"After" Benefit-Cost Analysis of the Elko, Nevada, Railroad Relocation

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This paper presents the "after" part of a before-after benefit-cost case study of the FHWA railroad relocation and grade separation demonstration project in Elko, Nevada. The object of the demonstration project was to reduce the effects on a small western city of two transcontinental railroads passing through the downtown. Construction began about 1979 and finished in 1983. The after benefit-cost study was completed in 1987 as part of an overall before-after report submitted to FHWA, the Nevada Department of Transportation, and the city of Elko. The main result of the benefit-cost study was the quantification and pricing of the primarily social and environmental benefits of the railroad relocation, including flood control as well as reduction of noise, vibration, accidents, and considerable delay and disruption in the downtown. Depending on the discount rate, benefit-cost ratios of 0.61 to 1.12 were calculated. Approximately 80 percent of the benefits went to the community and 20 percent to the railroads.

This paper presents the "after" part of a before-after benefit-cost case study of the FHWA railroad relocation and grade separation demonstration project in Elko, Nevada. The after benefit-cost study was completed in 1987 as part of an overall before-after report submitted to FHWA, the Nevada Department of Transportation, and the city of Elko.

The object of the demonstration project was to reduce the effects on Elko, a small western city (population 11,500 in 1985), of two transcontinental railroads passing through the downtown. Both the Southern Pacific Transportation Company (SP) and Western Pacific Railroad (WP), acquired in 1983 by the Union Pacific Railroad (UP), passed through the middle of the downtown and literally cut the town in two, sometimes for hours at a time. Besides the noise and vibration associated with the railroad tracks, the 18 mainline grade crossings in the downtown had become a significant source of accidents. The railroads that once had been the lifeblood of the town had become a blight and a hazard.

Consideration of the project was begun in the early 1970s with construction beginning about 1979 and finishing in 1983. The main action of the project was to remove the railroad tracks from the downtown and relocate them in an adjacent grade-separated corridor along a realigned section of the Humboldt River. The WP yard was also moved from immediately adjacent to the west side of the downtown to a more remote and spacious location at the eastern end of town. De Leuw, Cather and Company and Chilton Engineering (later Kennedy/Jenks/Chilton) performed the planning, environmental analysis, and design of the project.

A major purpose of the benefit-cost study was to demonstrate methods of pricing out intangible benefits, such as the reduction of noise and community disruption. This paper presents one way to price some of these benefits. The period of analysis is 30 years, from the base year of 1978 to 2008, to reflect a more typical analysis period for the flood control part of the demonstration project as well as to capture a significant fraction of the design life of the major bridges.

The selected annual discount rate is 4 percent in contrast to 7 percent or 10 percent used in some analyses. The results of discounting at the other percentages are presented, however. This choice reflects the belief that a 4-percent discount rate in a low risk, constant-dollar environment is equivalent to a private sector opportunity cost of 11 percent or greater. Selection of the discount rate is discussed in greater detail later in this paper (see Calculation of Benefit-Cost Ratio). Corresponding to the 4-percent discount rate, all benefits and costs used in the analysis are expressed in constant 1978 dollars.

The first three sections of the benefit-cost analysis correspond to the primary recipients of the benefit: the railroads, the highway users, and the community. Within each section, the basic assumptions of the analysis are presented together with the results of each step. The analysis concludes with a summary of net capital costs and the calculation of a benefit-cost ratio.

RAILROAD BENEFITS

Distance and Curvature

Because railroad operating costs vary by the distance traveled, the curvature of the track, and the tonnages carried, increased operating costs from increased post-project

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travel distance and curvature were calculated reflecting the following conditions:

- An initial analysis year of 1984, corresponding to the first full year of railroad operation in the new corridor.
- Increased distance of 0.35 miles and increased curvature of 79° eastbound and 88° westbound.
- Conservative tonnage projections with railroad tonnage assumed constant through the year 2000, then increasing from approximately 59 million gross tons/yr to 66 million gross tons/yr by 2008.

Based on these parameters, total increases in operating costs in 1984 are estimated to be $34,300/yr in 1978 dollars. From tonnage increases anticipated between 2000 and 2008, the increased costs are expected to rise to $38,700 by 2008. At a 4-percent discount rate, the 1978 present value of this increase in operating cost is $447,200.

Savings in Running Time

The running times between terminals were calculated to reflect speed limits raised from 20 to 35 mph eastbound and 35 to 65 mph westbound and changed mainline railroad operations resulting from relocation of the UP/WP yard. UP still stops when eastbound to refuel, resulting in less time saving than SP. Running time savings ranged from about 6 to 12 min per train, depending on the direction and carrier.

To calculate the value of these time savings, the cost of operating the trains is taken at $33.75/train hr, not including the costs of the crew. Because train crews are paid on a mileage basis, there is no direct cost saving to the railroad for less crew time. However, the time savings do constitute a social benefit to the train crews, valued here at one-half the average transportation wage rate for the Elko area based on unpublished county payroll data and a similar procedure used for the benefit-cost analysis of the Pensacola-Milton railroad bypass (*1*, pp. 4–10, 4–32).

Based on 2,555 trains per year in each direction for each railroad, the estimated savings would approximate $62,200/yr (in 1978 dollars) for 1984 through 2008. Although the freight traffic is assumed to increase about 1.4 percent per year between 2000 and 2008, the savings are not assumed to increase because trains may simply become longer with no increase in crew, here assumed to average 4.25 persons per train. This benefit stream corresponds to a 1978 present value of $798,800 at a 4-percent discount rate.

Freight Car Per Diem Payments

To place a value on the marginal effect of faster rail operations on more efficient service for shippers and railroad system benefits, the concept of freight car per diem payments is used. The 1978 average daily rate paid by each of the nation's railroads for the use of foreign cars on its system was $4.50/day. This value was applied to both foreign- and operator-owned cars to reflect the increase in car availability, reduction in the minimum size of the car fleet, or potential revenue to the owner from foreign carriers. Privately owned or leased cars are excluded from the computations because their compensation is on a mileage rather than a time basis.

The annual per diem savings from the time savings tabulated above are equal to $18,400 in 1978 dollars based on 1984 railroad traffic volumes. This value is estimated to remain constant through 2000 and then increase at 1.4 percent per year, corresponding to the expected growth in freight traffic. The 1978 present value of these avoided costs is $239,700.

Grade Crossings and Automatic Warning Systems

The grade-crossing warning system in Elko very likely would have required improvement by 1980 or 1985 if the demonstration project had not been implemented because 15 crossings were among the most dangerous in the state. The grade crossings averaged about six accidents per year and a fatality every other year, not including the secondary accidents between cars waiting in the queues or racing to the next open crossing. The remaining three crossings probably would have received automatic gates by 2000 because of the growth of traffic in Elko. The 1978 present values of the avoided community capital costs and avoided railroad maintenance costs for a new warning system with automatic gates are $1,071,400 and $1,557,500, respectively, based on initial costs of $64,200 per gate installed and annual maintenance costs of $80,800–$93,700/yr over the study period.

Other Maintenance Cost Reduction

A one-time approximation is taken of the value of avoided track renewals, totaling $2,098,000. The benefit is the cost that would have been expected in about 1988 if the project had not been implemented. Also included in this category are 2 years of benefits from the increased efficiency of the new yard for full-scale Western Pacific/Union Pacific operations from October 1983 through summer 1985. The value of the increased efficiency was estimated by De Leuw, Cather to be $400,000/year. The 1978 present value is $2,037,000.

Accident Cost Reduction

To determine the probable reduction in rail accident cost of the demonstration project, the following topics are considered: the probable project reduction in accident risk or exposure, the anticipated baseline accident frequencies and damages, and the estimated accident cost savings.

Reduction in Accident Risk or Exposure

Because about 45 percent of national rail accidents, including derailments, have been found to be related to track or roadbed conditions (*2*), the replacement of the aging mainline track through Elko with a new roadbed and continuously welded rail reduces the expected frequency of track-related derailments. The elimination of switches along this section of mainline also reduces the potential for derailments because of human factors, the source of about 25 percent of national rail accidents (*2*). To estimate the reduction in derailment exposure, the new mainline is assumed to reduce 55 percent of derailments (all track-related derailments plus a share of those related to human factors) by 95 percent for 10 yr. The human factor saving is assumed to continue after 10 yr. In addition to reducing the frequency of derailments, the demonstration project also eliminates rail accidents in the congested downtown area, thus reducing by 500 the number of persons who would have to be evacuated in the case of fire or the release of hazardous material along the mainlines.

Baseline Accident Frequencies and Damages

Two types of derailments are considered: small scale and large scale. In the small-scale derailment, the damage is confined to within 150 ft of the tracks. Damages usually range from $10,000 to $500,000, with an average figure of $150,000. With aging track, the rate for this type of accident might have approached two per year had the demonstration project not taken place.

In a large-scale derailment, damage can extend up to 0.5 mi on either side of the tracks because of fire, fumes, and explosions. Damages in this case can range from $1 million to $20 million plus, with an average figure of $10 million. The rate for this type of accident was based on the frequency of SP accidents involving damage to cars carrying hazardous material and release of hazardous material (*2*). Allocating the risk on the basis of track miles and considering the effect of two railroads passing through Elko leads to a no-project expected rate of 0.009 large-scale accidents per year in Elko—roughly a 9-percent chance of such an accident in the 10-yr no-project comparison period.

In the case of a large-scale accident or even the threat of explosion or hazardous fumes, a zone extending 0.5 mi to either side of the tracks and including 58 percent of the population of Elko, or 6,700 persons, would be at risk and require evacuation. The social cost of evacuations is estimated to be the value of 48 hr of evacuation time per person, valued at one-half the wage rate corresponding to the 1978 per capita income in Elko ($3.74/2 = $1.87/hr). The risk of evacuation is substantially higher than that for a large-scale accident because evacuations tend to be precautionary in nature. Based on the frequency per track mile of cars damaged carrying hazardous materials, the no-project expected rate of evacuations in Elko is estimated to be about 0.067 per year or roughly a 67-percent chance of an evacuation in the 10-year no-project comparison period.

Estimated Accident Cost Savings

Applying the expected accident reduction to the baseline accident rates gives an expected value of savings of $230,000/yr over 10 yr and $45,000/yr over the remaining life of the project. Assuming that all of the evacuation cost savings accrue to the community along with 20 percent and 60 percent of the savings in small- and large-scale accidents, respectively, the 1978 present values of the benefits are

Benefit	*Present Value*
Railroad Accident Savings	$1,128,683
Community Accident Savings	$823,041

HIGHWAY USER BENEFITS

Delays at Grade Crossings

The highway delay benefits were calculated using a grade crossing delay model developed by De Leuw, Cather and procedures developed by AASHTO and Stanford Research Institute. The grade-crossing delay model is based on measured crossing blockages in Elko. It calculates stopped delay including the effects of queueing, assuming random arrivals over the blockage times with arrival rates based on average daily traffic. Future delay was a function of rail traffic levels described under the heading Railroad Benefits above and of traffic increases based on expected population growth.

There are two components of benefit from the avoided delay at railroad grade crossings in downtown Elko. The first component is the avoided motor vehicle passenger time delay from either being stopped by a closed grade crossing or simply slowing to cross the railroad tracks. The second component is the reduction in vehicle operating costs for the speed-change cycles and idling associated with the railroad grade crossings. These components of cost are described below.

Avoided Motor Vehicle Delay

A total of 28,900 hr of vehicle delay is estimated to have been avoided in 1984 because vehicles were no longer stopped for railroad grade crossings in downtown Elko. It is anticipated that this figure would have exceeded 74,300 hr/yr by 2008. The slowing of vehicles for rough grade crossings is estimated to add 20,400 and 43,100 hr in 1984 and 2008, respectively. Because of a higher population growth rate prior to 1990, these delays and all traffic-related impacts increase faster prior to 1990 than later.

Based on data from the AASHTO *Manual on User Benefit Analysis of Highway and Bus-Transit Improvements* and updated to 1978 dollars with the consumer price index (CPI), a value of time is chosen of $1.06/hr, which reflects rates of about $7.50/hr for large trucks and $0.42/hr for passenger vehicles with an occupancy of 1.56 for average trips (*3*, pp. 19, 70). The latter value is low because the value of passenger vehicle time savings has been found to be sensitive to the amount of time saved, here less than 5 min per trip. The total value of time saved is then about $52,200 in 1984 and $124,500 in 2008.

Avoided Speed-Change and Idling Costs

Using volumes and times from the grade-crossing delay model, vehicle operating costs for the stop-start cycles and idle times were calculated from AASHTO procedures for a 25-mph approach speed (*3*, pp. 19, 70). Savings peaked at the end of the analysis period in 2008 with avoidance of the stop-start of 5,800 vehicles daily with annual operating cost savings of $68,000.

As with vehicle time savings, vehicle operating savings resulted when automobiles avoided the speed-change cycles associated with slowing for the rough crossings even when no train was present. Although the cost per vehicle is minor, the savings to society become substantial when all of the traffic across the crossings is considered. Based on the AASHTO data cited above and SRI nomographs for railroad crossings of average roughness and a 25-mph approach speed (*4*, pp. XI–6, XI–7), the number of vehicles that would have been slowed and the associated cost avoided ranged from 65,000 in 1984 to 138,000 in 2008 with annual cost savings of $150,000 and $319,000, respectively.

Accident Reduction

From city and state records of accidents between trains and automobiles for the 8 yr prior to the study, the following accident rates were calculated (excluding accidents from vehicles waiting in line or rushing to the next crossing):

Accident Type	*Accident Rate (accidents/million vehicles crossing)*
Property Damage Only	0.29
Injury	0.14
Fatal	0.04

Because most of the flashing-light crossing active warning systems would have been replaced with automatic gates if the demonstration project had not been implemented, this rate of exposure would have been reduced considerably. Based on data reported by SRI (*4*, pp. XI–6, XI–7) from NCHRP (*5*) and Voorhees (*6*, ch. XI, p. 7) and conservatively assuming that the reduction applies to all crossings, a factor of 0.35 was applied to these rates to estimate the reduction. This reduction factor compares favorably with a 40-percent factor found by the California Public Utilities Commission (PUC) (*7*).

The costs for motor vehicle property damage and fatalities were derived from the National Highway Transportation Safety Administration (*8*) and Forester (*9*), respectively (the latter as reported in *1*, pp. 4–10, 4–32). The cost of injuries in railroad grade crossing accidents was derived from a weighted distribution of injury types at urban railroad grade crossings by FRA and FHWA (*10*. p. 77). All costs were adjusted to 1978 levels with the CPI.

Accident Type	*Cost*
Property Damage Only	$1,400/acc
Injury	$33,200/acc
Fatal	$401,200/acc

Applying the above corrected rates to the total traffic that would have crossed the railroad tracks at grade, and using these per accident costs suggests a 1978 present value of accident reduction benefit equal to $3,192,400.

COMMUNITY BENEFITS

Reduced Disruption and Pollution

Because primary effects of railroads running through downtown Elko were the disruption of the community and the creation of vibration, noise, air, and visual pollution in an area important to the well-being of Elko, an important benefit to the community was the removal of these effects. It is difficult to quantify and assign a price to this benefit. Because these impacts have some effect on property values, the change in property values that is attributable to the relocation of the railroad is used as a surrogate price for these effects.

In traditional economic analysis, increase in land value as a result of a capital investment is considered a transfer effect. This effect is based on the theory that demand for land in a community is relatively constant and, as a result, increases in value in one location may result in decreases elsewhere. In this case, the increase in land value attributable to the project is assumed to be a surrogate measure for the benefit of reduced pollution and community disruption and for increased efficiency of commercial activity in the central business district.

Additional supporting evidence of this assumption comes from an examination of the demand for land in Elko. Because federal lands surround much of Elko, there has been a shortage of developable land for business, particularly land that is centrally located with respect to the downtown. Businesses in Elko have had the choice of accepting either the disutility of the railroads' environmental impacts downtown or the disadvantage of less central locations. The unexpected growth of Elko in the last 8 yr has accentuated this problem, even to the point of new businesses failing to locate in Elko because there were no available parcels of adequate size with utilities.

The demand for land, as measured by valuation in constant 1978 dollars, went up for all areas of the city. There was no measurable decrease in value from a transfer effect. At the most, some parcels did not increase in value because of the development or release of previously unavailable but more desirable parcels, which allowed supply to temporarily match demand. This is also expected to be the case in the release of yard property (see Release of Railroad Property). The proportional increase in value contributed by the project was only a fraction of the total increase. This effect was because of a latent value potential of property values to increase that was dependent on the project removing the railroad tracks before enabling public and private investment would be worthwhile. Property values in some residential areas also went up because of the project because residential neighborhoods had been adversely affected by the railroad impacts, particularly noise and community disruption, prior to the demonstration project.

The change in property value attributable to the project is thought to be a conservative measure of the reduction in these impacts. For example, the value of reducing interior noise of buildings is also valued by estimating the price for accomplishing the equivalent reduction through noise insulation. Based on unpublished Elko assessment data, this type of home improvement is thought to be similar to structural improvements in that only about 10 percent of the actual money spent on the improvement can be expected to show up in an increase in value of the property.

From an analysis of the change in property values by zone between 1978 and 1984, the total increase in property value attributable to the removal of the railroad is about \$4.1–\$5.3 million, exclusive of the value of released railroad property and some adjacent properties in the vicinity of the old WP yard. The 1978 present value of the midpoint of this range is \$3.68 million. This present value is net of the overlap with the noise reduction value discussed next, and assumes that the benefit is taken in 1984 after the removal of the trains. This tabulation also excludes the increase in value of the old WP yard released for use as a business park, which is presented after the analysis of community benefit.

Noise Reduction

The value of reducing noise by moving the railroad out of the downtown is quantified by assuming that it is worth the cost of reducing interior noise to acceptable levels by sound insulation. The number of homes and businesses exposed to excessive noise was defined by comparing before and after noise measurements and projections. The cost of insulating a home from noise by lowering the interior day-night average noise level (L_{dn}) to an acceptable level of 40 dB(A) is estimated to be \$5,000 per home. This estimate is based on the cost of double glazing windows of \$5–\$10/ft^2 and installing air conditioning where not already present to permit windows to stay closed all year. Comparable estimates were made for businesses, industries, and motels with a total cost or benefit of \$2.2 million, equivalent to a 1978 present value of \$1.81 million. Ten percent of this amount was subtracted from the increase in property value representing reduction of disruption and pollution.

Flood Control

A major benefit of the project was the reduction in damage to property from flooding. Prior to the demonstration project, the channel of the Humboldt River through Elko had a capacity of less than 2,000 ft^3/sec (cfs). Based on a 1975 study by the Army Corps of Engineers (ACOE) for winter conditions, the relocated channel was designed for the 100-yr flood, a flow of 12,500 cfs (*11*). Since the construction of the channel in 1981, damage from flooding has been averted in all but 1 yr. In 3 of the 5 yr of this wet cycle, peak flows have approached or equaled the largest flood of historical record, 7,100 cfs in 1962.

A model of Elko flood damage was constructed from hydraulic calculations of the preconstruction and postconstruction channels with flows that corresponded to the 10-, 50-, and 100-yr floods (*11*). Estimates of the damage averted by the new channel were made for the three flows from 1985 assessed property valuation and the depth of flooding, utilizing curves developed by the Flood Insurance Administration of the Department of Housing and Urban Development. Property values were corrected to 1978 levels using the CPI for the period. From this model, an estimated \$1.6 million in property damage was avoided in the 5 yr through 1986. Future flood damage was also estimated from the model based on the ACOE expected flows corrected by assuming a 60-percent chance of the current wet cycle's continuing for another 5 yr.

The city of Elko also avoided the costs of likely bridge damage and emergency repair by virtue of replacing the two downtown bridges prior to the start of the wet cycle. The expected value of the benefit was estimated to be \$600,000, based on a 75-percent chance of having lost the main Fifth Street Bridge. A capital credit is also taken for project cost of replacing the substandard and deteriorating Ninth Street Bridge because it would have had to be replaced in the immediate future in the no-project case.

Emergency Services

The demonstration project improved emergency vehicle service by eliminating the occasional 3–8-min train delays for police, fire, and ambulance service. Prices for these three factors are estimated to place a value on improved emergency services—reduced insurance costs, improved life-saving service, and avoided city expenditure for facilities.

Reduced Insurance Costs

Based on unpublished data from an Elko insurance agent, the relocation of the railroad tracks was one of four factors in the reduction of Elko's fire risk rating. Because the project improved the city's ability to fight two fires at once, one south of the river and one north, one-fourth of the estimated reduction in insurance cost for property improvements in the whole city is used as a measure of realistic, expected savings in property damage from fire. Assuming that 75 percent of the value of assessed property in Elko in 1978 was for improvements ($51.8 million × .75), a 0.6% insurance rate, and a 15-percent total decrease in premiums, the insurance savings would total about $25,000/yr from 1984 to 2008.

Improved Life-Saving Service

Comments on the effect of delayed emergency service have included stories about a hospital administrator who died of a heart attack at home while an ambulance waited for a train to clear the crossing or about fire engines delayed while responding to a life-threatening fire. In view of an expected 200-percent increase in vehicle delay in the no-project condition and the separation of the south of town from the hospital by the railroad tracks, it is assumed that the improvement in emergency access would save one life every 5 yr. From the $401,200 value of life noted in the Highway User Benefit section of this paper, the expected annual saving would be $80,200/yr.

Avoided City Expenditure for Emergency Facilities

The costs of a new ambulance station south of the river that was avoided because of the project is estimated to be $100,000. This cost is assumed to be a benefit in 1978. The 1978 present value of all of the emergency service benefits is $1,451,000.

Reduced Risk of Hazardous Derailments

From the previous presentation of the expected reduction in derailments under railroad benefits, the 1978 present value of the portion accruing to the community is $823,041.

Reclamation of River Property

The rechannelization of the Humboldt River converted 8.03 acres of private property from river bottom to usable property. The $300,000 increase in the value of the land reflects the social benefit of the land being available for productive use. A conversion date of 1982 gives a 1978 present value of $282,800.

Release of Railroad Property

After the completion in 1978 of the relocation project in Elko, the old Western Pacific yard was to be turned over to the city of Elko with specific restrictions regarding its ultimate use. The restrictions placed on the property by the federal government stated that, as original railroad land grant property, the land could be used only for public purposes unless it could be paid for at assessed market value by the city. An agreement was reached between the city of Elko and FHWA to auction the property for development of an industrial park and to credit the proceeds toward the project. The proceeds will be apportioned to the relocation project and to the various other property owners within the industrial park boundary. The credit to the project, based on the assessed value of about 40 acres of railroad parcels to be sold at public auction in 1987, is $1,129,000 in 1978 dollars, which is equivalent to a 1978 present value of $0.79 million.

In addition to the 40 acres to be sold of the 170 total acres in the planned industrial area, there are about 47 acres of existing railroad leases and 71 acres of land in city or private ownership according to unpublished city of Elko data. Because of the shortage of developable business property in Elko, the release of railroad property for business development is a social and economic benefit to the community that is valued at the net increase in value of the land for parcels previously leased, with transfers assumed to take place by 1990. The value of the 71 acres already in private or public hands also increased at a rate similar to the rate of increase in property values elsewhere in Elko. The average increase realized in 1984 is estimated to be $10,000 per acre in 1978 dollars by the Elko city assessor. In addition, 7.8 acres acquired by the city for a jail site and Silver Street right-of-way has a net value per acre of $20,000. The value of these lands credited as a project benefit is $1.34 million in 1978 dollars, equivalent to a 1978 present value of $981,000.

CALCULATION OF BENEFIT-COST RATIO

Selection of Discount Rate

Research performed by leading benefit-cost and financial investment authorities (*12*, pp. 214–251, 376; *13*, p.10; *14*, pp. 122, 129, 135) leads the author of this paper to suggest that 4 percent is the appropriate discount rate to use for public projects similar to the Elko demonstration project. Suggestions for higher rates have used the opportunity cost of leaving the funds in the private sector as a rationale for discount rates of 7 percent, 10 percent, or even higher. However, when the effects of inflation and uncertainty are subtracted from the interest rates, these higher rates are equivalent to 4 percent or less for a public project similar to the Elko railroad relocation. These effects are discussed in turn below.

Inflation

When a private investor invests money, he does so with the realization that his dollars will be worth less when he gets his money back. Over the 57 yr prior to 1983, the amount of real goods and services that $1 would purchase has declined about 3.2 percent/yr as measured by the CPI. From 1966 through 1982, this rate has averaged 6.9 percent/yr (*13*, p. 10). Hence the return that any prudent investor seeks on his money includes an allowance just to maintain the status quo against inflation. Examination of the minimum rates that the U.S. government must pay to borrow in the form of short-term Treasury bills confirms this expectation by indicating that, on the average, investors demand to keep up with the expected rate of inflation on risk-free investments: between 1926 and 1982, the average rate of return on Treasury bills and the CPI rate of increase have been virtually identical at about 3.2 percent each annually.

For the purposes of selecting a discount rate, it is only necessary to specify whether inflation is included or excluded from the rate. If inflation is included in the discount rate, then the value of project benefits in future years should be escalated by the expected inflation rate. If inflation is not included, benefits should be valued in constant dollars. Because the latter approach is simpler, although equivalent mathematically to the former, the latter is chosen here. The allowance for inflation is excluded in both the discount rate and in the valuation of the project benefits. Consequently, in the long run, the inflation-free discount rate would be expected to be about 3.2 percent below the equivalent private market rate for return on investment.

Uncertainty

Uncertainty has an even greater effect on the comparison of private rates of return with the proper discount rate. The private investor demands a higher return from risky investments than from safe investments. Brealey and Myers explain that the difference between the return on an average stock portfolio and on a Treasury bill is all risk premium, equal to an average of 8.3 percent/yr over the last 56 yr (*14*, pp. 122, 129, 135). If an investment is less risky or more risky than the standard stock portfolio, the risk premium should vary correspondingly.

The issue of uncertainty is extremely important for the selection of the proper discount rate. Mishan, a leading authority on benefit-cost economics, argues that the highest reasonable discount rate under certainty would be equal to the annual certain yield on a dollar of private investment (*12*). Correspondingly, Brealey and Myers explain that they would evaluate a safe private investment at the Treasury bill rate (3.1 percent through 1981), an investment of average risk at 3.1 percent + 8.3 percent = 11.4 percent, and so on (*14*, pp. 122, 129, 135).

To judge the amount of risk involved in the stock market, the standard deviation has been 21.9 percent on an average rate of return of 11.4 percent in the stock market over the last 56 yr (*14*, pp. 122, 129, 135). Assuming that returns on stocks are normally distributed, this standard deviation means that there is a 67 percent chance that the actual rate of return will be included in the range of + 21.9 percent around the average of 11.4 percent, and a 95 percent chance that the actual rate of return will be included in the range of + 43.8 percent around the average of 11.4 percent, and so on.

However, the case for this public investment in Elko is different. Because of the spreading of risk in public investments, a lower discount rate should be used than in the private sector where the effects of the risk have more effect on individual investors through lower rates of return or even losses (*12*, pp. 214–251, 376). In this case, there is so much spreading of risk by the investors that the individual risk is insignificant: $25 million spread over some 100 million employed taxpayers versus $20 million in benefits spread over some 10,000 beneficiaries or $.25 in investment versus $2,000 in benefits per person. Public benefits are lower than costs because 20 percent of the benefits go to the railroad. From this calculation, it is evident that this project also avoids spreading the benefits so widely that they become insignificant, a problem often associated with projects that spread risk. In this case the benefits are comparatively concentrated.

With respect to the risks faced by the beneficiaries, looking at the type of risk is informative. Elko growth is fairly predictable or, at least, is likely to continue, removing the question of whether people would be there to receive the benefits of less delay, fewer accidents, less environmental impact on the city, less flood damage, and so on. There are some uncertainties on the magnitude of the benefits because of uncertainty about actual growth, weather, and so on.

However, a significant amount of that uncertainty has been removed 9 yr into the 30-yr period because many of the major benefits have already been realized or adjusted for changing conditions. For example, benefits are now estimated to be much lower than expected in 1978 because of the lack of utility of the new yard to the Union Pacific, greatly lowered expectations for transcontinental rail traffic, and the elimination of possible gaming benefits in Elko. Furthermore, remaining variations in benefits will be more heavily discounted than those already accounted for, thereby reducing the effect of future benefit uncertainty on the actual benefit-cost ratio.

Because of the spreading of risk by the investors and the after adjustment of the benefits, this project appears to have very low risk compared with the risk faced by investors in the stock market. If an annual risk premium of 0 percent is used, the 4-percent discount rate corresponds to a private sector opportunity cost of about 15 percent/yr when the effects of inflation (3 percent) and average private sector risk (8 percent) are added. Because the stock market returns have averaged around 11 percent/yr, this discount rate seems more than adequate to account for the social opportunity cost of capital. In fact, one could reason backwards from the average 11-percent opportunity cost and conclude that a 4-percent discount rate for this project includes an annual risk premium of up to 4 percent (11 percent − 3 percent inflation − 4 percent or half the 8 percent average risk premium = 4 percent).

Capital Costs and Salvage Value

Capital costs for the project total $45,887,000 in actual dollars. These costs are offset by project credits, such as land transfers and salvage of the previous railroad trackwork, which in actual dollars amount to $2,599,000. In 1978 dollars, the offsetting credits total approximately $1,534,000. Minus an additional $139,000 in nonparticipating costs, net capital costs are $34,494,000. The 1978 present value of this net capital cost is $30,558,500. Because the Ninth Street Bridge would have been replaced in the no-project case (see Flood Control above), an additional credit is taken in 1983 for $600,000 of the cost of the bridge in 1978 dollars. The 1978 present value of the new net capital cost is $30,065,400 before salvage value is considered. These capital costs are summarized in Table 1.

TABLE 1 CAPITAL COSTS

Item	1,000 Actual $	1,000 1978 $	Present Value 1,000 1978 $ Discounted at 4%
Total Cost			
Before Credits	$45,887	$36,167	
Project Credits	(2,599)	(1,534)	
SUBTOTAL	43,288	34,633	
Non-Partici-pating Costs (in 1978 $)	(139)	(139)	
SUBTOTAL	43,149	34,494	$30,558.5
9th St. Bridge Credit (in 1978 $)	(600)	(600)	(493.1)
CAPITAL COSTS	$43,749	$33,894	$30,065.4

The salvage value is based on 100 percent of the initial cost of the land with adjustments for the increase in value of the land in the new yard because of improvements. The new yard covers about 230 acres of land exclusive of mainline right-of-way, of which about half was purchased

TABLE 2 BENEFIT-COST SUMMARY

	Discount Rate (1,000 1978 $) 4%	7%	10%
RAILROAD BENEFITS			
Distance and Curvature	($447)	($269)	($177)
Savings in Running Time	$799	$483	$319
Freight Car Per Diem Payments	$240	$144	$95
Grade Crossings & Protection	$1,558	$1,137	$873
Other Maintenance Cost Reduction	$2,037	$1,582	$1,240
Railroad Accident Reduction	$1,129	$813	$601
Subtotal	$5,315	$3,890	$2,950
HIGHWAY USER BENEFITS			
Delays at Grade Crossings	$4,293	$2,570	$1,618
Accident Reduction	$3,192	$1,927	$1,224
Subtotal	$7,486	$4,497	$2,842
COMMUNITY BENEFITS			
Reduced Disruption-Pollution	$3,681	$3,194	$2,781
Noise Reduction	$1,808	$1,569	$1,366
Flood Control	$2,717	$2,159	$1,751
Emergency Services	$1,451	$974	$693
Grade Crossings & Protection	$1,071	$1,021	$994
Reduced Risk of Haz. Derailments	$823	$593	$438
Reclamation of River Property	$283	$252	$226
Release of Railroad Property	$981	$788	$641
Subtotal	$12,815	$10,550	$8,891
TOTAL BENEFITS	$25,616	$18,936	$14,684
CAPITAL COSTS	$30,065	$27,647	$25,512
SALVAGE VALUE	$7,259	$3,093	$1,349
NET COSTS	$22,807	$24,554	$24,163
BENEFIT-COST RATIO	1.12	0.77	0.61

for approximately $600 per acre. The 1985 appraised value per acre of the entire yard was $59,000 per acre, giving an added value of $11.1 million in 1985 dollars or $6.8 million in 1978 dollars. The salvage also includes 46 percent of the construction cost of earthwork and major structures based on an approximate service period of 27 yr within the study period and a total estimated life of 50 years. In undiscounted 1978 dollars, the salvage value is $23.5 million. The 1978 present value of the salvage value is $7.3 million, giving a present value of the project net capital cost for benefit-cost purposes of $22.8 million.

Benefit-Cost Ratio

Table 2 summarizes the 1978 present value of the benefits and costs of the demonstration project. Based on total benefits of $25,402,000 and net costs of $22,806,600, a benefit-cost ratio of 1.12 is calculated for the project with a discount rate of 4 percent. Results of higher rates of 7 pecent and 10 percent are also shown, but are not believed relevant in this case.

Two factors have a large effect on the magnitude of this ratio. Inasmuch as no tourist or gaming revenue benefits (estimated previously to amount to more than one-third of the benefits of the project) are counted for the project, this ratio is conservative. An additional factor is the reduced benefit from the $5.5 million investment in WPRR yard facilities, particularly the diesel locomotive and car maintenance shop. Had the acquisition of Western Pacific by Union Pacific and the consequential lack of utility of the new yard been foreseen, the project would show a higher benefit-cost ratio by having avoided about 20 percent of the net investment.

The distribution of benefits is quite significant. The railroads account for only 20 percent of the total benefits; highway users, 30 percent; and the rest of the community, 50 percent. The monetary values calculated here reflect the preponderant social benefit of removing the railroads from the center of town.

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Publication of this paper sponsored by Committee on Application of Economic Analysis to Transportation Problems.