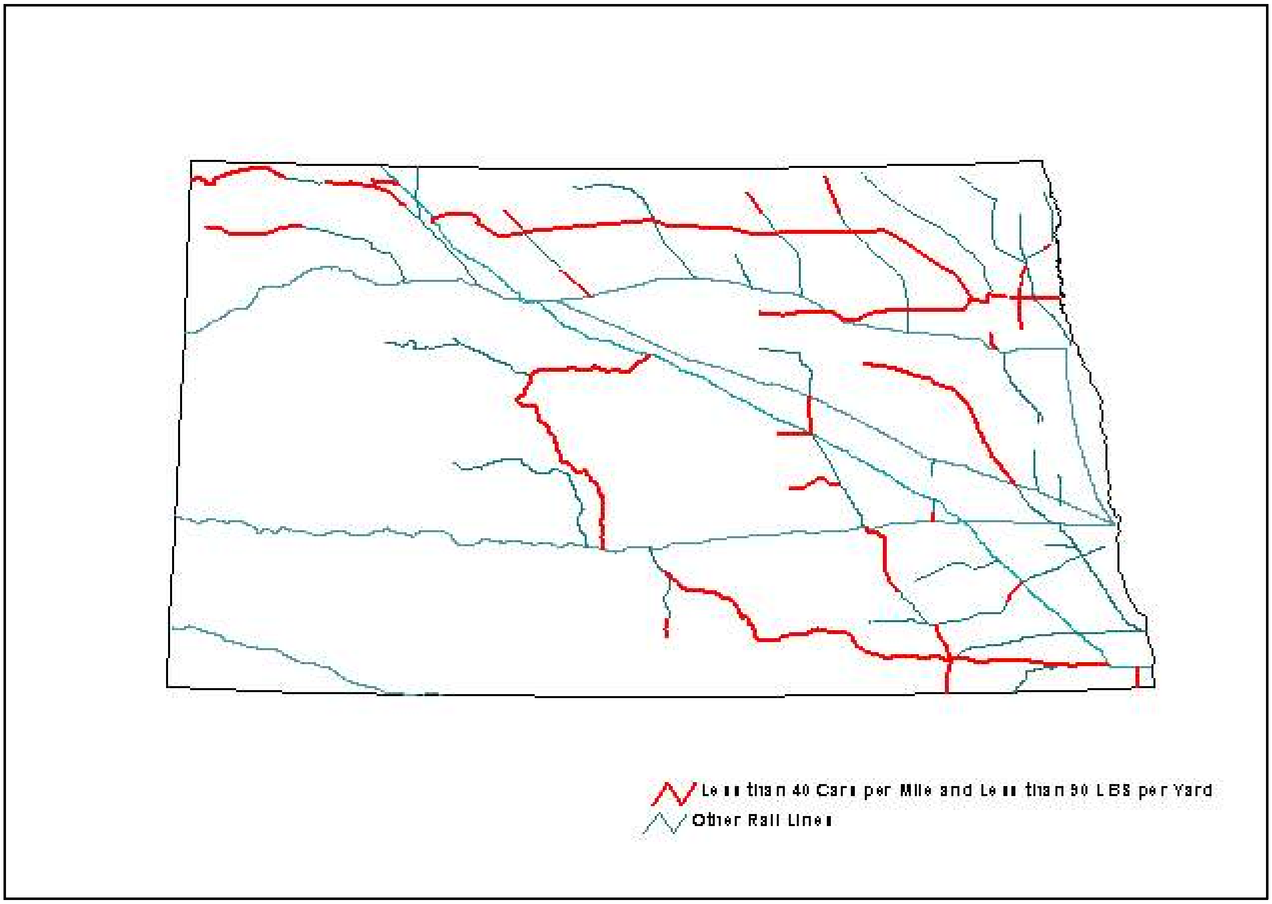

Figure 19: **North Dakota Rail Lines with Less than 40 Cars per Mile and Light Rail**

Table 23: Miles of Rail Line with Less than 40 Cars per Mile Originated and with Light Rail

Railroad	Miles
Burlington Northern-Sante Fe	238.9
Canadian Pacific	57.4
Dakota Missouri Valley & Western	323.0
Northern Plains	332.5
Red River Valley & Western	128.9
Total	**1,080.7**

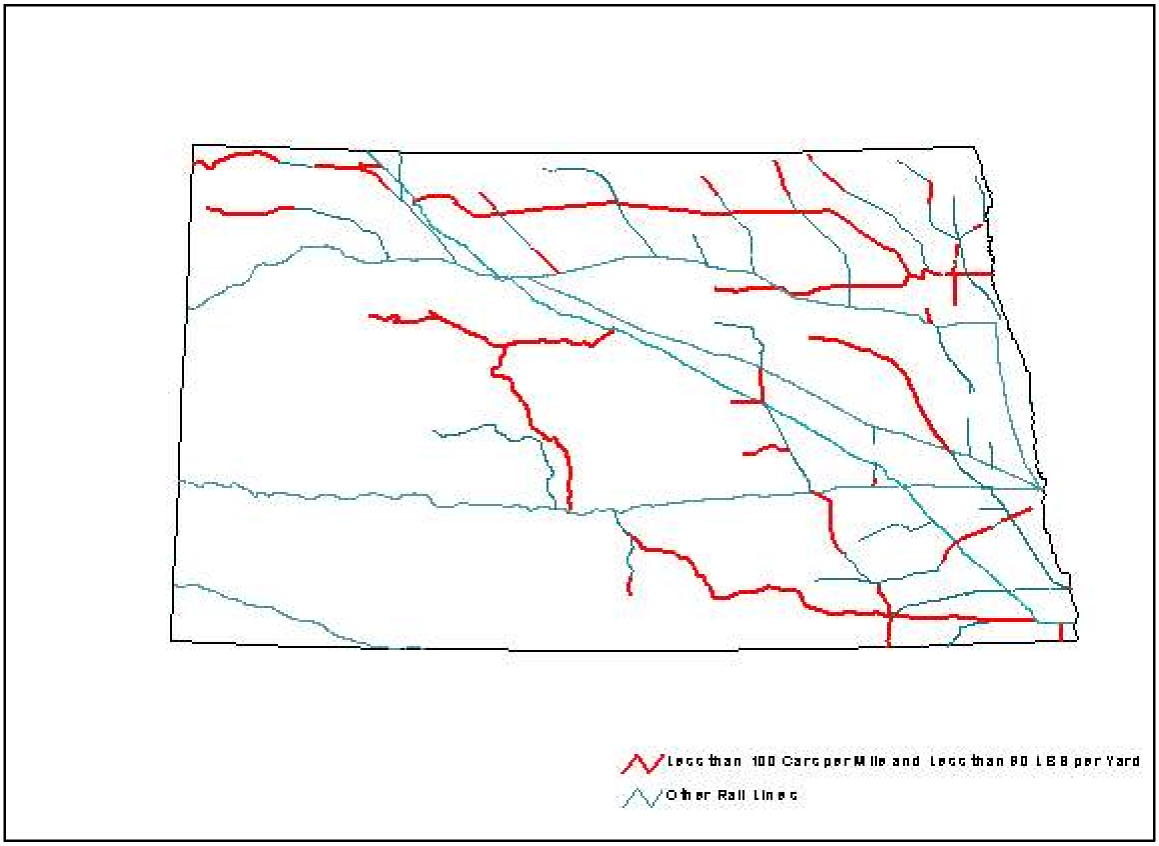

Figure 20: North Dakota Rail Lines with Less than 100 Cars Per Mile and Light Rail

Table 24: Miles of Rail Line with Less than 100 Cars per Mile Originated and with Light Rail

Railroad	Miles
Burlington Northern-Sante Fe	261.5
Canadian Pacific	119.1
Dakota Missouri Valley & Western	323.0
Northern Plains	332.5
Red River Valley & Western	151.4
Total	**1,187.5**

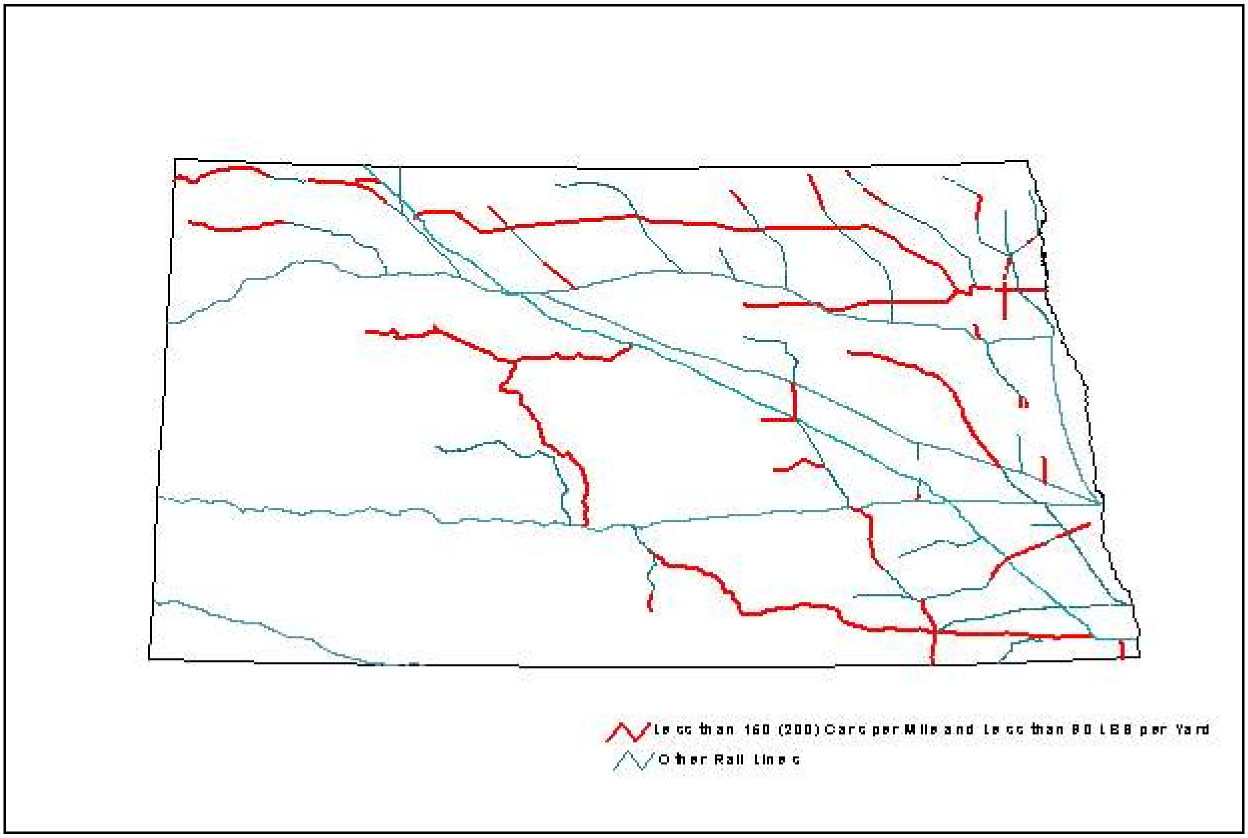

Figure 21: North Dakota Rail Lines with Less than 150 (200) Cars per Mile and Light Rail

Table 25: Miles of Rail Line with Less than 150 (200) Cars per Mile Originated and with Light Rail*

Railroad	Miles
Burlington Northern-Sante Fe	276.3
Canadian Pacific	119.1
Dakota Missouri Valley & Western	323
Northern Plains	332.5
Red River Valley & Western	151.4
Total	**1,202.3**

*** Lines having less than 150 cars per mile and 200 cars per mile are the same in North Dakota.**

Impacts of the Upgrading Decision on North Dakota Communities

The upgrading decision will have impacts on North Dakota communities, since rail lines that are not upgraded will be abandoned. When a rail branch line is abandoned, there are several potential negative impacts to shippers and local communities. These impacts result from a shift of rail traffic to truck. Potential impacts include an increase in the costs of shipping commodities and a resulting loss in net income of shippers, decreases in local gross business volume, decreases in local property values, increases in highway maintenance costs, increases in highway user costs, and decreased economic development opportunities.

However, rate savings passed on to producers as a result of shipping in larger sizes and larger cars may offset the impacts of reductions in personal income and gross business volume to some extent. Moreover, in areas where shuttle facilities are built, and where larger rail cars are used, shippers and communities will benefit from the changes. Thus, from a statewide perspective, the economic impacts may be negligible. That is, many of the negative impacts to communities may represent a shift in economic activity from one portion of the state to another.

On the other hand, the highway impacts that result from the shift to larger grain cars are likely to be felt statewide. Rail abandonment will result in longer and heavier truck trips throughout the state. This section of the report provides generalized estimates of the highway impacts of the shift to heavy rail cars for the state.

Generalized estimates of highway impacts are developed for four scenarios: (1) all lines with less than 35 cars per mile originated and with light rail are abandoned, (2) all lines with less than 40 cars per mile originated and with light rail are abandoned, (3) all lines with less than 100 cars per mile originated and with light rail are abandoned, and (4) all lines with less than 150

(200) cars per mile originated and with light rail are abandoned. These four scenarios represent a range of possibilities for lines that could be abandoned as a result of the shift to larger hopper cars.[58]

Under each scenario, the generalized estimates of highway impacts are developed through a multi-step process. First, three-year averages of grain rail cars originated per mile are obtained for all rail lines that potentially are subject to abandonment.[59] Next, these carloads are multiplied by a rail-truck conversion factor that takes into consideration commodity density, as well as railcar and truckload capacity (3.5 trucks per railcar for grain). The resulting estimate of the number of incremental truckloads that would be hauled in the absence of these rail lines is multiplied by an average length of haul of 44 miles to obtain an estimate of incremental truck miles.[60] Finally, the number of incremental truck miles is multiplied by marginal highway maintenance cost estimates under two assumptions: (1) all incremental traffic travels on principal arterial highways, and (2) all incremental traffic travels on minor arterial highways.[61]

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[58]The scenarios do not take into account proximity to competitors, the location of shuttle facilities, and other factors. Nonetheless, they provide a reasonable generalized illustration of lines that may be subject to abandonment.

[59]These are 1995 through 1997 annual averages from the North Dakota Grain Movement Database.

[60]This average length of haul is the average length of haul for local line-haul railroads obtained from the ASLRRA Annual Data Profile. It is beyond the scope of this study to provide detailed estimates of incremental truck haul miles.

[61]Marginal highway maintenance costs are developed from two sources. The Federal Highway Administration's *Federal Highway Cost Allocation Study* estimates the marginal pavement cost of an 80,000-pound five-axle truck mile on a rural interstate highway of 12.7 cents. The U.S. Department of Transportation (USDOT) *Comprehensive Truck Size and Weight Study* presents a range of unit costs that show how marginal pavement costs vary by highway type. The relationships developed in the USDOT study are used to adjust the FHWA marginal

Table 26 presents the generalized estimates of the annual highway impacts of the shift to heavier rail cars under the four scenarios. As the table shows, the highway impacts range between $1 million and $4.5 million per year.

Table 26: Generalized Annual Highway Impacts from the Switch to Heavy Rail Cars where all Lines Below Various Traffic Levels with Light Rail are Abandoned

Traffic Level Where Lines are Abandoned	Rail Cars Currently Carried	Estimated Incremental Truck Trips (Rail Cars Times 3.5)	Estimated Incremental Truck Miles (Trips * 44)	Estimated Incremental Hwy Maint. Cost if All Traffic is on Rural Principal Arterials	Estimated Incremental Hwy Maint. Cost if All Traffic is on Rural Minor Arterials
Less than 35 Cars per Mile	21,787	76,255	3,355,220	$1,023,342	$2,472,797
Less than 40 Cars per Mile	28,664	100,324	4,414,256	$1,346,348	$3,253,307
Less than 100 Cars per Mile	35,928	125,748	5,532,912	$1,687,538	$4,077,756
Less than 150 (200) Cars per Mile	39,063	136,721	6,015,724	$1,834,796	$4,433,589

Although these costs seem large, they are dwarfed in comparison to costs that would be needed to upgrade the lines in question. Although these generalized incremental highway maintenance costs occur annually while the rail upgrading costs occur only once, the present value of highway impacts does not exceed upgrading costs under any time frame.[62]

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pavement costs for principal and minor arterial highways. The estimated marginal pavement costs per truck mile on principal arterial and minor arterial highways are 30.5 cents and 73.7 cents, respectively.

[62]Under a scenario where all North Dakota light rail lines are subject to abandonment and the annual incremental highway impacts of $4,433,589 are realized in perpetuity, the present value of highway impacts are less than $74 million while the rail upgrading cost is nearly $258 million (this assumes a 6 percent discount rate).

Table 27 compares the total generalized highway impacts under an assumption that they are realized in perpetuity to the costs that would be needed to upgrade these lines. The table shows that highway impacts alone are small in comparison to the costs of upgrading. However, these highway impacts do not capture the entire public costs associated with abandonment – costs such as highway noise, pollution, and highway user costs. Nonetheless, it is unlikely that these costs would be large enough to justify an overall state upgrading subsidy. It is important to note, though, that there may be some specific cases, on a line by line basis, where impacts may justify an upgrading subsidy.

Table 27: Comparison of Total Highway Impacts and Upgrading Costs (Assumption that Highway Costs are Realized in Perpetuity – 6 percent Discount Rate)

Traffic Level Where Lines are Abandoned	Estimated Incremental Hwy Maint. Cost if All Traffic is on Rural Principal Arterials	Estimated Incremental Hwy Maint. Cost if all Traffic is on Rural Minor Arterials	Total Miles Abandoned (Turnouts)	Total Upgrading Cost to Prevent Abandonment[63]
Less than 35 Cars per Mile	$17,055,700	$41,213,283	895.5 (280)	$191,697,500
Less than 40 Cars per Mile	$22,439,133	$54,221,783	1080.7 (343)	$231,490,500
Less than 100 Cars per Mile	$28,125,633	$67,962,600	1187.5 (384)	$254,573,500
Less than 150 (200) Cars per Mile	$30,579,933	$73,893,150	1202.3 (391)	$257,810,500

[63] Assumes an upgrading cost of $205,000 per mile.

SUMMARY AND CONCLUSIONS

North Dakota's grain producers rely on an efficient rail system to move their products to export and domestic markets. In the 1999-2000 crop year, approximately 69 percent of all North Dakota grains and oilseeds transported to export and domestic markets were transported by rail.

A recent shift to larger grain hopper cars may threaten the viability of the state's light-density branch line network. The old industry standard of 263,000-pound cars capable of hauling 100 tons of grain is being replaced with 286,000-pound cars capable of hauling 111 tons of grain. Many light-density branch lines can not handle these larger cars, as they have light rail in place, shallow or poor ballast, and/or deferred tie maintenance. Although it is possible to load the larger rail cars at lighter weights or operate at lower speeds on such lines, railroads operating over such lines eventually will face a decision between upgrading and abandoning lines that cannot handle the 286,000 pound cars at full weight.

This study simulates the impacts of handling larger rail cars on many types of rail lines, models the decision process used by railroads in deciding whether to upgrade such lines or abandon them, estimates the costs of upgrading rail lines that are unlikely to be upgraded, and estimates generalized highway impacts that could result from the abandonment of non-upgraded lines.

In simulating the impacts of handling larger rail cars on different types of rail lines, the study estimates that rail lines that have rail in place that is less than 90 pounds per yard are likely to need some form of upgrading to handle the larger rail cars. More than 1,200 miles of rail line in North Dakota have rail that is less than 90 pounds per yard. The costs of upgrading all of these lines are estimated to range between $258 million and $324 million, excluding the costs of bridge upgrading.

In modeling the railroad decision process on whether to upgrade lines with light rail to handle the larger cars, it was shown that railroads are likely to rank investment alternatives based on their internal rates of return. In estimating the internal rate of return to an upgrading investment, railroads are likely to use a maximum of an eight-year time frame for evaluating the benefits to upgrading. Moreover, the internal rate of return to the upgrading investment will depend on the proximity of the rail line to competitors' rail lines, the actions taken by competitors in terms of upgrading their rail lines, the ability of trucks to serve destination markets directly, the location of new shuttle train facilities, operational cost savings resulting from the upgrade, service improvements from the upgrade, and the cost of upgrading.

A numerical illustration of originating traffic levels where railroads are more likely to upgrade lines shows that at current revenue splits, short lines are unlikely to make the investment upgrade in most cases, while Class I railroads may find it beneficial to upgrade at traffic levels as low as 35 to 40 cars per mile. The illustration shows that a larger revenue share for short lines or a loan guarantee program that extends the length of loan terms available to short lines could increase the likelihood of upgrading lines with light rail on Short Line systems.

Finally, the study estimates the generalized highway impacts that would result from eliminating rail lines with various traffic thresholds. The study shows that if all rail lines with less than 35 cars per mile originated and less than 90 pound per yard rail are eliminated (895.5 miles), the annual highway impacts would exceed $1 million, but the cost of upgrading these lines would exceed $191 million. Similarly, if all lines with less than 150 cars per mile originated and less than 90 pound per yard rail are eliminated (1,202.3 miles), the annual highway impacts would exceed $1.8 million, but the cost of upgrading these lines would exceed $257 million.[64] Thus, a state-funded subsidy to upgrade all such potentially abandoned lines does not appear to be warranted. However, some subsidy may be justified in some cases.

[64]These upgrading costs do not consider the costs of upgrading bridges. The need for upgrading bridges to handle heavy rail cars is very case specific. Thus, it is beyond the scope of this study to estimate bridge upgrading costs.

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