FINAL
HIAWATHA CORRIDOR LRT
BENEFIT-COST ANALYSIS

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FINAL HIAWATHA CORRIDOR LRT BENEFIT-COST ANALYSIS

This analysis of the Hiawatha Corridor Light Rail Transit project was prepared in response to the requirements of Minnesota Laws 1999, Chapter 250, Article 1, Section 65. The Federal Transit Administration does not require BCA to evaluate transit applications. Rather the Federal Transit Administration uses cost effectiveness measures to rate applications and award funding.

This benefit-cost analysis follows the guidelines issued by the Minnesota Department of Administration (Appendix 2) and the analysis is presented following the order used in these guidelines.

I. Project Description

The Hiawatha Corridor Light Rail Transit project consists of an 11.5 mile, 15 station light rail transit line in the Hiawatha Avenue/Trunk Highway 55 Corridor that links downtown Minneapolis, the Minneapolis-St. Paul International Airport and the Mall of America. The Hiawatha Corridor Light Rail Transit project is the transit component of the Trunk Highway 55 Corridor reconstruction project. Full details of the project are available in the documents submitted to the Federal Transit Administration (FTA) in September, 1999.

Goals and Objectives

The Hiawatha Corridor Light Rail Transit project presents an opportunity to provide a diversified, multi-modal, and balanced transportation system in the Hiawatha Corridor, and provides regional benefits as the first phase of a regional multi-modal transportation system.

The goals of Hiawatha Corridor Light Rail Transit project are to:

- Introduce diversified transportation services of high quality that create a balanced overall transportation system;
- Develop land use and transportation interactively;
- Produce a system that is cost-effective and is regarded as a good investment;
- Provide a clear and leading vision of a regional transportation system;
- Sustain and improve existing environmental assets; and
- Provide training and technology transfer to the Minnesota Department of Transportation, Metro Transit, and other area agencies to enhance the skill set for the design, construction, start-up, and operation of future light rail transit projects.

Funding Sources

The Hiawatha Corridor Light Rail Transit project is expected to cost $548.6 million in year-of-expenditure dollars. The Metropolitan Council and the Minnesota Department of Transportation have requested FTA Section 5309 Discretionary New Starts funding at no less than 50% share. The rest of the project funding will come from the State of Minnesota, the Hennepin County Regional Railroad Authority (HCRRA), and the Metropolitan Airports Commission (MAC). A description of full societal costs associated with the project is included in Section II.

Hiawatha LRT Capital Funding

Source	Amount (millions of dollars)
FTA	$274.3
State of Minnesota In-kind	17.3
State of Minnesota Cash	100.0
HCRRA In-kind	17.0
HCRRA Cash	70.0
Metropolitan Airports Commission	70.0
Total	$548.6

Relevant History or Need

The Hiawatha Corridor Light Rail Transit project has been the subject of numerous studies. The Trunk Highway 55 (Hiawatha Avenue) Final Environmental Impact Statement and Record of Decision prepared in 1985 identified reconstruction of the corridor with LRT as the preferred alternative. The conclusion of the studies is that the Hiawatha Corridor Light Rail Transit project is the most cost effective alternative to provide a balanced, multi-modal, integrated, and diversified transportation system in the Hiawatha Corridor.

The following state and local stakeholders have been involved in the development of the Hiawatha Corridor Light Rail Transit project:

- Metropolitan Council
- Metro Transit
- Minnesota Department of Transportation
- Hennepin County
- Hennepin County Regional Railroad Authority
- Metropolitan Airports Commission
- City of Minneapolis
- City of Bloomington
- Dakota County
- Dakota County Regional Railroad Authority
- University of Minnesota
- Minnesota Attorney General
- Minnesota Department of Administration

The federal stakeholders include:

- Federal Transit Administration
- Federal Highway Administration
- Federal Aviation Administration
- Federal property owners (General Services Administration, US Army, US Naval Reserve)

After a series of studies the aforementioned stakeholders have determined that the Hiawatha Corridor Light Rail Transit project is the most cost-effective means of achieving the goals and objectives outlined above.

Current status

The Hiawatha Corridor Light Rail Transit project is being developed at this time because of the availability of FTA Section 5309 Discretionary New Starts funds. A New Starts submission was made to FTA in September, 1999. Work is continuing on preliminary design and solicitation of a design-build contractor is anticipated during 2000.

II. Benefit-cost analysis

Assumptions: This benefit-cost analysis compares the base case of the metro surface transportation network (roadway and existing bus) without LRT to the "build" alternative of the metro surface transportation network (modified bus) with LRT. The Hiawatha LRT Corridor project submittal to FTA was used for all forecasts of ridership, capital and operating costs, and for changes in travel time and environmental emissions in the region. As noted in the New Starts criteria materials, these analyses were prepared using FTA's Technical Guidance on Section 5309 New Starts Criteria.

The base case used in this analysis is that used for the "No Build" alternative in the New Starts criteria materials. This base case assumes:

- identical highway and transit networks outside the corridor for the No Build and Build alternative
- ridership forecasts for the No Build and Build alternatives are based on the same set of growth forecasts and land use assumptions
- population and employment growth are allocated on the basis of locally adopted land use plans, and
- a consistent policy setting, i.e., the model assumptions, parameters, and inputs are the same for the No Build and Build alternatives except for changes in the transportation network or other data that are directly attributable to each alternative.

A full listing of the assumptions used in the analysis is presented as Table 1 of the attached tables. The specific values used and the sources for the major assumptions are included in the

table. Detailed explanations of how specific values were used are included in the following sections.

Definition of LRT alternative

The base case for this benefit-cost analysis is the "No Build" alternative used in the New Starts criteria materials. This alternative assumes completion of the highway improvements that are currently underway along Hiawatha Avenue and construction of the interchange planned for Trunk Highway 55/Trunk Highway 62.

The ridership forecast for the LRT line shows that the average weekday trips will be 18,265 in the opening year and rise to 24,558 in the forecast year (New Starts materials, page 3). Assuming 2003 as the opening year and 2020 as the forecast year, the compounded annual growth rate in ridership is 1.8 percent.

The LRT line is planned to open in phases and this phasing is used in the analysis. The first phase, from downtown Minneapolis to Fort Snelling, is planned to open in mid 2003. The full line to the Mall of America is planned to open by the end of 2004. For the benefit-cost analysis, ridership is assumed as follows:

- six months for 2003 and full year for 2004 from downtown Minneapolis to Fort Snelling, and
- full year of full line from 2005 on.

For years 2005 to 2020, ridership was increased by the 1.757 percent growth rate to reach 7,711,212 (forecast year average weekday ridership times 314 days per year). Beyond 2020, ridership was forecast to grow at half the previous growth rate (communication with Metro Transit). The ridership forecasts by year are used throughout the benefit-cost analysis to pro-rate benefits or other uses of the system that are forecast for 2020 but not for each individual year.

Timeframe of analysis

The study period was from 1999 (the base year) to 2028, which allows for the full 25-year life of the LRT railcars after the system's opening in 2003/2004. The base year for the analysis was assumed to be 1999. All costs and benefits were estimated in 1999 dollars. All costs and benefits were valued in the year they take place and discounted back to 1999 using the discount rate. The discount rate used was 3.3 percent in real terms and based on the guidelines from Department of Administration.

For cost estimates in the FTA submission materials, a 3 percent inflation rate was used to convert the costs to 1999 dollars, since 3 percent was assumed in the submission. For standard values, such as costs per crash, values in 1997 or other years before 1999 were converted into 1999 dollars using the GDP implicit price deflator, an index typically used for such purposes. In cases where expenditures were to take place in future years and the current (1999) cost was known, the 1999 dollar value was used.

The time horizon for the analysis extended to 2028. This terminal year was used since the LRT railcars have a 25-year life and the system begins operation in 2003/2004. For assets with lives

beyond 2028, a remaining capital value (also known as salvage value) was estimated. For further details, see the remaining capital value section on page 8.

Benefits and costs

The primary benefits of the Hiawatha Corridor LRT project evaluated in this analysis are the value of:

- travel time savings to riders of LRT and auto travelers in the region;
- any reductions in the likelihood of crashes, for people who formerly used bus and now use LRT, and for people who formerly used autos but now use LRT;
- avoided auto operating costs for people who used auto but now use LRT; and
- any reductions in emissions of environmental pollutants.

Travel time (Table 2). Travel time savings from the LRT project were modeled for the FTA Submission. This model reflects the reduced amount of time travelers spend on LRT and auto combined. The reduction in regional travel time for the LRT project versus the "no-build" case was used as the travel time saving for 2020. This saving was prorated for earlier years using the ridership forecast for each year. The travel time saving was valued using a standard value from U.S. DOT,[1] updated to 1999 dollars, of $9.12 per hour.

Crashes (Tables 3 and 4). Forecasting the future number of crashes is a difficult task, given that crashes are caused by vehicle malfunctions, driver error, infrastructure characteristics and multiple interactions of these factors. In the case of LRT, there is no existing experience in the Twin Cities to examine. In order to provide an estimate of the likely economic cost of crashes with the LRT system, the following approach was used:

- for bus riders forecast to use LRT (see Table 3), estimate reduction in **bus** crash rate per passenger mile (from Table 3A) times **bus** passenger miles avoided and add **LRT crash rate per passenger mile** (from Table 3A) times passenger miles traveled on LRT.
- for auto travelers forecast to use LRT (see Table 4), estimate reduction in **auto** crash rate per vehicle mile (from Table 4A) times **auto vehicle miles (vmt)** avoided and add **LRT crash rate per passenger mile** (from Table 3A) times passenger miles traveled on LRT.

For large bus and LRT crash rates, national data from FTA were used to estimate rates per million passenger miles traveled (see Table 3A for details). For auto crash rates, data for 1996–1998 on Trunk Highway 55 (using the improved segment to represent the improved highway) was used to develop auto crash rates (see Table 4A for details). Since no fatal crashes occurred in these three years on that roadway, a fatal crash rate for similar roadways (four-lane urban expressways) of 0.65 fatal crashes per hundred million vmt was added to the recorded crash history, since the occurrence of crashes involving fatalities is so rare that data for a 3-year period on a single stretch of roadway may not provide an accurate measure of the long-term likelihood of fatal crashes.

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[1] U.S. DOT Memorandum of April 9, 1997, on Departmental Guidance for Valuation of Travel Time in Economic Analysis.

Mn/DOT has adopted standard crash costs for different kinds of crashes, such as fatal or property-damage-only crashes.[2] These values were converted to 1999 dollars and used to estimate the fatal and injury crash costs for bus, LRT and auto travel. In the case of property-damage-only crashes, national FTA data were used for large bus and LRT, and Mn/DOT crash costs were used for auto. (The property-damage-only crash costs used were FTA's average for bus collisions, $1,393, and for LRT collisions, $8,016, and Mn/DOT's cost of $4,116 for autos, all estimated in 1999 dollars.)

Using the various crash rates and costs of crashes, measures of economic cost per million passenger miles or per million vmt for autos were developed. These measures were combined with the travel estimates to value the change in crash costs likely with the LRT system. Tables 3 and 4 develop these estimates.

Auto operating costs (Table 4): People who formerly used autos and are forecast to use LRT will avoid automobile operating costs. An estimate of how much this saving would be was made based on the number of LRT trips taken by people who formerly used autos. The number of trips was adjusted for an estimate of average vehicle occupancy of 1.24[3] (thus 200 LRT trips from auto represent 200/1.24 avoided auto trips or 161). The avoided auto trips were assumed to represent a distance of 8.1 miles per trip, the average length forecast for LRT riders on the new system. The avoided auto vmt were valued at 26.2¢ (25.9¢ in 1997 dollars) per mile, a national average.[4]

Emissions (Table 5): The modeling reported in the New Starts analysis forecast regional changes in emissions of CO, NOx, VOC, PM_{10} and CO_2. These reductions in environmental emissions benefit the entire region. The physical reductions in emissions versus the base case were valued using standard economic values from a Federal Highway Administration (FHWA) model, STEAM.[5]

Capital costs (Table 6): The LRT project requires a mix of public and private capital investment to implement, and on-going operations and maintenance costs will be incurred. Five major cost items were estimated for this analysis: the LRT system itself, accommodating investments along the Trunk Highway 55 corridor, costs of relocating utilities, and possible supplementary parking

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[2] Mn/DOT Memorandum of February 9, 1999, on Revised Crash Costs, from State Traffic Engineer, Office of Traffic Engineering.

[3] Auto occupancy for the *1990 Twin Cities Travel Behavior Inventory* was 1.08 for work trips and 1.348 for all other trips. The LRT submission to FTA forecast that work trips would be 39 percent of the total LRT trips and non-work trips 61 percent. Thus an estimate of the auto occupancy rate of former-auto riders on LRT is 1.24.

[4] Derived from American Automobile Association, *Your Driving Costs*, 1997 Edition. Auto operating costs for 15,000 miles per year are 10.8¢. In addition, variable depreciation per mile was estimated at 15.1¢. Thus this study uses 25.9¢ per mile as an estimate of variable operating costs per mile. (The AAA study is used by the U.S. Department of Transportation's Bureau of Transportation Statistics for its estimates of owning and operating an automobile. See http://www.bts.gov/programs/btsprod/nts/chp2/tbl2x18.html.)

[5] Federal Highway Administration model, Surface Transportation Efficiency Analysis Model (STEAM), see http://www.ota.fhwa.dot.gov/steam/. The specific values used were (in dollars per ton): $3,884 for CO, $3,731 for NOx, $1,774 for VOC, $11,066 for PM_{10} and $3.56 for CO_2.

at Fort Snelling. These costs represent the real use of economic resources to bring the project about and may involve a number of public and private entities.

- **LRT project costs.** These costs were taken from Hiawatha Corridor Light Rail Transit Financial Report (August 23, 1999). Since these costs are reported in nominal dollars in each year incurred, there were converted to 1999 dollars using the 3 percent inflation rate assumed in that analysis. The total nominal cost of the LRT project is $548.6 million. Although the state's share of the project will be financed by bonds that are repaid over a series of years, the present value of the interest payments and principal repayment, using a discount rate equal to the interest rate, is equivalent to using the full investment cost as it is incurred. [6] Thus no separate financial costs need to be included.
- **Accommodating investments along Trunk Highway 55.** A number of modifications to the Trunk Highway 55 Corridor roadway project will be made along Trunk Highway 55 to facilitate the LRT system. These costs total $42.96 million and are assumed in this analysis to be in 1999 dollars and to take place in 2001.
- **Relocation of utilities.** Costs will be incurred along the LRT corridor to relocate private and public utilities. The rough, preliminary estimate of the cost of these relocations for the purposes of this analysis is $100 million. Significant downward and upward variance from that estimate exists. Moreover, a portion of this cost will produce benefits to the utility companies since newer and more productive equipment will be used. This additional benefit is not quantified in this analysis but in the sensitivity analysis the total relocation cost is reduced to $50 million to represent both the fact that the costs may be lower and that they will produce their own accompanying benefits to the utility operators.
- **Supplementary parking at Fort Snelling.** At present there are approximately 1,100 parking spaces at the General Services Administration (GSA) location near Fort Snelling. The GSA currently uses a fraction of these spaces for its own needs. As part of the LRT project, a portion of the existing parking spaces will be used for construction of the station and related activities. The LRT project will involve constructing one parking deck and the number of spaces will be maintained at approximately 1,100 for use by both the GSA and LRT park and riders. A Congestion Mitigation and Air Quality (CMAQ) application has been made for $5.5 million in Federal funds (for a total of $6.875 million project cost) for 2001. If this application is successful, these funds will be directed toward adding an additional deck or decks to the parking ramp at Fort Snelling. The LRT project budget does not include these potential CMAQ funds so they are added to this benefit-cost analysis as a separate item.

Remaining Capital Value (Table 7): Assets with long lives retain value if the analysis period is shorter than their estimated useful life. In this study, the analysis period ends in 2028, when the LRT railcars are expected to reach the end of their useful life.

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[6] For example, if $10 million of bonds are issued to finance a $10 million investment, the present value of the investment ($10 million) is the same as the present value (using discount rate of 3.3 percent real) of 10 years of paying $0.33 million interest (at 3.3 percent real interest rate) and a final payment of $0.33 million plus $10 million principal repayment).

An estimate of the remaining capital value of the assets put in place for the LRT project was made by using the approach (sinking fund depreciation) recommended by MicroBencost, a PC-based transportation benefit-cost software package developed through the National Cooperative Highway Research Program.[7]

Table 7 shows the estimates of useful life of each type of asset, for both the LRT project elements, the utility relocations (50 year life assumed) and the highway investments associated with the LRT project. Remaining capital values are calculated using the approach in MicroBencost (e.g., what proportion of the value of an asset costing $1m and put in place in 2005 will remain in 2028 if it has a service life of 30 years?) and discounted back to 1999.

The resulting remaining capital values are shown as benefits in the summary results since they represent the present value in 1999 of what will remain in place in 2028 at the end the study period.

LRT operating costs (Table 8). The operating costs of the Hiawatha LRT system were estimated for the FTA submittal. In 1999 dollars, the annual operating costs are $11.384 million, which reflects both the costs of the LRT and some avoided costs of operating the bus system after LRT begins operation. Fares will produce revenue that can be used to cover part of these annual operating costs but, as the Guidelines in Appendix 2 require, these farebox revenues are not subtracted from the operating cost estimate since they represent a transfer.

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[7] McFarland, William F., Jeffery L. Memmott, and Margaret L. Chui. 1993. *Microcomputer Evaluation of Highway User Benefit*, Final Report for NCHRP 7–12. College Station, TX: Texas Transportation Institute, Texas A&M University, pp. A-35 to A-41.

Comparison

All of the benefits and costs of the LRT project were estimated in 1999 dollars. In order to calculate a net present value of benefits and costs for the project from the perspective of 1999, all of these real benefits and costs were discounted back to 1999 from the year they occur using a real discount rate of 3.3 percent. This discount rate was calculated using the State of Minnesota's current earning rate of 5.3 percent (from Department of Finance), less an estimate of long-term inflation of 2.0 percent (from the DRI trend long forecast).

The present value of benefits are shown in the following table for the base case assumptions.

Benefits of LRT project, present value, millions of 1999 dollars, 3.3% real discount rate	
Travel time savings for LRT and autos in region (Table 2)	$123.0
Reduced crash risk for bus to LRT and auto to LRT (Tables 3 & 4)	26.3
Avoided auto operating costs (Table 4)	66.3
Value of reduction in environmental emissions in region (Table 5)	25.5
Remaining capital value of investments at end of study period (Table 7)	77.1
Total Benefits	$318.1

Note: total does not add due to rounding

The present value of the costs of the project for the base case assumptions include the initial capital costs of the LRT project, accommodating expenditures along the Trunk Highway 55 corridor, and associated utility relocation costs.

Costs of LRT project, present value, millions of 1999 dollars	
Capital costs of LRT project (Table 6)	$460.6
Preliminary estimates for relocation of utilities (Table 6)	90.7
Accommodating investments along Trunk Highway 55 corridor (Table	40.3
Supplementary parking at Fort Snelling (Table 6)	6.4
LRT system operating costs (Table 8)	167.4
Total Costs	$765.4

Benefit-cost ratio: based on the estimates of the present values of the benefits and costs for the base case assumptions, the benefit-cost ratio for the LRT project is 0.42.

Supplementary analysis

A supplementary analysis was conducted to assess three areas where LRT offers the potential of changing behavior and thus producing economic gains beyond the conventional economic benefits of travel time savings, operating cost reductions, safety improvements, and reductions in environmental emissions.

For the supplementary analysis, estimates were made of each of these three areas and are less certain since the Twin Cities region has less experience of how changes such as LRT will actually affect residential location and auto ownership and use.

- The first area is the potential for **avoided public infrastructure** if people choose to locate in more central areas rather than on the suburban fringe due to the presence of LRT. The estimate assumes that all new riders to transit (i.e., those not already carried on buses) choose to relocate. The one-time public infrastructure saving associated with this change in location decision is assumed to be of the magnitude estimated in the recent report by a number of environmental groups: *Two Roads Diverge: Analyzing Growth Scenarios for the Twin Cities Region.* [8] The *Two Roads Diverge* report presents estimates for local, intermediate and regional infrastructure costs for a "Sprawling Scenario (2.1 units/acre)" and for a "Smart Growth Scenario (5.5 units/acre)." For local infrastructure costs, Table 4 of the report estimates that the "Sprawling Scenario" costs $18,374 per unit and the "Smart Growth Scenario" $7,813, for a difference of $10,561 per unit. The report estimates that intermediate and regional roadway costs would be higher by $871 million over 25 years, which averages $2,639 for each of the 330,000 households projected to be added to the Twin Cities region. For the regional sewer system, the report uses a $50 million additional capital cost for the "Sprawling Scenario," or $152 per household. This benefit-cost analysis uses the sum of these estimates of potential one-time avoided local, intermediate and regional infrastructure costs of $13,352 per residential unit as a general estimate of the potential local infrastructure saving if LRT riders chose to locate in more central areas rather than on the urban fringe.
- The second and third areas are the potential for **avoided costs associated with auto ownership or use**. The estimate assumes those new to transit who do not park and ride could potentially choose to own one fewer auto, or, alternatively, could use their auto less and so lead to a reduction in the region's capital cost of providing parking in downtown Minneapolis, at the Mall of America or at the airport.
  - **Ownership**: Based on Mn/DOT survey research, 15 percent of new users who do not park and ride are assumed to reduce auto ownership[9] and avoid annual fixed costs of

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[8] *Two Roads Diverge: Analyzing Growth Scenarios for the Twin Cities Region.* Center for Energy and the Environment, Minnesotans for An Energy-Efficient Economy, 1000 Friends of Minnesota, June 1999, p 23. Full report available at http://www.me3.org/sprawl/

[9] 1999 Statewide Transportation Tracking Study, Minnesota Department of Transportation, Research Summary, June 1999. Question asked was: "If dependable public transportation were available to you to take to some of the places you want to go, how likely would you be to reduce the number of vehicles owned by your household?" This question was only asked if the household had two or more vehicles. Respondents indicating "Very Likely" were 8% and "Somewhat likely" were 14%. For this study, the "Somewhat likely" figure was divided by two and

ownership. The avoided fixed costs of auto ownership were derived from data published by AAA that is used by the U.S. DOT in developing its costs of vehicle ownership. [10]

- **Parking capital**: The remaining 85 percent of new users to LRT who do not park and ride are assumed to no longer require a parking spot and a one-time capital saving is calculated, using the $10,000 per parking space estimate used by Mn/DOT in LRT planning.

The assumptions used in this supplementary analysis are likely to produce avoided costs that are somewhat higher than might actually occur, since all the new riders to transit are assumed to either relocate residential location and, except for those who car pool, avoid an auto purchase or the need for parking. In reality, many new riders may not make behavior changes. The resulting estimates should thus be considered relatively high.

The following table shows the supplementary analysis' estimates of avoided costs.

Potential for avoided costs, supplementary analysis, present value, millions of 1999 dollars (from Table 9)	
Potential avoided public infrastructure saving from people choosing to locate in more central areas rather than on the urban fringe	$32.3
Potential for avoided need for construction of parking ramps	11.1
Potential for avoided auto ownership by those using LRT	18.0
Total potential for avoided costs	$61.4

The benefits and costs estimated earlier showed a benefit-cost ratio for the LRT system of 0.42. If it were assumed that all of the potential for avoided costs estimated in the supplementary analysis were also added to the benefits, an adjusted benefit-cost ratio which included the supplementary analysis would be 0.50.

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added to the "Very Likely" group to give an estimate of 15%.

[10] American Automobile Association, *Your Driving Costs*, 1997 Edition. The AAA study calculated the fixed Ownership Costs as $5,103 for a new auto driven 15,000 miles per year. For this benefit-cost study, we adjusted this cost to reflect 10,000 miles as the "fixed" portion of depreciation by subtracting 5,000 miles times 15.1¢ per mile (AAA's variable depreciation rate) to give $4,348 per year.

Sensitivity

A number of the estimates used in this analysis are forecasts that are subject to uncertainty. In this section, these estimates are varied to assess how sensitive the base case benefit-cost results are to changes in the assumptions used.

The LRT project has undergone significant planning and design, and the Hiawatha LRT Corridor project submittal was made in September, 1999 to FTA. This submittal included estimates used in this analysis of the LRT project cost, ridership forecasts, changes in environmental emissions, and average trip length. Since these estimates have been developed to a high level of detail, they are unlikely to change significantly and so are not included in this sensitivity analysis.

Similarly, the supplementary parking at Fort Snelling that is the subject of a CMAQ request is for a fixed dollar value, so this cost estimate is not likely to change significantly.

Finally, a number of the standard economic values and national data are either established values or calculated from comprehensive national statistics. Mn/DOT has adopted standard costs for crashes, such as costs per fatality, or cost per injury. These crash costs derive from extensive national research studies. Similarly, the national data on large bus and LRT crashes cover the entire nation, so the rates derived from these statistics should be fairly robust.

A number of important assumptions are more likely to change or important alternative values can be used. These assumptions include the real discount rate, the value of travel time avoided, the avoided cost of auto operating costs, and the cost of environmental emissions.

- Discount rate. The rate used in the base case analysis is 3.3%, a value derived using the Department of Administration's recommendation in its guidelines. An alternative discount rate would be 7% in real terms, the discount rate recommended by U.S. Office of Management and Budget for Federal infrastructure projects.[11] As a lower value, a real discount rate of 2% is also used.

- For the following values, sensitivity analyses were conducted with plus and minus 20% of their assumed values.

    - Value of travel time. The value used in the base case of $9.12 per hour is derived from recommendations by U.S. DOT.

    - Auto operating costs. The value used in the base case was $0.262 per mile.

- Environmental emissions. The values used in the base case were those from the FHWA model, STEAM. These were varied by a factor of 2 (doubling) and a factor of 10, to reflect the greater uncertainty in these values.

- The estimate of the cost of relocating utilities (both public and private) is highly uncertain.

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[11] U.S. Office of Management and Budget. Circular No. A-94 (Revised), "Benefit-Cost Analysis of Federal Program; Guidelines and Discounts." Washington, D.C.: Executive Office of the President, October 29, 1992.

The base case assumes $100 million but the current estimate is $100 million ±50%. Moreover, the base case does not include any benefits that will accompany the use of new equipment that is more modern and productive as the utilities are relocated. In order to reflect both the uncertainty on the cost side and the omission of any value for benefits, this sensitivity analysis uses a cost of $50 million, rather than $100 million, as the utility relocation cost estimate.

Although this sensitivity analysis does not explicitly vary the forecasts made in the submission to FTA, the values that are varied have alternative interpretations. Thus, the value of travel time is varied by ±20%. This change is equivalent to keeping the value of travel time constant and changing the forecast of travel time (in hours) saved by ±20%.

Sensitivity analysis, LRT benefit-cost study

Base case assumptions, benefit-cost ratio		0.42	
Discount rate, 2% or 7%	0.48		0.27
Value of travel time, ±20%	0.45		0.38
Avoid auto operating costs, ±20%	0.43		0.40
Costs of environmental emissions, +100%, +900%	0.45		0.72
Utility relocation, $50 million instead of $100 million		0.42	

The sensitivity analysis shows that the benefit-cost ratio changes by a relatively small amount under most of the varied assumptions, except for the cases of using a much higher discount rate of 7%, or using a cost of environmental emissions of ten times that in the base case.

III. Conclusions

This benefit-cost analysis of the Hiawatha Corridor Light Rail Transit project estimates that the present value of the societal benefits of this project are $318.1 million and the present value of the societal costs are $765.4 million. The benefit-cost ratio is 0.42.

A supplementary analysis was conducted to estimate in general terms additional effects that LRT has the potential to create: allowing people to choose to live in more central areas and hence lower regional public infrastructure costs, reduce the number of autos they own, or place lower demands on the regional need for parking structures. A range of assumptions were made about how much behavior could change with LRT and a set of avoided cost values were used from a study by environmental groups to develop an estimate of the order of magnitude of avoided costs that might result from LRT. This supplementary analysis estimated that LRT could have the potential to avoid economic costs of public infrastructure, auto ownership costs, and regional parking investment of $61.4 million. If these potential avoided costs are added to the benefits estimated in the base case benefit-cost analysis, the benefit-cost ratio would be 0.50, an increase from 0.42.

In interpreting any benefit-cost analysis, a number of considerations are important. First, benefit-cost analysis is designed to measure the effect of the investment on economic efficiency, alone. That is, does the investment increase the size of the economy, or as economists phrase it—add to

economic wealth. There are other important reasons why governments make public investments, such as improving economic equity, or achieving other social goals. The Hiawatha Light Rail Transit investment is intended to achieve several such goals including stimulating urban redevelopment and providing essential transportation services to low and moderate income travelers.

Second, the Hiawatha Light Rail Transit line is the first in the Twin Cities and there may well be economies of scale with a larger system. Greater economic benefits may occur as a full transit network is developed and some system-wide facilities such as storage yards can be more efficiently used.

Finally, benefit-cost analysis may not capture the full efficiency effects that may accrue from the development of light rail. Kenneth Small, one of the nation's leading transportation economists states, "Formal analysis will often miss significant benefits by failing to foresee the many ramifications of a change" (Essays in Transportation Economics and Policy, 1999). Estimates do not exist of the region-wide benefits of a denser land use pattern , in general, (beyond the decisions of LRT riders) that might occur as a result of developing a light rail system. Nor do estimates exist for the possible agglomeration benefits of reducing the need for parking structures in downtown Minneapolis and allowing more high-value businesses such as those in the finance industry to locate there.

Small concludes, "Thus, project evaluation is typically embedded in a larger decision-making process...[p]roject evaluation and pricing should be viewed as parts of a single integrated planning procedure."(p. 138)

Appendix 1. Legislation

Minnesota Laws 1999, Chapter 250, Article 1, Section 65, to be codified as Minnesota Statutes 16C.065: Cost-Benefit Analysis.

(a) The commissioner or an agency official to whom the commissioner has delegated duties under section 16C.03, subdivision 16, may not approve a contract or purchase of goods or services in an amount greater than $5,000,000 unless a cost-benefit analysis has been completed and shows a positive benefit to the public. The management analysis division must perform or direct the performance of the analysis. A cost-benefit analysis must be performed for a project if an aggregation of contracts or purchases for a project exceeds $5,000,000.

(b) All cost-benefit analysis documents under this section, including preliminary drafts and notes, are public data.

(c) If a cost-benefit analysis does not show a positive benefit to the public, the governor may approve a contract or purchase of goods or services if a cost-effectiveness study had been done that shows the proposed project is the most effective way to provide a necessary public good.

(d) This section applies to contracts for goods or services that are expected to have a useful life of more than three years. This section does not apply for purchase of goods or services for response to a natural disaster if an emergency has been declared by the governor.

Appendix 2. Guidelines from Department of Administration

September, 1999. Management Analysis Division

COST-BENEFIT ANALYSIS GUIDELINES

Cost–Benefit Analysis (CBA) is the comparison of a potential project's costs to its benefits. The analysis produces information for determining if a project's benefits exceed its costs. The cost and benefit calculations are influenced by the data's accuracy, validity of assumptions, and estimation methodology.

This guideline is intended to provide direction to agencies that must conduct a cost–benefit analysis required by Minnesota Statutes 16.065. The guideline does not mandate how an agency should conduct the CBA or the format for presenting the results. The guideline lists the major components that the CBA should contain; it is not a CBA instructional tool. The guideline emphasizes the explanation and justification of the data's accuracy, validity of assumptions, and estimation methodology.

Project description. Describe the project requiring the CBA. This description should include the project's goals and objectives, funding sources, relevant history or need, and current state of the situation that the project will influence or change. Describe the distinct alternatives that the CBA examined for accomplishing the goals and objectives.

Benefits and costs. Define the major[12] economic, social, and environmental benefits and costs that each alternative creates. These benefits and costs should be the incremental ones resulting from the project, over the current situation. Identify the distinct groups that receive the benefits and bear the costs and each group's relevant characteristics and size. Explain how the alternative creates each of its benefits and costs.

If possible, estimate each benefit and cost's monetary value for each year that the project produces them. Show how the monetary value was calculated. State the major assumptions and substantiate their validity. Identify the data sources used for the estimates. For benefits and costs that accrue in future years, state whether the monetary values are in constant or current dollars. If a benefit or cost's monetary value cannot be estimated, describe it and its probable realization and potential size in non-monetary terms.

The benefits and costs should represent ones actually resulting from the project and not represent transfers between parties or different geographical areas within the state. The individual benefit and cost variables should be mutually exclusive: do not count separately one type of benefit and also include it as part of another type of benefit or as a negative cost.

The costs should include both capital and ongoing costs. If capital costs are funded through borrowing, the interest costs should be included in the ongoing costs.

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[12] The agency may determine which costs and benefits are the "major" ones; at a minimum, costs that represent 10 percent or more of the total costs and benefits should typically be included.

Time period. Specify the span of years in which the benefits and costs occur. Explain why this time period is the most appropriate one. Future benefit and cost estimates should reflect potential real changes in workload, inputs, or benefits. If the project has capital assets that have a useful life exceeding the CBA's time period, calculate the assets' residual values and include them as a benefit or negative cost.

Comparison. Compare the costs to benefits using one or more of the following methods: net present value, costs-to-benefit ratio, or internal rate of return. If you use the net present value or costs-to-benefit ratio methods, discount the project's future benefits and costs using the interest rate that the state receives on its General Fund investments or pays for general obligation borrowing. If necessary, you may use a different interest rate, but explain why it is more appropriate than the state's interest rate. If the future costs and benefits are measured in constant dollars, use the real rate of interest (one that does not factor in inflation).

Sensitivity analysis. The cost and benefit calculations are estimates and may differ from the actual costs and benefits realized from the project. The CBA should analyze the final results' sensitivity to changes in the major cost and benefit variables' estimates. For example, the sensitivity analysis could show how the net present value changes if one major benefit is 10 percent higher or lower. The sensitivity analysis can vary the major benefits and costs one at a time or in combinations.

COST-EFFECTIVENESS STUDY GUIDELINES

A cost-effectiveness study assumes that the benefits achieved from alternative projects are the same, and do not need quantification. The study focuses instead on determining each alternative's costs to identify which one is least costly. The guidelines listed above should be used when estimating the costs. The study should explain how each alternative provides the same level of benefits or achieves the same result.

Summary of results, present values, 1999 dollars

	Present Value, 1999 dollars	Share	Detail
Benefits			
Travel time savings	122,998,643	39%	Table 2
Crash risk			
Bus to LRT	23,735,786	7%	Table 3
Auto to LRT	2,540,715	1%	Table 4
Avoided auto operating costs	66,256,139	21%	Table 4
Environmental	25,472,565	8%	Table 5
Remaining capital value			
LRT system	40,853,224	13%	Table 7
Utility relocation	26,295,801	8%	Table 7
Accommodating highway investments along TH55	8,921,629	3%	Table 7
Supplementary parking at Fort Snelling	1,033,632	0%	Table 7
Present value of Total Benefits	318,108,133	100%	
Costs			
LRT Capital*	460,608,547	60%	Table 6
Utility relocation	90,719,163	12%	Table 6
Accommodating highway investments along TH55	40,261,466	5%	Table 6
Supplementary parking at Fort Snelling	6,442,762	1%	Table 6
LRT system operating costs	167,391,041	22%	Table 8
Present value of Total Societal Costs	765,422,980		
Net Present Value	(447,314,847)		
Benefit-cost ratio	0.42		

*Value of LRT Capital Costs in dollars-of-the-day is $548.6 million.

Supplementary analysis

Potential infrastructure saving	32,278,235	Table 9
Potential for avoided parking capital	11,096,248	Table 9
Potential for avoided auto ownership	18,015,468	Table 9
Total Benefits including supplementary analysis		
with infrastructure	350,386,367	
with infrastructure and parking	361,482,615	
with infrastructure, parking and auto ownership	379,498,083	
Benefit-cost ratio:		
with infrastructure	0.46	
with infrastructure and parking	0.47	
with infrastructure, parking and auto ownership	0.50	

Table 1. Assumptions

Assumptions	Value used		Source
Discount rate			
Discount rate, real (percent)	3.3%		Minnesota Dept of Finance; DRI inflation estimate for 2000 to 2020.
Submission to FTA			New Starts Criteria materials (NS) submitted to FTA, September 1999.
Inflation assumed in cost estimates	3.0%		Used to convert future costs to 1999 real dollars.
Days per year	314		Used to convert daily estimates to yearly equivalents.
Opening Year Ridership	18,265		Project Description, p 3
Ridership growth (year to year growth factor)	1.018		Compound growth based on initial year to design year ridership, 2003 to 2020, 17 years
Daily travel time savings (hours)	3,232		Submission to FTA, September 1999.
Share of ridership in 2003, due to portion of year	50%		Line expected to open in July 2003 for six months.
Share of ridership in 2003-4, as not all stations open	59%		Line open from Downtown to Fort Snelling only, representing 59% of forecast ridership.
LRT average trip length (miles)	8.1		Average length of transit trip, from ridership estimate (from Metropolitan Council).
Annual operating costs (1999 dollars, thousands)	11,384		Baseline with Hiawatha LRT in 2004 is $13.197 million, deflated at inflation rate.
2020 emission savings (tons per year)	Tons	Cost per ton	
CO (from Submission to FTA, September 1999.)	395	$3,884	FHWA Steam model
NOx (from Submission to FTA, September 1999.)	68	$3,731	FHWA Steam model
VOC (from Submission to FTA, September 1999.)	41	$1,774	FHWA Steam model
CO2 (from Submission to FTA, September 1999.)	9378	$3.56	FHWA Steam model
PM10 (from Submission to FTA, September 1999.)	2	$11,066	FHWA Steam model
Hence value of reduction in 2020 is	$1,916,140	(tons times cost per ton)	Value used in Table 5 as emissions savings in 2020.
Capital costs			
LRT project (dollars of the day, millions)	548.6		See Table 6 for detailed breakdown.
Utility relocation (1999 dollars, millions)	100.0		Estimate of US West and NSP and other utility relocations
Supplementary parking at Fort Snelling (1999 $m)	6.875		At Fort Snelling ($6.875m CMAQ application)
Economic values for benefits and costs			
Time value (dollars per hour)	9.12		U.S. DOT Guidance, $8.70 in 1995 updated to 1999$
Auto variable operating costs (dollars per mile).	0.262		Derived from AAA, Your Driving Costs, 1997 edition.
Auto Occupancy (people per auto)	1.24		1990 Twin Cities vehicle occupancy by type, weighted for LRT forecast trip purposes.
TH55 Improved Crash Rate (per million vmt)	2.735		From Table 3B. Based on 1996-1998 experience on TH55 from 32nd to 46th St (new design), OIM analysis, September 1999.
Mn/DOT crash values, 1999 dollars	**Per crash**		
Fatal	$3,498,402		Mn/DOT 1997 values, updated to 1999 by GDP price deflator for 1997 and 1998.
Weighted average of all injuries	$41,226		Mn/DOT, Office of Traffic Engineering
Injury Type A only	$267,525		Mn/DOT, Office of Traffic Engineering
Injury Type B only	$57,621		Mn/DOT, Office of Traffic Engineering
Injury Type C only	$27,781		Mn/DOT, Office of Traffic Engineering
Property damage only	$4,116		Mn/DOT, Office of Traffic Engineering
Supplementary analysis			
1. Potential for avoided infrastructure costs			"Two Roads Diverge" report
"Sprawling" scenario	$18,374		Per housing unit, one-time local infrastructure costs.
less "Smart Growth" scenario	$7,813		Per housing unit, one-time local infrastructure costs.
plus additional intermediate and regional roadways	$2,639		
plus additional regional sewer capital costs	$152		
Equals potential avoided infrastructure costs	$13,352		Per housing unit, one-time infrastructure costs.
2. Potential for avoided auto ownership			
Proportion of avoided auto trips who do NOT use park and ride	54%		Based on numbers of new riders to transit, and Fort Snelling P&R.
Likelihood of reducing auto ownership	15%		Mn/DOT Market Research Survey, 1999.
Annual fixed costs of ownership	$4,474		Derived from AAA, Your Driving Costs, 1997 edition.
3. Potential for avoided parking capital spending			
Capital cost of parking space	$10,000		Estimate used in Hiawatha LRT planning phase.

Table 2: Valuation of travel time savings for LRT alternative

	1	2	3	4	5	6	7
	Annual Ridership	Daily time savings (hours)	Yearly time savings (hours)	Yearly time savings (dollars)	Discount factor	Present value time savings (dollars)	Total discounted present value time savings (dollars)
1999				-	1.00	-	122,998,643
2000				-	1.03	-	
2001				-	1.07	-	
2002				-	1.10	-	
2003	1,691,887		222,664	2,030,692	1.14	1,783,375	
2004	3,443,218		453,151	4,132,731	1.18	3,513,464	
2005	5,938,484		781,545	7,127,681	1.22	5,866,058	
2006	6,042,807		795,275	7,252,895	1.26	5,778,421	
2007	6,148,963		809,245	7,380,309	1.30	5,692,093	
2008	6,256,983		823,462	7,509,961	1.34	5,607,054	
2009	6,366,902		837,928	7,641,890	1.38	5,523,287	
2010	6,478,751		852,648	7,776,138	1.43	5,440,770	
2011	6,592,565		867,626	7,912,743	1.48	5,359,487	
2012	6,708,378		882,868	8,051,749	1.53	5,279,418	
2013	6,826,226		898,378	8,193,196	1.58	5,200,545	
2014	6,946,145		914,160	8,337,128	1.63	5,122,850	
2015	7,068,170		930,219	8,483,589	1.68	5,046,316	
2016	7,192,338		946,561	8,632,623	1.74	4,970,926	
2017	7,318,688		963,189	8,784,274	1.79	4,896,662	
2018	7,447,257		980,110	8,938,590	1.85	4,823,507	
2019	7,578,086		997,328	9,095,617	1.91	4,751,445	
2020	7,711,212	3,232	1,014,848	9,255,402	1.98	4,680,460	
2021	7,778,945		1,023,762	9,255,402	2.04	4,530,939	
2022	7,847,272		1,032,754	9,418,709	2.11	4,463,587	
2023	7,916,200		1,041,826	9,501,439	2.18	4,358,948	
2024	7,985,733		1,050,977	9,584,897	2.25	4,256,762	
2025	8,055,877		1,060,208	9,669,087	2.33	4,156,972	
2026	8,126,636		1,069,521	9,754,017	2.40	4,059,521	
2027	8,198,018		1,078,915	9,839,693	2.48	3,964,355	
2028	8,270,026		1,088,392	9,926,121	2.56	3,871,420	

Column

1 Ridership forecasts, with adjustments for phased opening, developed from SRF memo, August 27, 1999 "Revised Hiawatha Corridor LRT Forecasts."
2 Travel time savings (hours per day) for 2020, for auto and LRT travelers combined.
3 Pro rated annual time savings, based on days per year and ridership forecasts (314 days per year).
4 Yearly hours saved times value per hour ($9.12 per hour).
5 Factor to discount future year to present value.
6 Column 4 divided by column 5
7 Net present value (sum of column 6 values).

Table 3: Bus to LRT, crash changes

	1	2	3	4	5	6	7	8	9	10	11
	New daily LRT riders from bus	Forecast annual LRT ridership	New LRT from bus daily	Avoided bus passenger miles daily	Avoided annual bus passenger miles	Avoided bus crash cost, annual	LRT crash cost, annual	Net avoided crash cost	Discount factor	Discounted present value of avoided crash costs	Total discounted present value avoided crash costs (dollars)
1999		-		-	-				1.00	-	23,735,786
2000		-		-	-				1.03	-	
2001		-		-	-				1.07	-	
2002		-		-	-				1.10	-	
2003		1,691,887	3,357	27,191	8,537,973	$1,191,791	$773,397	$418,394	1.14	367,438	
2004		3,443,218	6,832	55,337	17,375,925	$2,425,455	$1,573,968	$851,487	1.18	723,897	
2005		5,938,484	11,783	95,440	29,968,089	$4,183,159	$2,714,607	$1,468,552	1.22	1,208,613	
2006		6,042,807	11,990	97,116	30,494,547	$4,256,646	$2,762,295	$1,494,351	1.26	1,190,557	
2007		6,148,963	12,200	98,822	31,030,254	$4,331,423	$2,810,821	$1,520,602	1.30	1,172,771	
2008		6,256,983	12,415	100,559	31,575,371	$4,407,515	$2,860,200	$1,547,315	1.34	1,155,250	
2009		6,366,902	12,633	102,325	32,130,065	$4,484,943	$2,910,446	$1,574,497	1.38	1,137,991	
2010		6,478,751	12,855	104,123	32,694,503	$4,563,731	$2,961,574	$1,602,157	1.43	1,120,989	
2011		6,592,565	13,080	105,952	33,268,856	$4,643,903	$3,013,601	$1,630,302	1.48	1,104,242	
2012		6,708,378	13,310	107,813	33,853,300	$4,725,484	$3,066,542	$1,658,942	1.53	1,087,745	
2013		6,826,226	13,544	109,707	34,448,010	$4,808,498	$3,120,413	$1,688,085	1.58	1,071,494	
2014		6,946,145	13,782	111,634	35,053,168	$4,892,970	$3,175,230	$1,717,741	1.63	1,055,487	
2015		7,068,170	14,024	113,595	35,668,957	$4,978,927	$3,231,010	$1,747,917	1.68	1,039,718	
2016		7,192,338	14,270	115,591	36,295,564	$5,066,393	$3,287,770	$1,778,623	1.74	1,024,185	
2017		7,318,688	14,521	117,622	36,933,179	$5,155,396	$3,345,527	$1,809,868	1.79	1,008,884	
2018		7,447,257	14,776	119,688	37,581,995	$5,245,962	$3,404,299	$1,841,663	1.85	993,811	
2019		7,578,086	15,036	121,790	38,242,208	$5,338,119	$3,464,103	$1,874,016	1.91	978,964	
2020	15,300	7,711,212	15,300	123,930	38,914,020	$5,431,895	$3,524,958	$1,906,937	1.98	964,339	
2021		7,778,945	15,434	125,019	39,255,827	$5,479,607	$3,555,920	$1,923,687	2.04	941,732	
2022		7,847,272	15,570	126,117	39,600,636	$5,527,738	$3,587,154	$1,940,584	2.11	919,655	
2023		7,916,200	15,707	127,224	39,948,474	$5,576,292	$3,618,662	$1,957,629	2.18	898,096	
2024		7,985,733	15,845	128,342	40,299,367	$5,625,272	$3,650,448	$1,974,825	2.25	877,042	
2025		8,055,877	15,984	129,469	40,653,342	$5,674,682	$3,682,512	$1,992,171	2.33	856,482	
2026		8,126,636	16,124	130,606	41,010,427	$5,724,527	$3,714,858	$2,009,669	2.40	836,404	
2027		8,198,018	16,266	131,754	41,370,648	$5,774,809	$3,747,488	$2,027,321	2.48	816,796	
2028		8,270,026	16,409	132,911	41,734,033	$5,825,533	$3,780,404	$2,045,129	2.56	797,648	

Column

1 From SRF memo, August 27, 1999 "Revised Hiawatha Corridor LRT Forecasts."
2 Ridership forecasts from Table 2
3 Pro rated new LRT riders from bus using ridership forecast.
4 Avoided bus passenger miles is avoided bus trips times average trip length (LRT distance used of 8.1 miles).
5 Daily avoided bus passenger miles times number of days (314) for annual avoided bus passenger miles.
6 Multiply column 5 by bus crash cost per MPM from Table 3A ($139,587) to estimate avoided bus crash cost.
7 Multiply column 5 by LRT crash cost per MPM from Table 3A ($90,583) to estimate LRT crash costs.
8 Estimate of crash cost change is MINUS bus crash cost PLUS LRT crash cost
9 Factor to discount future year to present value.
10 Column 8 divided by column 9
11 Net present value (sum of column 10 values).

Table 3A. National LRT and bus crash cost data from FTA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Vehicle-Miles	Passenger-Miles	Fatalities	Injuries	Collisions	Property Damage	Fatal Rate per MVM*	Injury Rate per MVM*	Collision Rate per MVM*	Fatal Rate per MPM*	Injury Rate per MPM*	Collision Rate per MPM*	Average Property Damage per Collision	GDP implicit price deflator to 1999	Property Damage (1999 dollars)
1995														1995 to 1998	
Large Motor Bus	810,119,645	8,521,534,025	39	25,284	15,035	$23,305,005	0.048	31.21	18.56	0.005	2.97	1.76	$1,550	1.048	$24,430,044
Light Rail	34,461,491	858,701,487	15	1,319	290	$1,669,265	0.435	38.27	8.42	0.017	1.54	0.34	$5,756	1.048	$1,749,848
1996														1996 to 1998	
Large Motor Bus	779,119,052	8,283,906,554	44	24,111	14,091	$19,791,293	0.056	30.95	18.09	0.005	2.91	1.70	$1,405	1.029	$20,364,089
Light Rail	37,467,839	955,245,148	6	1,604	323	$3,839,037	0.160	42.81	8.62	0.006	1.68	0.34	$11,886	1.029	$3,950,146
1997														1997 to 1998	
Large Motor Bus	838,353,348	9,091,818,099	55	25,058	15,619	$17,801,076	0.066	29.89	18.63	0.006	2.76	1.72	$1,140	1.010	$17,981,368
Light Rail	40,747,527	1,023,708,132	3	1,087	352	$2,047,011	0.074	26.68	8.64	0.003	1.06	0.34	$5,815	1.010	$2,067,743
1995 - 1997															
Large Motor Bus	2,427,592,045	25,897,258,678	138	74,453	44,745	See far right	0.057	30.67	18.43	0.005	2.87	1.73	$1,403	(99$)	$62,775,502
Light Rail	112,676,857	2,837,654,767	24	4,010	965	See far right	0.213	35.59	8.56	0.008	1.41	0.34	$8,049	(99$)	$7,767,737

Source: U.S. National data from FTA Web Site

*MVM--million vehicle miles; MPM--million passenger miles

Crash costs per MPM using Mn/DOT crash values for fatal and injuries and LRT/bus values for collis

	Per fatal	Per injury	Per collision		
Mn/DOT crash costs in1999 dollars	**$3,498,402**	**$41,226**	Use LRT or bus		
Large Motor Bus	$18,642	$118,521	$2,424	$139,587	Bus crash cost per MPM
Light Rail	$29,588	$58,257	$2,737	$90,583	LRT crash cost per MPM
	= 3-year fatal rate*cost per fatal	=3-year injury rate*cost per injury	=3-year collision rate*cost per collision		

Column

1 to 6 National data on LRT and large bus crashes and passenger miles from FTA for 1995 to 1997.

7 to 12 Crash rates per million passenger miles.

13 Average cost in current dollars per collision.

14 GDP implicit price deflator to bring 1995, 1996 or 1997 dollars up to 1999 dollars.

15 Total property damage in 1999 dollars. Used in last part of table to calculate average collision costs for all three years in 1999 dollars.

Table 4: Auto to LRT, crash changes and auto operating costs avoided

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	New daily LRT riders from auto	Forecast annual LRT ridership	New LRT from auto daily	Avoided auto trips daily	Avoided auto vmt daily*	Avoided annual auto vmt*	Avoided auto crashes, annual	*Avoided auto crash costs annual*	Estimated crash costs for LRT, annual	Reduction in estimated annual crash costs	Discount factor	Annual discounted avoided crash costs	Total discounted present value of avoided crash costs	Auto operating costs avoided (dollars)	Annual discounted avoided auto operating costs	Total discounted present value of avoided auto operating costs
1999											1.00	-	$2,540,715	-	-	$66,256,139
2000											1.03	-		-	-	
2001											1.07	-		-	-	
2002											1.10	-		-	-	
2003		1,691,887	2,040	1,641	13,292	4,173,765	11.41	$514,890	$470,104	44,786	1.14	$39,331		$1,093,526	$960,347	
2004		3,443,218	4,153	3,340	27,052	8,494,174	23.23	$1,047,870	$956,725	91,145	1.18	$77,487		$2,225,474	$1,891,999	
2005		5,938,484	7,162	5,760	46,655	14,649,819	40.06	$1,807,251	$1,650,055	157,196	1.22	$129,372		$3,838,253	$3,158,869	
2006		6,042,807	7,288	5,861	47,475	14,907,177	40.76	$1,839,000	$1,679,042	159,958	1.26	$127,439		$3,905,680	$3,111,677	
2007		6,148,963	7,416	5,964	48,309	15,169,056	41.48	$1,871,306	$1,708,538	162,768	1.30	$125,535		$3,974,293	$3,065,189	
2008		6,256,983	7,546	6,069	49,158	15,435,535	42.21	$1,904,180	$1,738,553	165,627	1.34	$123,660		$4,044,110	$3,019,396	
2009		6,366,902	7,679	6,175	50,021	15,706,695	42.95	$1,937,631	$1,769,094	168,537	1.38	$121,812		$4,115,154	$2,974,287	
2010		6,478,751	7,814	6,284	50,900	15,982,619	43.71	$1,971,670	$1,800,173	171,497	1.43	$119,992		$4,187,446	$2,929,852	
2011		6,592,565	7,951	6,394	51,794	16,263,390	44.47	$2,006,307	$1,831,797	174,510	1.48	$118,200		$4,261,008	$2,886,081	
2012		6,708,378	8,091	6,507	52,704	16,549,094	45.25	$2,041,552	$1,863,976	177,576	1.53	$116,434		$4,335,863	$2,842,964	
2013		6,826,226	8,233	6,621	53,630	16,839,817	46.05	$2,077,417	$1,896,721	180,695	1.58	$114,694		$4,412,032	$2,800,491	
2014		6,946,145	8,377	6,737	54,572	17,135,647	46.86	$2,113,911	$1,930,042	183,870	1.63	$112,981		$4,489,539	$2,758,652	
2015		7,068,170	8,524	6,856	55,531	17,436,673	47.68	$2,151,047	$1,963,947	187,100	1.68	$111,293		$4,568,408	$2,717,439	
2016		7,192,338	8,674	6,976	56,506	17,742,989	48.52	$2,188,835	$1,998,448	190,387	1.74	$109,630		$4,648,663	$2,676,841	
2017		7,318,688	8,827	7,099	57,499	18,054,685	49.37	$2,227,287	$2,033,556	193,731	1.79	$107,992		$4,730,327	$2,636,850	
2018		7,447,257	8,982	7,223	58,509	18,371,856	50.24	$2,266,414	$2,069,280	197,134	1.85	$106,379		$4,813,426	$2,597,456	
2019		7,578,086	9,139	7,350	59,537	18,694,600	51.12	$2,306,229	$2,105,631	200,598	1.91	$104,790		$4,897,985	$2,558,651	
2020	9,300	7,711,212	9,300	7,479	60,583	19,023,014	52.02	$2,346,743	$2,142,622	204,121	1.98	$103,224		$4,984,030	$2,520,425	
2021		7,778,945	9,382	7,545	61,115	19,190,105	52.48	$2,367,356	$2,161,442	205,914	2.04	$100,804		$5,027,807	$2,461,340	
2022		7,847,272	9,464	7,611	61,652	19,358,664	52.94	$2,388,150	$2,180,427	207,723	2.11	$98,441		$5,071,970	$2,403,639	
2023		7,916,200	9,547	7,678	62,193	19,528,704	53.40	$2,409,127	$2,199,579	209,548	2.18	$96,134		$5,116,520	$2,347,291	
2024		7,985,733	9,631	7,746	62,740	19,700,237	53.87	$2,430,288	$2,218,899	211,388	2.25	$93,880		$5,161,462	$2,292,264	
2025		8,055,877	9,716	7,814	63,291	19,873,277	54.34	$2,451,635	$2,238,389	213,245	2.33	$91,679		$5,206,798	$2,238,527	
2026		8,126,636	9,801	7,882	63,847	20,047,836	54.82	$2,473,169	$2,258,051	215,118	2.40	$89,530		$5,252,533	$2,186,050	
2027		8,198,018	9,887	7,952	64,407	20,223,929	55.30	$2,494,892	$2,277,885	217,008	2.48	$87,431		$5,298,669	$2,134,803	
2028		8,270,026	9,974	8,021	64,973	20,401,569	55.79	$2,516,806	$2,297,893	218,914	2.56	$85,381		$5,345,211	$2,084,757	

*vmt--vehicle miles of travel

Column

1 From SRF memo, August 27, 1999 "Revised Hiawatha Corridor LRT Forecasts."

2 Ridership forecasts from Table 2.

3 Pro rated new LRT riders from auto using ridership forecast.

4 Avoided auto trips are new LRT riders from auto divided by average auto occupancy (1.24--see Assumptions).

5 Avoided auto vmt is avoided auto trips times average trip length (LRT distance used of 8.1 miles).

6 Daily avoided vmt times number of days (314) for annual avoided vmt.

7 Multiply by auto crash rate per million vmt (2.73--see Table 3B) to estimate avoided number of crashes.

8 Multiply by recent auto cost per crash on TH55 from Table 3B of $45,113 to obtain economic cost of avoided auto crashes.

9 Estimate LRT crash costs by avoided LRT miles (auto vmt times occupancy rate) times LRT crash cost from Table 3A of $90,583.

10 Change with LRT is MINUS avoided auto crash costs PLUS estimated LRT crash costs.

11 Factor to discount future year to present value.

12 Column 10 divided by column 11

13 Total discounted present value of avoided crash costs (sum of column 12 values).

14 Avoided annual auto vmt (column 6) times standard per mile VOC cost from Assumptions of $.26

15 Column 14 divided by column 11

16 Total discounted present value of avoided auto operating costs (sum of column 15 values).

Table 4A. Crash history for TH55 improved section, 1996-98

	Number of crashes by crash severity	1996	1997	1998	Grand Total	Share of total crashes	Mn/DOT standard crash cost by crash type	Share times standard crash cost
1	Fatal (assumed)	0.13	0.13	0.13	0.39	0.2%	**$3,498,402**	$8,151
	Injury Type A	3	6	4	13	7.8%	**$267,525**	$20,777
	Injury Type B	9	5	4	18	10.8%	**$57,621**	$6,196
	Injury Type C	9	21	17	47	28.1%	**$27,781**	$7,801
	Property damage only	37	27	25	89	53.2%	**$4,116**	$2,188
	Grand Total	58.13	59.13	50.13	167.39	100.0%	Crash	**$45,113**

^ Weighted average cost per crash

2		1996	1997	1998	Grand Total
	Segment length (miles)	2.0	2.0	2.0	
	Weighted AADT	27,858	28,276	27,719	
	Annual VMT	20,336,340	20,641,480	20,234,870	61,212,690

3	Crash rates (per million vmt)	1996	1997	1998	3-Yr crash rate	3-year crash rate times standard crash cost
	Fatal (assumed)	0.006	0.006	0.006	0.006	$22,289
	Rate A Injury	0.148	0.291	0.198	0.212	$56,815
	Rate B Injury	0.443	0.242	0.198	0.294	$16,944
	Rate C Injury	0.443	1.017	0.840	0.768	$21,331
	Rate Property Damage	1.819	1.308	1.235	1.454	$5,984
	Overall Rate (per MVM)	2.858	2.865	2.477	2.735	**$123,363**

^ 3-year crash rate per MVM

^ Average crash cost per MVM of travel

Data for crashes are for MN 55 from REF PT 193+00.800 to 195+00.800
approximately 32nd Street to 46th Street (inclusive)

Rows

1 Shows crashes by type, uses Mn/DOT standard values per crash to estimate cost per crash.
2 Shows vehicle miles of travel (vmt) calculations for corridor.
3 Uses number of crashes and vmt to calculate 3-year crash rate and average cost per million vmt (MVM).

Table 5: Changes in emissions

	1	2	3	4	5	6
	Annual Ridership	Value of emission savings in 99$	Value of emission savings in 99$	Discount factor	Present value time savings	NPV
1999				1.000	-	25,472,565
2000				1.033	-	
2001				1.067	-	
2002				1.102	-	
2003	1,691,887		420,413	1.139	369,211	
2004	3,443,218		855,596	1.176	727,390	
2005	5,938,484		1,475,639	1.215	1,214,446	
2006	6,042,807		1,501,562	1.255	1,196,302	
2007	6,148,963		1,527,940	1.297	1,178,430	
2008	6,256,983		1,554,782	1.339	1,160,825	
2009	6,366,902		1,582,095	1.384	1,143,482	
2010	6,478,751		1,609,889	1.429	1,126,399	
2011	6,592,565		1,638,170	1.476	1,109,571	
2012	6,708,378		1,666,948	1.525	1,092,994	
2013	6,826,226		1,696,232	1.575	1,076,665	
2014	6,946,145		1,726,030	1.627	1,060,580	
2015	7,068,170		1,756,352	1.681	1,044,735	
2016	7,192,338		1,787,206	1.737	1,029,127	
2017	7,318,688		1,818,602	1.794	1,013,753	
2018	7,447,257		1,850,550	1.853	998,607	
2019	7,578,086		1,883,059	1.914	983,689	
2020	7,711,212	$1,916,140	1,916,140	1.977	968,992	
2021	7,778,945		1,932,970	2.043	946,277	
2022	7,847,272		1,949,949	2.110	924,093	
2023	7,916,200		1,967,077	2.180	902,430	
2024	7,985,733		1,984,355	2.252	881,275	
2025	8,055,877		2,001,785	2.326	860,615	
2026	8,126,636		2,019,367	2.403	840,440	
2027	8,198,018		2,037,105	2.482	820,738	
2028	8,270,026		2,054,998	2.564	801,497	

Column

1 Ridership forecasts from Table 2

2 Value of savings for 2020 from Table 1: Assumptions.

3 Value of savings for 2020 from Table 1: Assumptions, prorated by ridership.

4 Factor to discount future year to present value.

5 Column 3 divided by column 4

6 Net present value (sum of column 5 values).

Table 6: Capital costs

	1	2	3	3	3	3	4	5	5	5	5
			1999 Dollars ($m)					Present value in 1999 dollars ($m)			
	LRT project ($m)	Inflation	LRT project	Utilities	Highways	Supplementary parking at Fort Snelling	Discount factor	LRT project ($000)	Utilities	Highways	Supplementary parking at Fort Snelling
1999	42.6	1.0000	43				1.000	42.6	-	-	-
2000	41.8	1.0300	41				1.033	39.3	-	-	-
2001	91.4	1.0609	86		42.96	6.9	1.067	80.7	-	40.3	6.4
2002	187.1	1.0927	171	100.00			1.102	155.3	90.7	-	-
2003	143.8	1.1255	128				1.139	112.2	-	-	-
2004	35.6	1.1593	31				1.176	26.1	-	-	-
2005	6.3	1.1941	5				1.215	4.3	-	-	-
2006		1.2299	-				1.255	-	-	-	-
2007		1.2668	-				1.297	-	-	-	-
2008		1.3048	-				1.339	-	-	-	-
2009		1.3439	-				1.384	-	-	-	-
2010		1.3842	-				1.429	-	-	-	-
2011		1.4258	-				1.476	-	-	-	-
2012		1.4685	-				1.525	-	-	-	-
2013		1.5126	-				1.575	-	-	-	-
2014		1.5580					1.627	-	-	-	-
2015		1.6047	-				1.681	-	-	-	-
2016		1.6528	-				1.737	-	-	-	-
2017		1.7024	-				1.794	-	-	-	-
2018		1.7535	-				1.853	-	-	-	-
2019		1.8061	-				1.914	-	-	-	-
2020		1.8603	-				1.977	-	-	-	-
2021		1.9161	-				2.043	-	-	-	-
2022		1.9736					2.110	-	-	-	-
2023		2.0328					2.180	-	-	-	-
2024		2.0938					2.252	-	-	-	-
2025		2.1566					2.326	-	-	-	-
2026		2.2213					2.403	-	-	-	-
2027		2.2879					2.482	-	-	-	-
2028		2.3566					2.564	-	-	-	-
Total	548.6		504.3				Totals	460.6	90.7	40.3	6.4

1 Table 2, Total LRT Funding Requirements, from "Hiawatha Corridor Light Rail Transit Financial Report," submitted to FTA 9/29/1999.

2 Convert to real 1999 dollars by using inflation factor assumed in Submittal documents of 3%

3 Convert LRT spending to real 1999 dollars; add utilities, highways and potential future parking in 1999 dollars.

4 Discount factor for each year of 3.3%

5 Calculate present values as real 1999 costs discounted by column 4, total present values are shown at bottom of column 5).

Table 7: Remaining capital value

		Through 1999	2000	2001	2002	2003	2004	2005	Total ($million)	Life (years)
	1 Actual expenditures, in nominal dollars									
LRT	ROW	26.6	16.8						43.40	100
	Facilities and Systems		6.6	69	146.9	96	24.8	4.5	347.80	30
	Vehicles		4	8.9	26.9	37.2	6.9	0.4	84.30	25
	Soft costs	16	14.4	13.5	13.3	10.6	3.9	1.4	73.10	0
									548.60	
	2 Expenditures in real 1999 dollars									
	Inflation factor:	1.00	1.03	1.06	1.09	1.13	1.16	1.19		
LRT	ROW	26.60	16.31	0.00	0.00	0.00	0.00	0.00	42.91	
	Facilities and Systems	0.00	6.41	65.04	134.43	85.29	21.39	3.77	316.34	
	Vehicles	0.00	3.88	8.39	24.62	33.05	5.95	0.33	76.23	
	Soft costs	16.00	13.98	12.73	12.17	9.42	3.36	1.17	68.83	
Utilities	*Utility relocation (NO INFLATION)*				*100.00*					50
TH55 costs	Guideway--elevated			30.45						50
	Guideway--roadway			7.60						30
	Special conditions			0.66						30
	Soft Costs			4.26						0
	Total TH55 costs			42.96						
Supplementary parking										
	At Fort Snelling			6.88						35
	3 Remaining capital value factors from Table 7A.									
LRT	ROW	0.37	0.38	0.39	0.41	0.42	0.44	0.45		
	Facilities and Systems	0.02	0.04	0.06	0.08	0.11	0.13	0.15		
	Vehicles									
	Soft costs									
Utilities	*Utility relocation*				0.29					
TH55 costs	Guideway--elevated			0.29						
	Guideway--roadway			0.08						
	Special conditions			0.08						
	Soft Costs			0.00						
Supplementary parking				0.16						
	4 Remaining capital value, in 1999 dollars, in year expenditures take place.									
LRT	ROW	9.72	6.18	0.00	0.00	0.00	0.00	0.00	15.90	
	Facilities and Systems	0.00	0.26	4.04	11.31	9.12	2.79	0.58	28.10	
	Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Soft costs	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
	Total	9.72	6.44	4.04	11.31	9.12	2.79	0.58	43.99	
Utilities	*Utility relocation*				28.99					
TH55 costs	Guideway--elevated			8.83						
	Guideway--roadway			0.64						
	Special conditions			0.06						
	Soft Costs			0.00						
Supplementary parking				1.10						
	5 Discount factor	1.00	1.03	1.07	1.10	1.14	1.18	1.22		
	6 LRT capital discounted	9.72	6.23	3.78	10.26	8.01	2.37	0.48		

7 Total discounted present values in 1999 dollars (millions)

7 LRT capital	40.85
7 *Utility relocation*	26.30
7 Highways	8.92
7 Supplementary parking	1.03

Sections

1 Table 2, Total LRT Funding Requirements, from "Hiawatha Corridor Light Rail Transit Financial Report," submitted to FTA 9/29/1999.
Table I1. Assumed useful life of assets, from "Documentation on Capital Cost Annualization Factors," FTA.
2 Convert to real 1999 dollars by using inflation factor assumed in Submittal documents of 3%
3 Factors for remaining capital value of asset with life of given years for analysis period to 2028 (see separate Table 7A: Remaining Capital Value factors).
4 Calculate remaining capital value in 1999$ by year for each type of investment.
5 Discount factor for each year of 3.3%
6 Discount each year's LRT remaining capital value
7 Net Present Value is sum of line 6 for LRT, and discounted remaining capital values for Utilities, Highway and Parking.

Table 7A. Remaining Capital value factors for assets for period until 2028, by year and expected life

(1+r)^N	(1+r)^-t
1.03	0.97
1.07	0.94
1.10	0.91
1.14	0.88
1.18	0.85
1.22	0.82
1.26	0.80
1.30	0.77
1.34	0.75
1.38	0.72
1.43	0.70
1.48	0.68
1.53	0.66
1.58	0.63
1.63	0.61
1.68	0.59
1.74	0.58
1.79	0.56
1.85	0.54
1.91	0.52
1.98	0.51
2.04	0.49
2.11	0.47
2.18	0.46
2.25	0.44
2.33	0.43
2.40	0.42
2.48	0.40
2.56	0.39
2.65	0.38

Expected life->	30	35	50	100
1999	0.02	0.10	0.24	0.37
2000	0.04	0.12	0.26	0.38
2001	0.06	0.14	0.27	0.39
2002	0.08	0.16	0.29	0.41
2003	0.11	0.18	0.31	0.42
2004	0.13	0.20	0.33	0.44
2005	0.15	0.23	0.34	0.45
2006	0.18	0.25	0.36	0.47
2007	0.21	0.27	0.38	0.49
2008	0.23	0.30	0.41	0.50
2009	0.26	0.32	0.43	0.52
2010	0.29	0.35	0.45	0.54
2011	0.32	0.38	0.47	0.56
2012	0.35	0.40	0.50	0.58
2013	0.38	0.43	0.52	0.60
2014	0.41	0.46	0.54	0.62
2015	0.45	0.49	0.57	0.64
2016	0.48	0.52	0.60	0.66
2017	0.52	0.56	0.63	0.69
2018	0.55	0.59	0.65	0.71
2019	0.59	0.63	0.68	0.74
2020	0.63	0.66	0.72	0.76
2021	0.67	0.70	0.75	0.79
2022	0.72	0.74	0.78	0.82
2023	0.76	0.78	0.81	0.84
2024	0.80	0.82	0.85	0.87
2025	0.85	0.86	0.88	0.90
2026	0.90	0.91	0.92	0.93
2027	0.95	0.95	0.96	0.97
2028	1.00	1.00	1.00	1.00

Asset placed in 2002 has 0.16 of its value left in 2002 if it has life of 35 years and analysis period goes to 2028.

Table 8: Operating costs of LRT system

	1	2	3	4	5	6	7
	Nominal operating costs ($000)	Inflation assumed in FTA submittal	Operating costs in 1999 dollars (000)	Operating cost in 1999 dollars (000s)	Discount factor	Present Value Operating Costs (000s)	NPV
1999		1.00	11,384	1999	1.00	-	167,391
2000		1.03		2000	1.03	-	
2001		1.06		2001	1.07	-	
2002		1.09		2002	1.10	-	
2003		1.13		2003	3,358	1.14	2,949
2004	13,197	1.16	11,384	2004	6,717	1.18	5,710
2005	13,592	1.19	11,383	2005	11,384	1.22	9,369
2006	14,000	1.23	11,383	2006	11,384	1.26	9,070
2007	14,420	1.27	11,383	2007	11,384	1.30	8,780
2008	14,853	1.30	11,384	2008	11,384	1.34	8,499
2009	15,298	1.34	11,383	2009	11,384	1.38	8,228
2010	15,757	1.38	11,383	2010	11,384	1.43	7,965
				2011	11,384	1.48	7,711
				2012	11,384	1.53	7,464
				2013	11,384	1.58	7,226
				2014	11,384	1.63	6,995
				2015	11,384	1.68	6,772
				2016	11,384	1.74	6,555
				2017	11,384	1.79	6,346
				2018	11,384	1.85	6,143
				2019	11,384	1.91	5,947
				2020	11,384	1.98	5,757
				2021	11,384	2.04	5,573
				2022	11,384	2.11	5,395
				2023	11,384	2.18	5,223
				2024	11,384	2.25	5,056
				2025	11,384	2.33	4,894
				2026	11,384	2.40	4,738
				2027	11,384	2.48	4,587
				2028	11,384	2.56	4,440

Source: Submission to FTA, September 1999.

Inflation 3.0%

1 LRT system operating costs from FTA submittal.
2 Inflation assumed in FTA submittal.
3 LRT system operating costs in 1999 dollars.
4 Operating costs in 1999 dollars per year. Adjust for phasing in 2003 and 2004.
5 Discount factor for each year.
6 Discount each operating cost
7 Net Present Value is sum of column 6.

Table 9: Supplementary analysis of potential for avoided infrastructure, auto ownership and parking construction

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	LRT riders that represent avoided auto trips	Yearly increase in number of avoided auto round trips	Smoothed addition to avoided auto trips	Estimate of infrastructure saving (1999$)	Potential avoided infrastructure	Estimate of potential for avoided auto ownership	Estimate of potential avoided auto ownership cost ($)	Additional potential for avoided parking construction	Annual increment, smoothed	Estimate of potential avoided parking construction ($)	Discount factor	Present value avoided infrastructure	NPV avoided infrastructure	Present value avoided auto ownership	NPV avoided auto ownership	Present value avoided parking capital	NPV avoided parking capital
1999	-			13,352			4,474			10,000	1.00		32,278,235		18,015,468		11,096,248
2000	-	-									1.03						
2001	-	-									1.07						
2002	-	-									1.10						
2003	1,641	821	154		2,059,643	66	297,337	377	70.8	708,041	1.14	1,808,800		261,124.40		621,809	
2004	3,340	849	154		2,059,643	135	605,121	390	70.8	708,041	1.18	1,751,017		514,446.55		601,945	
2005	5,760	1,210	154		2,059,643	233	1,043,645	555	70.8	708,041	1.22	1,695,079		858,916.73		582,715	
2006	5,861	51	154		2,059,643	237	1,061,979	23	70.8	708,041	1.26	1,640,928		846,084.77		564,100	
2007	5,964	51	154		2,059,643	242	1,080,636	24	70.8	708,041	1.30	1,588,508		833,444.51		546,079	
2008	6,069	52	154		2,059,643	246	1,099,619	24	70.8	708,041	1.34	1,537,762		820,993.10		528,634	
2009	6,175	53	154		2,059,643	250	1,118,937	24	70.8	708,041	1.38	1,488,637		808,727.71		511,747	
2010	6,284	54	154		2,059,643	255	1,138,593	25	70.8	708,041	1.43	1,441,081		796,645.55		495,399	
2011	6,394	55	154		2,059,643	259	1,158,595	25	70.8	708,041	1.48	1,395,044		784,743.91		479,573	
2012	6,507	56	154		2,059,643	264	1,178,949	26	70.8	708,041	1.53	1,350,479		773,020.06		464,252	
2013	6,621	57	154		2,059,643	268	1,199,660	26	70.8	708,041	1.58	1,307,336		761,471.37		449,421	
2014	6,737	58	154		2,059,643	273	1,220,735	27	70.8	708,041	1.63	1,265,573		750,095.22		435,064	
2015	6,856	59	154		2,059,643	278	1,242,179	27	70.8	708,041	1.68	1,225,143		738,889.02		421,166	
2016	6,976	60	154		2,059,643	283	1,264,001	28	70.8	708,041	1.74	1,186,005		727,850.23		407,711	
2017	7,099	61	154		2,059,643	287	1,286,206	28	70.8	708,041	1.79	1,148,117		716,976.37		394,687	
2018	7,223	62	154		2,059,643	293	1,308,801	29	70.8	708,041	1.85	1,111,439		706,264.95		382,078	
2019	7,350	63	154		2,059,643	298	1,331,794	29	70.8	708,041	1.91	1,075,934		695,713.56		369,872	
2020	7,479	65	154		2,059,643	303	1,355,190	30	70.8	708,041	1.98	1,041,562		685,319.81		358,056	
2021	7,545	33	154		2,059,643	306	1,367,093	15	70.8	708,041	2.04	1,008,288		669,254.03		346,618	
2022	7,611	33	154		2,059,643	308	1,379,101	15	70.8	708,041	2.11	976,078		653,564.88		335,545	
2023	7,678	33	154		2,059,643	311	1,391,215	15	70.8	708,041	2.18	944,896		638,243.52		324,826	
2024	7,746	34	154		2,059,643	314	1,403,435	15	70.8	708,041	2.25	914,711		623,281.34		314,449	
2025	7,814	34	154		2,059,643	316	1,415,762	16	70.8	708,041	2.33	885,490		608,669.92		304,404	
2026	7,882	34	154		2,059,643	319	1,428,197	16	70.8	708,041	2.40	857,202		594,401.02		294,679	
2027	7,952	35	154		2,059,643	322	1,440,742	16	70.8	708,041	2.48	829,818		580,466.63		285,265	
2028	8,021	35	154		2,059,643	325	1,453,397	16	70.8	708,041	2.56	803,309		566,858.90		276,152	
Total		4,010.7	4,010.7					1,841	1,841								

1 From table on auto to LRT riders.

2 LRT trips divided by two to give avoided car commuters.

3 Smooth by spreading increases to average over 26 years.

4 From 1000 Friends of Minnesota report.

5 **Assume all avoided auto drivers relocate; multiply column 3 by column 4.**
FOR THOSE NOT PARK AND RIDE, ASSUME EITHER NO LONGER OWN CAR (COLUMN 6) OR NO LONGER NEED PARKING SPACE (COLUMN 8)

6 Share of avoided auto trips that do NOT park and ride at Fort Snelling of 0.54--OTM calculation).
times likelihood of reducing vehicle ownership of 0.15 (from Mn/DOT market research) with dependable public transit.

7 Avoided cost is column 6 times fixed costs of auto ownership per year of $4,474

8 Share of avoided auto trips that do NOT park and ride at Fort Snelling.
times likelihood of not reducing vehicle ownership of .85 (from Mn/DOT market research) with dependable Mn/DOT market research

9 Smooth by spreading increases to average over 26 years.

10 Avoided cost is column 9 times capital cost of parking space of $10,000

11 Discount factor for each year.

12, 14, 16 Discount each type of avoided cost

13, 15, 17 Net Present Value is sum of column 12, 14, or 16