The Interstate 70 East Corridor Project
Social Benefit-Cost Analysis

Prepared for

Colorado Department of Transportation

By

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New York

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-Final Draft Technical-

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Executive Summary

John Dunham & Associates was commissioned by the Colorado Department of Transportation to conduct a social benefit-cost analysis for the I-70 East Corridor Project. This study builds on an earlier economic impact analysis of the same project and is based, in part, on data from that impact study. The purpose of the social benefit-cost analysis is to determine the societal impacts (in dollar terms) of three potential alternative development proposals:

- **Full Corridor Project** with construction and improvements running from I-25 to Tower Road
- **Intermediate Project** with construction and improvements running from I-25 to I-225
- **Viaduct Project** with construction and improvements between I-25 and I-270[1]

This analysis examines 9 separate cost and benefit categories and aggregates 8 of them into a single cost-benefit statistic. If the statistic is greater than 1.0, the project has a social benefit in excess of the social cost. The larger the number, the more beneficial the project is to society. The areas examined were:

- Discounted construction costs
- Net business productivity changes
- Net regional time savings
- Vehicle operating cost savings
- Net pollution effects
- Net changes in automobile accidents
- Net changes in noise
- Net changes in local property values
- Potential economic development impacts

Based on a discounted cash flow analysis of the benefit and cost streams of the first 8 indicators, the Full Corridor Project alternative has a Benefit-Cost Statistic of 7.78, suggesting a net benefit to society of the project of almost $13.4 billion. The Intermediate Project alternative has a slightly smaller statistic, 7.06, and a net benefit of over $10.7 billion and the Viaduct Project alternative has a statistic of 4.56 and a net social benefit of just over $4.4 billion.

Even after performing a sensitivity analysis and reducing the main benefit category (productivity changes) by 75 percent, all three alternatives presented a net benefit over 20 years.

[1] Note that these development proposals have not yet been detailed in any planning documents, but are for the purpose of Alternative Analysis only.

Interestingly, the social costs and benefits basically net themselves out across all three project types, with the benefits from noise reduction, improved land use, and reduced pollution being offset by the potential that more accidents could result from faster speeds on I-70.[2] This means that the net benefit calculation depends almost entirely on the productivity implications for local businesses. In other words, the cost of constructing the road is more than fully offset by greater economic activity in regional businesses.

These figures do not even take into account the potential economic development benefits of the project, which may be as high as $402 million depending on which alternative is selected.

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[2] All things being equal, a faster roadway will lead to additional accidents. See Libby, Thomas J., Raghavan Srinivasan, Lawrence E. Decina, & Loren Staplin, *Safety Effects of Automated Speed Enforcement Programs*, Transportation Research Record 2078, 2007 for a synopsis of studies examining this effect. Were the I-70 East Corridor Project to include substantial accident prevention and safety features it is possible that the number of accidents could be reduced. For the purpose of this analysis only the most moderate approach is used, which would suggest a slight increase in the overall number of accidents.

Introduction

John Dunham & Associates was commissioned by the Colorado Department of Transportation to conduct a social benefit-cost analysis for the I-70 East Corridor Project. This study builds on an earlier economic impact analysis of the same project and is based, in part, on data from that impact study.

The purpose of the social benefit-cost analysis was to determine the societal impacts (in dollar terms) of three potential alternative development proposals:

- **Full Corridor Project** with construction and improvements running from I-25 to Tower Road
- **Intermediate Project** with construction and improvements running from I-25 to I-225
- **Viaduct Project** with construction and improvements between I-25 and I-270[3]

The improvement of the Interstate 70 Corridor (I-70) between Interstate 25 to the west and Tower Road to the east will generate both economic and social benefits, and will also incur significant costs in terms of resources and other externalities. A social benefit-cost analysis is designed to calculate and compare these benefits and costs by converting various and disparate outcomes into dollar terms. Some of these conversions are relatively simple (for example the discounted value of construction expenses), while others are more complicated (the value of time, or the value of emissions).

This analysis examines 9 separate cost and benefit categories and aggregates 8 of them into a single cost-benefit statistic. If the statistic is greater than 1.0, the project has a social benefit in excess of the social costs. The larger the number, the more beneficial the project is to society. Since valuing externalities in dollar terms (for example the value of a ton of carbon emissions) is very subjective, benefit-cost analysis is best used when analyzing different alternatives to the same problem. In this case, the analysis examines the three project alternatives and provides a comparative benefit-cost statistic for each.

Benefit-cost analysis can be extremely complex and can include a large number of variables. This is particularly the case for new infrastructure construction (for example the development of a new airport or seaport) or when differing types of alternatives are being examined (for example analyzing different ways to get people to an airport – rail, boat, bus, etc.). Since this analysis is examining three alternatives to reconstructing a single roadway in a developed industrial area, many items that might generally be included in a benefit-cost analysis would not show substantial differences. For example, while one might examine the impact of different transportation alternatives on area wildlife, it is unlikely that any changes to I-70 will greatly change the number of deer strikes along this particular corridor.

Even so this analysis examines the following areas:

3 Note that these development proposals have not yet been detailed in any planning documents, but are for the purpose of Alternative Analysis only.

- Discounted construction costs
- Net business productivity changes
- Net regional time savings
- Vehicle operating cost savings
- Net pollution effects
- Net changes in automobile accidents
- Net changes in noise
- Net changes in local property values
- Potential economic development impacts

Since many of the components occur in the short term (for example construction costs), while others occur over time, the analysis will examine benefits and costs over a 20 year period, with construction occurring over the first 5 years and future benefit and cost streams occurring on a discounted basis over the fifteen years following completion of construction. Since detailed construction and traffic data are not yet available, it is assumed that reasonable traffic control and flow measures are used during the construction period such that there are no net changes in delays as a result of the construction itself.

All macroeconomic projections (inflation, wage rates, etc.) are taken from the Congressional Budget Office's *Long Term Budget Outlook* report.[4]

Where appropriate, figures will be discounted to 2013 dollars using a 5.0 percent discount rate. While the Federal Office of Management and Budget suggests that a discount rate of 2.7 percent should be used for a 20-year project time horizon, this seems excessively low. It is unlikely that real interest rates will continue to be set at zero for any length of time, and therefore a higher discount rate is appropriate. Currently Colorado Regional Transportation District bonds with 15-year maturities are paying a coupon of 5 percent and this appears to be a more reasonable discount rate to use in this analysis.[5]

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4 *The 2013 Long-Term Budget Outlook*, Congress of the United States, Congressional Budget Office, September 2013, on-line at: www.cbo.gov/sites/default/files/cbofiles/attachments/44521-LTBO2013.pdf. The CBO report is used as a source for long term forecasts of major economic variables as it is one of the few public/government forecasts that projects out over the lifetime of this project.

5 See for example *REGIONAL TRANSPORTATION DISTRICT COLORADO FASTRACKS PROJECT SERIES A - 759136LN2* on Municalbonds.com at: www.municipalbonds.com/bonds/issue/759136LN2

Project Alternatives

The I-70 East Corridor Project encompasses as much as 12 miles of heavily trafficked roadway running along the northern part of the city and county of Denver, and through parts of the surrounding communities of Commerce City and Aurora. After careful deliberation by the Colorado Department of Transportation, the solution to existing and predicted congestion levels encompasses both elevated and below grade alternatives. In addition, while building the new roadway, the existing roadway will be maintained in order to prevent congestion from worsening during the completion of the I-70 East Corridor Project. The project could also include managed lanes which will reduce congestion and enhance the flow of traffic through the project area by providing motorists with "free-flow" options and a way to avoid congestion.

The full area under consideration for upgrade includes those stretches of I-70 running between I-25 to the West and Tower Road to the east. This encompasses the raised portion of the highway (the viaduct) which runs between I-25 and roughly Colorado Boulevard in the East. The structure was completed in 1964 and was one of the first parts of the Interstate built in Denver. The entire section of roadway under consideration was completed in 1966.

The following chart shows the anticipated construction cost estimates for each segment of the I-70 East Corridor Project as provided by the Colorado Department of Transportation. These estimates come from the Draft Environmental Impact Study (DEIS) and are not broken out by year, nor are they assumed to be discounted to current dollars.

Exhibit 1 Estimated Construction Costs by Segment

	I-25 to West of Brighton Blvd	West of Brighton Blvd to Dahlia St	Dahlia St to Quebec St	Quebec St to I-225	I-225 to Tower Road	Total Project Costs
Construction Spending	$34,392	$914,032,603	$159,818,500	$445,666,468	$148,580,041	$1,668,135,971
Engineerig Spending	$3,968	$94,555,097	$16,532,948	$46,103,428	$15,370,349	$172,565,790
Railroad Spending	$0	$12,544,000	$1,872,000	$2,850,000	$0	$17,266,000
State Government Costs	$4,220	$106,100,786	$19,321,335	$49,451,211	$16,416,404	$191,293,957
Total Costs	$42,579	$1,127,232,486	$197,544,783	$544,071,107	$180,366,794	$2,049,261,718

Table does not add exactly due to rounding

These 5 segments together constitute the *Full Corridor* alternative examined in this analysis. The first 4 sections (from I-25 to I-225) constitute the *Intermediate Project* alternative, while the first 3 sections (from I-25 to I-270) constitute the *Viaduct Project* alternative. In each case, the actual schedule of when and how these particular construction zones will be worked on is not yet known; however, for the purpose of this analysis it is assumed that there will be a 5-year construction period, with costs spread evenly across the 5 years. The 5-year construction costs across alternatives are as shown on the chart on the following page with the figures inflated for each year based on the long-term Consumer Price Index forecast from the Congressional Budget Office.

The I-70 East Corridor Project is designed to help reduce traffic congestion along this important industrial corridor. By reducing congestion, the project should reduce delays which impact the lives of the hundreds of thousands of people who use the corridor every day. Delays affect commuters, shoppers, tourists, and even emergency first-responders; leading to frustration and lost time, slower emergency responses, and reduced economic welfare. In addition, lost time impacts business productivity and economic activity in the region.

Exhibit 2 Estimated Five Year Construction Schedule By Alternative

	Full Corridor	Intermediate Project	Viaduct Project
Year 1	$409,852,344	$373,778,985	$264,964,763
Year 2	$420,098,652	$383,123,459	$271,588,882
Year 3	$430,601,118	$392,701,546	$278,378,604
Year 4	$441,366,146	$402,519,084	$285,338,070
Year 5	$452,400,300	$412,582,061	$292,471,521
Total Costs	$2,154,318,560	$1,964,705,136	$1,392,741,841

Each of the alternatives is expected to reduce travel times through the project area. In the case of the Full Corridor alternative, once the project is completed it is expected that travel times will be reduced by 45.3 percent, which is equal to about 12 minutes per vehicle using the Corridor.[6] Additionally, the travel times could be further improved by commuters who choose to enter the proposed managed toll lanes. These reduced delays (which are equal to 3.392 million hours in total) can be translated to both time and dollar impacts. These reductions would be smaller for the other alternatives, with the Intermediate Project reducing delays by 2.748 million hours in total (9.8 minutes per vehicle), and the Viaduct Project reducing delays by 1.230 million hours (4.4 minutes per vehicle).

These time savings translate to both benefits and costs depending on the particular variable being examined. For example, faster transit time across the corridor reduces emissions, which can lead to societal benefits. On the other hand, higher speeds can lead to an increase in automobile accidents with their associated societal costs. The interplay between these costs and benefits are what lead to differences in the benefit-cost statistic between project alternatives. The remainder of this paper discusses each of the nine benefit and cost components and measures them for each of the three alternatives.

[6] Based on Alternative 3 from the I-70 East *Environmental Impact Statement*, *Traffic Technical Report*, November 2008, at: www.i-70east.com/DEIS/I-70EastDEIS_V3_TrafficTechnicalReport.pdf. According to the report, traffic forecasts for Alternative 3 were obtained from the DRCOG (2030) regional model. The version of the DRCOG model used in this analysis did not produce reliable results in assigning vehicle trips to tolled facilities. Therefore, for Alternatives 3 the AIMSUN model was used to split trips within the corridor to either general purpose lanes or tolled express lanes, thus providing mainline and ramp link volumes for use in the analyses.

Benefit-Cost Components

In developing a social benefit-cost analysis it is important that an objective approach be taken. Benefit-cost analysis should not be politically based, nor should it simply be an accounting exercise. Care must be taken to ensure that appropriate criteria are taken into account and that they are applied uniformly across alternatives. Different analysts may disagree on which criteria are most important, however, every analysis should specifically state what criteria are used and why. In the case of this analysis, eight specific criteria are being used to develop the benefit-cost statistic. These are:

- Discounted construction costs
- Net business productivity changes
- Net regional time savings
- Changes in vehicle operating costs
- Net pollution effects
- Net changes in automobile accidents
- Net changes in noise
- Net changes in local property values
- Potential economic development impacts

A large number of additional criteria could be used in calculating the analysis. These could include for example, public benefits from reduced unemployment or reductions or increases in wildlife; however, as the analysis of the eight listed variables will show, many of the social impacts of this project are not significantly large and many do not differ substantially across the three alternatives. In addition, the potential economic development impacts are largely speculative. Therefore, that the figures are not used in the benefit-cost calculation itself, but are rather presented separately.

Discounted construction costs

As was outlined above in the discussion on Alternatives, the I-70 East Corridor Project will cost taxpayers at a minimum $1.4 billion over an estimated 5-year construction period. Most of this money will come from the Federal Highway Trust Fund, and will be paid for with taxes on the purchase of gasoline and diesel fuel. The following chart shows the anticipated construction cost estimates for each segment of the I-70 East Corridor Project.

Exhibit 3 Estimated Construction Costs by Highway Segment

	I-25 to West of Brighton Blvd	West of Brighton Blvd to Dahlia St	Dahlia St to Quebec St	Quebec St to I-225	I-225 to Tower Road	Total Project Costs
Construction Spending	$34,392	$914,032,603	$159,818,500	$445,666,468	$148,580,041	$1,668,135,971
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These 5 segments together constitute the *Full Corridor* alternative examined in this analysis.

The first 4 sections (from I-25 to I-225) constitute the *Intermediate Project* alternative, while the first 3 sections (from I-25 to I-225) constitute the *Viaduct Project* alternative. In each case, the actual schedule of when and how these particular construction zones will be worked on is not yet known; however, for the purpose of this analysis it is assumed that there will be a 5-year construction period, and that the costs will be spread evenly across the 5 years.

According to a recent economic impact analysis of the project, the construction will generate as many as 14,166 jobs in Colorado with an economic impact of over $1.8 billion depending on which alternative is used.

Exhibit 4 Estimated Economic Impact of Construction

	Direct			Total (including Supplier and Induced)			
	Jobs	Wages	Economic Impact	Jobs	Wages	Economic Impact	Sales Taxes
Full Corridor Project							
Regional	8,199	$501,750,487	$1,034,526,888	11,156	$645,878,948	$1,460,060,340	$16,200,947
Total	8,199	$501,750,487	$1,034,526,888	14,166	$790,434,108	$1,846,977,184	$21,820,133
Intermediate Project							
Regional	7,486	$458,096,759	$944,407,106	10,190	$589,594,434	$1,332,683,327	$14,759,368
Total	7,486	$458,096,759	$944,407,106	12,931	$721,494,249	$1,685,735,846	$19,887,319
Viaduct Project							
Regional	5,329	$326,024,102	$671,282,062	7,246	$419,358,381	$946,958,184	$10,481,907
Total	5,329	$326,024,102	$671,282,062	9,195	$513,005,959	$1,197,648,565	$14,123,972

For the purpose of a benefit-cost analysis these types of economic impacts are generally not considered, as they represent a transfer from one social entity (taxpayers) to another (contractors). This does not mean that construction is necessarily a good or bad thing, but rather on a social level it is generally neutral. What is measured in a benefit-cost analysis is however, is the opportunity cost of the construction. This means that the overall payment for the roadway is recognized as a net cost, from which the resulting changes brought about by the project are netted against.

In the case of this project, assuming a 5-year construction schedule with costs applied linearly over that period the net cost of construction will be $1.954 billion for the Full Corridor Project, $1.782 billion for the Intermediate Project and $1.263 billion for the Viaduct Project, all in discounted 2013 dollars. Figure 5 below outlines these amounts.

Exhibit 5 I-70 East Corridor Project Discounted Construction Costs

	Full Corridor	Intermediate Project	Viaduct Project
Year 1	$409,852,344	$373,778,985	$264,964,763
Year 2	$400,093,954	$364,879,485	$258,656,079
Year 3	$390,567,908	$356,191,878	$252,497,600
Year 4	$381,268,672	$347,711,119	$246,485,753
Year 5	$372,190,846	$339,432,283	$240,617,044
Total Costs	$1,953,973,724	$1,781,993,750	$1,263,221,239

In addition to the construction costs, there are incremental maintenance costs that the various alternatives would incur. Since the lowered roadway replacement to the viaduct has lower maintenance costs, those alternatives that do not extend further to the east will have lower maintenance costs than the status quo, while The Full Corridor alternative would face higher maintenance costs. These differences must also be included into the construction costs.[7]

Inflating costs at 2.5 percent per year, which is the Congressional Budget Office's long-term forecast of the Consumer Price Index, and discounting back to 2013 dollars, provides an estimate of additional maintenance costs for the Full Corridor alternative of $16.36 million, and a savings for the Intermediate alternative of $11.46 million. The Viaduct alternative would provide a maintenance cost savings of $25.62 million over 20 years. These costs form the first step in the Benefit/Cost analysis. Exhibit 6 below shows them in a tabular format that will be built upon as each step in the analysis is added.

Exhibit 6 Benefit-Cost Analysis – Step 1 Construction Costs

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes			
Net Regional Time Savings			
Vehicle Operating Cost Savings			
Net Pollution Effects			
Net Changes in Automobile Accidents			
Net Changes in Noise			
Net Changes in Local Property Values			
Total Net Benefit	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Cost-Benefit Statistic			

<u>Net business productivity changes</u>

Nearly all businesses in the state and the metropolitan area rely to some extent on transportation. In fact, according to the United States Department of Commerce, nationally, over 67 percent of all freight is delivered by truck, and even the smallest service firm relies on trucks and other transportation services to some extent. One of the major benefits of the I-70 East Corridor Project will be to reduce the cost of providing trucking and transportation services for local businesses. As costs fall, firms pass on savings to their customers, their employees or their investors. At the same time, some firms benefit from delays and higher spending on fuel, automotive maintenance and even lodging. These are; however, not societal benefits but rather transfers from some firms to others. Only those changes brought about through productivity improvements should be included in a benefit-cost analysis.

The I-70 corridor contains many major manufacturing and transportation operations, including: Safeway's distribution center between Colorado Boulevard and Dahlia Street, Nestle's pet food plant at York Street, the Denver Mattress facility on Havana, Intertech Plastics, at I-225, and the

[7] Cost differentials based on Engineers Estimates provided to John Dunham and Associates by the Colorado Department of Transportation.

Union Pacific Railroad's intermodal facility at York Street just to name a few. Examining the role of transportation for each of these firms demonstrates how improvements to the I-70 East Corridor Project will reduce costs substantially for these and other firms in the metropolitan region. For example, the Full Corridor Alternative will reduce costs per $1 million in sales by $55 for grocery distributors, by $537 for pet food manufacturers, by $395 for mattress producers, by $149 for injection molders and by $117 for rail transportation companies.[8] In addition to local firms, there are hundreds of other companies in the Denver metropolitan area that depend on this important transportation link including major freight companies like UPS and Federal Express, large wholesalers like Pepsi and Coca-Cola Enterprises and manufacturers like Coors Brewing Company, Lockheed-Martin and the Ball Corporation. Each of these companies will also see savings as a result of the project.

The following table demonstrates the expected change in delay times for each of the construction zones on the I-70 East Corridor Project based on the Draft Environmental Impact Statement.[9] As the table shows, the majority of the delay is currently occurring in the section of the roadway between I-270 and I-225, which significant delays also occurring on the viaduct between York Street and Colorado Boulevard, and then through to Holly Street. On the other hand, there are currently only minimal delays on the section of I-70 between Holly Street and I-270 through what is essentially an industrial corridor.

If the I-70 East Corridor Project were to be implemented, the expected congestion would be reduced so much so that not only would existing delays be markedly reduced, but expected future traffic volumes would be accommodated.[10] The engineers reports included in the DEIS, suggest that, overall, if the Full Corridor Project were to be implemented, delay times would be reduced by 45.3 percent from their current levels through the project corridor, with only the currently uncongested segment between Holly Street and I-270 seeing increased delays over 30 years.[11]

Exhibit 7 Estimated Delay Savings By Alternative

Alternative	Current Delay Hours Per Day	Expected Delay Hours Per Day	Change (Hours)	Change (PCt)
Full Corridor Project	28,805	15,760	(13,046)	-45.3%
Intermediate Project	28,805	18,235	(10,570)	-36.7%
Viaduct Project	28,805	24,073	(4,733)	-16.4%

Using these as a guide, delay hour savings in year 30 can be mapped against the actual cost of transportation for businesses in Colorado and in the region. While much of this benefit is likely

8 Based on the share of output in each of these industries as calculated by MIG, Inc. in its 2010 IMPLAN tables for the State of Colorado

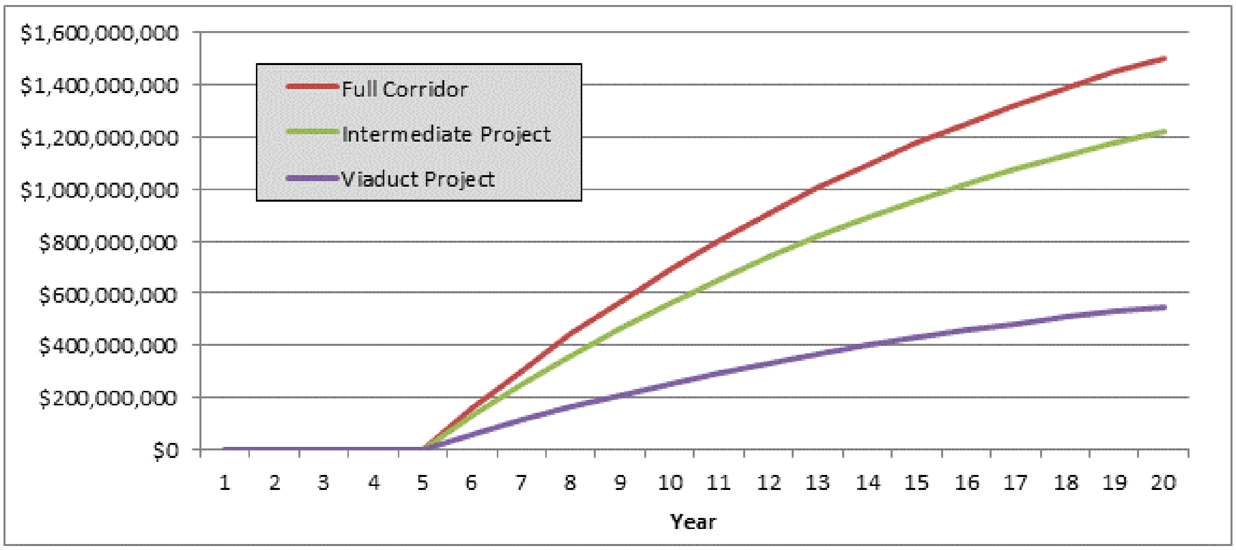
9 *Draft Environmental Impact Statement*, Colorado Department of Transportation, http://www.i-70east.com/DEIS/I-70EastDEIS_V1_Ch03_AlternativesConsidered.pdf.

10 Note that the time savings calculated here do not take into account the additional potential savings that could result from the addition of managed lanes. Data on these potential time savings were not available in the DEIS.

11 Op. Cit. *Draft Environmental Impact Statement*. This analysis assumes that the delay savings outlined in the DEIS will accrue linearly from the time that construction ends (year 5) through year 20.

to occur immediately after the project is completed, in order to make the analysis more moderate, the benefits are assumed to accrue linearly over the entire 30 year period. Based on the models, the productivity benefits in the out years can reach as high as $1.5 billion on a discounted basis. These figures are based on current output per employee ratios as calculated by the US Department of Commerce, Bureau of Economic Analysis. These will increase over time as generalized productivity improvements occur. So a 10 percent transportation time savings 15 years from now will be more valuable on a nominal basis than would one today. Therefore, the figures are inflated each year based on national productivity changes (about 1.7 percent per year) as estimated by the Congressional Budget Office. Exhibit 8 below shows graphically how these productivity benefits grow over the course of time.

Exhibit 8 Estimated Annualized Productivity Benefits By Alternative



It is important to note that this analysis is somewhat static in that it only looks at marginal changes to existing business operations. Were the roadway improvements undertaken under the I-70 East Corridor Project to enhance the overall business environment in the Denver metropolitan area, it could help the community attract additional businesses. Anecdotal evidence suggests that this is likely. For example, the Metro Denver Economic Development Corporation has identified *Mobility* as one of its strategic initiatives.[12]

The Benefit/Cost analysis begins to take shape as each of the factors is added to the model. Exhibit 9 on the following page adds the productivity benefits to the construction costs presented in Exhibit 6. With both benefits and costs now presented in the table, it is possible to begin calculating an interim benefit/cost statistic. This statistic will change as each new component is added to the model.

[12] See: *Our initiatives are a blueprint for economic success*, Metro Denver Economic Development Corporation at: www.metrodenver.org/about-metro-denver-edc/initiatives.html

Exhibit 9 Benefit-Cost Analysis – Step 2 Productivity Benefits

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings			
Vehicle Operating Cost Savings			
Net Pollution Effects			
Net Changes in Automobile Accidents			
Net Changes in Noise			
Net Changes in Local Property Values			
Total Net Benefit	$13,627,575,774	$10,915,898,688	$4,442,549,880
Cost-Benefit Statistic	7.92	7.17	4.59

Higher business productivity and cost savings leads to greater employment, higher overall wages, lower product costs and makes the state and the region more economically competitive, making Denver and the surrounding area a more attractive place for entrepreneurs to invest, and for people to work and live. This enhances tax revenues for Colorado and the various regional governments. Additional jobs that might be attracted to the region due to improved access are not included in this section of the analysis. This benefit is documented further below in the section on land use and values.

Net regional time savings

Changes in business productivity and business activity due to the I-70 East Corridor Project is the largest impact resulting from the reduction in delays, but all drivers will benefit from significantly reduced congestion along the roadway. These benefits can be calculated based on general time savings.

Aside from replacing aging structures (viaducts, bridges) that are beyond their operational lifespan, the I-70 East Corridor Project also incorporates managed lanes which can provide motorists with an option of avoiding traffic and congestion. Overall, the project is designed to significantly manage traffic and congestion on one of the critical roadways leading through Denver. Based on data provided by the Colorado Department of Transportation, portions of the project area carry as many as 208,000 vehicles per day using this transportation artery through the state's main city as a local road, a commuter route, and for the movement of goods and services locally as well as to other destinations including the Denver International Airport, farming communities, energy development sites and various tourist areas such as Colorado's many ski resorts.[13]

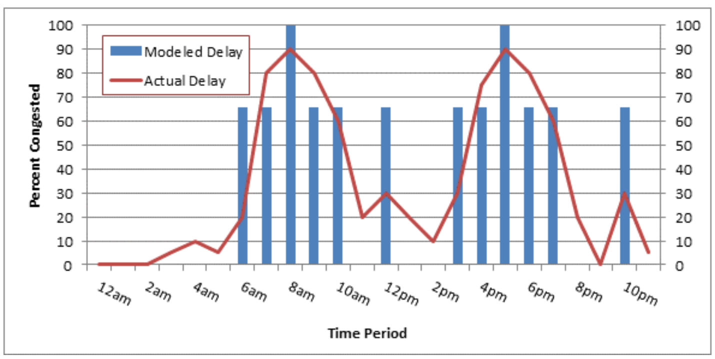
In terms of private vehicles, such as those bringing commuters to work, it is estimated that the full implementation of the I-70 East Corridor Project will reduce commuting times across the project area by about 45 percent or an average of 12 minutes for each vehicle operating on I-70 within the project corridor. Additionally, the travel times could be further improved by commuters who choose to enter the proposed managed toll lanes.

[13] Op. cit., *Draft Environmental Impact Statement*.

A detailed traffic study of the preferred alternative with estimates of congestion mitigation is not yet available. An analysis presented in the Economic Impact Analysis of the project based on *Alternative 3* in the DEIS can be used to calculate expected time savings for commuters and non-business travel.[14] The traffic time savings from the I-70 East Corridor Project were calculated by comparing projected traffic congestion conditions in 2030 between the "No Action" alternative and *Alternative 3* from that study.[15]

The DEIS provides measures of the percentage of day congested and peak-hour person-hours of delay.[16] This analysis uses estimates person-hours of delay at the two daily peak hours (which account for 8 percent of a 24-hour day and are assumed to be 100 percent congested). Delays occur not only during the peak hour, but also during shoulder hours and other periods throughout the day depending on specific road and business characteristics (for example schools letting out or factories which shift work may cause delays during non-peak hours). To account for this, the analysis assumes that person-hours of delay during these periods are approximately two-thirds of those during peak-hours. Combining the percent of day congested and peak and non-peak person-hours of delay yields projected daily person hours of delay in 2030 for Alternative 3 from the DEIS and the status quo or "No Action" alternative. The difference between these two amounts yields the daily time savings if the Full Corridor Project is implemented. Exhibit 10 below shows an example of how these calculations are made.

Exhibit 10 Example of Delay Calculation Model



Daily time savings is converted to annual time savings assuming that congested conditions only occur on weekdays. Commercial traffic is netted out of the time savings figure based on traffic distributions for this road type obtained from the US Department of Transportation (USDOT).[17] The remaining private motorist time savings is valued at 60 percent of hourly local median household income according to USDOT time valuation preferred methodology for the road classification.[18]

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14 Alternative 3 from the DEIS is comparable to the Full Corridor Project in this Benefit/Cost Analysis.
15 This is being used as a proxy as data for the preferred alternative is not yet available.
16 Congestion and person hours of delay figures obtained in the *DEIS Traffic Technical Report*, Colorado Department of Transportation, www.i-70east.com/DEIS/I-70EastDEIS_V3_TrafficTechnicalReport.pdf.
17 Op. Cit., USDOT.
18 Op. Cit., USDOT.

The results of this process yields over 13,000 hours of travel time saved per day or approximately 3.4 million hours per year. Private motorist time savings is about 77 percent of that figure or about 2.6 million hours per year. Personal time savings is valued at $18.86 per hour and is worth about $47.5 million per year in 2013 dollars.[19]

This $47.5 million figure therefore, serves as a discounted value for travel time savings following the implementation of the Full Project Alternative. While much of this will occur immediately after the construction is completed, to moderate the benefit-cost analysis, the 2.6 million hour figure will be assumed to occur at year 30, with the hours reduced based on a linear trend from year 30 back to year 5. In addition, the $18.86 per hour value represents the current wage rate. Wages are forecast to grow at 3.9 percent per year, based on the most recent long term macroeconomic estimates form the Congressional Budget Office.[20] Discounting this flow back to 2013 suggests that the benefit over a 20-year period will be just under $445.5 million.

A similar analysis conducted on the other two alternatives finds that the Intermediate alternative will lead to a social benefit of just under $379.0 million and the Viaduct alternative, $161.6 million discounted to 2013 dollars. Exhibit 11 below adds the value of regional time savings to the benefit/cost framework.

Exhibit 11 Benefit-Cost Analysis – Step 3 Time Savings

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings	$445,498,399	$360,961,587	$161,613,636
Vehicle Operating Cost Savings			
Net Pollution Effects			
Net Changes in Automobile Accidents			
Net Changes in Noise			
Net Changes in Local Property Values			
Total Net Benefit	$14,073,074,174	$11,276,860,276	$4,604,163,516
Cost-Benefit Statistic	8.14	7.37	4.72

Vehicle Operating Cost Savings

Beyond increases in productivity, the proposed redevelopment will reduce fuel and associated vehicle operating costs for drivers using the facility. This is due to the fact that the reduction in congestion will ensure that the typical driver will spend less time on the road. Secondly, at low speeds, most vehicles are less fuel efficient than they are at moderate speeds. For example, the

19 *The Value of Travel Time Savings: Departmental Guidance for Conducting Economic Evaluations, Revision 2*, US Dept. of Transportation, at: www.dot.gov/sites/dot.dev/files/docs/vot_guidance_092811c.pdf

20 This is the combination of 2.5 percent inflation and 1.4 percent real wage growth.

average auto driving 70 mph burns about 0.052 gallons of gas per mile, while one traveling at 15 mph takes 0.089 gallons per mile.[21]

To determine vehicle operating cost savings, differential fuel burn rates are multiplied by the reduction in personal delay hours from the congestion model, by the speed in miles per hour, and by the price of gasoline (or diesel). The current gas prices are taken from AAA's *Daily Fuel Gauge Report*, [22] and are projected for the next 30 years based on the estimated long-term growth rate in prices from the US Department of Energy.[23]

Fuel use rates were available in two groupings: auto and truck. For the purpose of this analysis, it is assumed that all autos use gasoline and that all trucks use diesel. The two fuel sources have different costs and growth rates, and the different vehicle types have different fuel efficiency dynamics.

The overall savings in vehicle operating costs depends on the redevelopment project undertaken. The Full Corridor Project and the Intermediate Option have fairly similar impacts, while the Viaduct Alternative saves significantly less fuel. Data on actual speeds are not currently available, but assuming that the no-traffic scenario consists of traveling speeds of 70 mph and that congestion speeds are 15 mph, the Full Corridor Project saves $127.0 million over the first 20 years. The Intermediate alternative saves $131.4 million, and the Viaduct alternative saves approximately $46.1 million. The reason for high value for the Intermediate alternative is a result of the fact that fuel consumption rates follow a U-shaped pattern whereby fuel is consumed relatively rapidly at both low and high speeds, and at a lower rate at moderate road speeds (bottom out at about 40-55 miles per hour). The Intermediate alternative fares best since it increases average traffic speeds up to near this efficient threshold, but not so high that fuel efficiency begins to diminish.

Exhibit 12 Benefit-Cost Analysis – Step 4 Savings in Vehicle Operating Costs

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings	$445,498,399	$360,961,587	$161,613,636
Vehicle Operating Cost Savings	$127,042,356	$131,446,645	$46,087,083
Net Pollution Effects			
Net Changes in Automobile Accidents			
Net Changes in Noise			
Net Changes in Local Property Values			
Total Net Benefit	$14,200,116,530	$11,408,306,921	$4,650,250,599
Cost-Benefit Statistic	8.21	7.44	4.76

21 *California Life-Cycle Model. Benefit Cost Analysis Model (Cal-B/C).* California Department of Transportation. September 1999. Available online at http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_files/tech_supp.pdf

22 *AAA's Daily Fuel Gauge Report. Current State Averages.* American Automobile Association, October 2013. Available on-lihttp://fuelgaugereport.aaa.com/?redirectto=http://fuelgaugereport.opisnet.com/index.asp

23 *Energy Price by Sector and Source, United States, Reference Case.* U.S. Energy Information Administration. October 2013. Available online at http://www.eia.gov/analysis/projection-data.cfm#annualproj

Since the actual number of miles driven by both passenger and commercial vehicles is not expected to change based on the alternative selected, additional vehicle operating costs (outside of fuel expenditures) are likely to be only marginally different in that the benefits of not riding brakes will be offset by increased costs from cracked windshields, suspension issues and other problems that can result from higher speeds. Exhibit 12 on the prior page adds the net vehicle operating cost savings to the benefit/cost model. As the exhibit shows, the benefit/cost statistic grows as each of the benefit categories is netted against the initial construction costs.

Net pollution effects

The main purpose for a social benefit-cost analysis is to document those impacts of a specific project (be they positive or negative) that cannot be accounted for in a general economic impact analysis. While economic impact models calculate the impact of a project in terms of employment, economic output (GDP) and taxes generated, these impacts are often transfer payments – spending by one individual or group that benefits another. For example, tax payments are always a transfer from business, workers or consumers to the government, and while they form part of an economic impact, they are netted out of a social cost-benefit analysis.

On the other hand, there are many impacts that a project might have that are not valued as part of the economy since they are not internalized into prices. Economists call these "externalities," and they can include such things as pollution, noise, even the personal costs of accidents. Changes in roadway design – including the speed profile can influence these in both positive and negative ways.

In principle it is straightforward to value externalities in a cost-benefit analysis; however, it is difficult to select which effects should be valued. There are dozens of different effects that could result from a roadway improvement project. Faster traffic may lead to more deer strikes, better drainage could add pollutants to waterways, and more lanes can increase the noise footprint. There are also hundreds of different pollutants that can be measured and could be impacted by the different alternatives being examined.

In the case of most highway projects, it is standard to measure the value of changes to carbon monoxide emissions, mono-nitrogen oxides and hydrocarbons.

Changes in emissions levels are calculated in two parts: Moving traffic emissions and idling emissions. Data for moving traffic emissions come from the Federal Highway Administration's *Freight Facts and Figures 2012*.[24] These data are provided in terms of grams per mile and are broken down by vehicle type: gasoline cars, gasoline light trucks, gasoline heavy trucks, diesel cars, diesel light trucks, and diesel heavy trucks.

Data for idling emissions come from the 2008 Environmental Protection Agency report *Idling Vehicle Emissions for Passenger Cars, Light Duty Trucks and Heavy Duty Trucks, and Data for*

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24 *Freight Management and Operations: Freight Facts and Figures 2012*. U.S. Department of Transportation, Federal Highway Administration, September 19, 2011, at www.ops.fhwa.dot.gov/freight/freight_analysis

both Gasoline and Diesel Vehicle Types.[25] The data is then converted into tons, multiplied by the length of roadway included in each alternative, estimates of daily traffic volumes and then adjusted by delay times.[26] Emissions fall as congestion is reduced, but increase as roads improve and more vehicles use them. The net effect is used to calculate either the societal cost or benefit.

Exhibit 13
Benefit-Cost Analysis – Step 5 Pollution Savings

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings	$445,498,399	$360,961,587	$161,613,636
Vehicle Operating Cost Savings	$127,042,356	$131,446,645	$46,087,083
Net Pollution Effects	$3,341,402	$3,101,044	$2,540,209
Net Changes in Automobile Accidents			
Net Changes in Noise			
Net Changes in Local Property Values			
Total Net Benefit	$14,203,457,931	$11,411,407,965	$4,652,790,808
Cost-Benefit Statistic	8.21	7.45	4.76

Costs per ton of pollution come from the US Department of Transportation (U.S. DOT), and are based on dollars per ton for each pollutant as of 2000 inflated to 2013 using nominal GDP as an inflator.[27]

In the case of externality costs like pollution and noise, current prices are used for each year reflecting that the cost of externalities will rise in line with the discount rate. In other words, the value to a person of clean air, a quiet environment, or their own life will be reflective of the overall economy, and will grow in relationship to the growth of the overall economy. Based on these undiscounted rates, the societal benefit from the project of reduced pollution would be as high as $3.3 million, with the viaduct section alone contributing $2.5 million of that. These benefits are shown on Exhibit 13 above. In this case the benefit/cost statistic between the three alternatives narrows slightly, reflecting the fact that most of the pollution benefits occur along the viaduct section of the roadway.

Net changes in automobile accidents

Since the I-70 East Corridor Project is designed to reduce congestion, it will increase the average speed of traffic using the stretch of highway, particularly during rush hours and shoulder periods.

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25 *Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks*, US Environmental Protection Agency, Office of Transportation and Air Quality, October, 2008. Available on-line at www.epa.gov

26 *Online Transportation Data System*. Colorado Department of Transportation. Annual Average Daily Traffic data retrieved September 30, 2013. On-line at http://dtdapps.coloradodot.info/Otis/TrafficData

27 *Transportation Performance Management: Appendix F Procedures for Estimating Air Pollution Costs.* U.S. Department of Transportation, Federal Highway Administration, August 2005. Available on-line at http://www.fhwa.dot.gov/asset/hersst/pubs/tech/tech00.cfm

One of the unintended consequences of faster road speed is an increase in the number and severity of automobile accidents. Modern road design techniques can be used to help reduce accidents, but in general, faster speeds lead to increases in accidents.[28] Just like pollution, the market does not price external effects such as the pain, aggravation and potential loss of life associated with automobile accidents; therefore, their effects do not show up in economic impact studies. In fact, it would be perverse to even suggest that there is a positive economic impact resulting from increased ambulance calls, or from fixing damaged cars.

Exhibit 14 Estimated Cost of Accidents by Type

Accident Type	Estimated Cost
Property Damage Only (PDO)	$2,845
Injury	$385,828
Fatality	$4,262,857

To determine these effects, data on motor vehicle occurrences are taken from the Colorado Department of Transportation's *Crashes and Rates on State Highways 2011*.[29] This lists the specific numbers of accidents on any given section of highway in the state. In 2011, there were 680 property damage only accidents, 75 injury accidents, and 4 fatal accidents on the section of road subject to redevelopment. Since any one accident may include more than one injury or fatality, both measures are inflated by the Denver ratio of injuries-to-injury-accidents or fatalities-to-fatal accidents. The base year includes the 680 property damage only accidents, 87 injuries, and 4-5 fatalities.

Placing a value on health and human life is an ethically complex but also necessary step in conducting a benefit-cost analysis. To do this, motor vehicle accidents are categorized into three categories: property damage only, injury accident, and fatal accident. Dollar values were placed on the different accidents according to the standards set in Appendix A of the U.S. DOT report *The Economic Impact of Motor Vehicle Crashes 2000* (adjusted for inflation).[30] The estimate for "property damage only (PDO)" accidents is the average of U.S. DOT's PDO and no injury categories, the estimate for the cost of accidents where an injury is involved is the average cost of U.S. DOT's MAIS1 – MAIS4 costs, and U.S. DOT's fatality cost is used for these types of accidents. These estimates were compared to those found in The National Safety Council's

[28] All things being equal, a faster roadway will lead to additional accidents. See Libby, Thomas J., Raghavan Srinivasan, Lawrence E. Decina, & Loren Staplin, *Safety Effects of Automated Speed Enforcement Programs*, Transportation Research Record 2078, 2007 for a synopsis of studies examining this effect. Were the I-70 East Corridor Project to include substantial accident prevention and safety features it is possible that the number of accidents could be reduced. For the purpose of this analysis only the most moderate approach is used, which would suggest a slight increase in the overall number of accidents.

[29] *Crashes and Rates on State Highways 2011*, Colorado Department of Transportation, Safety and Traffic Engineering Branch, March 13, 2012. Available on-line at http://www.coloradodot.info/library/traffic/traffic-manuals-guidelines/safety-crash-data/accident-rates-books-coding/2011_Accident_and_Rates_Book.pdf/view

[30] *The Economic Impact of Motor Vehicle Crashes, 2000*, U.S. Department of Transportation, National Highway Traffic Safety Administration, May, 2002. Available on-line at http://www-nrd.nhtsa.dot.gov/Pubs/809446.PDF

Estimating the Costs of Unintentional Injuries.[31] The numbers used in this analysis tend to be higher than that source suggesting that the analysis may be overestimating these costs. This is not a bad thing when contemplating the value of a human life. In fact, by valuing life at a somewhat higher rate than the National Safety Council, this analysis is erring on the side of caution.

The net social costs of potential increased auto accidents are added to the model in Exhibit 15 below. This provides an example of how an initiative like the I-70 East Corridor project can both mitigate and create externalities.

Exhibit 15 Benefit-Cost Analysis – Step 6 Accidents

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings	$445,498,399	$360,961,587	$161,613,636
Vehicle Operating Cost Savings	$127,042,356	$131,446,645	$46,087,083
Net Pollution Effects	$3,341,402	$3,101,044	$2,540,209
Net Changes in Automobile Accidents	($931,220,567)	($764,053,107)	($338,892,681)
Net Changes in Noise			
Net Changes in Local Property Values			
Total Net Benefit	$13,272,237,364	$10,647,354,858	$4,313,898,127
Cost-Benefit Statistic	7.74	7.01	4.49

It is important to understand that the I-70 through the project area was constructed over 40 years ago, and construction and design techniques have improved considerably since then. It is quite likely that the design alternatives being considered for the I-70 East Corridor Project could improve roadway conditions significantly and thereby speed traffic even further while at the same time reducing the number and severity of accidents. Were this to happen, rather than being a social cost, the net change in automobile accidents would provide a social benefit.[32]

<u>Net changes in noise</u>

Since all of the traffic data are based on a single estimate, no matter which alternative is used, there will be a similar number of vehicles using the road. Noise calculations are based on the number and type of vehicles traveling a specific distance, and are not generally impacted by road speeds. All three of the proposed alternatives remove the existing viaduct structure and replace it with a lowered roadway, which will lead to lowered overall noise during the 20-year study period.

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31 *Estimating the Costs of Unintentional Injuries*, The National Safety Council, 2011. Available on-line at: www.nsc.org/news_resources/injury_and_death_statistics/Pages/EstimatingtheCostsofUnintentionalInjuries.aspx

32 No design information is currently available, therefore this benefit/cost analysis assumes that other than increasing capacity and reducing delay times, all other aspects of the roadway are substantially similar to existing conditions.

The value of this noise reduction is derived by subtracting the noise cost of the lowered interstate from the noise cost associated with an elevated interstate. This model assumes that vehicle miles traveled (VMT) grows linearly, with an additional 15,400 VMT on the particular section of road each year. Further assumptions are that the existing traffic noise averages 65 dB, and that the lowered highway would reduce traffic noise by a level of 10 dB.

Exhibit 16 Benefit-Cost Analysis – Step 7 Noise Savings

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings	$445,498,399	$360,961,587	$161,613,636
Vehicle Operating Cost Savings	$127,042,356	$131,446,645	$46,087,083
Net Pollution Effects	$3,341,402	$3,101,044	$2,540,209
Net Changes in Automobile Accidents	($931,220,567)	($764,053,107)	($338,892,681)
Net Changes in Noise	$8,444,330	$8,444,330	$8,444,330
Net Changes in Local Property Values			
Total Net Benefit	$13,280,681,694	$10,655,799,188	$4,322,342,457
Cost-Benefit Statistic	7.74	7.02	4.49

The lowered road represents a one and one half mile stretch of Interstate 70, from Brighton Boulevard to Colorado Boulevard. The value for the 10 dB noise reduction for each vehicle mile traveled comes from the *Handbook on Estimation of External Cost in the Transport*.[33] The values used in this analysis are the mean of the day and night values listed in the study and their value for buses is used to proxy for light truck category. Cars are valued at $0.0195 per VMT, light trucks are valued at $0.096 per VMT, and heavy trucks at $0.1765 per VMT.

Based on these assumptions, the social value of reduced noise over 20-years due to the lowering of the roadway is $8.4 million, a figure that would be constant across alternatives. This figure is added to the benefit/cost model in Exhibit 16 above.

Net changes in local property values

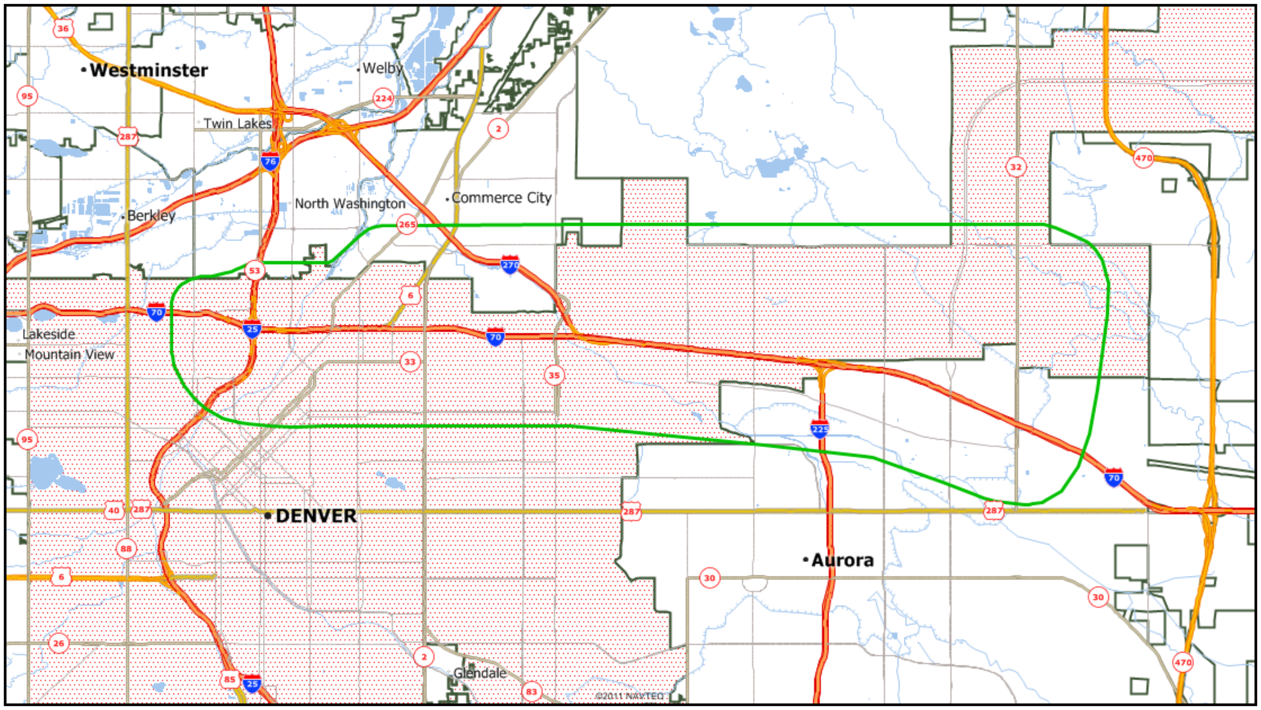
A neighborhood level land use study was conducted for this report using data on land and improvement values by parcel from the City of Denver and Adams County. While there will be the potential for both “winners and losers,” in balance the overall change in land use/value is considered to be positive.

Tax block and lot data from the City of Denver (including commercial, industrial and residential properties) was used to see if there were any significant impacts on land values associated with being near the existing viaduct and at-grade highway structure. Data were from the US Department of Commerce, Bureau of the Census, and the City of Denver. [34]

[33] Litman, Todd, *Noise*, Transportation Cost and Benefit Analysis, Victoria Transport Policy Institute, February 12, 2012. Available online at www.vtpi.org/tca/tca0511.pdf

[34] Detailed property value data by parcel for Denver is available at: http://data.denvergov.org/dataset/city-and-county-of-denver-parcels.

Exhibit 17 Area Included in the Project Corridor



An examination of current property uses and values along the Denver portion of the project area (from the Globeville neighborhood through to Montbello) shows that most of the land use patterns are long established and reflect the fact that the region is a road and rail transportation corridor. Residential land values generally increase as one moves away from the roadway, rising by as much as $2.80 per square foot one mile from the roadway. Industrial property values generally increase (improving by $1.98 per square foot as distance from the road way increases by a mile); however, a more thorough analysis shows that most of the variation in land and property values in the corridor has less to do with Interstate 70 than they do with other more generalized effects. In fact, once what economists call "neighborhood fixed effects" are taken into account, the impact of the Interstate on property values virtually disappears – both for residential areas and for industrial facilities. In total, the mitigation of the environmental and aesthetic issues with I-70 will likely increase property values in the Denver portion of the project corridor by just $89.7 million, or about 0.7 percent. The regression tables in the Appendix show the relative impacts of the highway, as well as key demographics on property values in the Denver portion of the corridor by type.

Overall, residential property values should increase due to highway noise and aesthetic improvements; however, the data suggest that being near a park in this part of Denver has a negative impact on property values. As such, the development of parkland on the decked areas of the highway may not generate the level of benefits that some may claim.[35] In each case the

[35] While this may seem counterintuitive, the industrial nature of the neighborhoods that I-70 traverses may explain this. In primarily residential neighborhoods, parks may be considered amenities, while often in more industrial areas, parks may be considered more as vacant space, or vacant land and may not be considered either safe or particularly useful.

regression results find that the neighborhood fixed effects, as well as the current demographic makeup of the surrounding community seem to most influence property values.

All of this suggests that the neighborhoods surrounding I-70 have developed over a long period of time and reflect the overall industrial nature of the whole North Denver region.

Exhibit 18 Estimated Changes in Property Values in the Denver Portion of the Project Corridor

	Current Value			Expected Increase in Values		
Use Type	**Land**	**Improvements**	**Total**	**Land**	**Improvements**	**Total**
Commercial	$64,703,500	$30,383,728	$95,087,228	$720,218	$226,712	$946,930
Industrial	$873,440,700	$2,457,431,150	$3,330,871,850	$49,384,800	$6,464,376	$55,849,176
Residential	$2,301,205,800	$6,500,118,196	$8,801,323,996	$31,076,303	$1,649,150	$32,725,453
Parks	$25,269,200	$182,444,197	$207,713,397	$130,408	$52,222	$182,630
Institutional Uses	$5,784,200	$1,844,184	$7,628,384	N/A	N/A	N/A
Post Office	$8,758,900	$62,623,566	$71,382,466	N/A	N/A	N/A
Total	$3,279,162,300	$9,234,845,021	$12,514,007,321	$81,311,728	$8,392,460	$89,704,189

The main beneficiaries of the project in Denver will be those areas zoned either industrial or residential, with the largest impacts being in the industrial zones. In other words, better transportation systems improve the value of industrial facilities.

Most of the areas impacted by the I-70 East Corridor Project are currently used by other transportation systems (for example rail yards), host institutional venues (for example the stock show yards) or are vacant. Much of the rest of the area consists of industrial sites and residential parcels with relatively low property values.

Exhibit 19 Estimated Changes in Property Values in the Adams County Portion of the Project Corridor

	Current Value			Expected Increase in Values		
Use Type	**Land**	**Improvements**	**Total**	**Land**	**Improvements**	**Total**
Commercial	$302,241,456	$751,784,975	$1,054,026,431	$147,789	$10,355	$158,143
Industrial	$58,697,614	$142,039,451	$200,737,065	$101,690	$415,029	$516,719
Residential	$84,043,376	$309,119,673	$393,163,049	-$1,402,325	-$7,922,825	-$9,325,150
Other	$30,958,171	$64,650,560	$95,608,731	$29,958	-$1,075,847	-$1,045,889
Total	$475,940,617	$1,267,594,659	$1,743,535,276	-$1,122,889	-$8,573,287	-$9,696,177

This does not mean that there may not be large impacts on specific properties. For example a house directly next to the highway would likely be priced lower than the same house placed 5 blocks away; but in general, the highway does not seem to be what is impacting local land values and use, and that these reflect the overall neighborhood conditions that have been in place for the past 50-years.

Similar results can be found examining data from Adams County (including the Cities of Aurora and Commerce City); however, in this case, the increased traffic and speed of traffic will slightly reduce land and housing values within the project area. This is partially offset by changes in commercial and industrial values, but overall, it is likely that property values will fall in the Adams County portion of the project area in response to increased traffic. Together, the change in property values would equal about $80.0 million if the Full Corridor alternative is constructed.

It is likely that the changes in land values will be similar for all three Alternatives. This is because most of the noise reduction and highway sight line remediation is occurring in communities in Denver. Likewise, the expected traffic levels are not likely to change much if the eastern parts of the I-70 East Corridor Project are not undertaken. Also, these changes are likely to occur in the first few years after the project is completed, so no cash flow or discounting adjustments are taken for this part of the analysis.

Exhibit 20 Benefit-Cost Analysis – Step 8 Land Values

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings	$445,498,399	$360,961,587	$161,613,636
Vehicle Operating Cost Savings	$127,042,356	$131,446,645	$46,087,083
Net Pollution Effects	$3,341,402	$3,101,044	$2,540,209
Net Changes in Automobile Accidents	($931,220,567)	($764,053,107)	($338,892,681)
Net Changes in Noise	$8,444,330	$8,444,330	$8,444,330
Net Changes in Local Property Values	$80,008,012	$80,008,012	$80,008,012
Total Net Benefit	$13,360,689,706	$10,735,807,200	$4,402,350,469
Cost-Benefit Statistic	7.78	7.06	4.56

The addition to property values rounds out the benefit/cost model which is presented in Exhibit 20 above. This exhibit presents the model in its entirety, so that a proper alternatives analysis can be conducted.

Potential economic development impacts

There are no documented instances of companies that have either left Denver or did not locate to the city exclusively due to the fact that there is congestion along the I-70 East Corridor. JDA attempted to contact both the Adams County Economic Development Corporation and the Metro Denver Economic Development Corporation to see if there was any anecdotal evidence to this but neither organization was willing to provide any information.

This does not mean that improved access in northern Denver and Aurora would not help local economic development agencies or real estate developers to attract new business to the area. As the benefit-cost analysis shows, improved access leads to productivity benefits, reducing costs for employers, and also leads to increased land values (particularly industrial land values). This suggests that improved access along the I-70 East Corridor will eventually lead to increased business activity in the region.

Currently, based on property records, 12.8 percent of the industrial acreage in the project area located within Denver is undeveloped, and 34.5 percent in Adams County (including the cities of Commerce City and Aurora) were unimproved. While this does not mean that these properties are unused or vacant, and there may be site specific reasons for why these areas are not currently developed, this can serve as a proxy for the developable industrial space within the project corridor.

Assuming that the improvements to the highway were sufficient to attract sufficient new industrial businesses to the area to fill the vacant space suggests that there is an economic development potential of an additional $401.7 million in economic activity in the region.

Exhibit 21 Potential Economic Development Effects

Component	Full Corridor	Intermediate Project	Viaduct Project
Potential Economic Development Value	$ 401,746,697	$ 330,850,221	$ 141,792,952

These estimates are based on an analysis of existing industrial businesses in the region.[36] Assuming that new activities would be similar to existing businesses, and that those businesses that are most transportation-reliant would be the first to locate to the vacant sites, then a wide range of different types of industrial operations could be attracted to the corridor[37]. The top ten industrial targets would include: Surgical and medical instrument manufacturing, animal processing, concrete manufacturers, and milk and putter manufacturing. The table below outlines the potential new economic activity for each of these industry types depending on the alternative selected.

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36 Based on 2012 employment levels for firms located in the project boundary. Source: Dun & Bradstreet zip code level data.

37 Transportation dependency is based on the percent of output for each sector accounted for by truck transportation (in other words the truck transportation margin). Based on the 2010 Colorado IMPLAN tables, MIG, Inc., 2011.

Exhibit 22 Potential Economic Development Effects – Top 10 Industry Sectors

Industrial Sector	Full Corridor	Intermediate Project	Viaduct Project
Surgical and medical instrument, laboratory and medical instrument manufacturing	$ 62,278,512	$ 51,288,186	$ 21,980,651
Animal (except poultry) slaughtering, rendering, and processing	$ 51,216,424	$ 42,178,232	$ 18,076,385
Breweries	$ 31,307,718	$ 25,782,827	$ 11,049,783
Ready-mix concrete manufacturing	$ 22,228,463	$ 18,305,793	$ 7,845,340
Wholesale trade businesses	$ 17,288,129	$ 14,237,283	$ 6,101,693
Fluid milk and butter manufacturing	$ 10,092,195	$ 8,311,219	$ 3,561,951
Soft drink and ice manufacturing	$ 9,619,003	$ 7,921,532	$ 3,394,942
Fertilizer manufacturing	$ 9,127,079	$ 7,516,418	$ 3,221,322
Cheese manufacturing	$ 8,636,165	$ 7,112,136	$ 3,048,058
Pharmaceutical preparation manufacturing	$ 7,793,229	$ 6,417,954	$ 2,750,552

Cost-Benefit Ratios and Alternatives Analysis

Exhibit 23 Benefit-Cost Analysis – Alternatives Analysis

Component	Full Corridor	Intermediate Project	Viaduct Project
Discounted Construction Expense	($1,970,335,764)	($1,770,530,709)	($1,237,600,564)
Net Business Productivity Changes	$15,597,911,539	$12,686,429,397	$5,680,150,443
Net Regional Time Savings	$445,498,399	$360,961,587	$161,613,636
Vehicle Operating Cost Savings	$127,042,356	$131,446,645	$46,087,083
Net Pollution Effects	$3,341,402	$3,101,044	$2,540,209
Net Changes in Automobile Accidents	($931,220,567)	($764,053,107)	($338,892,681)
Net Changes in Noise	$8,444,330	$8,444,330	$8,444,330
Net Changes in Local Property Values	$80,008,012	$80,008,012	$80,008,012
Total Net Benefit	$13,360,689,706	$10,735,807,200	$4,402,350,469
Cost-Benefit Statistic	7.78	7.06	4.56

The Benefit-Cost Statistic is the key statistic in determining which alternative has the best impact on a social basis – not just on an economic basis. In this case, all three alternatives have a benefit-cost ratio that is greater than 1.0 which indicates that the benefits outweigh the costs.

Exhibit 24 Benefit-Cost Analysis – Net Benefit By Year

Year	Full Corridor Project	Intermediate Project	Viaduct Project
0	($409,852,344)	($373,778,985)	($264,964,763)
1	($809,946,298)	($738,658,470)	($523,620,842)
2	($1,200,514,206)	($1,094,850,348)	($776,118,442)
3	($1,581,782,878)	($1,442,561,467)	($1,022,604,195)
4	($1,953,973,725)	($1,781,993,750)	($1,263,221,239)
5	($1,722,031,884)	($1,576,618,128)	($1,125,517,320)
6	($1,427,307,613)	($1,334,979,453)	($1,015,823,320)
7	($998,862,479)	($984,442,598)	($857,434,266)
8	($445,316,553)	($532,014,782)	($653,489,389)
9	$225,143,482	$15,649,223	($406,970,112)
10	$1,004,747,090	$652,233,064	($120,706,327)
11	$1,886,123,369	$1,371,745,375	$202,617,591
12	$2,862,285,246	$2,168,506,926	$560,457,023
13	$3,926,614,349	$3,037,138,319	$950,401,605
14	$5,072,846,549	$3,972,548,226	$1,370,169,952
15	$6,295,058,126	$4,969,922,135	$1,817,604,628
16	$7,587,652,559	$6,024,711,610	$2,290,667,330
17	$8,945,347,907	$7,132,624,024	$2,787,434,294
18	$10,363,164,765	$8,289,612,762	$3,306,091,905
19	$11,836,414,781	$9,491,867,881	$3,844,932,519
20	$13,360,689,706	$10,735,807,201	$4,402,350,470

In the case of these three alternatives, the cost of construction varies only slightly between the Full Corridor project and the Intermediate Project. The Viaduct only alternative is about a third less expensive than the Full Corridor; however, its benefits pale in comparison to the larger project.

Looking at each alternative over time shows that the Full Corridor alternative pays for itself in just 9 years, as does the Intermediate Alternative. The Viaduct only alternative requires a longer payout period, about 11 years but still have a net social benefit over the 20 year time horizon of this analysis.

Interestingly, the social costs and benefits basically net themselves out across all three project types, with the benefits from noise reduction, improved land use, and reduced pollution being offset by more accidents that would result from faster speeds on I-70. This means, that the net benefit calculation depends almost entirely on the productivity implications for local businesses. In other words, the cost of constructing the road is more than fully offset by greater economic activity in regional businesses.

Since this is such an important factor, a sensitivity analysis was performed on that component of the model. The societal benefit from an improved business environment in the corridor area is so large that even if it were to be reduced by half, each of the alternatives would still have a positive net social benefit. The same is true if the value of productivity savings were reduced by 75 percent. Even with this sizable reduction, the Full Corridor alternative and the Intermediate Project alternative would have net social benefits of greater than $1 billion.

Exhibit 25 Benefit-Cost Analysis – Sensitivity Analysis

	Total Net Benefits ($ Millions)		
Sensitivity	**Full Corridor Project**	**Intermediate Project**	**Viaduct Project**
100%	$ 13,360,689,706	$ 10,735,807,201	$ 4,402,350,470
50%	$ 5,561,733,937	$ 4,392,592,503	$ 1,562,275,248
25%	$ 1,662,256,052	$ 1,220,985,153	$ 142,237,637
16%	$ 258,444,013	$ 79,206,507	$ (368,975,903)

The most efficient alternative is that which maximizes the differences between the total benefits and total costs. By that measure, it is clear that the Full Development Alternative is the best decision for policymakers. There is a net gain of almost $13.4 billion, whereas the Intermediate and Viaduct Alternatives yield $10.7 billion and $4.4 billion respectively. This does not even take into account the sizable economic development potential that a better, more efficient I-70 East Corridor could bring to the Denver metropolitan area.

Appendix

Appendix 1 Regression Calculation for Denver Industrial Properties

INDUSTRIAL LAND VALUES

Regression Statistics	
Multiple R	0.67984
R Square	0.462182
Adjusted R	0.461399
Standard E	7.376472
Observatio	5506

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	8	257039.9	32129.99	590.4908	0
Residual	5497	299104.6	54.41234		
Total	5505	556144.5			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	20.50688	1.106245	18.53738	1.84E-74	18.3382	22.67556	18.3382	22.67556
In Half	-1.92868	0.239297	-8.05978	9.3E-16	-2.3978	-1.45956	-2.3978	-1.45956
Median Inc	-0.00014	9.12E-06	-15.5128	3.75E-53	-0.00016	-0.00012	-0.00016	-0.00012
Pct Vacant	44.93928	7.939639	5.660116	1.59E-08	29.37444	60.50411	29.37444	60.50411
Pct hisp	-34.0477	0.901516	-37.7671	1E-277	-35.815	-32.2803	-35.815	-32.2803
Median Ag	0.545505	0.020554	26.54043	3.8E-146	0.505211	0.585798	0.505211	0.585798
pct white	-44.0039	1.026178	-42.8814	0	-46.0156	-41.9922	-46.0156	-41.9922
institut	-5.18948	1.291623	-4.0178	5.95E-05	-7.72157	-2.65739	-7.72157	-2.65739
Park	1.640017	0.231011	7.099309	1.41E-12	1.187144	2.09289	1.187144	2.09289

INDUSTRIAL IMPROVEMENT VALUES

Regression Statistics	
Multiple R	0.094563
R Square	0.008942
Adjusted R	0.0075
Standard E	13.15133
Observatio	5506

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	8	8578.533	1072.317	6.199882	5.32E-08
Residual	5497	950747.9	172.9576		
Total	5505	959326.5			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	11.09093	1.972297	5.623358	1.97E-08	7.22445	14.95741	7.22445	14.95741
In Half	-1.61006	0.426637	-3.77385	0.000162	-2.44644	-0.77369	-2.44644	-0.77369
Median Inc	-4E-06	1.63E-05	-0.24333	0.807763	-3.6E-05	2.79E-05	-3.6E-05	2.79E-05
Pct Vacant	-8.85536	14.15539	-0.62558	0.531615	-36.6055	18.89481	-36.6055	18.89481
Pct hisp	-0.07019	1.607291	-0.04367	0.965169	-3.22112	3.080735	-3.22112	3.080735
Median Ag	0.043679	0.036645	1.191963	0.233327	-0.02816	0.115517	-0.02816	0.115517
pct white	-6.12868	1.829548	-3.34983	0.000814	-9.71532	-2.54204	-9.71532	-2.54204
institut	-2.17686	2.302803	-0.94531	0.344543	-6.69126	2.337547	-6.69126	2.337547
Park	0.641145	0.411864	1.556692	0.119601	-0.16627	1.44856	-0.16627	1.44856

Appendix 2 Regression Calculation for Denver Residential Properties

RESIDENTIAL LAND VALUES

Regression Statistics	
Multiple R	0.676473
R Square	0.457616
Adjusted R	0.45745
Standard E	5.325234
Observatio	26204

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	8	626743.6	78342.95	2762.628	0
Residual	26195	742841	28.35812		
Total	26203	1369585			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	40.75991	0.884396	46.08786	-	39.02645	42.49338	39.02645	42.49338
In Half	-2.83256	0.108354	-26.1416	0.0000	-3.04494	-2.62017	-3.04494	-2.62017
Median Inc	-0.00014	3.95E-06	-34.7566	0.0000	-0.00014	-0.00013	-0.00014	-0.00013
Pct Vacant	21.43343	2.357267	9.092491	0.0000	16.81306	26.0538	16.81306	26.0538
Pct hisp	-35.1586	0.466302	-75.3987	-	-36.0725	-34.2446	-36.0725	-34.2446
Median Ag	-0.04738	0.016021	-2.95716	0.0031	-0.07878	-0.01598	-0.07878	-0.01598
pct white	-39.5977	0.424431	-93.2958	-	-40.4296	-38.7658	-40.4296	-38.7658
institut	-2.63748	0.58962	-4.47318	0.0000	-3.79316	-1.48179	-3.79316	-1.48179
Park	-0.4064	0.07578	-5.3629	0.0000	-0.55494	-0.25787	-0.55494	-0.25787

RESIDENTIAL IMPROVEMENT VALUES

Regression Statistics	
Multiple R	0.360474
R Square	0.129941
Adjusted R	0.129675
Standard E	4.286586
Observatio	26204

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	8	71885.22	8985.652	489.02	0
Residual	26195	481328.3	18.37482		
Total	26203	553213.6			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	-19.7131	0.711901	-27.6908	2.2E-166	-21.1085	-18.3177	-21.1085	-18.3177
In Half	-1.69898	0.087221	-19.4791	6.49E-84	-1.86994	-1.52802	-1.86994	-1.52802
Median Inc	5.63E-05	3.18E-06	17.72149	7.33E-70	5.01E-05	6.25E-05	5.01E-05	6.25E-05
Pct Vacant	24.80123	1.897499	13.07048	6.43E-39	21.08203	28.52043	21.08203	28.52043
Pct hisp	9.052658	0.375353	24.11773	4E-127	8.316946	9.78837	8.316946	9.78837
Median Ag	0.576767	0.012897	44.72253	0	0.551489	0.602045	0.551489	0.602045
pct white	2.82205	0.341649	8.260084	1.52E-16	2.152399	3.491701	2.152399	3.491701
institut	4.0428	0.474619	8.517998	1.71E-17	3.112522	4.973078	3.112522	4.973078
Park	-0.13649	0.061	-2.23758	0.025257	-0.25606	-0.01693	-0.25606	-0.01693

Appendix 3 Regression Calculation for Denver Commercial Properties

COMMERCIAL LAND VALUES

Regression Statistics	
Multiple R	0.619387
R Square	0.383641
Adjusted R	0.35429
Standard E	7.135212
Observatio	177

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	8	5323.703	665.4629	13.07104	1.41E-14
Residual	168	8553.09	50.91125		
Total	176	13876.79			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	31.94244	6.590003	4.847106	2.83E-06	18.93256	44.95233	18.93256	44.95233
In Half	-0.89112	1.292594	-0.68941	0.491519	-3.44294	1.660698	-3.44294	1.660698
Median Inc	-0.00025	5.12E-05	-4.83389	3E-06	-0.00035	-0.00015	-0.00035	-0.00015
Pct Vacant	15.3368	35.39818	0.433265	0.665378	-54.5458	85.21936	-54.5458	85.21936
Pct hisp	-36.8094	6.461987	-5.6963	5.36E-08	-49.5666	-24.0523	-49.5666	-24.0523
Median Ag	0.495421	0.132949	3.7264	0.000265	0.232955	0.757887	0.232955	0.757887
pct white	-53.6328	6.131713	-8.74679	2.21E-15	-65.7379	-41.5276	-65.7379	-41.5276
institut	-13.6366	6.159705	-2.21384	0.028186	-25.797	-1.47623	-25.797	-1.47623
Park	1.323934	1.294283	1.02291	0.307821	-1.23122	3.879088	-1.23122	3.879088

COMMERICIAL IMPROVEMENT VALUES

Regression Statistics	
Multiple R	0.24554
R Square	0.06029
Adjusted R	0.015542
Standard E	5.125505
Observatio	177

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	8	283.1616	35.3952	1.347321	0.22346
Residual	168	4413.494	26.2708		
Total	176	4696.656			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	3.895601	4.73386	0.822923	0.411718	-5.44991	13.24112	-5.44991	13.24112
In Half	-0.93442	0.928522	-1.00635	0.315694	-2.76749	0.898656	-2.76749	0.898656
Median Inc	3.48E-06	3.68E-05	0.094587	0.924756	-6.9E-05	7.61E-05	-6.9E-05	7.61E-05
Pct Vacant	27.52437	25.42791	1.082447	0.280605	-22.675	77.72378	-22.675	77.72378
Pct hisp	0.989587	4.6419	0.213186	0.831441	-8.17438	10.15356	-8.17438	10.15356
Median Ag	-0.18454	0.095502	-1.9323	0.055005	-0.37308	0.004	-0.37308	0.004
pct white	5.620466	4.404652	1.27603	0.203706	-3.07513	14.31606	-3.07513	14.31606
institut	6.10189	4.424759	1.379033	0.169718	-2.6334	14.83718	-2.6334	14.83718
Park	-0.42998	0.929734	-0.46248	0.644335	-2.26545	1.405483	-2.26545	1.405483

Appendix 4 Regression Calculation for Adams County Industrial Properties

Land Values

Regression Statistics	
Multiple R	0.381576
R Square	0.1456
Adjusted R Square	0.114903
Standard Error	49214.04
Observations	174

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	6	6.89E+10	1.15E+10	4.743142	0.000173
Residual	167	4.04E+11	2.42E+09		
Total	173	4.73E+11			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	-173199	202323	-0.85605	0.393196	-572639	226241.7	-572639	226241.7
Close	44729.58	12714.23	3.518073	0.00056	19628.25	69830.9	19628.25	69830.9
vacant	-77887.6	545530.3	-0.14277	0.886641	-1154912	999137	-1154912	999137
income	2.226527	1.157539	1.9235	0.056118	-0.05877	4.511823	-0.05877	4.511823
age	-4769.33	5775.289	-0.82582	0.410086	-16171.3	6632.651	-16171.3	6632.651
hispanic	117091.1	126109.2	0.92849	0.354494	-131883	366064.9	-131883	366064.9
white	414184	236238.6	1.753244	0.081395	-52215	880582.9	-52215	880582.9

Improvement Values

Regression Statistics	
Multiple R	0.263818
R Square	0.0696
Adjusted R	0.036172
Standard E	326677.7
Observatio	174

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	6	1.33E+12	2.22E+11	2.082108	0.057856
Residual	167	1.78E+13	1.07E+11		
Total	173	1.92E+13			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	-449511	1342999	-0.33471	0.738266	-3100955	2201934	-3100955	2201934
Close	180918.1	84395.71	2.143688	0.033505	14298.07	347538.1	14298.07	347538.1
vacant	-1084397	3621173	-0.29946	0.764961	-8233574	6064781	-8233574	6064781
income	9.463078	7.683625	1.23159	0.219834	-5.70648	24.63264	-5.70648	24.63264
age	-29365.9	38335.77	-0.76602	0.444747	-105051	46319.3	-105051	46319.3
hispanic	371149.3	837100	0.443375	0.658068	-1281513	2023812	-1281513	2023812
white	1684887	1568127	1.074458	0.284167	-1411021	4780795	-1411021	4780795

Appendix 5 Regression Calculation for Adams County Commercial Properties

Land Values

Regression Statistics	
Multiple R	0.380182
R Square	0.144538
Adjusted R Square	0.138659
Standard Error	113744.2
Observations	880

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	6	1.91E+12	3.18E+11	24.58358	5.24E-27
Residual	873	1.13E+13	1.29E+10		
Total	879	1.32E+13			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	-420250	170432.9	-2.46578	0.013863	-754756	-85743.8	-754756	-85743.8
Close	75397.75	10975.93	6.86937	1.22E-11	53855.45	96940.05	53855.45	96940.05
vacant	1870489	484795.6	3.858305	0.000123	918988	2821990	918988	2821990
income	0.428075	1.039615	0.411763	0.680614	-1.61236	2.468513	-1.61236	2.468513
age	6403.66	4777.104	1.34049	0.180435	-2972.29	15779.61	-2972.29	15779.61
hispanic	225677.2	101994.4	2.212644	0.02718	25494.41	425860	25494.41	425860
white	57808.02	199695.4	0.289481	0.772282	-334131	449747.2	-334131	449747.2

Improvement Values

Regression Statistics	
Multiple R	0.175419
R Square	0.030772
Adjusted R Square	0.02411
Standard Error	354559.3
Observations	880

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	6	3.48E+12	5.81E+11	4.619439	0.000125
Residual	873	1.1E+14	1.26E+11		
Total	879	1.13E+14			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	26864.8	531267.5	0.050567	0.959682	-1015846	1069575	-1015846	1069575
Close	4450.679	34213.79	0.130084	0.89653	-62700.2	71601.58	-62700.2	71601.58
vacant	407179.9	1511188	0.269444	0.787652	-2558805	3373165	-2558805	3373165
income	-2.14159	3.240652	-0.66085	0.508881	-8.50197	4.218786	-8.50197	4.218786
age	53659.14	14891.02	3.603457	0.000332	24432.76	82885.52	24432.76	82885.52
hispanic	679494.5	317933.2	2.137224	0.032857	55491.74	1303497	55491.74	1303497
white	-2814521	622483.5	-4.52144	6.99E-06	-4036261	-1592782	-4036261	-1592782

Appendix 6 Regression Calculation for Adams County Residential Properties

Land Values

Regression Statistics	
Multiple R	0.483583
R Square	0.233852
Adjusted R	0.23247
Standard E	53508.43
Observatio	3332

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	6	2.91E+12	4.84E+11	169.1492	3.6E-188
Residual	3325	9.52E+12	2.86E+09		
Total	3331	1.24E+13			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	560401.8	102896.3	5.446278	5.52E-08	358655.4	762148.3	358655.4	762148.3
Close	-31939.6	12880.34	-2.47972	0.013198	-57193.8	-6685.45	-57193.8	-6685.45
vacant	-2135496	464749.5	-4.59494	4.49E-06	-3046720	-1224272	-3046720	-1224272
income	-0.69801	0.54416	-1.28274	0.199674	-1.76494	0.368909	-1.76494	0.368909
age	-9261.19	1585.554	-5.84098	5.69E-09	-12370	-6152.43	-12370	-6152.43
hispanic	-360006	49343.56	-7.29591	3.69E-13	-456753	-263259	-456753	-263259
white	418673.4	38083.18	10.99366	1.22E-27	344004.6	493342.3	344004.6	493342.3

Improvement Values

Regression Statistics	
Multiple R	0.589936
R Square	0.348024
Adjusted R	0.346848
Standard E	249455.7
Observatio	3332

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	6	1.1E+14	1.84E+13	295.8138	2.4E-304
Residual	3325	2.07E+14	6.22E+10		
Total	3331	3.17E+14			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	2339620	479701.4	4.877243	1.13E-06	1399080	3280160	1399080	3280160
Close	-128278	60048.01	-2.13625	0.032732	-246012	-10542.8	-246012	-10542.8
vacant	-3960256	2166657	-1.82782	0.067666	-8208373	287860.4	-8208373	287860.4
income	5.553201	2.536869	2.188998	0.028666	0.579218	10.52718	0.579218	10.52718
age	-59751.6	7391.838	-8.08345	8.73E-16	-74244.6	-45258.6	-74244.6	-45258.6
hispanic	-1821559	230039.1	-7.91847	3.25E-15	-2272591	-1370526	-2272591	-1370526
white	1777835	177543.4	10.01353	2.83E-23	1429730	2125941	1429730	2125941