INVESTMENT ANALYSIS OF THE U. S. HIGHWAY 20 CORRIDOR IN HARDIN AND GRUNDY COUNTIES IN IOWA

Jeff Agee

102:261
Problems in Transportation and Land Use
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INTRODUCTION

For a number of years, the US 20 corridor across Iowa has been of interest to professionals at the Iowa Department of Transportation and to a number of interest groups in northern Iowa. Many sections of US 20 across Iowa have been upgraded to expressway or to freeway standards. Others are two lanes wide and are well beyond their useful life. One example of such a segment is the US 20 corridor from its interchange with Interstate 35 in Hamilton County to just east of the Black Hawk county line. The purpose of this report is to help determine a design and a routing of the new US 20 that would be in the best interests of Iowans. Special consideration will be given to the needs of the residents of Hardin and Grundy Counties. A variety of interest groups have registered their opinions on this project. These concerns will be addressed in this report.

After careful consideration of the needs of residents in Hardin and Grundy Counties, the following alternative routing and design packages were developed for evaluation:

(1) Keep existing alignment; expand all of it to four lanes.

(2) Move alignment south; expand highway to four lanes west of US 65 and east of Iowa 14.

(3) Move alignment south; expand highway to four lanes west of US 65.

(4) Move alignment south; expand entire corridor to four lanes.

(5) Move alignment south; reconstruct entire corridor as a two-lane road.

(6) Rebuild the existing alignment as a two-lane road.

(7) Move alignment south; expand highway to four lanes east of Iowa 14.

This report is divided into several sections. The first four sections discuss the concerns of the various interest groups involved with this project. Section One explores the potential economic development impacts of the alternative routing and design packages which are being evaluated. Section Two includes an evaluation of how road users will benefit from the different alternatives. That section is divided into subsections on safety impacts and on potential travel time savings. The results from Section Two are applied in a benefit-cost analysis later in this report. Section Three includes a discussion on the environmental impacts of the seven routing and design packages. Section Four addresses concerns which landowners have had about how these alternatives will affect them.

Section Five of this report includes a benefit-cost analysis for each of the seven alternatives. Benefits are defined to include revenues generated from motor fuel taxes and registration fees which are attributable to travel over the corridor. Benefits also are defined to include money saved through accident reduction and through travel time savings. These benefits shall be discounted over the project life to indicate their present value. The project life is defined to be 40 years. Costs are defined as project costs for the corridor as estimated by the Iowa Department of Transportation. These, too, are discounted over the life of the project. The reader will be presented with two measures to determine whether or not the project is worthy of consideration from an economic standpoint.

These include: (1) net present value and (2) benefit-cost ratio of the alternative. Usage of net present value is recommended in this report. Section Six is a brief summary of this report which includes some recommendations on actions that could be taken. In addition, an appendix and a short bibliography are provided.

SECTION I

ECONOMIC DEVELOPMENT IMPACTS OF ALTERNATIVE ROUTING SCHEMES

In recent years, one of the biggest concerns which has emerged in the area of highway investment analysis has been that of the potential economic impacts of alternative highway investments. This was evident in the establishment of the RISE (Revitalize Iowa's Sound Economy) program by the Iowa General Assembly in 1985 (see Forkenbrock and Plazak, 1986, p. 11).

The Iowa Falls RISE Regional Development Project Application

Apparently, civic leaders and businessmen in the Iowa Falls area believe that the expansion of US 20 to four lanes from Interstate 35 to US 65 could help existing businesses to continue to thrive in that area. At least two communities in Hardin County (Iowa Falls and Eldora) have submitted applications for RISE regional development funds. These funds would be used to relocate US 20 to the south of its present alignment and construct this route as a four-lane highway between Interstate 35 and US 65 (City of Iowa Falls, 1987, p. 1). Funds requested total over $15.7 million for a two-year period. Although the project has been programmed for 1992, the Iowa DOT has postponed the project for a number of years, yet owns the right of way for the project.

In addition to stressing the economic benefit of such an expansion of highway to Iowa Falls, the applicants emphasize that other communities which have experienced difficult economic times

in recent years might benefit as well. For example, the cities of Waterloo and Fort Dodge are seen to possibly benefit from being connected to each other and to interstate highways. The strong role of agriculture in north central Iowa has been emphasized by applicants in the regional RISE application, and these applicants also emphasize the number of manufacturers and trucking companies in Hardin County as well. These applicants also explained to the Iowa DOT that there are many tourist attractions in Hardin County because of the scenic beauty of the Iowa River valley and a rich history in the county. Applicants stress that although Iowa Falls and other communities have been aggressive and even successful in attracting industries to the region, some industries which have not come to the region stated as their reason the lack of a four-lane highway (City of Iowa Falls, 1987, pp. 8-9).

In another section of the regional RISE application, public officials from the City of Iowa Falls have stated that there has been a great deal of congestion on the present alignment of US 20 as it passes through Iowa Falls. "Highways 20 and 65 through Iowa Falls create a serious bottleneck for traffic, particularly for semis that have difficulty making turns on the narrow roadway through the city. The increased costs to shippers, (as well as) traffic congestion and safety are concerns of industrial firms in Iowa Falls, the Chamber of Commerce and the city" (City of Iowa Falls, 1987, p. 10). The applicants for the RISE funds continue by explaining how "the project addresses the regional development project objectives... in the RISE administrative rules" (City of Iowa Falls, 1987, p. 10). Such objectives include:

- Improving or maintaining highway access between urban centers or metropolitan areas and the interstate road system.

- Improving or maintaining highway access between urban centers or metropolitan areas.

- Improving or maintaining highway access to economically distressed areas of the state, as defined by the party requesting a project to further this objective.

- Improving or maintaining highway access to points of shipment or processing of products, including grain storage elevators.

- Improving or maintaining highway access to trucking terminals or points of embarkation or shipment by other modes, including trailer on flatcar and container on flatcar terminals, barge terminals, air cargo terminals and freight forwarding terminals.

- Improving or maintaining highway access to scenic, recreational, historic or cultural sites, or other locations identified as tourist attractions.

(City of Iowa Falls, 1987, pp. 10-11).

The applicants for the RISE funds admit that "identifying definite economic impacts" can be difficult, but they are convinced that they must be connected to the interstate system by a four-lane highway in order to survive economically. A number of resolutions have been passed by city councils in Hardin County in support of the realignment and expansion of US 20 between Interstate 35 and US 65. In addition, a number of industries in the Iowa Falls area have gone on record in favor of this project. These businesses cite the current trend in trucking to use larger loads, as well as safety factors, travel time savings and greater fuel efficiency in their efforts to win support for the project.

Opinions of Other Parties Concerning Economic Impacts of Highway Relocation and Expansion

A number of groups in Iowa believe that expansion of some primary highways from two to four lanes may be critical to the economic development of the state. Such parties have included the Iowa General Assembly, the Iowa Department of Transportation, the US 20 Corridor Association, and a number of economic development groups all over the state.

The US 20 Corridor Association has taken a great interest in expanding US 20 from two to four lanes between the Missouri and Mississippi Rivers. This effort has been supplemented by a similar movement in northwest Illinois to build a four-lane highway from East Dubuque to Rockford, where motorists could take Interstate 90 into Chicago (Augustine, 1987). The US 20 Corridor Association emphasized in a brochure produced in 1983 that among the five major east-west corridors across Iowa, US 20 served the regions with the largest farm population and the greatest hog, corn and soy bean production in the state. In addition, US 20 is second only to Interstate 80 in the percent of retail sales and the percent of wholesale firms per corridor (US 20 Corridor Association, 1983). The US 20 Corridor Association emphasized in the same brochure that US 20 is only slightly behind Interstate 80 in the amount of industry attracted to the regions in which each highway serves. Tourism also is emphasized in this brochure.

The Iowa General Assembly has emphasized the link between general transportation improvements and economic development in

its passage of the RISE program in 1985. As Forkenbrock and Plazak have stated (1986, p. 11): "RISE is funded by a dedicated two-cent per gallon motor fuel tax. The legislation establishing RISE stipulates that program funds...are to be used to directly facilitate and encourage economic development within the state." It is apparent that a rural-urban debate might surface in a program such as RISE. For example, who gets targeted for development: communities in metropolitan areas or small towns in rural areas? Although the number of jobs gained for the state as a whole might increase substantially as a result of targeting development for metropolitan areas, there might be some questions as to the equity of such an approach (Forkenbrock and Plazak, 1986, p. 12).

This point is very important in our consideration of the US 20 corridor. Certainly, communities such as Iowa Falls, Cedar Falls and Waterloo may benefit from the alternatives advocating relocation and expansion of US 20. However, a number of smaller communities along the current route may suffer economically as a result of the relocation. In addition, fewer communities would be closer to US 20 than those which would now be distanced from that highway as a result of any relocation project.

The Iowa Department of Transportation has actively compiled statements made by public officials, representatives of businesses and economic development groups, and others who often were quoted in local newspapers. The Iowa DOT appears to be advocating transportation improvements as a means toward achieving economic development in the state. What the Iowa DOT needs to consider more is the distribution of jobs which might be

created (more in larger communities while there might be losses in smaller communities) and the quality of the jobs which are created. An impact analysis would need to be performed each time a plant came into a community to determine whether such a plant would be beneficial or detrimental to the community as a whole.

Research on the Relationship Between Transportation Improvements and Economic Development

Two researchers at the University of Minnesota (Stephanedes and Eagle) have performed some research on the relationship between state trunk highway expenditures and employment levels (Stephanedes and Eagle, 1986). Using a time series analysis of data from 1957 to 1982, Stephanedes and Eagle state that highway expenditures do not have an impact on manufacturing and retail employment in areas over 25 miles from cities with a population over 30,000. Regional employment rates tend to increase immensely for two or three years after highway improvements are made, but decrease back to their original level by about the tenth year after the highway improvement. Stephanedes and Eagle have stated that this long-term leveling of employment might be due to improved access to metropolitan areas. In addition, Stephanedes and Eagle have concluded that an increase in highway expenditures in a region leads to a rather microscopic increase (and sometimes even a slight decrease) in employment in the manufacturing and retail sectors of the regional economy (Stephanedes and Eagle, 1986, pp. 21-24).

That study was performed exclusively in Minnesota. However, other literature states that there is not much of a correlation

between highway improvements and increases in long-term employment in areas of North America where such research has been performed (R. Briggs, 1981, as quoted by Stephanedes and Eagle, 1986, p. 16). At the moment, Stephanedes and Eagle are doing additional research on highway impacts on regional employment in Minnesota. Such research may point to a need for state Departments of Transportation to reassess their emphasis on highway projects promoting economic development once this report is released.

Summary

It is apparent that many of those in political and economic power in Iowa see a relationship between highway improvements and economic development. This is particularly true for many communities along or near the existing and proposed alignments of US 20 between Interstate 35 and the Black Hawk County line. The role of highway improvements in stabilizing employment levels in a region is not questioned here. However, recent research performed in a relatively homogeneous region to our north indicates that highway improvements have no major effect in increasing employment in a region in the long run. While there might be initial increases in employment in a region, these employment rates would fall to their former level in the long run. Also, this research indicated that employment levels would not increase in areas further than a half-hour drive from major cities (such as Fort Dodge and Waterloo in this case).

It appears that the only segments of highway worthy of consideration as candidates for upgrading to four lanes from an

economic development standpoint are US 20 from Interstate 35 to US 65 and from Iowa 14 to the Black Hawk County line. The rest of this corridor, under the present or altered alignment, should be two lanes, at least from an economic development perspective.

SECTION II

IMPACTS OF ALTERNATIVE ROUTES AND DESIGNS ON ROAD USERS

A second major concern of citizens in Hardin and Grundy counties has been the ease with which motorists are able to travel along the US 20 corridor without experiencing accidents or unreasonable delay. Obviously, a major concern of a number of road users in the area has been accessibility to an interstate highway, namely Interstate 35. In this section, we discuss the other two issues which concern road users: safety and travel time savings. An attempt then will be made to quantify the potential impacts into dollar figures so that these impacts can be taken into consideration when we examine the economic feasibility of the various alternatives later in this report. Let us now consider the impacts which these alternatives might have on safety and travel time savings.

Possible Safety Impacts of the Alternatives Being Examined

In examining the question of how different alternatives might alter accident rates along the US 20 corridor, an accident study performed on the US 30 corridor in 1983 by the Iowa DOT is quite useful. This study examined a 37-mile segment of US 30 between the east junction of US 169 in Boone County and US 65 in Story County in order to compare accident rates for three classes of highway: freeway, expressway and two-lane highway. For our purposes, only the accident rates for expressways and two-lane highways will be considered in the US 20 corridor. The accident rates derived from the US 30 study were more reliable

than those found in other studies, because compared to most other studies, these segments of US 30 had nearly the same weather conditions, and similar traffic volumes were evident along this entire corridor (Iowa DOT, 1982, p. 15).

Since the US 30 study was one of the best accident studies performed on a primary highway in Iowa, it is appropriate to use the same ratio between accidents on an expressway and accidents on a two-lane road that the Iowa DOT developed. This ratio (about 0.82, or an 18% reduction in accidents once an expressway replaces a two-lane road) was used to estimate accident rates for certain sections of alternatives which were improved to expressway standards. A figure of 0.18 was multiplied by "total value lost" figures furnished by the Iowa DOT (along with accident data for the US 20 corridor) to determine the approximate savings of property, injuries and lives saved in dollar terms for each alternative. Certainly, no attempt is made to place a definite value to society on an injury or the loss of human life. However, with the value of awards resulting from litigation having increased faster than inflation in recent years, the amount of money saved because of a highway improvement might be understated here.

Alternative 1: Keep Existing Alignment; Expand It to Four Lanes

According to accident data recently compiled by the Iowa DOT for 1983-1985 and the first three quarters of 1986, there were 371 accidents in the US 20 corridor studied here. As is evident in Table 2-1, over two-thirds of these accidents involve only

property damage, while several more involve personal injuries in addition to property damage. There also were three fatalities along the corridor during this time period (Iowa DOT, 1987). This means that about one fatality occurs along the corridor each year, usually in a rural area. Monetary losses resulting from all accidents are substantial, as Table 2-3 indicates. Nearly 59% of accidents involving property damage, and over 53% of accidents involving personal injuries occur in urban areas along the corridor.

TABLE 2-1

TYPES OF ACCIDENTS ALONG THE US 20 CORRIDOR

ACCIDENTS FOR THE ENTIRE CORRIDOR

Year	Property Damage Accidents	Personal Injury Accidents	Fatality Accidents
1983	51	32	1
1984	80	37	1
1985	77	28	0
1986	46	17	1
TOTALS	254	114	3
ANNUAL	68	30	1

ACCIDENTS FROM I-35 TO US 65

Year	Property Damage Accidents	Personal Injury Accidents	Fatality Accidents
1983	24	21	1
1984	43	14	0
1985	38	15	0
1986	27	9	0
TOTALS	132	59	1
ANNUAL	35	16	0

ACCIDENTS FROM US 65 TO IOWA 14

Year	Property Damage Accidents	Personal Injury Accidents	Fatality Accidents
1983	22	8	0
1984	30	20	0
1985	34	13	0
1986	14	7	0
TOTALS	100	48	0
ANNUAL	27	13	0

ACCIDENTS FROM IOWA 14 TO BLACK HAWK CO. LINE

Year	Property Damage Accidents	Personal Injury Accidents	Fatality Accidents
1983	5	3	0
1984	7	3	1
1985	5	0	0
1986	5	1	1
TOTALS	22	7	2
ANNUAL	6	2	1

SOURCE: Office of Project Planning, Iowa DOT, 1987.

Through the employment of traffic count and accident data provided by the Iowa DOT, an accident rate of 155.1 per 100,000,000 vehicle miles traveled along the corridor was determined. This estimate far exceeded the accident rate for two-lane segments of US 30 which were studied; this rate was 68.8, or less than half the accident rate here. Much of US 20 is narrow, even for two-lane standards, and is in an advanced stage of its useful life. In applying the ratio discussed earlier in this subsection, the accident rate might be reduced to 127.1 per 100,000,000 vehicle miles if the two-lane road were replaced with a four-lane expressway in the existing alignment. Approximate savings to society as a result of the improvement would be significant; these are discussed briefly in Table 2-4. However, we must take two additional points into consideration before we discuss the next alternative. First, US 20 is very old, and even a two-lane road replacing the existing road might reduce the accident rate if it is a modern, well-built facility. Second, the ratio employed here might be even lower in this case, since any modern facility will reduce the accident rate along this

corridor; the expressway might reduce the accident rate further.

TABLE 2-2

ACCIDENT RATES PER 100 MILLION VEHICLE MILES

	Current	Predicted with Four Lanes
ENTIRE CORRIDOR	155.1	127.1
I-35 TO US 65	219.4	179.9
US 65 TO IOWA 14	139.8	114.6
IOWA 14 TO BLACK HAWK CO. LINE	73.7	60.4

TABLE 2-3

COSTS TO SOCIETY OF ACCIDENTS

	Average Annual Cost
ENTIRE CORRIDOR	$1,411,669
I-35 TO US 65	$554,205
US 65 TO IOWA 14	$462,304
IOWA 14 TO BLACK HAWK CO. LINE	$395,160

SOURCE: Office of Project Planning, Iowa DOT, 1987.

Alternative 2: Move Alignment South; Expand US 20 to Four Lanes West of US 65 and East of Iowa 14

Once again, our accident data are useful in that the corridor could be decomposed into three segments: from Interstate 35 to US 65 on the north side of Iowa Falls, from US 65 to Iowa 14, and from Iowa 14 to the Black Hawk county line. On the segment from Interstate 35 to US 65, there were 192 accidents from January 1983 to September 1986. Although this segment represents less than 25% of the corridor, nearly 52% of all accidents occurred on it. The exact nature of these accidents is discussed in Table 2-1. On an annual basis, over two-thirds of accidents involve only property damage, while not quite one-third involve personal injuries. The "total value lost" in this

corridor was significant; this is discussed in Table 2-3. In examining the accident loss data in Table 2-3, we find that about 39% of all losses occurred in less than 25% of the corridor. It is interesting to note that over three-fourths of all accidents involving property damage and over 60% of all accidents involving personal injuries occurred within Iowa Falls between 1983 and 1986. Some industries have indicated highway safety as a major factor in which Iowa Falls needs to improve.

On the segment from Iowa 14 to the Black Hawk county line, there were 31 accidents during the same time period. While it is interesting to note that this is a small number relative to other segments of the corridor, we must remember that two of the three fatalities in the corridor occurred in this segment of highway. This might increase the "total value lost" figure substantially over what it might be under normal circumstances. Once again, the exact nature of these accidents is summarized in Table 2-1. The "total value lost" during this period was not as large as that of other segments along the corridor; this is evident in Table 2-3. This segment currently contains no urban areas; however, the City of Dike is near the segment.

By using the same data and techniques as those used in Alternative 1, accident rates per 100,000,000 vehicle miles from Interstate 35 to US 65 and from Iowa 14 to the Black Hawk county line were determined. These accident rates are summarized in Table 2-2. The reader also can see that there is a substantial reduction in the accident rate on both segments of the corridor when the highway is expanded to four lanes (See Table 2-2). Approximate annual savings to society because of

these improvements is estimated according to segment of highway and according to alternative in Table 2-4. The reader can see that savings resulting from expansion of these two segments to four lanes could result in substantial savings annually. Additional savings to society, along with a reduction in the accident rate in the segment from US 65 to Iowa 14, might occur if a high-grade two-lane road were built linking these two segments. However, additional traffic may be drawn from other roads (such as Iowa 175), leading to increased volumes and, possibly, accident rates. On the other hand, shortening the route by 18 miles may lead to fewer accidents. In addition, this route will be passing through fewer urban areas; this may lead to fewer accidents.

TABLE 2-4

POTENTIAL ANNUAL SAVINGS FROM A REDUCTION IN THE ACCIDENT RATE BY UPGRADING TO FOUR LANES

Segment of Highway	Annual Savings
ENTIRE CORRIDOR	$254,429
I-35 TO US 65	$99,886
US 65 TO IOWA 14	$83,322
IOWA 14 TO BLACK HAWK CO. LINE	$71,221

Alternative	Annual Savings
Alternative 1	$254,429
Alternative 2	$171,107
Alternative 3	$99,886
Alternative 4	$254,429
Alternative 5	$0
Alternative 6	$0
Alternative 7	$71,221

Alternative 3: Move Alignment South; Expand Highway to Four Lanes West of US 65

Once again, accidents in the segment from Interstate 35 to US 65 would drop significantly if it were upgraded to four lanes

(see Table 2-2). Societal savings resulting from this improvement are the largest of the three segments studied here (see Table 2-4). If a modern, high-grade two-lane highway were constructed on the new alignment from US 65 to the Black Hawk county line, there also could be a reduction in the accident rate and additional annual savings to society. A shortened route passing through fewer urban areas might lead to fewer accidents, but more traffic might be attracted to US 20 from Iowa 175 and various county roads, leading to more accidents.

Alternative 4: Move Alignment South; Expand Entire Corridor to Four Lanes

Before we consider the safety impacts of this alternative, let us examine some characteristics of the segment of US 20 from US 65 to Iowa 14 which we did not consider previously. This segment had 148 accidents from January 1983 to September 1986: about two-thirds of these involved just property damage, while not quite one-third involved personal injuries. There were no fatalities. Annual accident data are summarized for this segment in Table 2-1. Total value lost as a result of these accidents is moderate when compared to the other segments in the corridor (see Table 2-3). The segment has an accident rate of about 139.8 per 100,000,000 vehicle miles.

As in the first alternative, the accident rate per 100,000,000 vehicle miles for the entire corridor would be reduced from 155.1 to 127.1. Savings to society resulting from the improvement would be among the largest of any of the alternatives under discussion. The degree to which the accident

rate would be reduced from US 65 to Iowa 14 is summarized in Table 2-2. Once again, the shortening of the route due to realignment, coupled with little passage through urban areas, might reduce accidents further. However, the attractiveness of US 20 as an expressway might lure other motorists to the route, making it more prone to accidents.

Alternative 5: Move Alignment South; Reconstruct Entire Corridor as a Two-Lane Road

It is difficult to determine the impacts of this alternative on reducing the accident rate. Although it might appear that a two-lane road would have little impact on reducing the accident rate, a number of features of this alternative might be beneficial to motorists. For example, the new alignment will be straighter than was the original alignment. Also, a modern, high-grade two-lane road would lead to fewer accidents than would the fifty-year-old road on which motorists presently travel. The new route would pass through few urban areas, leading to a reduction in the accident rate. Finally, motorists on Iowa 175 and on area county roads might not be as inclined to travel on US 20 if it remained a two-lane road.

Alternative 6: Rebuild Existing Alignment as a Two-Lane Road

Again, it is difficult to determine the impacts of this alternative on reducing the accident rate. Fewer of the features of this alternative would be beneficial to road users. This alternative involves several turns, and passes through a number of communities. However, a modern, high-grade road certainly

would be superior to the fifty-year-old road which presently exists. Also few motorists would be diverted to US 20.

Alternative 7: Move Alignment South; Expand Highway to Four Lanes East of Iowa 14

The accident rate would not be reduced from Interstate 35 to Iowa 14 under this alternative. However, the accident rate per 100 million vehicle miles would be reduced from 73.7 to 60.4 from Iowa 14 to near the Black Hawk county line as a result of this improvement (See Table 2-2 for details). The amount of savings to society as a result of such an improvement might total over $70,000 (See Table 2-4). This particular improvement may be significant in that most fatalities along the entire corridor occur in this segment of highway. Constructing a high-grade two-lane highway west of Iowa 14 might lead to a further reduction in the accident rate. However, the diversion of traffic to US 20 from Iowa 175 and various county roads leading into the Waterloo area might stabilize the accident rate.

Possible Travel Time Savings under the Alternatives Examined

In examining this road user concern, a number of assumptions had to be made. First of all, it was assumed that the "average wage" for truck operators was $10 per hour. This assumption was made through consultation with the manager of a major trucking firm in Iowa City (Crouse Cartage Company, 1987). In addition, it was assumed that the value of an hour to drivers and occupants of all other vehicles was $6. Data furnished by

the Iowa DOT involving average daily vehicle miles along the corridor was used to calculate total savings to society per hour of travel along the corridor that is saved. However, assumptions also had to be made concerning the number of occupants per vehicle. Data provided by the Iowa DOT for similar corridors was used to make such assumptions; interested readers are referred to Table 2-5, where vehicle occupancy data used in this analysis are listed. Through calculations, the "total societal savings per hour of travel saved" was found to be nearly $8,869,000 per year.

TABLE 2-5

ASSUMPTIONS OF AVERAGE VEHICLE OCCUPANCY

Vehicle Type	Average Occupancy
Automobiles	1.81
Pickups/Vans	1.56
Single Unit Trucks	1.30
Semi Trucks	1.05
Buses	16.40

SOURCE: Office of Transportation Inventory, Iowa DOT, 1980.

To do these calculations, an average speed of 51 miles per hour on the original two-lane road was assumed. An average speed of 53 miles per hour on any two-lane segment to be constructed in the future also was assumed, as was an average speed of 55 miles per hour on all four-lane segments in the alternatives. The existing route is 71 miles long and average travel time is 84 minutes. A relocated two-lane US 20 would be 53 miles long and would involve 60 minutes of travel. In other words, all alternatives involving the new alignment cut 18 miles from the route, and at least 24 minutes in travel time are saved under these alternatives. (Iowa DOT, 1987a).

The travel time along the corridor, time saved, and money saved annually under each alternative are summarized in Table 2-6. It should be evident to the reader that relocation of the corridor is more significant than is the expansion of the corridor to four lanes, at least as far as time savings are concerned. On the other hand, savings resulting from accident reductions are most significant when the corridor is improved to four lanes. It is obvious that travel time savings ultimately will be greater than savings generated from accident reductions in our benefit-cost analysis presented later in this report.

TABLE 2-6

TIME AND MONEY SAVINGS TO ROAD USERS

Alternative	Travel Time	Time Saved	Money Saved per Year*
Alternative 1	1 hr. 17.5 min.	6.5 min.	$967,517
Alternative 2	1 hr. 0.2 min.	23.8 min.	$3,517,136
Alternative 3	1 hr. 0.7 min.	23.3 min.	$3,444,115
Alternative 4	59.1 min.	24.9 min.	$3,676,563
Alternative 5	1 hr. 1.4 min.	22.6 min.	$3,346,755
Alternative 6	1 hr. 24.0 min.	0.0 min.	$0
Alternative 7	1 hr. 0.9 min.	23.1 min.	$3,419,776

*Assumes a value of time of $10.00 per hour for truck operators and $6.00 per hour for drivers and occupants of other vehicles.

SECTION III

ENVIRONMENTAL IMPACTS OF ALTERNATIVE ROUTES AND DESIGNS

Generally speaking, there are few environmental problems with relocating the US 20 corridor in two locations: between Interstate 35 and US 65 and between Iowa 14 and the Black Hawk county line. In fact, US 20 could be relocated in nearly all of Grundy County with few negative environmental impacts. However, there exists an environmentally sensitive area in eastern Hardin County known as the "Greenbelt." This is an area that is valued by not only local residents, but also by individuals throughout Iowa and the midwest for its beauty and its recreational offerings. The purposes of this section are to discuss the environmental uniqueness of the Greenbelt, then examine the impacts of the various alternatives on the environmental stability of the area, and to suggest modifications to some alternatives which would mitigate their negative impacts on this beautiful area.

The Greenbelt and its Environmental Uniqueness

All alternatives which have been suggested that are relocated from the original corridor (Alternatives 2 through 5, and Alternative 7, see Section II) would pass through the Iowa River Greenbelt in Hardin County as they are proposed at the moment. Glacial movements of several thousand years ago formed this unique area in Iowa (Iowa State Highway Commission, 1974, p. 21). Glacial deposits have led to the beauty of this area, and surrounding the area are some of the richest soils on earth.

A number of trees thrive in this area which do not thrive anywhere else in Iowa. These include "white, red and bur oak and shagbark hickory...maple, basswood...brown birch, beech, ironwood and rock elms" (Iowa State Highway Commission, 1974, p. 25). A number of other tree varieties exist here, as do several types of wildflowers, ferns and mosses. Also, some prairie grasses remain undisturbed in the area. The Iowa State Highway Commission noted in its environmental impact statement that more than 300 species of plants had been identified in the Greenbelt. Some of this vegetation is identified as occurring naturally only in this area and in the northeast section of the state (Iowa State Highway Commission, 1974, p. 25). In addition, limestone bluffs are unique to this area of north central Iowa.

One must also remember that this rare forest cover provides excellent habitat for forest game species such as white-tailed deer, fox squirrels, raccoon and fox. A number of birds, including game birds, exist in the area, as do cottontail rabbits, mink, muskrat, beavers, and a variety of fish and aquatic animals in the Iowa River and in adjacent oxbow lakes (Iowa State Highway Commission, 1974, p. 26).

Officials from the Iowa Department of Transportation emphasized the environmental uniqueness of the area at a public hearing on March 25, 1987. At that hearing, the archaeological significance of the area also was mentioned. A number of Indian mounds are located in the area. Certainly, these burial mounds should be preserved as part of our cultural heritage. It should also be emphasized that the Hardin County Conservation Board has been somewhat more active in preserving natural areas in its

county than have most other county conservation boards in the state. The Greenbelt serves as an "outdoor classroom" for a number of high school and college students in the area. The Greenbelt is of such tremendous significance to people in this area that the region itself often is informally known as the "Greenbelt." Banks and a variety of other businesses are proud to use the term "Greenbelt" as part of their business name.

A representative of the Sierra Club in Cedar Falls stated that saving the Greenbelt will maintain the quality of life in the communities around it. She mentioned that projected traffic counts do not justify expansion to four lanes through the Greenbelt. This representative also mentioned that recreation-based tourism also should be promoted as an economic development objective in the area, since 2,000 to 2,500 canoeists and over 3,000 horseback riders come to the Greenbelt each year. Ultimately, this representative requested that the corridor be placed entirely outside the Greenbelt (Public Hearing, March 25, 1987).

A representative of the Hardin County Conservation Board stated that limestone cliffs, oxbow lakes and timber of all sorts are assets to the area. He also stated that it might be best to move the proposed alignment of US 20 between Interstate 35 and US 65 either to the north or to the south. This move might allow more viable options to keep the Greenbelt free of environmental disturbance (Public Hearing, March 25, 1987).

Impacts of Alternatives on Environmental Stability of Greenbelt

Obviously, the first and sixth alternatives suggested in this report would have no impact on the Greenbelt, since these would be built on the present alignment of US 20. In addition, Alternatives 2, 3, 5 and 7 would have some impact on the environmental stability of the Greenbelt. However, Alternative 4 would have the greatest impact on the environmental stability of the Greenbelt; this is the only alternative which includes four-lane expressway as it passes through the Greenbelt. Such an expressway would, most likely, attract additional traffic from other highways, such as Iowa 175 and various county roads. Here, we discuss some of the probable impacts of Alternatives 2, 3, 4, 5 and 7 on the environmental stability of the area.

Air Pollution

As far as air quality is concerned, the Iowa State Highway Commission stated in 1974 that construction initially would lower air quality in the Greenbelt and other areas. "Traffic volumes and local meteorological conditions" were seen to be primary determinants in measuring air contamination. The Iowa State Highway Commission speculated in 1974 that maximum traffic volumes for the heaviest-traveled sections of US 20 would not exceed what were Iowa Department of Environmental Quality standards for at least twenty years after completion. Low concentrations of carbon monoxide, coupled with strong winds in the area, would mean that air quality would be affected very

little. This is particularly true of the Greenbelt (Iowa State Highway Commission, 1974, pp. 32-35).

Noise Pollution

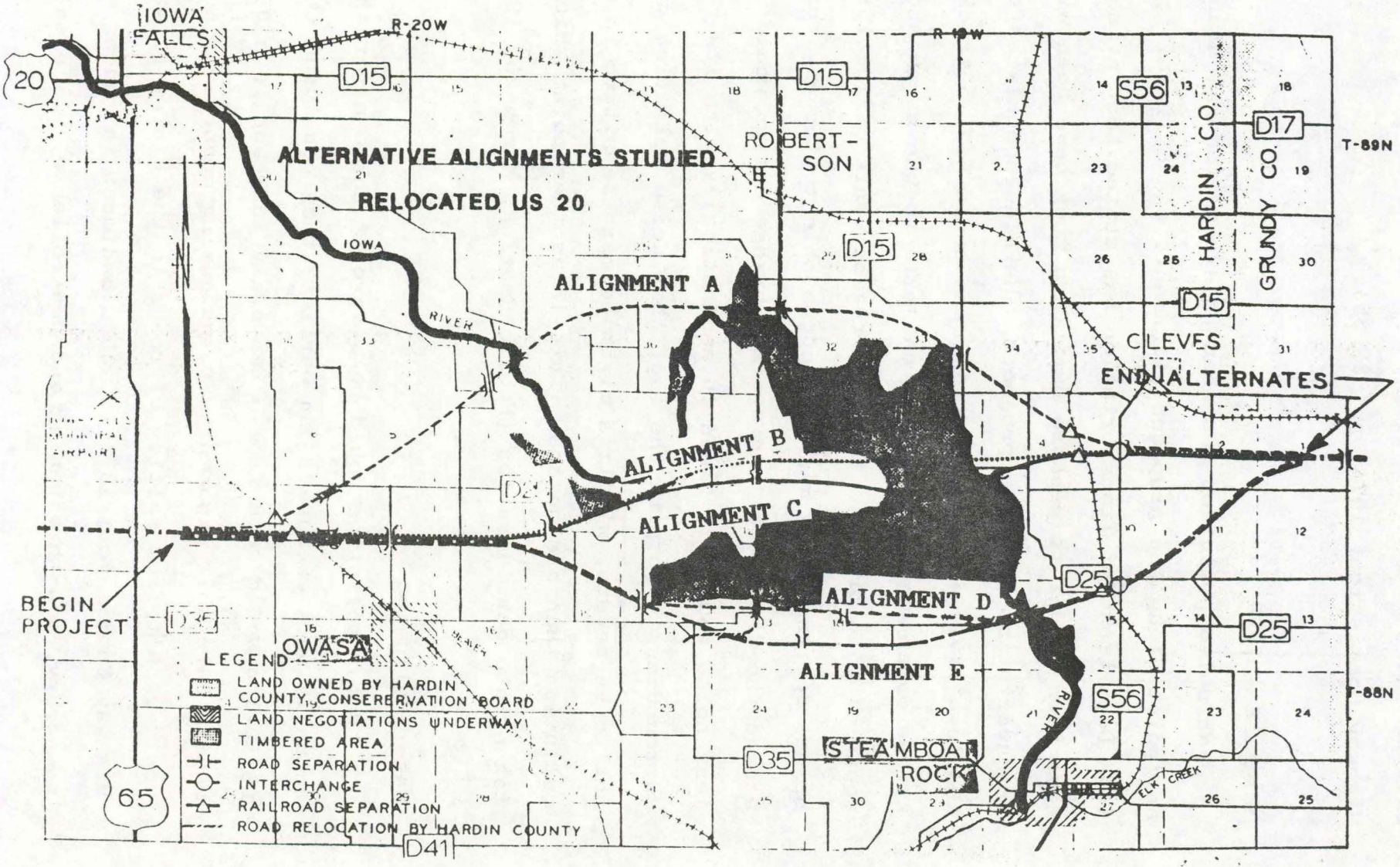
No noise pollution was seen to exceed federal standards at any point along the proposed alignment. An official from the Iowa Department of Transportation has stated that noise impacts have been harder to measure here than they have been with other transportation planning projects. He also speculated that near the Iowa River in the Greenbelt, one could hear a truck cross a bridge on an expressway up to one mile to the north and the south of that bridge. For that reason, this official suggested bridge designs which might be compatible to the environment around the Greenbelt. An optimal bridge design would lead to less noise and would blend in aesthetically with its surroundings. Despite the fact that noise pollution might appear not to be severe, wildlife might be more sensitive to noise pollution than are humans. This is another point which must be taken into consideration (Public Hearing, March 25, 1987).

Water Pollution

Water pollution could be severe if these alternatives actually were executed. An earlier study concluded that water pollution would come from a temporary increase in sediment load due to bare soil exposed to rains during construction, and also would result from salting of roads in the winter (Iowa State Highway Commission, 1974, p. 40). Sediment increases are seen as temporary, non-threatening and controllable, while salting is

FIGURE 3-1

MAP OF ALTERNATIVE ALIGNMENTS WHICH AVOID THE GREENBELT



seen as a potentially dangerous form of water pollution. While man and other higher animals might not be affected a great deal by salt pollution, plants, and to some extent fish, would be affected the most by such pollution. Trees are seen as being harmed the most by such pollution. It appears that those plants which are closest to the highway, particularly those near stream crossings, would suffer the most from salt pollution if US 20 were relocated (Iowa State Highway Commission, 1974, pp. 40-42).

Impacts on Wildlife

The Iowa State Highway Commission admitted in 1974 that a great deal of timber and grassland natural to the Greenbelt would be taken if construction occurred through the area. There has been speculation that birds of various species would replace deer if these trees were removed. Some plant species might disappear because of too much sunlight caused by clearance of trees; these would be replaced by plants which thrive on sunlight (Iowa State Highway Commission, 1974, pp. 42-43).

Alternative Alignments Which Might Mitigate Adverse Impacts on the Greenbelt

Before we continue, it needs to be emphasized that Alternatives 2, 3, 4, 5 and 7 involve merely different mixes in the number of lanes over the same route. Each alternative is assumed to have the same alignment. However, the alignment which this segment of the corridor should have has been disputed greatly. Five alternative alignments through the Greenbelt were proposed by the Iowa State Highway Commission. Various

alternative alignments which have been proposed are illustrated in Figure 3-1. Alternative Alignments B and C were seen to have similar effects on the environment, and will be discussed together. The same is true for Alternative Alignments D and E. Alternative Alignment A will be discussed separately. An additional alternative alignment has been proposed by the City of Eldora; the potential environmental impacts of this alternative alignment are unknown.

Impacts of Alternative Alignment A

This alternative alignment totals 38.3 miles from just east of US 65 to two miles east of County Road S56 in Grundy County. This alignment is the longest of the five proposed alignments (See Figure 3-1). Little timber exists along creek crossings in the area, but "about four acres of bottomland timber" would need to be removed around the Iowa River in order to construct this alignment. Little damage to aquatic wildlife is foreseen, but the alternative might affect deer migration to some extent. Timber located east of the Iowa River also would be removed, and deer and smaller animals might be affected. Few other environmental effects are foreseen for Alternative Alignment A (Iowa State Highway Commission, 1974, pp. 69-71).

Impacts of Alternative Alignments B and C

Alternative Alignment B totals 37.1 miles, while Alternative Alignment C is 37.2 miles long (See Figure 3-1). About 12 acres of timber would be removed with Alignment B, while 7 acres would be removed with Alignment C. Aquatic life could be affected

permanently by the implementation of these alternatives. Deer migration would be harmed immensely under these alternatives. The "horseshoe bend" area, where the largest concentration of deer thrive alongside unique plant species, would be bisected, raising the ire of numerous citizens in Hardin County. The "horseshoe bend" area was seen to support "about one-half of Hardin County's deer herd" according to researcher Gladfelter, as quoted by the Iowa State Highway Commission in 1971. Smaller animals, including a number of rare birds, would no longer have a habitat if these alignments were implemented (Iowa State Highway Commission, 1974, pp. 69-71). Neither of these alignments is recommended as part of a relocated US 20.

Impacts of Alternative Alignments D and E

Alternative Alignment D totals 37.6 miles, while Alternative Alignment E is 37.7 miles long (See Figure 3-1). As in Alignments A, B and C, there would be an insignificant environmental impact at creek crossings. Again, deer migration would be affected adversely, but not to the extent that it would be affected under Alignments B and C. About 10 acres of timber would be removed at the Iowa River crossing under Alignment D. Very little timber would be removed under Alignment E, but some agricultural land would be utilized, removing some habitat for birds. The Iowa State Highway Commission saw Alternative Alignment E as being the least damaging alignment to the Greenbelt (Iowa State Highway Commission, 1974, p. 71). All five alternative alignments merge to form one alignment again in western Grundy County.

Recommendations

It is obvious that only Alternative Alignments A and E are worthy of consideration. While Alternative Alignment E harms the Greenbelt the least, two points favor Alternative Alignment A. First, it might be more in the economic interests of workers in Ackley and other communities along the present corridor to have the new corridor as close to them as possible so that they do not lose major industries. In addition, county roads which lead to these communities should be improved if a selection from Alternatives 2, 3, 4, 5 and 7 is made (See Section II). Second, road users might enjoy seeing a portion of the Greenbelt while not causing too much environmental damage to the area. Indeed, one official of the Iowa Department of Transportation favored Alternative Alignment A over Alternative Alignment E for many of the same reasons (Public Hearing, March 25, 1987). If there were a great deal of concern about deer migration, fences could be installed along with underpasses. This has been implemented on some highway projects in Minnesota (Public Hearing, March 25, 1987). Alternative Alignment A should be adopted. We assume such adoption for Alternatives 2, 3, 4, 5 and 7 in our economic analysis of the various alternatives (See Section II).

SECTION IV

IMPACTS OF VARIOUS ROUTING ALTERNATIVES ON LANDOWNERS

Another concern of citizens in Hardin and Grundy Counties is how landowners would be affected by the location and width of US 20. A number of individuals might fear a loss of farmland or a severance of their farmland into two pieces, particularly if sections of US 20 were diagonal. Although access to and across the highway has been expressed as a concern in the past, we now realize that US 20 would be either a two-lane road or an expressway. This means that landowners might not have a great deal of difficulty in having accessibility to and across US 20. The sale price of land acquired through eminent domain is another concern of landowners: they want just compensation, while those who implement the project want to keep costs to a minimum. Finally, noise and visual impacts are concerns of landowners. However, as we discussed earlier, noise levels would be reasonable for at least twenty years after construction (Iowa State Highway Commission, 1974, p. 37). Visual impacts, on the other hand, may be a legitimate concern.

Landowner Concerns With Alternative 1

Outside of some noise and visual impacts during construction, it appears that landowners would have few other concerns about our first alternative, keeping the existing alignment and expanding all of it to four lanes. There would be no diagonal severance under this proposition, and access to and across the highway would remain good. Difficulties and costs in

acquiring right-of-way would be minimal in rural areas. However, there may be some difficulties and/or expenses which the Iowa DOT has underestimated in urban areas. Loss of farmland might be a concern under this alternative.

Landowners Concerns With Alternative 2

This alternative involves moving the alignment south and expanding it to four lanes west of US 65 and east of Iowa 14. With all alternatives involving the realignment of US 20, we must remember that the right-of-way already has been purchased for up to a four-lane expressway between Interstate 35 and US 65 on the proposed alignment. This is a sunk cost. The right-of-way for the rest of the proposed corridor has not been purchased yet, however. There may be the same difficulties with acquiring additional right-of-way from Iowa 14 to the Black Hawk county line that there would be in expanding US 20 along its original corridor. However, this segment of highway is largely rural; the only area where there may be problems concerning the sale price of land or other land acquisition difficulties is near Dike.

The largest difficulties with this alternative will occur between US 65 and Iowa 14. In this segment, the loss of farmland would total almost 1500 acres. The amount of roadway which would be diagonal would total almost 9 miles. Some 19 farms would be diagonally severed, and three barns would be torn down for the highway. Some land could be diagonally severed to the point where the Iowa DOT would have to purchase small parcels of land which could no longer be cultivated, since there would be a "taking" involved. The sale price of this land would need to be

reasonable. However, noise and visual impacts might be minimal (Iowa State Highway Commission, 1974, pp. 35-38).

Landowner Concerns With Alternative 3

This alternative involves moving the alignment south and expanding the highway to four lanes west of US 65. Once again, there would be few problems with landowners west of US 65, since the Iowa DOT owns enough right-of-way to construct an expressway there. Fewer problems would exist in building a two-lane road from Iowa 14 to the Black Hawk county line than existed with Alternative 2. However, there may continue to be some land acquisition problems near Dike. The same problems which existed in Alternative 2 between US 65 and Iowa 14 would exist in this alternative.

It must be remembered that when diagonal severance and the taking of land to rebuild primary highways occur, landowners have the law on their side. The Code of Iowa, section 306.9, states the following: "Relocation of primary highways through cultivated land shall be avoided to the maximum extent possible...diagonal routes shall be avoided wherever feasible and prudent alternatives exist" (Public Hearing, March 25, 1987). In addition, the taking of cultivated land means less property on the tax rolls for county governments, unless economic development takes place near the relocated highway. However, such economic development may be undesirable to some current landowners.

Landowner Concerns With Alternative 4

This alternative involves moving the alignment south and expanding the entire corridor to four lanes. Once again, there would be no problems with this alternative between Interstate 35 and US 65. There would be few land acquisition problems from Iowa 14 to the Black Hawk county line, but there might once again be problems near Dike. As in every alternative where the corridor is being relocated, the largest land acquisition difficulties would exist between US 65 and Iowa 14. Again, this is because of problems with diagonal severance of farmland; these problems exist in every alternative alignment which was advanced by the Iowa DOT (Iowa State Highway Commission, 1974, pp. 72-74). Legal problems might accompany this alternative as well.

Landowner Concerns With Alternative 5

This alternative involves moving the alignment south and reconstructing the entire corridor as a two-lane road. About the same difficulties which were true of Alternative 3 would be true under this alternative. Few problems would be encountered between Iowa 14 and the Black Hawk county line except for near Dike. No problems would be expected between Interstate 35 and US 65, since that land already has been purchased. However, severe difficulties might be encountered in purchasing right-of-way from US 65 to Iowa 14. This is because of state laws governing diagonal severance and the relocation of primary highways.

Landowner Concerns With Alternative 6

This alternative involves rebuilding the existing alignment as a two-lane road. Few problems with landowners would occur. There would be no loss of farmland, no diagonal severance of properties, and no sale price to be negotiated on land. Access to and across the highway would be excellent once it was constructed. However, noise and visual impacts might be great during the construction period, although they would be minimal once the highway was completed. The major problem with this alternative from the perspective of the landowner would surface during construction: he might view his temporary inability to use US 20 as a "taking," particularly if he is in business along the corridor. However, this would not be a permanent problem.

Landowner Concerns With Alternative 7

This alternative involves moving the existing alignment south and expanding it to four lanes only from Iowa 14 to the Black Hawk county line. Again, there would be no problems from Interstate 35 to US 65, since the Iowa DOT already owns the right-of-way. Difficulties once again would occur between US 65 and Iowa 14, since there would be a substantial taking and diagonal severance of land. As stated earlier, this violates the intent of Section 306.9 of the Code of Iowa. From Iowa 14 to the Black Hawk county line, few problems are foreseen concerning land acquisition for the expressway. However, there again could be problems near Dike. The intent of Section 306.9 of the Code of Iowa may be violated through the relocation of this segment of US 20. Obviously, the biggest land acquisition problems would

occur from US 65 to Iowa 14.

Additional Comments

It has been interesting to observe the friction between environmentalists and landowners concerning the location of the corridor. Environmentalists prefer a diagonal highway to save the Greenbelt. Landowners, although somewhat concerned about the Greenbelt, want to save their land. The Iowa DOT is attempting to compromise by proposing an expansion of an east-west gravel county road into a paved US 20 corridor. Diagonal roadways would be implemented only to avoid passing through the "horseshoe bend" area of the Greenbelt. Indeed, compromise will be necessary in order to marginally placate all of the interest groups involved with this project (Public Hearing, March 25, 1987).

SECTION V

BENEFIT-COST ANALYSIS OF THE VARIOUS ALTERNATIVES

At this point, we diverge from the more local concerns of Hardin and Grundy counties to examine the economic viability of each of our alternatives. This benefit-cost analysis will quantify travel time and accident savings into dollars of benefit. The amount which road users "pay in" to finance this corridor is seen as a benefit as well. Costs shall include land acquisition costs, as well as resurfacing and maintenance costs. These benefits and costs shall be discounted over time, and net present values or benefit-cost ratios should make it easier for the decision maker to determine viable alternatives. Let us now begin our discussion on benefit-cost analysis as applied to this project.

Explanation of Revenues Generated: Sources

"Revenues generated" are considered an indicator of user benefit levels in this analysis because they demonstrate a willingness to pay. Two types of revenues which are fairly simple to calculate are motor fuel tax revenues and registration fees. It is possible to attribute a certain proportion of statewide revenues to usage of the US 20 corridor. It must be remembered that motor fuel tax revenues and registration fees constitute about 80% of all highway financing revenues in the state (Forkenbrock, 1986). In addition, we only take state motor fuel tax revenues into consideration here. Federal motor fuel tax revenues could be attributed to the corridor as well;

however, these are excluded in this analysis.

Registration Fee Revenues

The amount of registration fee revenues attributed to the US 20 corridor was calculated by dividing total annual vehicle miles traveled on the US 20 corridor from Interstate 35 to just east of the Black Hawk county line by the total annual vehicle miles traveled for the state. This figure then was multiplied by the total fees generated in 1985. This was done for each class of vehicle except motorcycles, for which no data existed. These revenues will be underestimated slightly because traffic volumes have increased slightly since 1985. Table 5-1 lists estimated registration fees attributed to financing this corridor.

TABLE 5-1

REGISTRATION FEES ATTRIBUTED TO FINANCING THE US 20 CORRIDOR

Vehicle Classification	Total Fees
Autos, Pickups, Vans	$244,183
Recreational Vehicles	$5,755
Buses	$361
Trucks	$115,236
Semi Trucks	$17,890
Other (Trailers)	$3,653
Total	$387,078

SOURCES: Forkenbrock (1986, Table 2); Data provided by the Iowa Department of Transportation.

Motor Fuel Tax Revenues

Motor fuel tax revenues were calculated by initially dividing average daily vehicle miles along the corridor by the average number of miles per gallon for each class of vehicle. This determines the number of gallons of fuel consumed while

traveling along the corridor. After this, the classes of vehicles assumed to consume non-diesel fuel were aggregated into one group (cars, pickups, vans and recreational vehicles), while all other vehicles were assumed to consume diesel fuel. The number of gallons of non-diesel fuel were multiplied by $0.16, while the number of gallons of diesel fuel were multiplied by $0.185 (The current state motor fuel tax rates). This gives us the amount of motor fuel tax revenues generated daily. This figure was multiplied by 365 to determine the amount of motor fuel tax revenues generated annually. This figure is estimated at $795,357.

It follows that the amount of revenues generated, without considering license fees, use taxes and federal motor fuel taxes, is the sum of registration fee and motor fuel tax revenues. This total is $1,182,435 per year. This amount has been entered under "revenues" (column five) in our benefit-cost analysis for all alternatives (See Appendix).

Explanation of Costs Incurred

For purposes of this analysis, it was assumed that right-of-way costs will be incurred during the year in which the project was initially programmed (1992 in this case). It also was assumed that all construction costs will be incurred during the year following initial programming (1993). Resurfacing was assumed to occur every ten years following initial programming, while maintenance was assumed to occur annually following completion of the project. This methodology was similar to that of the Wisconsin Department of Transportation in its investment

analysis of a project in 1975 (Wisconsin DOT, 1975, pp. 47-48).

Assumptions concerning right-of-way, construction, resurfacing and maintenance costs are summarized in Table 5-2.

TABLE 5-2

SUMMARY OF COSTS OF ROAD CONSTRUCTION (PER MILE)

Right-of-Way	Cost
Two-Lane Rural	$50,000
Four-Lane Rural	$150,000
Construction	**Cost**
All Two-Lane	$624,000
Four-Lane Existing Alignment	$710,000
Four-Lane New Alignment	$1,143,000
Resurfacing	**Cost**
All Two-Lane	$73,000
All Four-Lane	$172,000
Maintenance	**Cost**
All Two-Lane	$5,890
All Four-Lane	$7,830

SOURCE: Iowa DOT, 1985.

One additional assumption that was made was that there would be no right-of-way costs west of US 65, since the Iowa DOT owns this land. This is treated as a "sunk cost" in our analysis. Readers interested in learning about the breakdown of costs for each alternative are referred to the Appendix. For purposes of replication, the existing alignment is 71 miles long. Also, the new alignment is 16 miles from Interstate 35 to US 65, 26.2 miles from US 65 to Iowa 14, and 12 miles from Iowa 14 to just east of the Black Hawk county line, for a total length of 54.2 miles.

Additional Benefits Included in the Analysis

In addition to annual revenues generated, the annual amount saved by society through a reduction in the accident rate and annual time savings converted to a dollar value were assumed to be benefits. These benefits were explained in Tables 2-4 and 2-6, and a portion of section two explains how these benefits were quantified into dollar terms. These have been entered as additional benefits in columns (6) and (7) under each alternative in the Appendix. All benefits occur annually following the completion of the project. All benefits are added together in column (8) under each alternative in the Appendix. It is apparent that most benefits resulting from time savings occur through relocation of the corridor. On the other hand, most benefits resulting from a reduction in the accident rate occur when a segment of the corridor is upgraded to four lanes. Additional benefits might be underestimated in that fuel savings were not considered here.

Procedure Used in this Analysis

Costs of capital (right-of-way, construction and resurfacing) are entered in column (1) of each page of the Appendix. Maintenance costs are assumed to occur annually following completion of any alternative. These columns are added to determine total project cost for each alternative. Benefits include revenues, time saved and money saved through accident reductions. These columns are added to determine total benefits for each alternative. Total costs then are subtracted from total benefits. Finally, this result is discounted at 7% and at 9% to

determine the net present value of each alternative. The project life is assumed to be 40 years. Benefit-cost ratios were calculated by dividing total discounted benefits by total discounted costs at 7% and at 9%. Discount rates of 7% and 9% were chosen carefully to reflect a range of estimates of what the opportunity cost of capital is expected to be over the next fifty years.

Net Present Value and Benefit-Cost Ratio for each Alternative

Ultimately, the purpose of these calculations was to develop some numbers which could measure the economic efficiency of any given alternative examined here. Most economists and planners believe that net present value is a better criterion for measuring the economic viability of a project than is the benefit-cost ratio (Stokey and Zeckhauser, 1978, p. 146). This is because the benefit-cost ratio tends to mask the magnitude of a number of projects. For example, a project of greater statewide significance might have a lower benefit-cost ratio than a project of lesser significance. However, the "payoff" to society of the former project may be much greater than that of the latter project. The reader is advised to measure economic viability with net present value. However, benefit-cost ratios are included for the sake of comparison.

Net Present Values

Table 5-3 includes a listing of net present values for each of our alternatives, discounted at 7% and at 9%. It is obvious that Alternatives 1, 4 and 6 would be ruled out on the basis of

economic efficiency. Thus, reconstruction of any road on the existing alignment (two- or four-lane) is judged to be economically inefficient. Construction of a four-lane US 20 from Interstate 35 to just east of the Black Hawk county line also is regarded to be economically inefficient. However, losses to society would not be as great as those incurred from alternatives which involve keeping the existing alignment.

TABLE 5-3

NET PRESENT VALUES OF ALTERNATIVES

Alternative	Discount Rate	
	7%	9%
Number 1	($36,329,335)	($37,238,045)
Number 2	$1,239,987	($7,851,872)
Number 3	$7,899,737	($1,290,737)
Number 4	($14,199,788)	($22,889,365)
Number 5	$15,118,060	$5,808,854
Number 6	($36,884,622)	($36,773,260)
Number 7	$8,458,311	($752,279)

Table 5-3 also indicates that the economic efficiency of Alternatives 2, 3 and 7 depends on which discount rate is most applicable at a given time. Each alternative appears to be feasible with a 7% discount rate, but is economically inefficient at 9%. However, it appears that Alternatives 3 and 7 are more efficient than is Alternative 2. In other words, either expanding the highway to four lanes between Interstate 35 and US 65 or between Iowa 14 and just east of the Black Hawk county line is superior to expanding both of these end segments to four lanes.

Table 5-3 illustrates that Alternative 5, moving the alignment south and keeping it a two-lane highway, is the most

efficient alternative. The net present value of this alternative is positive at both 7% and 9%. However, that does not mean that this alternative should automatically be selected. Alternatives using the existing alignment damage the environment the least. Also, Alternatives 2, 3 and 7 show possible economic development potential. Expanding US 20 to four lanes between Iowa 14 and just east of the Black Hawk county line could lead to greater economic growth in the Waterloo area (See the discussion of research on the relationship between transportation improvements and economic development in Section I). Businesses in the Iowa Falls area are concerned about traffic safety and accessibility to Interstate 35. As a result, it can not be prematurely asserted that Alternative 5 is the best alternative, although it is the most efficient one when examining net present values.

Benefit-Cost Ratios

Table 5-4 lists benefit-cost ratios for each of our alternatives, again discounted at 7% and at 9%. A benefit-cost ratio of less than one is defined to be economically inefficient, while a benefit-cost ratio greater than or equal to one is economically efficient. Again, Alternatives 1, 4 and 6 are considered to be economically inefficient under both discount rates. This means that any highway improvement on the present alignment would be economically inefficient. In fact, some terrible benefit-cost ratios are achieved under Alternatives 1 and 6. Building a four-lane highway along the entire corridor on the new alignment also would be economically inefficient.

TABLE 5-4

BENEFIT-COST RATIOS OF ALTERNATIVES

Alternative	Discount Rate	
	7%	9%
Number 1	0.37	0.31
Number 2	1.02	0.84
Number 3	1.19	0.97
Number 4	0.79	0.65
Number 5	1.45	1.18
Number 6	0.19	0.16
Number 7	1.20	0.98

Again, Table 5-4 indicates that the economic efficiency of Alternatives 2, 3 and 7 depends on the discount rate which is used. These alternatives all appear to be economically efficient with a 7% discount rate, but are economically inefficient at 9%. However, Alternatives 3 and 7 appear to be only slightly inefficient. Substantial economic growth resulting from one of these alternatives could make it economically efficient.

In this case, benefit-cost ratios appear to tell us what net present values told us: that Alternative 5, or moving the alignment south and constructing it as a two-lane highway, is the most efficient alternative. Again, there are potential advantages to other alternatives which do not exist with Alternative 5. Moving the alignment south and expanding the highway to four lanes between Interstate 35 and US 65 and/or between Iowa 14 and just east of the Black Hawk county line appears to be economically efficient with a low discount rate. However, these alternatives are inefficient with a high discount rate. Economic development might occur in Waterloo if the expansion is made from Iowa 14 to just east of the Black Hawk

county line (See Section I). However, we are uncertain as to whether such economic development would take place in the Iowa Falls area as a result of expansion to four lanes from Interstate 35 to US 65. Two things are certain: keeping the corridor on the existing alignment is inefficient, as is expanding the entire corridor to four lanes on either alignment.

SECTION VI

CONCLUSIONS AND POLICY RECOMMENDATIONS

We have looked at seven alternatives and five attributes related to these alternatives. We began by examining possible economic development impacts of the various alternatives. After this, we examined how these alternatives would affect road users, particularly in regard to accident reductions and travel time savings. Environmental impacts of the various alternatives were examined, as were impacts of these alternatives on landowners near each proposed route. Finally, we attempted to measure the economic efficiency of each alternative through the employment of net present values and benefit-cost ratios. We now list a summary of advantages and disadvantages associated with each alternative, without actually recommending any one of these alternatives over all of the others. However, some alternatives may be ruled out here. Let us begin to list the advantages and disadvantages of each alternative.

Alternative 1

Advantages

1. Economic stability of communities along existing route.
2. Substantial reduction in the accident rate.
3. Environmental stability of the Greenbelt would be assured.

Disadvantages

1. Few travel time savings would be realized.
2. Taking of a great deal of urban land might occur.
3. Negative net present value and benefit-cost ratio below one at 7% and at 9%.

Alternative 2

Advantages

1. Some economic development is possible in the Waterloo area.
2. Substantial travel time savings.

Disadvantages

1. Diagonal severance of land between US 65 and Iowa 14.
2. Some environmental disruption of the Greenbelt.

Alternative 3

Advantages

1. Substantial reduction in the accident rate between Interstate 35 and US 65.
2. Economic stability of Iowa Falls might be assured.
3. No additional right-of-way costs for expressway from Interstate 35 to Iowa Falls.

Disadvantages

1. Diagonal severance of land from US 65 to Iowa 14.
2. Some environmental disruption of the Greenbelt.

Alternative 4

Advantages

1. Substantial reduction in the accident rate along corridor.
2. Substantial travel time savings along entire corridor.
3. Economic development potential in larger communities.

Disadvantages

1. Greatest environmental disruption of the Greenbelt.
2. Diagonal severance of land from US 65 to Iowa 14.
3. Greatest taking of cultivated land, in violation of Section 306.9, Code of Iowa.
4. Economic difficulties of smaller communities along present route may surface.
5. Negative net present value and benefit-cost ratio below one at 7% and at 9%.

Alternative 5

Advantages

1. Substantial travel time savings along entire corridor.
2. Least expensive of the alternatives.
3. Largest net present values and benefit-cost ratios at 7% and at 9%.

Disadvantages

1. No economic development potential in larger communities.
2. Loss of economic stability in communities on original route.
3. Little reduction in the accident rate.
4. Diagonal severance of land from US 65 to Iowa 14.
5. Some environmental disruption of the Greenbelt.

Alternative 6

Advantages

1. Greater economic stability for communities along existing route.
2. No diagonal severance of land or taking of cultivated land.
3. No environmental disruption of the Greenbelt.

Disadvantages

1. Little potential for economic growth of larger communities in area.
2. No travel time savings.
3. Little reduction in the accident rate.
4. Negative net present values and the lowest benefit-cost ratios at 7% and at 9%.
5. Inconvenience for those adjacent to existing route during construction.

Alternative 7

Advantages

1. Economic development is possible in the Waterloo area.
2. Substantial travel time savings.

Disadvantages

1. Diagonal severance of land between US 65 and Iowa 14.
2. Some environmental disruption of the Greenbelt.

It is possible that some interest groups have awaited the following recommendation. Alternatives 1, 4 and 6 are economically inefficient. No intangible factor could be expected to convert their negative net present values into positive ones. This means that alternatives which involve keeping the existing alignment are economically inefficient. In addition, alternatives involving expressway throughout the corridor are

considered to be economically inefficient. These alternatives are not worthy of consideration at this time.

Although moving the alignment south and reconstructing the entire corridor as a two-lane road (Alternative 5) appears to be the most efficient alternative, we need to examine several other factors. The research of Stephanedes and Eagle (1986) implies that Waterloo could experience some degree of economic growth if either Alternative 2 or 7 were implemented. We are less certain as to whether Iowa Falls would experience economic growth if either Alternative 2 or 3 were implemented. We also are uncertain about the magnitude of growth resulting from such highway improvements. In other words, we do not know whether net-present values resulting from partial expansion to four-lane highway would exceed the net present value of alternative 5 at 7% and at 9%.

In summary, it is not technically possible to suggest a single best alternative. Because a larger community can expect to generate a greater absolute amount of economic growth, it might be wise to expand to four lanes near Waterloo before considering an expansion between Interstate 35 and US 65. If substantial economic growth could be expected in Iowa Falls through such an expansion, then the segment of US 20 from Interstate 35 to US 65 could be expanded as well. It is interesting to note that net present values and benefit-cost ratios were similar for both the expansion from Interstate 35 to US 65 and from Iowa 14 to just east of the Black Hawk county line. However, the state might benefit most from a larger absolute amount of economic growth. Waterloo could offer such

growth potential. Each of the three alternatives involving partial expressway, as well as the alternative which involves two-lane highway through the entire new alignment, deserves serious consideration.

APPENDIX

BENEFIT-COST ANALYSIS OF EACH ALTERNATIVE

ORIGINAL CALCULATIONS

f Alter. ime Saved	No. 1 Acc. Red.	Total	Benefits- Costs	NPV 7%	9%
(6)	(7)	(8)	(9)	(10)	(11)
0	0	0	(7,100,000)	(7,100,000)	(7,100,000)
0	0	0	(43,310,000)	(40,476,634)	(39,733,945)
967,517	254,429	2,404,381	1,848,451	1,614,509	1,555,804
967,517	254,429	2,404,381	1,848,451	1,508,887	1,427,343
967,517	254,429	2,404,381	1,848,451	1,410,174	1,309,489
967,517	254,429	2,404,381	1,848,451	1,317,920	1,201,366
967,517	254,429	2,404,381	1,848,451	1,231,701	1,102,171
967,517	254,429	2,404,381	1,848,451	1,151,122	1,011,166
967,517	254,429	2,404,381	1,848,451	1,075,815	927,675
967,517	254,429	2,404,381	1,848,451	1,005,435	851,078
967,517	254,429	2,404,381	(10,363,549)	(5,268,303)	(4,377,675)
967,517	254,429	2,404,381	1,848,451	878,186	716,336
967,517	254,429	2,404,381	1,848,451	820,734	657,188
967,517	254,429	2,404,381	1,848,451	767,042	602,925
967,517	254,429	2,404,381	1,848,451	716,861	553,142
967,517	254,429	2,404,381	1,848,451	669,964	507,470
967,517	254,429	2,404,381	1,848,451	626,134	465,569
967,517	254,429	2,404,381	1,848,451	585,172	427,127
967,517	254,429	2,404,381	1,848,451	546,890	391,860
967,517	254,429	2,404,381	1,848,451	511,112	359,505
967,517	254,429	2,404,381	(10,363,549)	(2,678,138)	(1,849,177)
967,517	254,429	2,404,381	1,848,451	446,425	302,588
967,517	254,429	2,404,381	1,848,451	417,220	277,604
967,517	254,429	2,404,381	1,848,451	389,925	254,682
967,517	254,429	2,404,381	1,848,451	364,416	233,648
967,517	254,429	2,404,381	1,848,451	340,576	214,361
967,517	254,429	2,404,381	1,848,451	318,295	196,661
967,517	254,429	2,404,381	1,848,451	297,472	180,423
967,517	254,429	2,404,381	1,848,451	278,011	165,526
967,517	254,429	2,404,381	1,848,451	259,823	151,859
967,517	254,429	2,404,381	(10,363,549)	(1,361,429)	(781,112)
967,517	254,429	2,404,381	1,848,451	226,940	127,816
967,517	254,429	2,404,381	1,848,451	212,093	117,263
967,517	254,429	2,404,381	1,848,451	198,218	107,580
967,517	254,429	2,404,381	1,848,451	185,250	98,698
967,517	254,429	2,404,381	1,848,451	173,131	90,548
967,517	254,429	2,404,381	1,848,451	161,805	83,072
967,517	254,429	2,404,381	1,848,451	151,220	76,213
967,517	254,429	2,404,381	1,848,451	141,327	69,920
967,517	254,429	2,404,381	1,848,451	132,081	64,147
967,517	254,429	2,404,381	(10,363,549)	(692,082)	(329,951)
967,517	254,429	2,404,381	1,848,451	115,365	53,991
38,700,680	10,177,160	96,175,240	(25,319,960)	(36,329,335)	(37,238,045)
			B/C RATIO	0.3690259	0.3125943

of Alter. Time Saved (6)	No. 2 Acc. Red. (7)	Total (8)	Benefits-Costs (9)	NPV 7% (10)	NPV 9% (11)
0	0	0	(3,110,000)	(3,110,000)	(3,110,000)
0	0	0	(48,352,800)	(45,189,531)	(44,360,367)
3,517,136	171,107	4,870,678	4,497,120	3,927,959	3,785,136
3,517,136	171,107	4,870,678	4,497,120	3,670,990	3,472,602
3,517,136	171,107	4,870,678	4,497,120	3,430,831	3,185,873
3,517,136	171,107	4,870,678	4,497,120	3,206,384	2,922,819
3,517,136	171,107	4,870,678	4,497,120	2,996,621	2,681,486
3,517,136	171,107	4,870,678	4,497,120	2,800,580	2,460,079
3,517,136	171,107	4,870,678	4,497,120	2,617,365	2,256,953
3,517,136	171,107	4,870,678	4,497,120	2,446,135	2,070,599
3,517,136	171,107	4,870,678	(2,231,480)	(1,134,371)	(942,601)
3,517,136	171,107	4,870,678	4,497,120	2,136,549	1,742,782
3,517,136	171,107	4,870,678	4,497,120	1,996,775	1,598,882
3,517,136	171,107	4,870,678	4,497,120	1,866,145	1,466,865
3,517,136	171,107	4,870,678	4,497,120	1,744,060	1,345,747
3,517,136	171,107	4,870,678	4,497,120	1,629,963	1,234,630
3,517,136	171,107	4,870,678	4,497,120	1,523,330	1,132,689
3,517,136	171,107	4,870,678	4,497,120	1,423,673	1,039,164
3,517,136	171,107	4,870,678	4,497,120	1,330,535	953,361
3,517,136	171,107	4,870,678	4,497,120	1,243,491	874,644
3,517,136	171,107	4,870,678	(2,231,480)	(576,657)	(398,165)
3,517,136	171,107	4,870,678	4,497,120	1,086,113	736,170
3,517,136	171,107	4,870,678	4,497,120	1,015,059	675,385
3,517,136	171,107	4,870,678	4,497,120	948,654	619,619
3,517,136	171,107	4,870,678	4,497,120	886,592	568,445
3,517,136	171,107	4,870,678	4,497,120	828,591	521,521
3,517,136	171,107	4,870,678	4,497,120	774,384	478,460
3,517,136	171,107	4,870,678	4,497,120	723,723	438,954
3,517,136	171,107	4,870,678	4,497,120	676,377	402,710
3,517,136	171,107	4,870,678	4,497,120	632,128	369,459
3,517,136	171,107	4,870,678	(2,231,480)	(293,143)	(168,189)
3,517,136	171,107	4,870,678	4,497,120	552,125	310,966
3,517,136	171,107	4,870,678	4,497,120	516,004	285,290
3,517,136	171,107	4,870,678	4,497,120	482,247	261,734
3,517,136	171,107	4,870,678	4,497,120	450,698	240,123
3,517,136	171,107	4,870,678	4,497,120	421,213	220,296
3,517,136	171,107	4,870,678	4,497,120	393,658	202,106
3,517,136	171,107	4,870,678	4,497,120	367,904	185,419
3,517,136	171,107	4,870,678	4,497,120	343,836	170,109
3,517,136	171,107	4,870,678	4,497,120	321,342	156,064
3,517,136	171,107	4,870,678	(2,231,480)	(149,019)	(71,045)
3,517,136	171,107	4,870,678	4,497,120	280,672	131,355
140,685,440	6,844,280	194,827,120	101,507,600	1,239,987	(7,851,872)
			B/C RATIO	1.0245772	0.8399223

of Alter. Time Saved	No. 3 Acc. Red.	Total	Benefits- Costs	NPV 7%	NPV 9%
(6)	(7)	(8)	(9)	(10)	(11)
0	0	0	(1,910,000)	(1,910,000)	(1,910,000)
0	0	0	(42,124,800)	(39,368,970)	(38,646,606)
3,444,115	99,886	4,726,436	4,376,158	3,822,306	3,683,325
3,444,115	99,886	4,726,436	4,376,158	3,572,249	3,379,197
3,444,115	99,886	4,726,436	4,376,158	3,338,550	3,100,181
3,444,115	99,886	4,726,436	4,376,158	3,120,140	2,844,202
3,444,115	99,886	4,726,436	4,376,158	2,916,019	2,609,360
3,444,115	99,886	4,726,436	4,376,158	2,725,251	2,393,909
3,444,115	99,886	4,726,436	4,376,158	2,546,964	2,196,246
3,444,115	99,886	4,726,436	4,376,158	2,380,340	2,014,905
3,444,115	99,886	4,726,436	(1,164,442)	(591,943)	(491,873)
3,444,115	99,886	4,726,436	4,376,158	2,079,081	1,695,905
3,444,115	99,886	4,726,436	4,376,158	1,943,067	1,555,876
3,444,115	99,886	4,726,436	4,376,158	1,815,950	1,427,410
3,444,115	99,886	4,726,436	4,376,158	1,697,149	1,309,550
3,444,115	99,886	4,726,436	4,376,158	1,586,121	1,201,422
3,444,115	99,886	4,726,436	4,376,158	1,482,356	1,102,222
3,444,115	99,886	4,726,436	4,376,158	1,385,380	1,011,213
3,444,115	99,886	4,726,436	4,376,158	1,294,747	927,718
3,444,115	99,886	4,726,436	4,376,158	1,210,044	851,118
3,444,115	99,886	4,726,436	(1,164,442)	(300,914)	(207,772)
3,444,115	99,886	4,726,436	4,376,158	1,056,899	716,369
3,444,115	99,886	4,726,436	4,376,158	987,757	657,219
3,444,115	99,886	4,726,436	4,376,158	923,137	602,953
3,444,115	99,886	4,726,436	4,376,158	862,745	553,155
3,444,115	99,886	4,726,436	4,376,158	806,304	507,493
3,444,115	99,886	4,726,436	4,376,158	753,555	465,590
3,444,115	99,886	4,726,436	4,376,158	704,257	427,147
3,444,115	99,886	4,726,436	4,376,158	658,184	391,878
3,444,115	99,886	4,726,436	4,376,158	615,125	359,521
3,444,115	99,886	4,726,436	(1,164,442)	(152,969)	(87,765)
3,444,115	99,886	4,726,436	4,376,158	537,274	302,602
3,444,115	99,886	4,726,436	4,376,158	502,125	277,616
3,444,115	99,886	4,726,436	4,376,158	469,276	254,694
3,444,115	99,886	4,726,436	4,376,158	438,575	233,664
3,444,115	99,886	4,726,436	4,376,158	409,884	214,371
3,444,115	99,886	4,726,436	4,376,158	383,069	196,670
3,444,115	99,886	4,726,436	4,376,158	358,008	180,432
3,444,115	99,886	4,726,436	4,376,158	334,587	165,533
3,444,115	99,886	4,726,436	4,376,158	312,698	151,866
3,444,115	99,886	4,726,436	(1,164,442)	(77,762)	(37,073)
3,444,115	99,886	4,726,436	4,376,158	273,123	127,822
137,764,600	3,995,440	189,057,440	108,849,120	7,899,737	(1,290,737)
			B/C RATIO	1.1863033	0.9688086

f Alter. ime Saved	No. 4 Acc. Red.	Total	Benefits- Costs	NPV 7%	NPV 9%
(6)	(7)	(8)	(9)	(10)	(11)
0	0	0	(5,730,000)	(5,730,000)	(5,730,000)
0	0	0	(61,950,600)	(57,897,755)	(56,835,413)
3,676,563	254,429	5,113,427	4,689,041	4,095,590	3,946,672
3,676,563	254,429	5,113,427	4,689,041	3,827,654	3,620,800
3,676,563	254,429	5,113,427	4,689,041	3,577,247	3,321,835
3,676,563	254,429	5,113,427	4,689,041	3,343,222	3,047,555
3,676,563	254,429	5,113,427	4,689,041	3,124,506	2,795,922
3,676,563	254,429	5,113,427	4,689,041	2,920,099	2,565,066
3,676,563	254,429	5,113,427	4,689,041	2,729,065	2,353,272
3,676,563	254,429	5,113,427	4,689,041	2,550,527	2,158,965
3,676,563	254,429	5,113,427	(4,633,359)	(2,355,365)	(1,957,181)
3,676,563	254,429	5,113,427	4,689,041	2,227,730	1,817,158
3,676,563	254,429	5,113,427	4,689,041	2,081,990	1,667,117
3,676,563	254,429	5,113,427	4,689,041	1,945,786	1,529,465
3,676,563	254,429	5,113,427	4,689,041	1,818,491	1,403,179
3,676,563	254,429	5,113,427	4,689,041	1,699,524	1,287,320
3,676,563	254,429	5,113,427	4,689,041	1,588,340	1,181,028
3,676,563	254,429	5,113,427	4,689,041	1,484,430	1,083,512
3,676,563	254,429	5,113,427	4,689,041	1,387,318	994,047
3,676,563	254,429	5,113,427	4,689,041	1,296,559	911,970
3,676,563	254,429	5,113,427	(4,633,359)	(1,197,348)	(826,734)
3,676,563	254,429	5,113,427	4,689,041	1,132,465	767,587
3,676,563	254,429	5,113,427	4,689,041	1,058,378	704,208
3,676,563	254,429	5,113,427	4,689,041	989,139	646,063
3,676,563	254,429	5,113,427	4,689,041	924,428	592,704
3,676,563	254,429	5,113,427	4,689,041	863,952	543,778
3,676,563	254,429	5,113,427	4,689,041	807,432	498,879
3,676,563	254,429	5,113,427	4,689,041	754,609	457,687
3,676,563	254,429	5,113,427	4,689,041	705,242	419,896
3,676,563	254,429	5,113,427	4,689,041	659,105	385,226
3,676,563	254,429	5,113,427	(4,633,359)	(608,671)	(349,221)
3,676,563	254,429	5,113,427	4,689,041	575,688	324,237
3,676,563	254,429	5,113,427	4,689,041	538,026	297,465
3,676,563	254,429	5,113,427	4,689,041	502,828	272,904
3,676,563	254,429	5,113,427	4,689,041	469,932	250,370
3,676,563	254,429	5,113,427	4,689,041	439,189	229,698
3,676,563	254,429	5,113,427	4,689,041	410,458	210,732
3,676,563	254,429	5,113,427	4,689,041	383,605	193,332
3,676,563	254,429	5,113,427	4,689,041	358,510	177,369
3,676,563	254,429	5,113,427	4,689,041	335,055	162,724
3,676,563	254,429	5,113,427	(4,633,359)	(309,418)	(147,515)
3,676,563	254,429	5,113,427	4,689,041	292,651	136,961
147,062,520	10,177,160	204,537,080	82,591,440	(14,199,788)	(22,889,365)
			B/C RATIO	0.7914818	0.6523807

of Alter. Time Saved (6)	No. 5 Acc. Red. (7)	Total (8)	Benefits-Costs (9)	NPV 7% (10)	NPV 9% (11)
0	0	0	(1,910,000)	(1,910,000)	(1,910,000)
0	0	0	(33,820,800)	(31,608,223)	(31,028,257)
3,346,755	0	4,529,190	4,209,952	3,677,135	3,543,432
3,346,755	0	4,529,190	4,209,952	3,436,575	3,250,855
3,346,755	0	4,529,190	4,209,952	3,211,752	2,982,436
3,346,755	0	4,529,190	4,209,952	3,001,638	2,736,180
3,346,755	0	4,529,190	4,209,952	2,805,269	2,510,257
3,346,755	0	4,529,190	4,209,952	2,621,746	2,302,988
3,346,755	0	4,529,190	4,209,952	2,450,230	2,112,833
3,346,755	0	4,529,190	4,209,952	2,289,935	1,938,379
3,346,755	0	4,529,190	253,352	128,791	107,019
3,346,755	0	4,529,190	4,209,952	2,000,118	1,631,495
3,346,755	0	4,529,190	4,209,952	1,869,269	1,496,784
3,346,755	0	4,529,190	4,209,952	1,746,981	1,373,197
3,346,755	0	4,529,190	4,209,952	1,632,692	1,259,813
3,346,755	0	4,529,190	4,209,952	1,525,880	1,155,792
3,346,755	0	4,529,190	4,209,952	1,426,056	1,060,360
3,346,755	0	4,529,190	4,209,952	1,332,763	972,807
3,346,755	0	4,529,190	4,209,952	1,245,573	892,483
3,346,755	0	4,529,190	4,209,952	1,164,087	818,792
3,346,755	0	4,529,190	253,352	65,471	45,206
3,346,755	0	4,529,190	4,209,952	1,016,759	689,161
3,346,755	0	4,529,190	4,209,952	950,242	632,258
3,346,755	0	4,529,190	4,209,952	888,076	580,053
3,346,755	0	4,529,190	4,209,952	829,978	532,146
3,346,755	0	4,529,190	4,209,952	775,680	488,219
3,346,755	0	4,529,190	4,209,952	724,935	447,907
3,346,755	0	4,529,190	4,209,952	677,509	410,924
3,346,755	0	4,529,190	4,209,952	633,186	376,994
3,346,755	0	4,529,190	4,209,952	591,763	345,867
3,346,755	0	4,529,190	253,352	33,282	19,095
3,346,755	0	4,529,190	4,209,952	516,868	291,109
3,346,755	0	4,529,190	4,209,952	483,055	267,073
3,346,755	0	4,529,190	4,209,952	451,453	245,020
3,346,755	0	4,529,190	4,209,952	421,918	224,790
3,346,755	0	4,529,190	4,209,952	394,316	206,229
3,346,755	0	4,529,190	4,209,952	368,520	189,201
3,346,755	0	4,529,190	4,209,952	344,411	173,579
3,346,755	0	4,529,190	4,209,952	321,880	159,246
3,346,755	0	4,529,190	4,209,952	300,822	146,098
3,346,755	0	4,529,190	253,352	16,919	8,066
3,346,755	0	4,529,190	4,209,952	262,750	122,968
133,870,200	0	181,167,600	116,840,880	15,118,060	5,808,854
			B/C RATIO	1.45104	1.1763558

f Alter. ime Saved	No. 6 Acc. Red.	Total	Benefits-Costs	NPV 7%	NPV 9%
(6)	(7)	(8)	(9)	(10)	(11)
0	0	0	0	0	0
0	0	0	(44,304,000)	(41,405,606)	(40,645,872)
0	0	1,182,435	764,245	667,521	643,250
0	0	1,182,435	764,245	623,852	590,137
0	0	1,182,435	764,245	583,039	541,410
0	0	1,182,435	764,245	544,896	496,707
0	0	1,182,435	764,245	509,249	455,694
0	0	1,182,435	764,245	475,933	418,068
0	0	1,182,435	764,245	444,798	383,549
0	0	1,182,435	764,245	415,699	351,880
0	0	1,182,435	(4,418,755)	(2,246,271)	(1,866,530)
0	0	1,182,435	764,245	363,087	296,170
0	0	1,182,435	764,245	339,334	271,716
0	0	1,182,435	764,245	317,135	249,280
0	0	1,182,435	764,245	296,387	228,698
0	0	1,182,435	764,245	276,998	209,814
0	0	1,182,435	764,245	258,876	192,490
0	0	1,182,435	764,245	241,940	176,597
0	0	1,182,435	764,245	226,113	162,015
0	0	1,182,435	764,245	211,320	148,638
0	0	1,182,435	(4,418,755)	(1,141,890)	(788,442)
0	0	1,182,435	764,245	184,575	125,105
0	0	1,182,435	764,245	172,500	114,776
0	0	1,182,435	764,245	161,215	105,299
0	0	1,182,435	764,245	150,668	96,602
0	0	1,182,435	764,245	140,812	88,628
0	0	1,182,435	764,245	131,600	81,310
0	0	1,182,435	764,245	122,990	74,596
0	0	1,182,435	764,245	114,944	68,437
0	0	1,182,435	764,245	107,424	62,786
0	0	1,182,435	(4,418,755)	(580,479)	(333,046)
0	0	1,182,435	764,245	93,829	52,846
0	0	1,182,435	764,245	87,690	48,482
0	0	1,182,435	764,245	81,954	44,479
0	0	1,182,435	764,245	76,592	40,807
0	0	1,182,435	764,245	71,581	37,437
0	0	1,182,435	764,245	66,899	34,346
0	0	1,182,435	764,245	62,522	31,510
0	0	1,182,435	764,245	58,432	28,908
0	0	1,182,435	764,245	54,609	26,522
0	0	1,182,435	(4,418,755)	(295,086)	(140,683)
0	0	1,182,435	764,245	47,698	22,323
0	0	47,297,400	(34,466,200)	(36,884,622)	(36,773,260)
			B/C_RATIO	0.1923547	0.1599402

of Alter. Time Saved (6)	No. 7 Acc. Red. (7)	Total (8)	Benefits-Costs (9)	NPV 7% (10)	NPV 9% (11)
0	0	0	(3,110,000)	(3,110,000)	(3,110,000)
0	0	0	(40,048,800)	(37,428,783)	(36,742,019)
3,419,776	71,221	4,673,432	4,330,914	3,782,788	3,645,244
3,419,776	71,221	4,673,432	4,330,914	3,535,316	3,344,260
3,419,776	71,221	4,673,432	4,330,914	3,304,034	3,068,129
3,419,776	71,221	4,673,432	4,330,914	3,087,882	2,814,797
3,419,776	71,221	4,673,432	4,330,914	2,885,871	2,582,382
3,419,776	71,221	4,673,432	4,330,914	2,697,075	2,369,159
3,419,776	71,221	4,673,432	4,330,914	2,520,631	2,173,540
3,419,776	71,221	4,673,432	4,330,914	2,355,730	1,994,073
3,419,776	71,221	4,673,432	(813,686)	(413,637)	(343,710)
3,419,776	71,221	4,673,432	4,330,914	2,057,586	1,678,372
3,419,776	71,221	4,673,432	4,330,914	1,922,978	1,539,790
3,419,776	71,221	4,673,432	4,330,914	1,797,176	1,412,652
3,419,776	71,221	4,673,432	4,330,914	1,679,603	1,296,011
3,419,776	71,221	4,673,432	4,330,914	1,569,722	1,189,000
3,419,776	71,221	4,673,432	4,330,914	1,467,030	1,090,826
3,419,776	71,221	4,673,432	4,330,914	1,371,057	1,000,758
3,419,776	71,221	4,673,432	4,330,914	1,281,361	918,126
3,419,776	71,221	4,673,432	4,330,914	1,197,534	842,318
3,419,776	71,221	4,673,432	(813,686)	(210,272)	(145,187)
3,419,776	71,221	4,673,432	4,330,914	1,045,972	708,962
3,419,776	71,221	4,673,432	4,330,914	977,544	650,424
3,419,776	71,221	4,673,432	4,330,914	913,593	596,719
3,419,776	71,221	4,673,432	4,330,914	853,825	547,436
3,419,776	71,221	4,673,432	4,330,914	797,967	502,247
3,419,776	71,221	4,673,432	4,330,914	745,764	460,777
3,419,776	71,221	4,673,432	4,330,914	696,976	422,731
3,419,776	71,221	4,673,432	4,330,914	651,379	387,826
3,419,776	71,221	4,673,432	4,330,914	608,765	355,804
3,419,776	71,221	4,673,432	(813,686)	(106,892)	(61,328)
3,419,776	71,221	4,673,432	4,330,914	531,719	299,473
3,419,776	71,221	4,673,432	4,330,914	496,934	274,746
3,419,776	71,221	4,673,432	4,330,914	464,424	252,060
3,419,776	71,221	4,673,432	4,330,914	434,041	231,248
3,419,776	71,221	4,673,432	4,330,914	405,646	212,156
3,419,776	71,221	4,673,432	4,330,914	379,109	194,637
3,419,776	71,221	4,673,432	4,330,914	354,307	178,566
3,419,776	71,221	4,673,432	4,330,914	331,128	163,822
3,419,776	71,221	4,673,432	4,330,914	309,465	150,296
3,419,776	71,221	4,673,432	(813,686)	(54,338)	(25,906)
3,419,776	71,221	4,673,432	4,330,914	270,299	126,501
6,791,040	2,848,840	186,937,280	109,499,360	8,458,311	(752,279)
			B/C RATIO	1.2046831	0.9813921

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