Technical Report Documentation Page

1. Report No. FHWA/TX-13/5-6235-01-1	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle Project Evaluation Toolkit (PET) for Abstracted Networks: Final Implementation Report	5. Report Date August 2012; Published May 2013 6. Performing Organization Code
7. Author(s) Kara Kockelman, Dan Fagnant, Brice Nichols, and Steve Boyles	8. Performing Organization Report No. 5-6235-01-1
9. Performing Organization Name and Address Center for Transportation Research The University of Texas at Austin 1616 Guadalupe Street, Suite 4.202 Austin, TX 78701	10. Work Unit No. (TRAIS) 11. Contract or Grant No. 5-6235-01
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, TX 78763-5080	13. Type of Report and Period Covered Technical Report June 2011–August 2012 14. Sponsoring Agency Code

15. Supplementary Notes

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

16. Abstract

This report summarizes the research completed for TxDOT Project No. 5-6235-01 and discusses the implications and future applications of the work. This project extended the capabilities of the Project Evaluation Toolkit (PET), while introducing the software to a large network of potential users across the state of Texas.

17. Key Words abstracted networks, project evaluation toolkit (PET)	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161; www.ntis.gov.

19. Security Classif. (of report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages 44	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Project Evaluation Toolkit (PET) for Abstracted Networks

Kara Kockelman
Dan Fagnant
Brice Nichols
Steve Boyles

CTR Technical Report:	5-6235-01-1
Report Date:	August 2012
Project:	5-6235-01
Project Title:	Implementation of Project Evaluation for Abstracted Networks
Sponsoring Agency:	Texas Department of Transportation
Performing Agency:	Center for Transportation Research at The University of Texas at Austin

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Center for Transportation Research
The University of Texas at Austin
1616 Guadalupe, Suite 4.202
Austin, TX 78701

www.utexas.edu/research/ctr

Disclaimers

Engineering Disclaimer

NOT INTENDED FOR CONSTRUCTION, BIDDING, OR PERMIT PURPOSES.

Project Engineer: Dr. Kara Kockelman
Professional Engineer License State and Number: Texas #93443
P. E. Designation: Research Supervisor

Acknowledgments

The authors express appreciation to M. Kim Soucek, the TxDOT Project Director, Duncan Stewart, Ron Hagquist, and members of the Project Monitoring Committee for their support and guidance. Others who contributed significant feedback and expertise to this project include MPO contacts and especially Zhen Ding and colleagues from NCTCOG.

Table of Contents

List of Figures

List of Tables

1. Introduction

This report summarizes the research completed for TxDOT Project No. 5-6235-01 and discusses the implications and future applications of the work. This project extended the capabilities of the Project Evaluation Toolkit (PET), while introducing the software to a large network of potential users across the state. The research team provided multiple training and demonstration sessions in various locations, garnering interest and feedback from the staff of metropolitan planning organizations (MPO) and other agencies. Multiple case studies were produced on various metro-area networks, providing additional resources for demonstrating the Toolkit's capabilities and creating "tutorials" for teaching PET to new users. Along with these analyses, the research team gathered feedback from presentation attendees, which helped shape further development of the Toolkit by refining features and developing new capabilities. The following sections track the project timeline, beginning in summer 2011 and terminating in late summer 2012.

2. Developing Regional Abstracted Networks

The project team produced abstracted networks for five major metro regions in Texas to provide a basis for analysis and presentation to potential users. Abstract network creation in PET is necessarily user-intensive, requiring selection of critical links from a roadway network, analysis of these links' features, and link-by-link input to the Toolkit. By creating a series of networks, users in these regions' MPOs were given a basis for learning and testing the Toolkit on their regional networks, without tedious dedication to PET upfront. Throughout fall 2011, the team modeled five networks in which air quality standards were of concern, including (1) Austin, (2) Dallas-Fort Worth (DFW), (3) Houston, (4) San Antonio, and (5) Tyler-Longview. These networks include mostly major, high-volume links, along with some lower-volume links deemed crucial for connectivity, particularly in areas where significant development was occurring or exceptional distance separated nodes. Network sizes ranged from 70 links and 22 nodes (Tyler-Longview) to 314 links and 98 nodes (San Antonio). Each link required specific information, including length, functional classification, area type, number of lanes, volume, and capacity. Additional information was sometimes necessary for arterials or freeways, including land use, median presence, number of entrance and/or exit ramps, and tolling prices. The team also developed five location-specific time-of-day (TOD) reference stations, which were applied to specific links. These networks are available on the PET website, along with the graphics depicting the nodes and links for each network. More details on this work can be found in this project's Tech Memo #1 (dated November 30, 2011).

3. Producing Regional Case Studies

From early 2012 to spring 2012, the project team worked with contacts at three major MPOs to develop and present case studies on recently developed regional networks. Projects were analyzed on major networks with input from corresponding MPOs, as follows:

- DFW – North Central Texas Council of Governments (NCTCOG)
- Houston – Houston Greater Area Council (H-GAC)
- Austin – Capital Area Metropolitan Planning Organization (CAMPO)

The project team used project suggestions and input from MPO contacts along with regional implementation plans listing projects planned for construction in less than 5 years. These projects were modeled in PET by the research team and results were prepared for presentation sessions scheduled for spring 2012. Presentation of the case studies provided context for discussion of the Toolkit and examples of realistic applications, similar to how each MPO might use PET. Though the case studies were developed solely by the research team, case study results and networks were made available for an easy starting point in major MPOs when learning the Toolkit.

All projects compared various major capacity expansion projects under various toll pricing scenarios. Brief project summaries and results for each region are presented below and detailed analyses are found in Appendix A.

3.1 Dallas-Fort Worth: LBJ Express

This project began construction around the time of analysis, but presented a representative application of the Toolkit to a real-world project, recommended by NCTCOG modeler Zhen Ding. The project, as designed, adds a new six- to eight-lane toll facility along a 13-mile stretch of IH 35E and IH 635 in northwest Dallas. The team modeled this alternative as a high occupancy toll facility (HOT) where single occupancy vehicles (SOV) pay full toll and high occupancy vehicles (HOV) (two or more total occupants) pay half-tolls. A second alternative assumed similar HOT pricing, but free HOV admittance. Finally, a third alternative assumed a flat-rate toll for all levels of vehicle occupancy. Over a project life of 50 years, each alternative yielded cost-benefit ratios greater than 1, mostly due to traveler welfare and reliability improvements (Table 3.1). Providing free entry to HOVs yielded highest benefits, followed by half-rate HOV entry, showing that these policies either reduced user costs to those who would already by traveling in HOVs or induced some SOVs to ride-share to reduce travel costs.

Table 3.1: LBJ Express PET Analysis—Results Summary

	No Build	I-635 HOT (Proposed)	I-635 HOT (free HOVs)	I-635 Flat Rate
Net Present Value	$0	$1.84 B	$5.10 B	$1.55 B
Internal Rate of Return	N/A	9.37%	13.78%	9.38%
Benefit/Cost Ratio	N/A	1.69	2.90	1.58
Payback Period (yrs)	N/A	16.6	9.6	15.1

3.2 Houston: Hempstead Tollway

Houston’s case study was similar to the LBJ Express in Dallas, though the project was not currently under construction and is planned for possible implementation sometime between 2013 and 2016. Known as the “Hempstead Tollway,” this analysis considered a 26-mile toll-road expansion along US 290 in northwest Houston under various lane-pricing scenarios similar to

DFW (flat-rate tolling, HOVs admitted for half the rate of SOVs, and HOVs admitted at no cost). The major $2.3 billion project was analyzed over a 30-year project life, and across all scenarios showed toll revenues making back only to 5 to 37% of project costs. However, when considering traveler benefits, much higher values were returned overall, with cost-benefit ratios well over 1, as shown in Table 3.2.

Table 3.2: Hempstead Tollway PET Analysis—Results Summary

	No Build	Hempstead Tollway Flat Rate	Hempstead Tollway HOT	Hempstead Tollway Free HOV
Net Present Value	$0	$23.3 B	$19.4 B	$14.8 B
Internal Rate of Return	N/A	78.72%	58.23%	58.89%
Benefit/Cost Ratio	N/A	10.19	8.64	6.84
Payback Period (yrs)	N/A	3.6	4.0	3.2

Results indicated that, while all alternatives returned significant traveler welfare and reliability benefits, flat-rate tolling returned greatest benefits in this case, followed by half-price HOV admittance, and finally free HOV pricing. Interestingly, these results are starkly opposed to those seen in the LBJ Express analysis, but it may be that on this network such a large number of users are encouraged to travel when HOV pricing is more favorable that the overall flows are reduced, thereby increasing overall congestion as more HOVs flock to the route and diminish overall traveler benefits. In addition to these benefits in each scenario, emissions for each alternative resulted in reduced emissions relative to the base case, although these gains were much less significant relative to welfare and reliability benefits.

3.3 Austin: US 290 Improvements

Austin's case study focused on a 5.2-mile stretch of US 290 between US 183 and State Highway (SH) 130. This case study examined capacity expansion scenarios (similar to a currently active project) on an existing four-lane arterial. Three alternative scenarios were investigated over a 20-year design life, including a grade-separated freeway (Freeway Upgrade, keeping the same number of lanes), a grade-separated tollway (Tollway Upgrade, keeping the same number of lanes and tolling at $0.11 per vehicle-mile and $0.40 per heavy-truck mile), and a grade-separated tollway with tolls set by TOD (Tolling by TOD, with double tolls during the PM peak and half-price tolls during off-peak times). Initial project costs were assessed at $131 million in the freeway expansion scenario and at $138 million for the tolled projects. All projects were deemed favorable, as shown in Table 3.3.

Table 3.3: US 290 Improvements PET Analysis—Results Summary

	No Build	Freeway Upgrade	Tollway Upgrade	Tolling by TOD
Net Present Value	$0	$690 M	$376 M	$265 M
Internal Rate of Return	N/A	60%	29%	21%
Benefit/Cost Ratio	N/A	6.6	3.7	2.9
Payback Period (yrs)	N/A	2.0	4.8	8.1

From a project financing standpoint, the Tollway Upgrade project was anticipated to recover almost all necessary funds over the project life (showing a 6.0% internal rate of return [IRR] only when comparing expenditures and revenues), while the Tolling by TOD scenario exhibited an 8.2% project financing IRR. All scenarios were predicted to substantially reduce injury and fatal crashes by 65 to 80 per year. Finally, system-wide emissions were reduced the most in the Freeway Upgrade scenario's design year (with volatile organic compounds [VOCs], and four mobile air source toxins [MSATS] all falling by over 4%), while emissions changed by less than 1% in the other two scenarios. Fagnant (2012) discusses further details; Appendix A also includes a similar evaluation of US 183 on the Austin network.

4. Presentation and Training Sessions

Following completion of the case studies and Toolkit improvements, the project team prepared materials for three presentation sessions to multiple MPOs in May 2012. Two-hour sessions were conducted in Austin, Dallas, and Houston, on May 16, 17, and 24, respectively. In addition to major MPOs receiving case studies on their regional networks (e.g., CAMPO, NCTCOG, H-GAC), other MPOs also attended the meetings and provided useful feedback and response, namely MPOs from San Antonio (SAMPO), Tyler, and Longview. These attendees tended to have unique needs for the Toolkit and their inclusion in the process helped broaden the discussion on future Toolkit applications.

During each presentation, the project team provided a detailed overview of the Toolkit's functions, capabilities, and applications by discussing technical details and demonstrating case study results relevant to the audience. The team also concentrated a significant portion of the presentation on going through important points of the Toolkit itself, discussing important functions as the presenters clicked through various features. Outside of this demonstration, PowerPoint presentations were tailored for each meeting, with region-specific case studies presented and discussed. These presentations were made available on the PET website as part of training material. Additionally, detailed case study write-ups, as included in the appendix of this project's Tech Memo 2 (dated May 31, 2012) may be included in the website as well, to provide a sample methodology and analytical framework.

5. Responding to Suggestions for Toolkit Modifications

The project team focused on gathering input and gauging interest during presentation sessions, which led to Toolkit improvements throughout the end of this project and suggestions for future work. Each group at the presentation sessions expressed unique ideas, although many agreed that using PET's back-end with their agency's own travel demand model (TDM) results appeared a commonly desired feature (in response, the project team recently integrated this feature as a full Toolkit capability). Other commenters expressed interest in a visualization module that was under development at the time, but is now complete, and should relieve some user-intensive network development and provide a greater sense of tangibility or familiarity to the Toolkit overall. Similarly, users were eager to try to the new Multi-Criteria Analysis Module (MCAM) and Budget Allocation Module (BAM), companion spreadsheets that will be posted on the PET website by the end of August. The MCAM prioritizes project alternatives based on a set of monetized and non-monetized costs and benefits (such as fatal crashes prevented, emissions reductions, and initial project costs), while the BAM recommends an optimal set of projects to be funded from many candidate projects, based on project costs and benefits, as well as funding constraints for project type, region, and available budget. Some suggestions for modifications reached beyond the reasonable scope of the Toolkit, namely use of PET for detailed, micro-network analyses on more local roads. Although discussed and considered by the team, concentrating work on this approach was deemed beyond the intentions of PET as a sketch-planning Toolkit (as local analyses would require such details as signal timing and very specific traffic behavior, which are generally not available for projects in the preliminary planning phase).

In addition to the comments gathered during the presentation sessions in May 2012, the project team sent follow-up emails to these attendees and other colleagues in public agencies, private industry, and research across the nation to gather further thoughts on PET and suggestions for future development and implementation. Comments were gathered from Texas MPOs, and federal agencies such as the Federal Transit Administration, Federal Highway Administration, and Victoria Transport Policy Institute. Many respondents found PET to be a unique tool that held great potential as a method of performance-based project analysis, especially when competing for project grants through current programs such as MAP-21.

6. Conclusion

This implementation project began critical outreach to public agencies by working directly with MPO staff, gathering critical feedback into the development of PET, and determining how the tool could be potentially integrated as part of each agency's planning software. By first developing base networks for major metro regions in the state, the research team provided a useful base for users to relate with presentations and better understand Toolkit functions and capabilities. Case studies helped to further provide learning material, while strengthening the Toolkit through repeated testing and debugging. With much-improved teaching materials, the research team was able to better showcase the Toolkit on multiple occasions and reach out to potential users across the state, interested in the tool for a variety of reasons. The presentations introduced PET to many planners who are considering using it for project analyses in the future, with further development and encouragement from the research team. The process has produced tangible results and positive feedback and has also highlighted areas for improvement for use by MPO staff in future use.

References Used for Case Study Analysis

CAMPO (2009) Traffic Counts: TxDOT Annual & CRTMA for 2008 – Austin-Round Rock MSA. Accessed online at: http://www.campotexas.org/pdfs/Traffic%20Counts%202008%20for%20website.pdf.

CAMPO (2010) Regional Transportation Plan. Capital Area Metropolitan Planning Organization. May, 2010.

Fagnant, Daniel and Kara Kockelman (2012) Anticipating Roadway Expansion and Tolling Impacts: A Toolkit for Abstracted Networks. Under review for publication in *Transportation Research Record*.

Florida Department of Transportation (2011) Preliminary Estimates Section Transportation Costs. Annual Roadway Construction Costs, revised December 2011.

Florida Department of Transportation (2012) Generic Cost Per Mile Models. Updates March 16, 2012. Available at ftp://ftp.dot.state.fl.us/LTS/CO/Estimates/CPM/summary.pdf.

Harris County Toll Road Authority (HCTRA) (2012) Projects Under Construction – Hempstead/US 290 Managed Lanes. Available at https://www.hctra.org/about_construction2/hempsteadus-290-managed-lanes.html.

Houston-Galveston Area Council (2012) 2013-2016 Transportation Improvement Program (TIP). March 7, 2012. Available at http://www.h-gac.com/taq/tip.

LBJ Group (2012) LBJ Express FAQ. Available at http://lbjexpress.com/FAQs.asp.

Lomax, T., B. Stockton, D. Ellis, and P. Lasley (2012) Mobility Investment Priorities Project: Early Recommendation Report. Texas Transportation Institute.

NCTCOG (2007) Managed Lane Policies. Available at http://www.nctcog.org/trans/committees/rtc/ManagedLanePolicies_091307.pdf.

NTTA (2011) NTTA Toll Rates. North Texas Tollway Authority. Available online at https://www.ntta.org/roadsprojects/rates/Documents/TollRateChart122011.pdf.

TxDOT (2007) US 290 Corridor, From FM 2920 to IH 610. Draft Environmental Impact Statement. Available online at http://mobility.tamu.edu/mip/pdfs/MIP-Early-Recommendations-Report-Summary.pdf

TxDOT (2008) IH 35E Managed Lanes Preliminary Financial Feasibility Study, Final Draft. September 1, 2008.

TxDOT (2010) Segment 3 My35. Available at http://ftp.dot.state.tx.us/pub/txdot-info/pub_inv/committees/segment3/workshops/projects.pdf.

TxDOT (2012a) US 183 South Project – Purpose and Need. Accessed April 2012. Available online at http://www.txdot.gov/inside-txdot/projects/studies/austin/us183.html.

TxDOT (2012b) LBJ Express Project Tracker. Spring 2012. Available at http://ftp.dot.state.tx.us/pub/txdot-info/dal/lbj_tracker.pdf

TTI (2011) Congested Corridors Report. Texas Transportation Institute.

Appendix A: Detailed Case Study Documentation

This appendix contains detailed analysis of case studies performed on abstracted Austin, DFW, and Houston networks. Each section presents detailed methodology and results for each case study.

1. LBJ Express Case Study on DFW Network for NCTCOG

Introduction

The LBJ Express managed lanes project in Dallas was examined with PET for training of and presentation to North Central Texas Council of Governments (NCTCOG) modeling and planning staff. The LBJ Express project includes capacity expansion on IH 35E and IH 635 northwest of Dallas. Modeling these projects provides useful, pertinent examples for Toolkit users in analyzing managed toll facilities and generates valuable training materials for PET as well.

IH 635 LBJ Managed Lanes

Thirteen miles of managed lanes are being added on IH 35E (from IH 635 to Loop 12) and on IH 635 (from IH 35E to US 75) in northwest Dallas County. A comprehensive development agreement was executed for the project in 2009 and construction began in early 2011. With total project costs well over $2 billion, the project is a major infrastructure investment and will provide significant capacity expansion on the DFW freeway network. Major capacity expansion projects are ideally suited for PET and this project (although already in the first stages of construction) provides a perfect opportunity to showcase the Toolkit’s capabilities. PET was developed specifically to handle dynamic toll pricing (e.g., tolling by vehicle class and time of day) and this project provides an excellent real-world application of pricing comparisons on a new managed lane facility. The case study presents three alternative pricing strategies for LBJ; straight tolls that do not vary by vehicle class or time of day, tolls that vary by vehicle class only, and tolls that vary by both vehicle class and time of day.

Modeling in PET

The DFW network was created in 2011 and refined in 2012, while analyzing case studies. It includes major road networks (freeways, toll roads, and important major and minor arterials). Testing throughout the early part of 2012 helped calibrate and debug the network. Figure A1 shows the abstracted network.

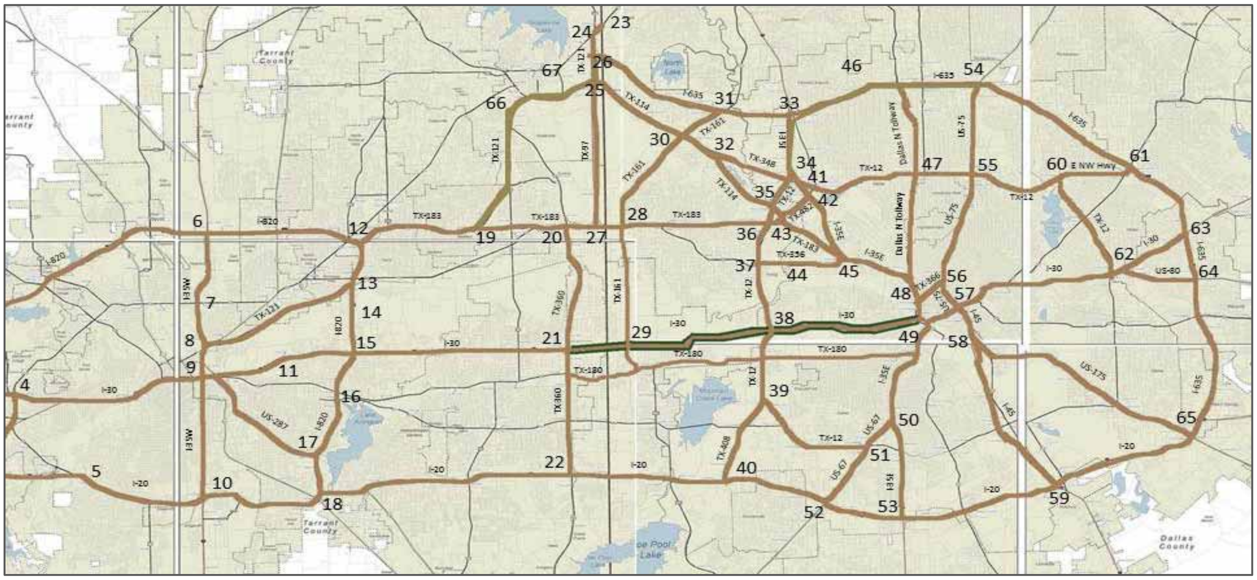


Figure A1: DFW PET Network, with Numbered Nodes and Abstracted Links (Thickened Lines)

In order to model separate managed lanes, additional links must be added that run adjacent the "free" main lanes. This allows the user to change toll prices only on managed lanes, leaving main lanes as a free network route. The added links must not share both start and end nodes of adjacent links, as this cannot be interpreted by the TDM. Therefore, new managed lane nodes are created, very close (0.1 miles or so) to main lane start and end nodes. Figure A2 shows the managed lane nodes in green, very close to main lane nodes, which are in orange.

For this project, four new nodes were added (71, 72, 73, and 74), shown in Figure A2. These nodes were located 0.1 miles from the original IH 635 nodes and on connecting roads (TX 12, IH 35E, Dallas North Tollway, and US 75). It is important to properly connect the new managed lane nodes to the rest of the network, or else the TDM will fail to recognize the managed lanes as a feasible route. Best practice is to place the managed lanes node along a connecting link, 0.1 miles before connecting with the old main-lane link. With the new managed-lane node, a link connects nodes 47 and 71, then 71 to 34 (0.1 mile link), rather than connecting node 47 directly with node 34, illustrated in Figure A2. This avoids creating a single spur from a node connecting the new toll links, which showed poor results in initial modeling.

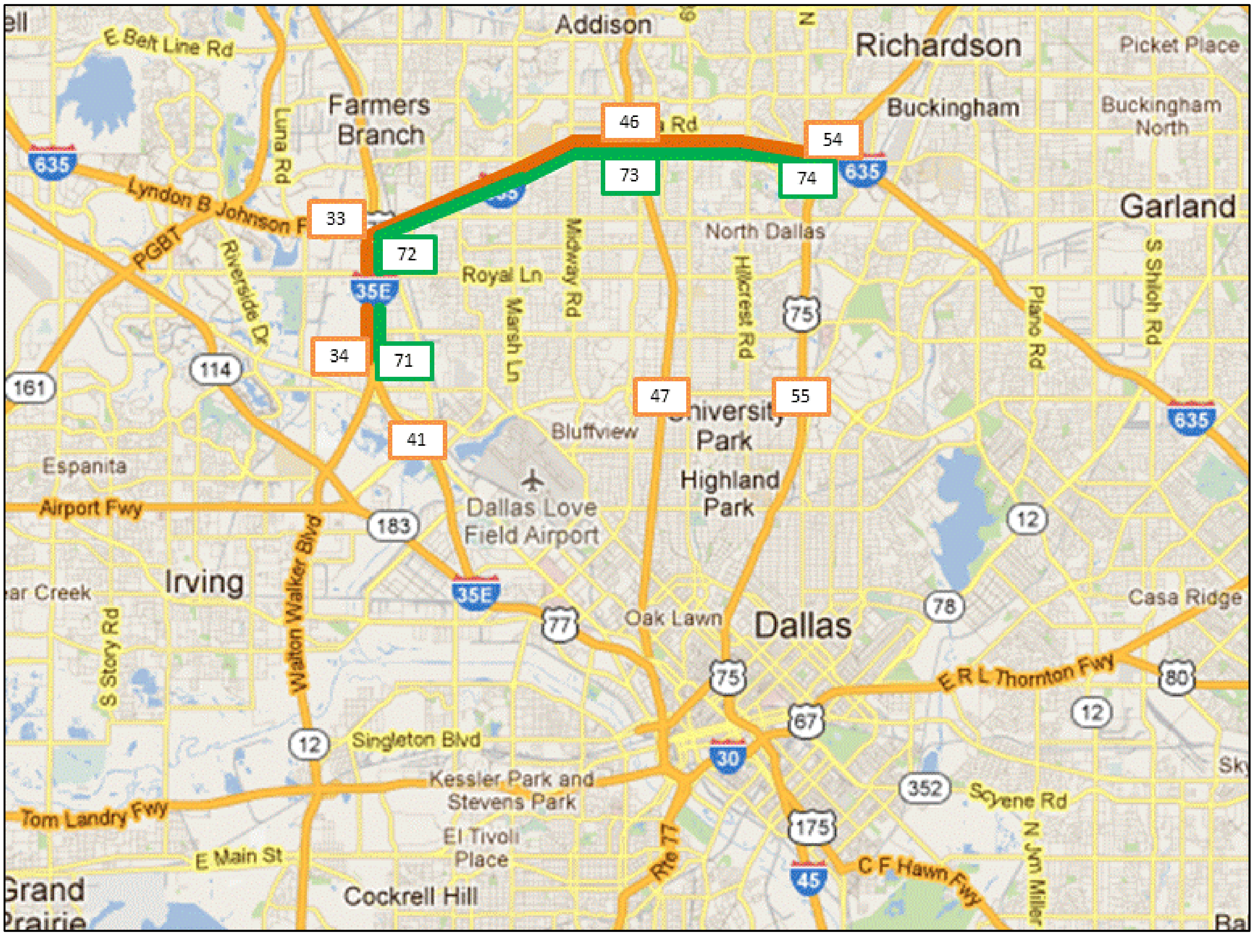


Figure A2: LBJ Express Links and Nodes for DFW Abstracted Network, with Adjacent Nodes Included

It should also be noted that some network alterations helped return more reasonable data. If adding capacity on the edge of networks, extra links beyond this boundary can help avoid bias in the TDM. For instance, to model this specific section of IH 635, extensions of IH 35E, the Dallas North Tollway, and US 75 were extended for one mile north of the IH 635 intersection.

Project Costs

Total costs are estimated by TxDOT and the LBJ comprehensive development agreement to be $2.6 billion (of which only $490 million is provided by TxDOT/public funds) (TxDOT 2012). Annual maintenance is taken to be $1.7 million and handled by the developer, for a term of 52 years (TxDOT 2012). PET allows very specific cost estimates (construction cost per lane mile, ITS/signal/electrical, bridges and structures, utilities and fixed costs, traffic control, environmental construction, ROW purchase, and more), but this data is not necessary, since only total costs are used for financing calculations in PET. Therefore, all values in the Engineer's Estimate spreadsheet are selected to equal a final value close to the estimated $2.6 billion total costs. (Actual total initial project costs are $2.7 million for all alternatives.) Maintenance is assumed at per/lane-mile rates estimated from the *IH 35 Managed Lanes Feasibility Study* (TxDOT 2008). Maintenance costs of managed lanes are given at $68,000 per year. Total lane miles are calculated to be 95 miles, including the six-lane facility for 2.5 miles along IH 35E and the eight-lane facility along 10 miles of IH 635. Total annual maintenance costs are therefore estimated at $6.46 million for all alternatives. Interim projects were also assumed for both the base case and for all alternatives, since some sort of rehabilitation would likely be required over the 50-year project life. The *IH 35 Managed Lanes Feasibility Study* (TxDOT 2008) includes a major pavement rehabilitation project 35 years after construction at $160 million, which is assumed for this project as well. A rehabilitation project is assumed to be required earlier for the GP lanes (2025) at the same cost of $160 million.

Toll Rates

LBJ tolls will be flat and fixed for the first 6 months after construction, then vary by time of day and demand, in an attempt to maintain 50 mph free-flow speed (LBJ Group 2012). Designers claim that tolls will range from $0.15 to $0.55 per mile. This type of dynamic tolling cannot truly be modeled by the Toolkit, but toll rates can be separately controlled for vehicle classes and times of day. Truck toll rates are four times passenger vehicle rates, based on current North Texas Toll Authority (NTTA 2011) data. Toll rate configurations for PET vary across scenarios as shown in Table A1 for peak hours (AM, Mid-Day, PM, and Evening).

Table A1: LBJ Express Tolling Rates for PET Alternatives

	Alternative 1	**Alternative 2**	**Alternative 3**
Single Occupant Vehicle	$0.55	$0.55	$0.55
2 Occupant Vehicle	$0.28	$0.00	$0.55
3+ Occupant Vehicle	$0.28	$0.00	$0.55
Transit	$0.00	$0.00	$0.55
Heavy Truck	$2.20	$2.20	$2.20

During off-peak hours (7 PM to 5 AM), SOV rates are reduced 50% to match HOV rates ($0.28/mi). Alternative 1 is the proposed pricing strategy under NCTCOG managed lane policy and is compared to other potential strategies—alternatives 2 and 3, which represent free HOV travel and flat rates across all vehicle classes, respectively.

Results

The resulting alternative scenarios yielded similar results overall, with positive traveler benefits and financing values, indicating that the project (regardless of lane pricing specifics) will benefit the region. Table A2 contains the outputs from PET:

Table A2: Project Financing for IH 635 Alternatives (Includes Traveler Welfare, Reliability, and Crashes)

	No Build	**I-635 HOT**	**I-635 HOT (free**	**I-635 Flat**
Net Present Value	$0	$1,843B	$5,103B	$1,551B
Internal Rate of Return	N/A	9.37%	13.78%	9.38%
Benefit/Cost Ratio	N/A	1.69	2.90	1.58
Payback Period	N/A	16.6	9.6	15.1

These results include measures of traveler welfare, reliability, and crash costs over the design life of 50 years. In this analysis the HOV alternative yields highest IRR and benefit/cost (B/C) ratio, as well as the shortest payback period, mostly from traveler welfare increases. Though the fewest tolls are collected in this alternative (see Table A3), project impacts greatly benefit travelers over the project life.

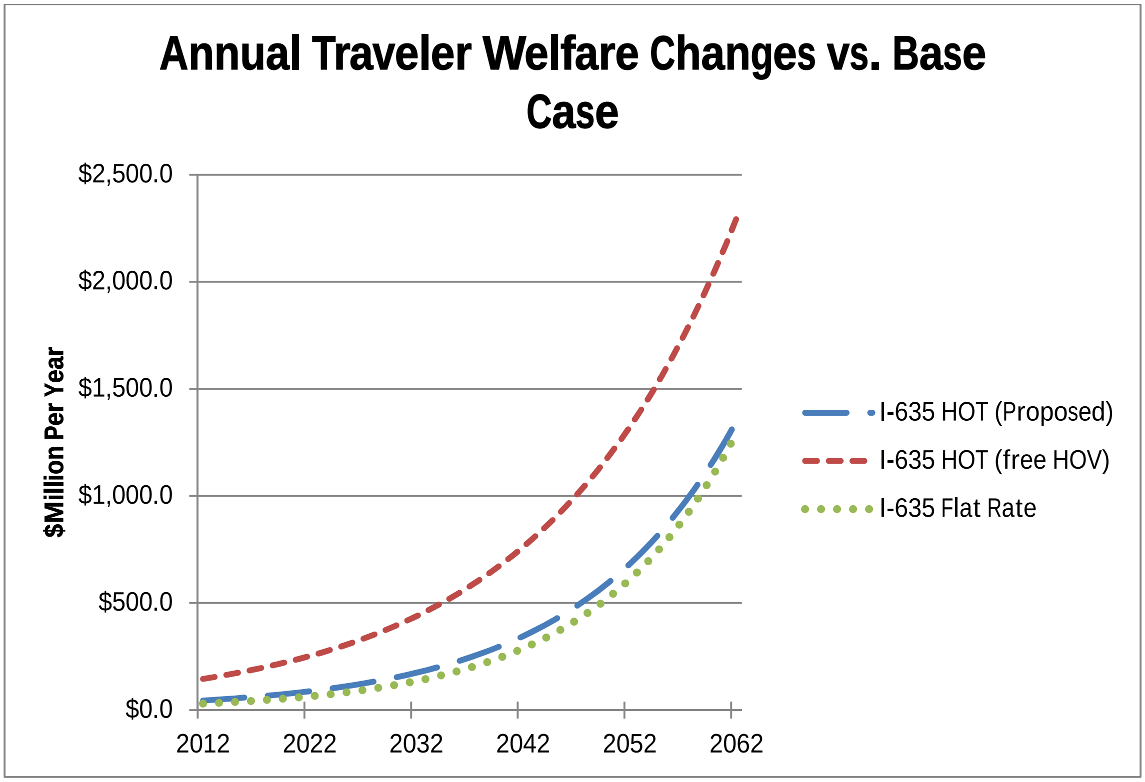
Table A3: Project Impacts Estimates for LBJ Express Analysis

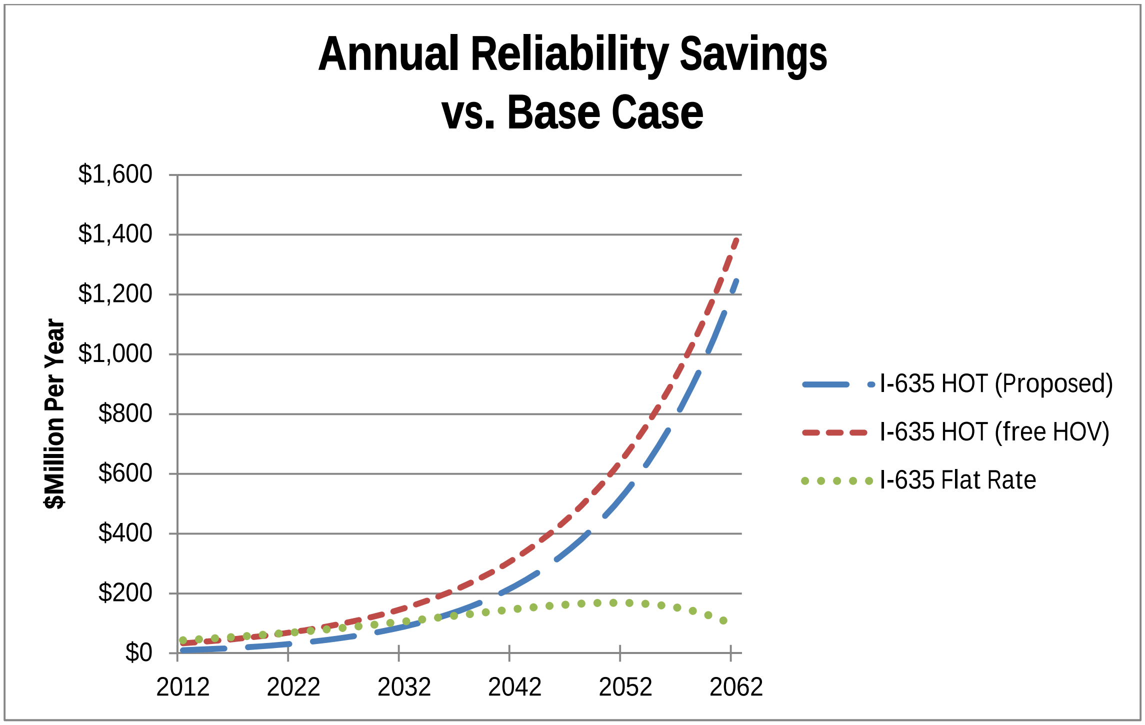
Project Financing (Thousands $)	**No Build**	**I-635 HOT (Proposed)**	**I-635 HOT (free HOV)**	**I-635 Flat Rate**
NPV of New Tolling Revenues	$0	$866K	$206K	$1.2M
NPV of Initial and Future Project	$0	$2.7M	$2.7M	$2.7M
Project Financing Perspective NPV	$0	-$1.8M	-$2.5M	-$1.5M
Project Financing Perspective IRR	N/A	2.8%	N/A	3.9%
Project Financing Perspective PP	N/A	> 50 years	> 50 years	> 50 years

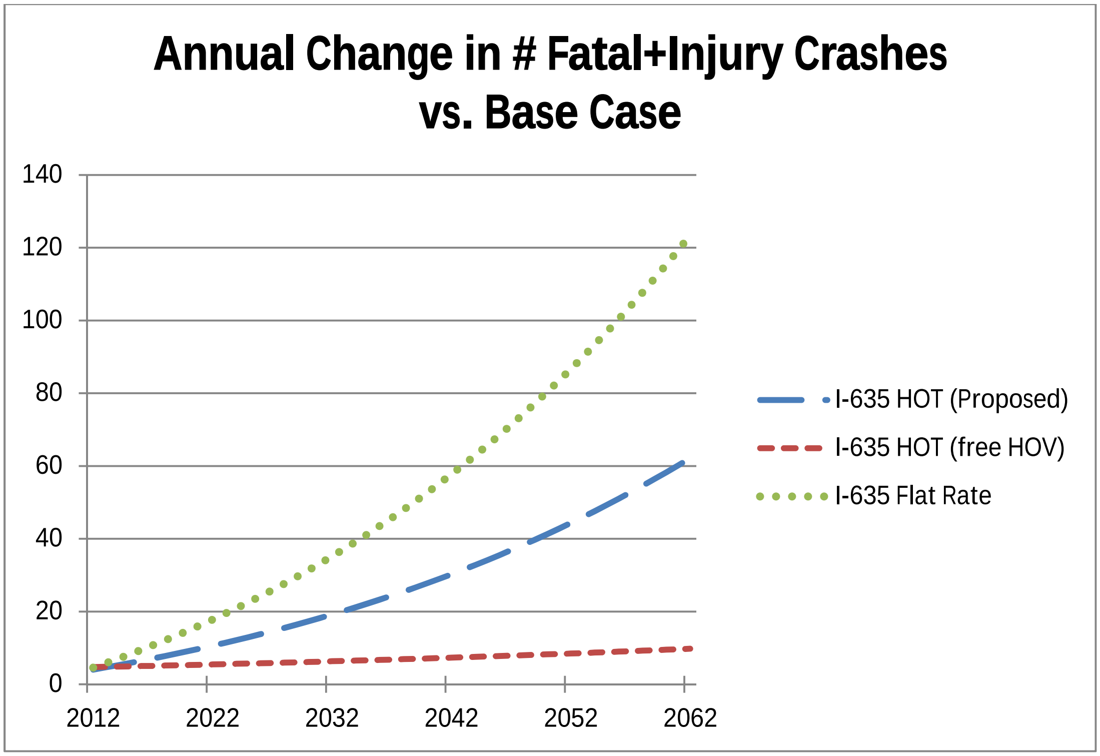
Of course, PET currently assumes a toll rate that does not vary with analysis year. Daily average free-flow speed on the toll links are kept at a constant 55 mph. If a dynamic pricing strategy were employed as suggested for the actual project (allowing more traffic optimizes the system at average daily speeds of 50 mph) and design year toll rates were included, toll revenues may actually cover project costs over a 50-year analysis period. From this preliminary study, however, the HOV alignment appears to generate the greatest traveler benefits; the flat-rate tolling, while still providing substantial traveler benefits, would yield much greater tolling revenues. Overall, every tolling strategy alternative provides project benefits that justify the project cost.

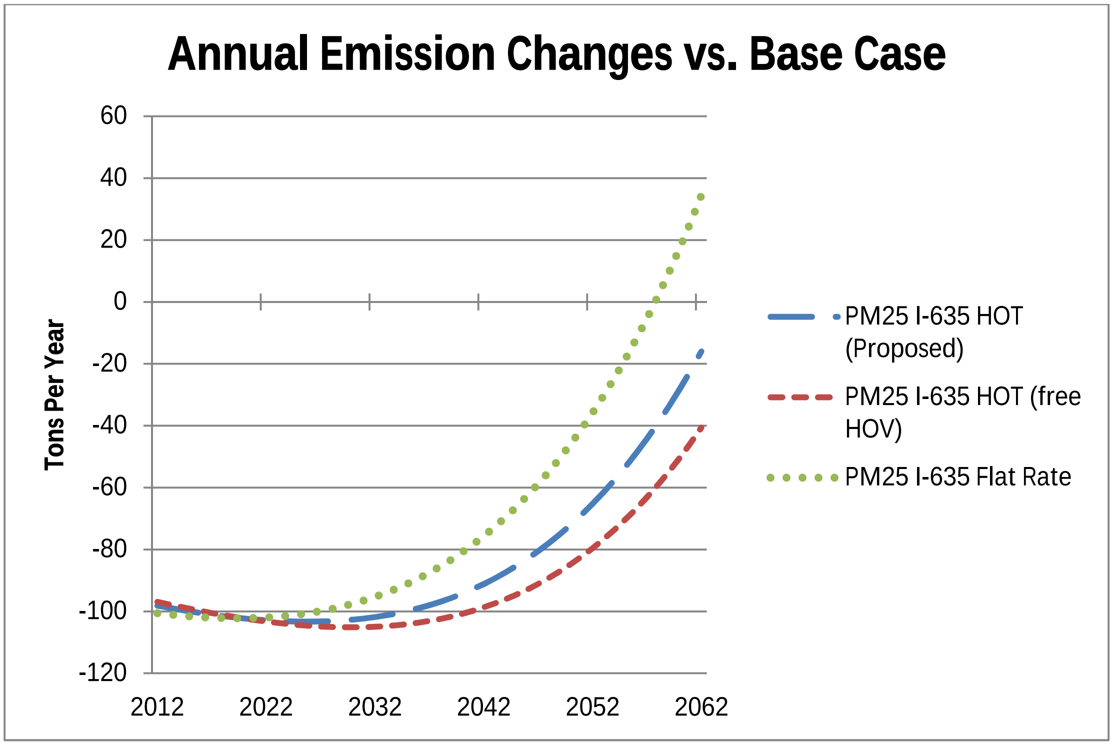
Charts

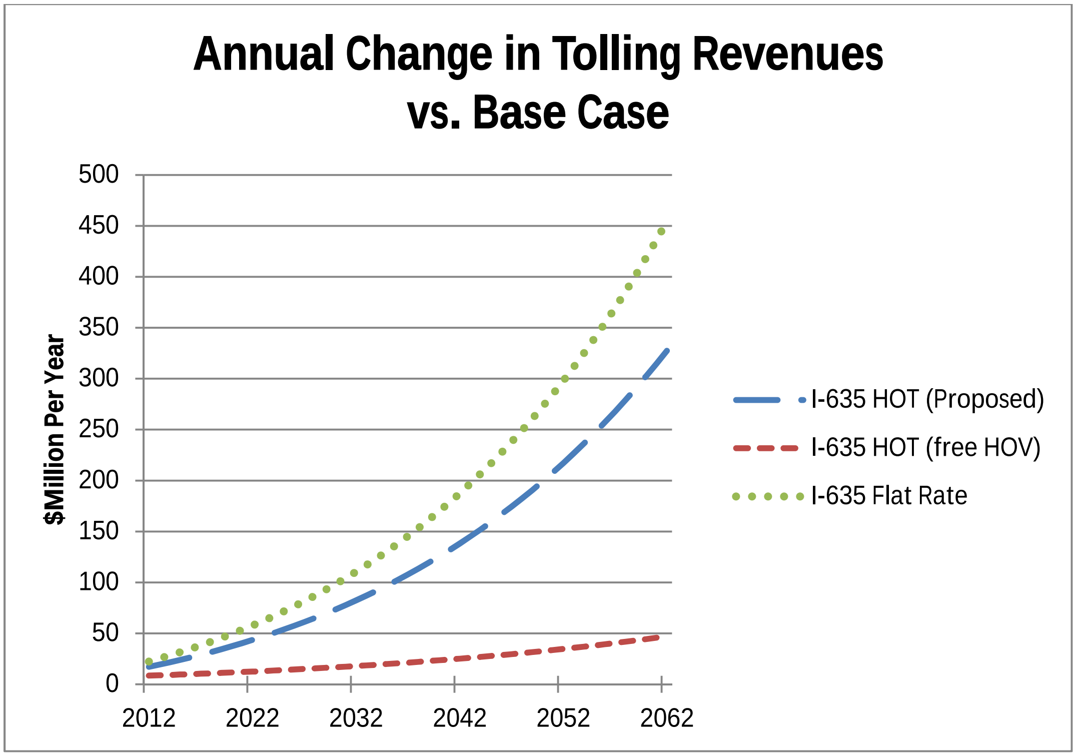
The following pages present several charts automatically created in PET for the **LBJ Express** analysis. These charts provide an additional resource for analyzing results and comparing trends over time.

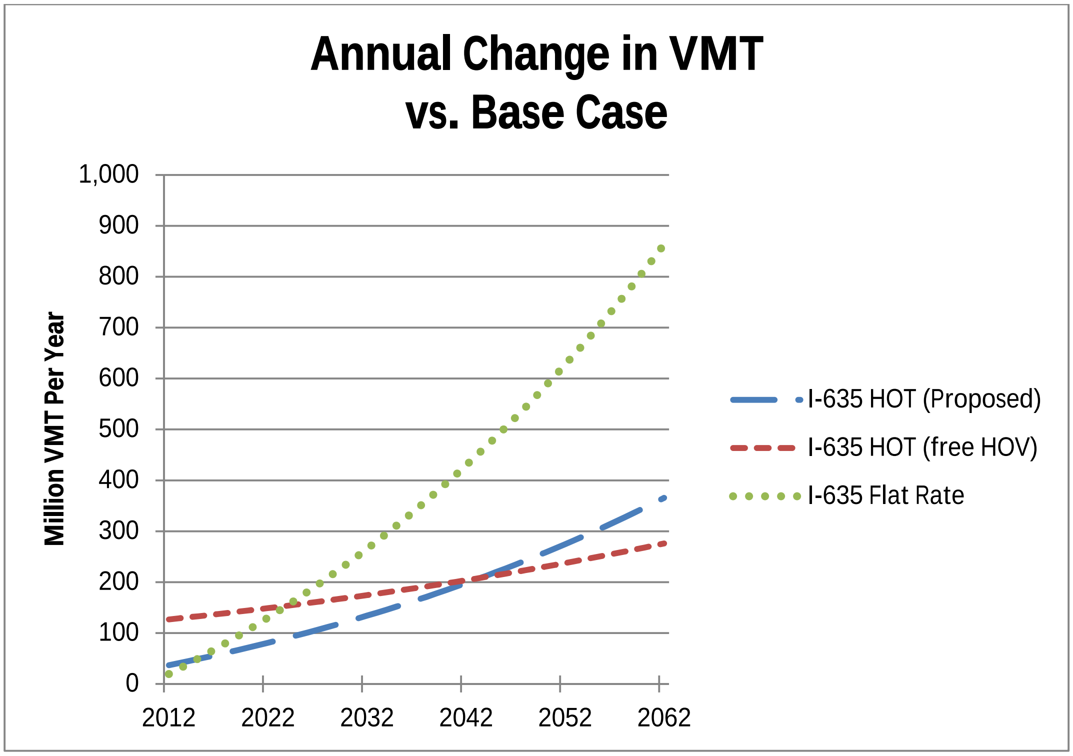

Annual Traveler Welfare Changes vs. Base Case
$Million Per Year
$2,500.0
$2,000.0
$1,500.0
$1,000.0
$500.0
$0.0
2012
2022
2032
2042
2052
2062
I-635 HOT (Proposed)
I-635 HOT (free HOV)
I-635 Flat Rate


Annual Reliability Savings vs. Base Case
$Million Per Year
$1,600
$1,400
$1,200
$1,000
$800
$600
$400
$200
$0
2012
2022
2032
2042
2052
2062
I-635 HOT (Proposed)
I-635 HOT (free HOV)
I-635 Flat Rate


Annual Change in # Fatal+Injury Crashes vs. Base Case
140
120
100
80
60
40
20
0
2012
2022
2032
2042
2052
2062
I-635 HOT (Proposed)
I-635 HOT (free HOV)
I-635 Flat Rate


Annual Emission Changes vs. Base Case
Tons Per Year
60
40
20
0
-20
-40
-60
-80
-100
-120
2012
2022
2032
2042
2052
2062
PM25 I-635 HOT (Proposed)
PM25 I-635 HOT (free HOV)
PM25 I-635 Flat Rate


Annual Change in Tolling Revenues
vs. Base Case
$Million Per Year
500
450
400
350
300
250
200
150
100
50
0
2012
2022
2032
2042
2052
2062
I-635 HOT (Proposed)
I-635 HOT (free HOV)
I-635 Flat Rate


Annual Change in VMT
vs. Base Case
Million VMT Per Year
1,000
900
800
700
600
500
400
300
200
100
0
2012
2022
2032
2042
2052
2062
I-635 HOT (Proposed)
I-635 HOT (free HOV)
I-635 Flat Rate

2. US 183 Case Study on Austin Network for CAMPO

Introduction

TxDOT and CAMPO are planning upgrades to US 183 from US 290 to SH 71 in southeast Austin, likely beginning in 2015. TxDOT (2012) claims that traffic on this roadway has nearly tripled since 1990 and is projected to double or nearly triple again by 2030. Crashes in the area are also higher than statewide averages for urban divided roadways (TxDOT 2012). CAMPO considers US 183 a key connection for mobility and includes the route in the future network of toll roads throughout Travis and Williamson counties (CAMPO 2010). TxDOT's current plans for this 7-mile stretch include upgrades to a six-to-eight lane tolled facility with three non-tolled frontage roads in each direction. This preference was created in PET by modeling separate links for the new toll lanes.

Separate links for the US 183 toll facility were created as a means of more accurately representing the project and allowing managed-lanes modeling. Links running parallel to the previous US 183 links were created, with short connector links (0.1 mile in length) acting as on- and off-ramps between them, as shown in Figure A3. The toll facility was "inserted" into the network from Cameron Road to SH 71, for a total of 8 miles. Ramp links were placed at all points where US 183 normally intersected other links of the network (e.g., FM 969, Airport Boulevard, Cesar Chavez, and SH 71).

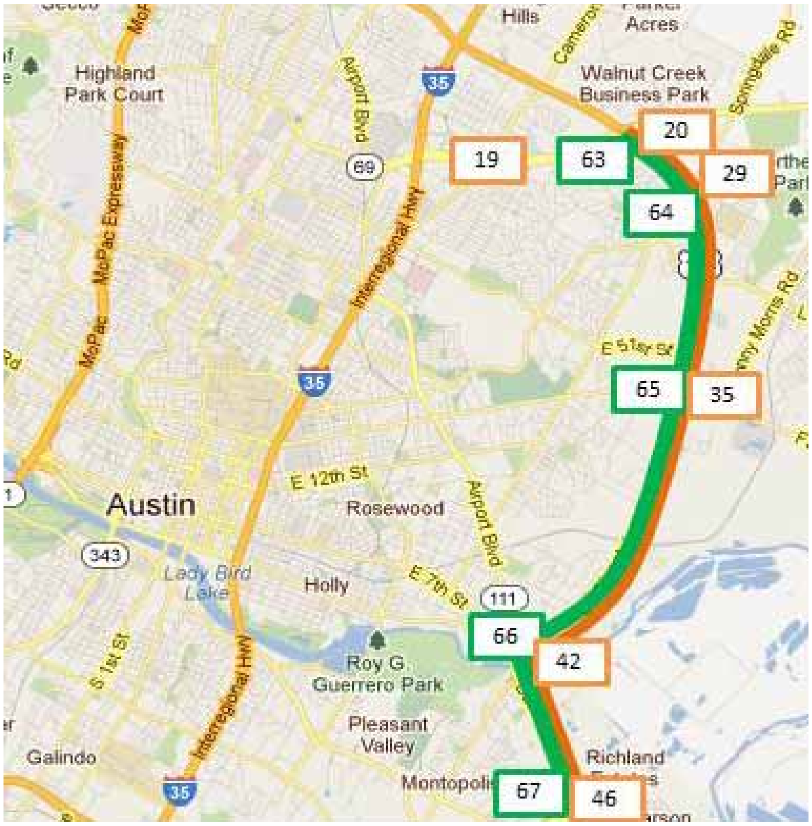


Figure A3: US 183 Links and Nodes

The Engineer's Estimate spreadsheet handles most major accounting for project costs and economic analysis in PET. Since this is a sketch toolkit, these numbers are quite rough estimates, as approximated from early projected costs from TxDOT and CAMPO. CAMPO's 2035 plan divides the US 183 toll project into two segments: (1) Springdale Road to Boggy Creek (2 miles north of the Airport Boulevard/Cesar Chavez confluence) and (2) Boggy Creek to Patton Avenue (near SH 71). Segments 1 and 2 are slated to be complete by 2017 and 2022, and projected to cost $288.2 million and $320.5 million, respectively (CAMPO 2010). These costs include engineering, ROW acquisition, utility relocation, and construction costs of six tolled lanes and three frontage roads, totaling just over $600 million dollars. TAMU's 2012 Mobility Report (Lomax et al. 2012) reports an expected price range of $550 million to $800 million, but the details behind this estimate are not provided.

Alternatives 2 and 3: HOT and HOV Toll Facilities

This scenario converts existing 183 from a partial freeway/arterial to a full free facility from IH 35 to TX 71, near Austin-Bergstrom International Airport. In PET, this required changing the link class for eight links (four directional segments) and adding one extra lane for a distance of 8 miles. The facility is currently partial freeway, but has some direct access to cross streets. In addition to added lanes, some at-grade separation might be necessary to maintain connectivity, specifically at Loyola Lane and either Hudson Street, Bluestein Drive, or Techni Center Drive. The Florida DOT (FDOT 2011) estimated $150/ft^2 for overpass construction. Assuming a 1000 ft. overpass length with a cross section of 100 ft. (six 12-foot lanes with an 8-foot divided median and a 10-foot outside median). This totals $15 million per overpass. Widening costs for this alternative are estimated at $3.9 million per mile, based on the Florida DOT's (2008) generic cost-per-mile models (FDOT 2011). Added to this expense are likely right-of-way (ROW) purchase costs, which are assumed rather arbitrarily given the discrepancies between TxDOT and CAMPO estimates for the toll projects. TxDOT (2010) estimates, which do not include ROW costs, are about $200 million to $350 million lower than CAMPO (2010) estimates, which do include ROW considerations. Similar ROW would be required for a freeway conversion, in terms of new frontage roads and space required for overpasses, so a ROW cost of $250 million is assumed for this alternative. In addition to initial construction costs, annual maintenance costs are taken to be $1.3 million, based on TxDOT (2008) estimates for general-purpose lane maintenance costs.

Alternative 2: HOT

This alternative models the addition of a six-lane toll facility added adjacent the US 183 GP lanes, for the same geographical scope as Alternative 1. Three directional links are added to the Austin network alongside the general-purpose lanes. These links are added in all scenarios, but capacity is set at 1 in the base case and Alternative 1. To avoid computation problems with the TDM, total number of network links must remain constant throughout all alternative networks. By setting capacity to 1, the link is effectively closed off in scenarios where it is not applicable. Capacity of 1 is used in place of 0, since zero-capacity values may return errors in the TDM or within Toolkit spreadsheets.

TxDOT (2010) estimates project cost at $250 million to $400 million, not including any ROW purchase, while CAMPO (2010) has estimated a total of over $600 million, including ROW costs. CAMPO (2010) estimates are used since they include more in-depth analysis and more measures (like ROW costs). Final project cost as entered in the Toolkit is just below $655 million. Annual maintenance costs are estimated at $3.3 million based on TxDOT (2008) feasibility study estimates for managed-lane maintenance costs. Toll lane pricing Alternative 2 is set to $0.50/mi. for SOV, $0.25/mi. for HOV, transit free and $2.00/mi. for trucks. Alternative 3 is identical to Alternative 2 in every way except toll pricing, which exempts all HOV from tolls. This comparison enables a finer evaluation of tolling policy impacts on the project and allows a broader evaluation of the tollway construction project

Preliminary Results and Issues

When running this case study, ramp capacity initially restricted access to toll links, resulting in virtually no volume on toll links and very slow average daily link speeds (less than 10 mph on some links). When capacity was increased on these ramp sections (up to 5,730 passenger car per hour), more travelers used the toll facility, which greatly increased free-flow speed along the GP lanes. For instance, the most congested link (Martin Luther King Jr. to Springdale Road) saw average PM-peak speeds around 6 mph in design year, while the toll scenarios increased this average speed to around 35 mph on GP lanes with increased ramp capacity. The tolled links maintained PM-peak free-flow speeds of around 45 mph.

Results

Over a 30-year period, Alternatives 2 and 3 appear to generate enough toll revenue ($900 million to $1,100 million) to pay for project costs, as shown in Table A4, but these may not be entirely correct. Alternative 1 also results in increased toll rates (nearly $400 M), which is an inaccurate result; the freeway expansion should not result in significant toll revenue generation since no lane-pricing changes were made to this scenario. The TDM seems to be generating excessive trips from all of the most external network nodes in alternate scenarios, some of which are on toll roads. This leads to an artificial increase in toll revenues across the entire network. Despite this, it is clear that the toll links do provide some revenue relative to the freeway scenario (which is generating likely artificial new revenue of nearly $400 million). Relative to this, the HOT and HOV lanes are actually generating revenues closer to $500 million to $700 million. With toll project costs at over $650 million, these actual tolling revenues may not necessarily cover project costs. To conclusively state that tolling revenues do or do not cover project costs, the TDM calculations must be examined in more detail. Dr. Boyles is currently assessing these results and making changes to the TDM. While this issue has not occurred on other networks, it may be an improvement that makes all analyses on other networks more accurate and robust.

Table A4: Project Financing Summary Measures for US 183

	No Build	**US 183 Freeway**	**US 183 HOT**	**US 183 HOV**
NPV of New Tolling Revenues	$0	$397.4K	$1,1M	$912.4K
NPV of Initial and Future Project Costs	$0	$340.7K	$654.7K	$654.7K
Project Financing Perspective NPV	$0	$56.6K	$456.1K	$257.7K
Project Financing Perspective IRR	N/A	7.1%	11.1%	8.9%
Project Financing Perspective PP	N/A	20.9	13.7	17.1

Project impacts provide another important metric besides tolling revenues. Both the freeway expansion and the HOV alternative provide substantial traveler benefits ($3.5 million and $4.4 million respectively). The HOT scenario provides fewer benefits ($1.1 million) and in fact returns a B/C ratio just less than 1, as seen in Table A5.

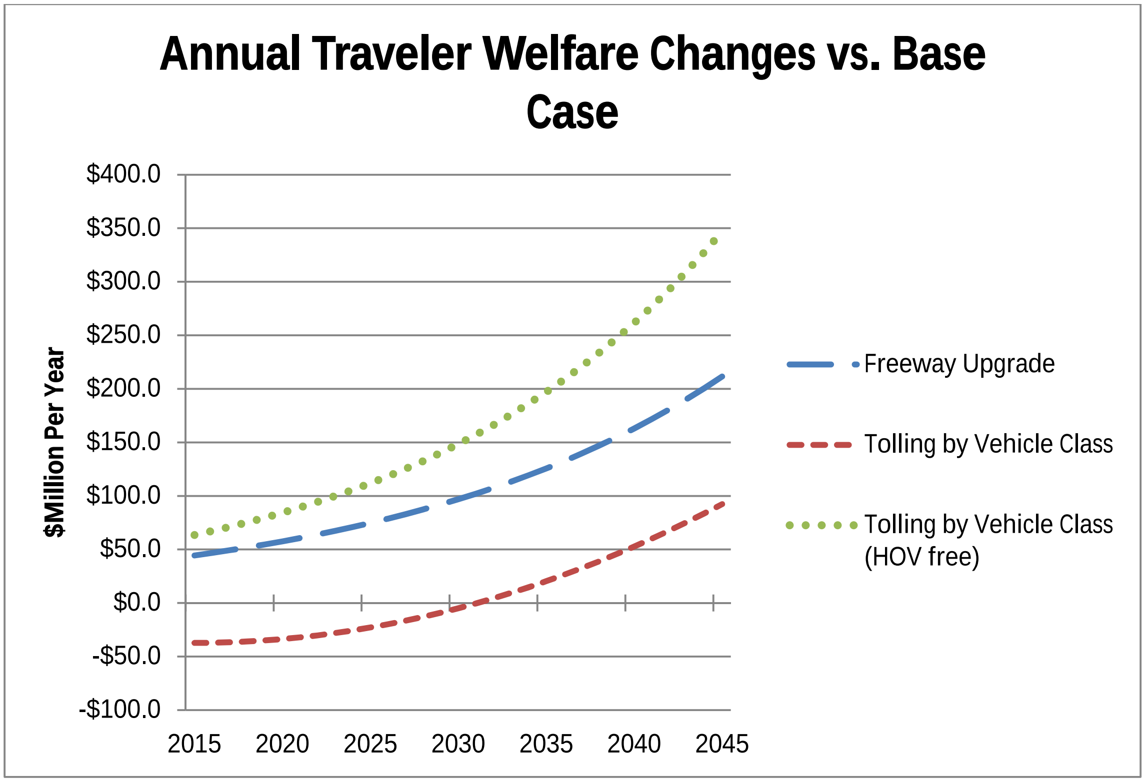
Table A5: Traveler Benefits Summary Measures for US 183

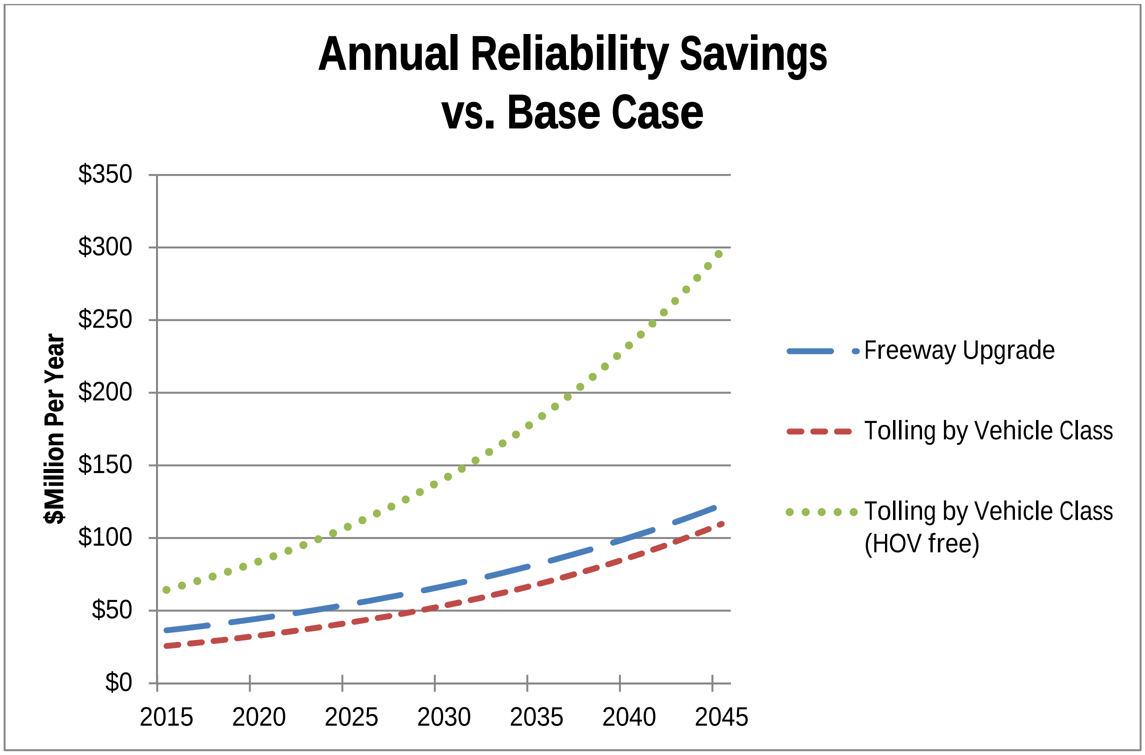
	No Build	**US 183 Freeway**	**US 183 HOT**	**US 183 HOV**
Net Present Value	$0	$3.53B	$1.16B	$4.39B
Internal Rate of Return	N/A	106.7%	13.9%	45.4%
Benefit/Cost Ratio	N/A	11.37	2.77	7.71
Payback Period	N/A	1.0 yrs.	9.2 yrs.	2.4 yrs.

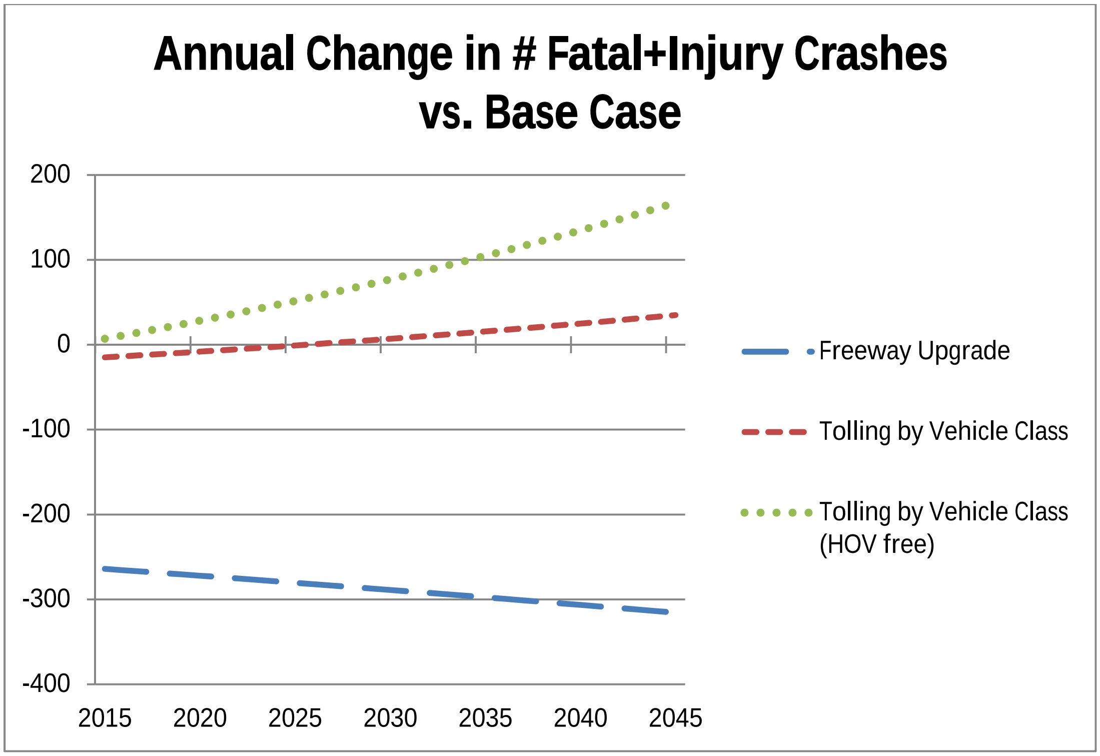
From these comparisons, it appears that the freeway expansion and tolling with HOV are the strongest projects for consideration. These two projects (Alternatives 1 and 3) provide the greatest benefit to travelers by reducing congestion and reducing travel costs; link-volume comparison shows these alternatives increase free-flow speed on either the GP lanes or new toll links. As a lower cost project, the freeway expansion project would return increased traveler impacts, but the toll alignment may produce different results on a longer scale. While these results appear encouraging, it is cautioned again that results are skewed by inaccurate toll revenues.

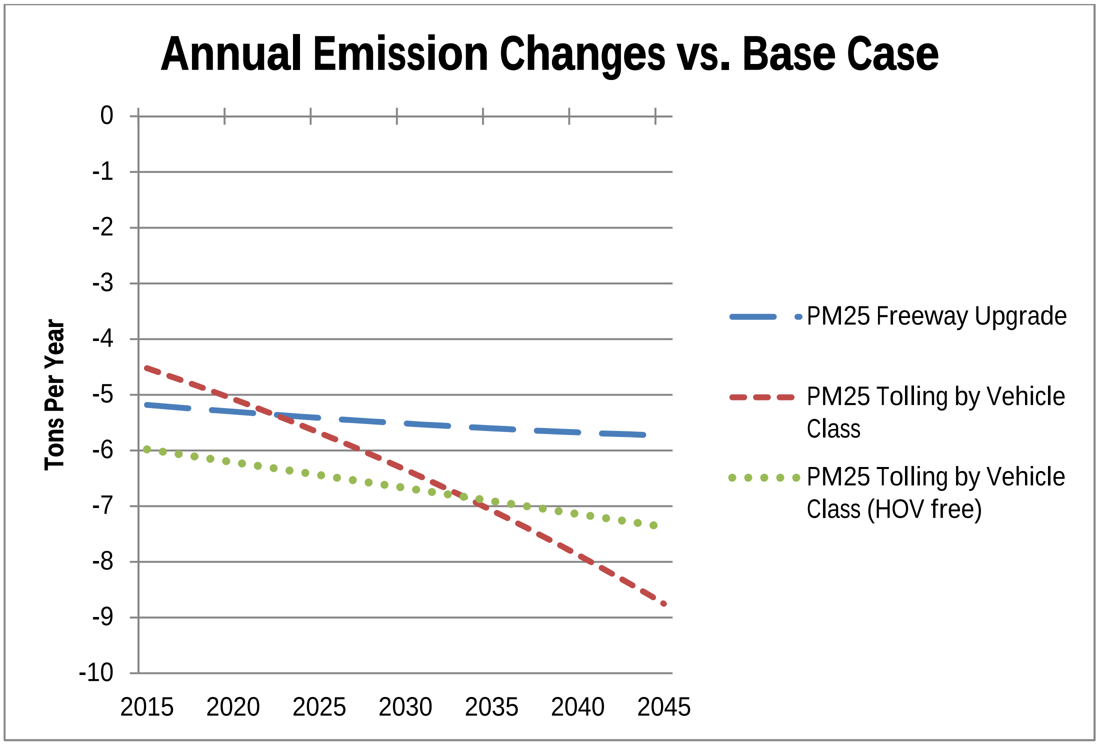
Charts

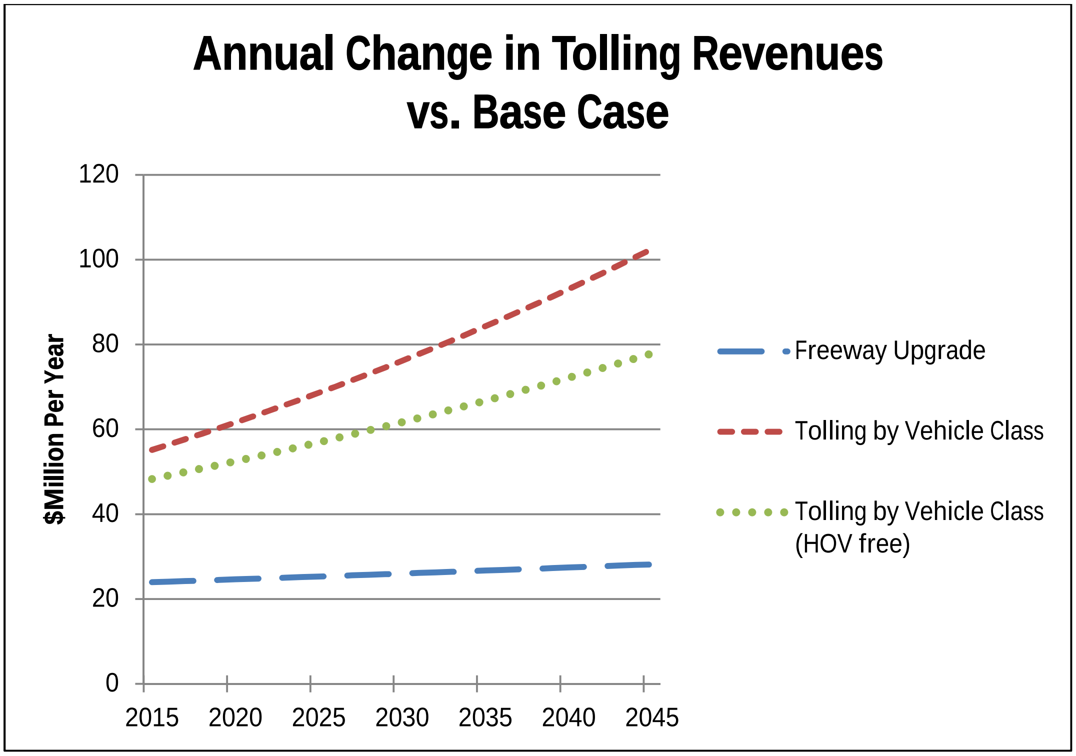
The following pages present several charts automatically created in PET for the **US 183** analysis. These charts provide an additional resource for analyzing results and comparing trends over time.

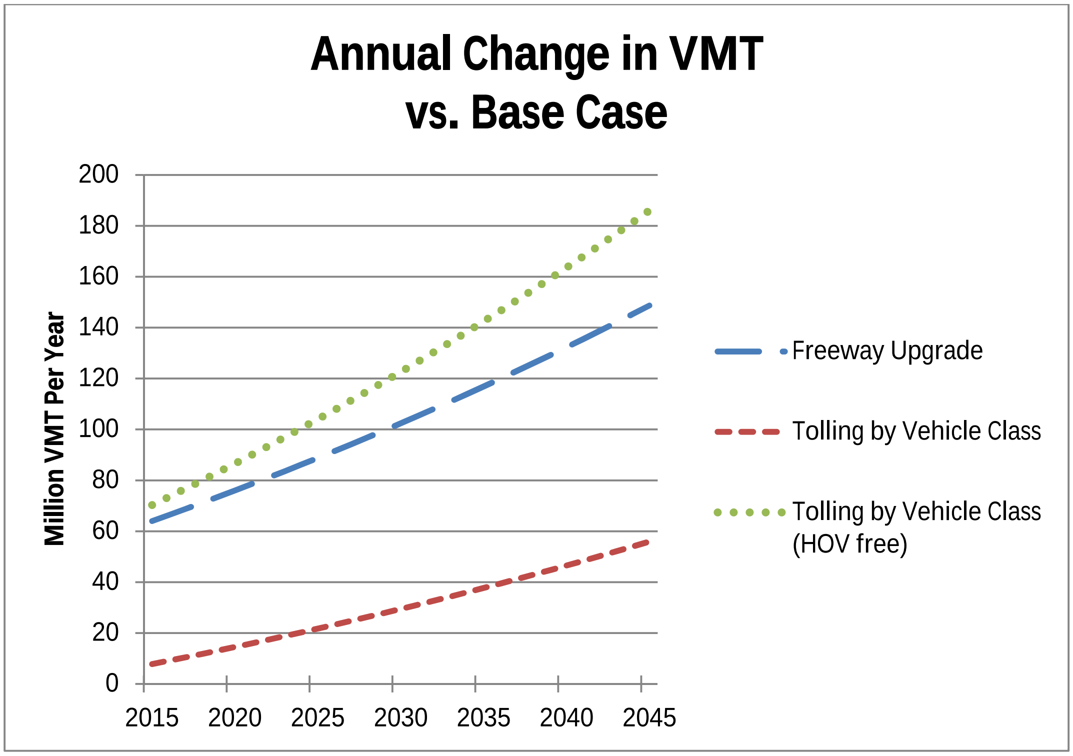

Annual Traveler Welfare Changes vs. Base Case
$Million Per Year
$400.0
$350.0
$300.0
$250.0
$200.0
$150.0
$100.0
$50.0
$0.0
-$50.0
-$100.0
2015
2020
2025
2030
2035
2040
2045
Freeway Upgrade
Tolling by Vehicle Class
Tolling by Vehicle Class (HOV free)


Annual Reliability Savings vs. Base Case
$Million Per Year
$350
$300
$250
$200
$150
$100
$50
$0
2015
2020
2025
2030
2035
2040
2045
Freeway Upgrade
Tolling by Vehicle Class
Tolling by Vehicle Class (HOV free)


Annual Change in # Fatal+Injury Crashes vs. Base Case
200
100
0
-100
-200
-300
-400
2015
2020
2025
2030
2035
2040
2045
Freeway Upgrade
Tolling by Vehicle Class
Tolling by Vehicle Class (HOV free)


Annual Emission Changes vs. Base Case
Tons Per Year
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
2015
2020
2025
2030
2035
2040
2045
PM25 Freeway Upgrade
PM25 Tolling by Vehicle Class
PM25 Tolling by Vehicle Class (HOV free)


Annual Change in Tolling Revenues
vs. Base Case
$Million Per Year
120
100
80
60
40
20
0
2015
2020
2025
2030
2035
2040
2045
Freeway Upgrade
Tolling by Vehicle Class
Tolling by Vehicle Class (HOV free)


Annual Change in VMT
vs. Base Case
Million VMT Per Year
200
180
160
140
120
100
80
60
40
20
0
2015
2020
2025
2030
2035
2040
2045
Freeway Upgrade
Tolling by Vehicle Class
Tolling by Vehicle Class (HOV free)

3. Hempstead Tollway Case Study on Houston Network for H-GAC

Introduction

US 290 in northwest Harris County is one of the most congested areas in the Houston metropolitan area, and the eleventh most congested roadway in Texas, responsible for 2.8 million hours of annual delay and annual economic losses of $62 million (TTI 2011). The Houston Greater Area Council (H-GAC) and TxDOT have considered adding managed lanes on the adjacent Hempstead Highway, which is currently an arterial running adjacent to US 290. The project is to add four toll lanes between IH 610 and the proposed Grand Parkway (SH 99), a distance of approximately 25 miles. PET is used to evaluate the project as described by HGAC and compare against similar alternatives, specifically a traditional toll facility and directional managed lanes along US 290. The alternatives are compared via PET in terms of project financing, traveler welfare, toll revenue, emissions, and crashes.

H-GAC identifies some sections of the Hempstead Tollway as separate key projects for 2013 through 2017, namely a 14-mile stretch from IH 610 to north of SH 6, a distance of 14 miles, with remaining segments to be constructed in 2030, as indicated in Figure A4.

Figure A4: Alignment of Proposed Hempstead Tollway with Recommended Construction Years

H-GAC's Regional Transportation Plan (RTP) details costs for multiple segments of the Tollway and places total project costs (from IH 610 to SH 99) at just over $2.3B. The Harris County Toll Road Authority (HCTRA) is leading the project and has not yet indicated how toll prices will be managed, but has stated that HOV and transit accommodations may be included (HCTRA 2012). Therefore, this case study will consider two different tolling strategies: flat rate tolling for all vehicle classes and times of day and tolling by vehicle class and time of day, as detailed in the Project Alternatives section.

Modeling in PET

A network of freeways, toll roads, and major arterials had been previously created for PET for case study analysis by UT-Austin researchers, represented in Figure A5. The network contains over 250 links, 20 of which were added to precisely model the Hempstead Tollway.

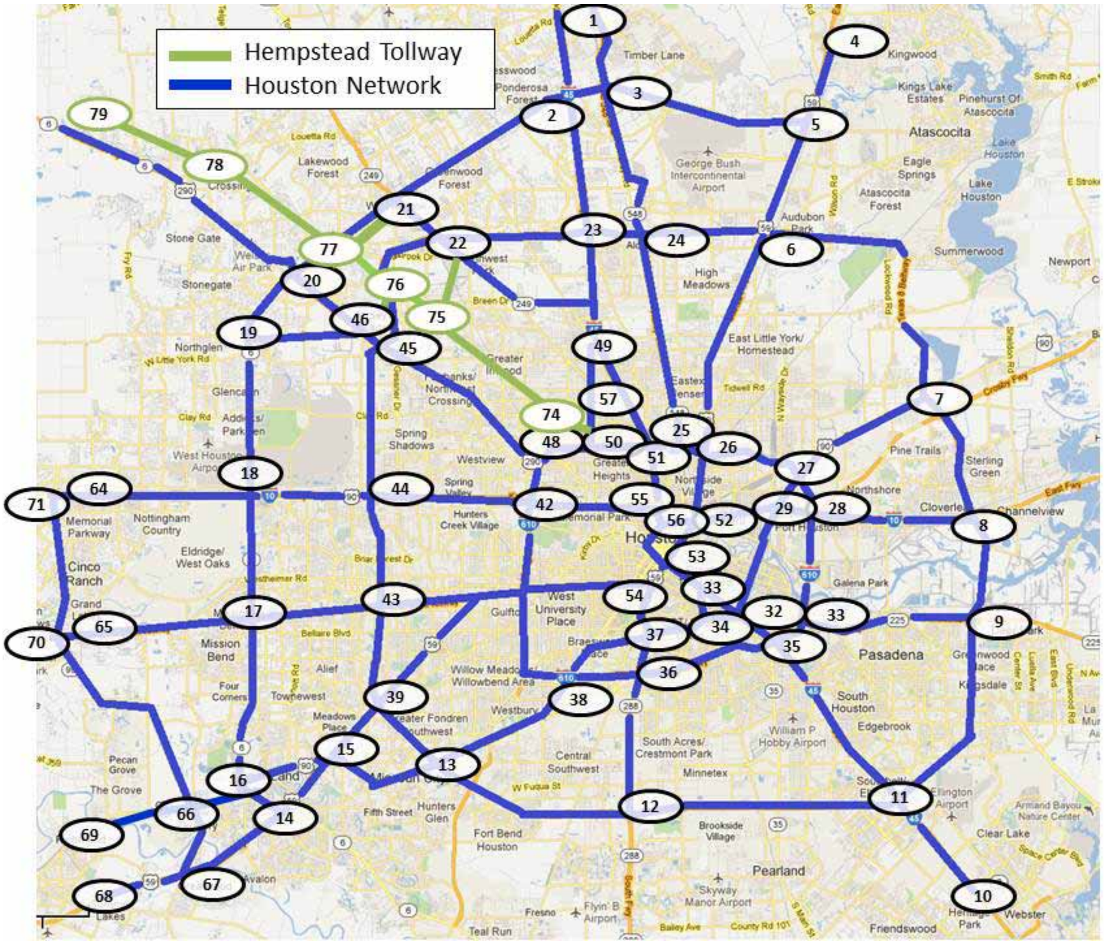


Figure A5: Abstracted Houston Network Created for PET, including Hempstead Tollway Links

TOD splits were created to represent six area-specific peak travel behaviors, including US 290, which has a 28% AM peak and near 36% PM peak. Demand elasticity and TOD scale parameter were left at default values of -0.69 and 0.1, respectively. These values may be manipulated by the user if the output appears suspect. Modeling managed lanes (including basic HOV and directional lanes) requires the addition of links running adjacent to the main-lane segments. This allows toll and capacity alteration separate from the main lanes. For this project, 10 links were added to represent the proposed Tollway: 5 to model northbound lanes and 5 to model southbound lanes. In addition, connecting links (essentially ramps) were created between the new toll road and all adjacent nodes on US 290. These connecting “ramp” nodes were kept very short in length (0.1 miles) to avoid distortion of a truly representative, accurate network. Figure A6 indicates US 290 links and nodes in (solid) orange and the new Hempstead Tollway links and nodes in (dashed) green.

Figure A6: Links and Connections Added to PET Houston Network

It was important to fully connect the new link to adjacent nodes in the network. For instance, Hempstead Tollway terminates (via node 74) at IH 610, next to node 48. For better connectivity, the terminal node 74 is connected to both node 48 as well as node 50, further east on IH 610. It was also important to remove the previous link between 50 and 48. All connecting links were modified in this way along the US 290 corridor.

PET requires the network be identical for the base case and all alternate scenarios; therefore, these links were added to the base network, but capacity and AADT were set at 1. (Users must not use 0 values for capacity or AADT, or errors in computation could occur.) Each scenarios set unique tolling rates and capacity parameters, as detailed below.

Alternative 1: Flat-rate Tolling
This alternative adds a four-lane toll road alongside US 290 from IH 610, 26 miles northwest, to the expected intersection of SH 99. Toll rates are fixed at a flat rate for passenger vehicles at $0.50 per mile. Truck tolls (five-axle vehicles) rates are four times this, similar to other Houston toll roads. Transit vehicles pay no toll. Northbound and southbound capacity of the roadway is set at 3,820 vehicles per hour. (Typical capacity of 1,910 passenger car per hour per lane is assumed for freeway facilities on the network). H-GAC's RTP provides project costs by task and segment. Specific measures of engineering, contingency, and indirect costs are inputs for PET, so the tollway can be accurately described and estimated from RTP data as provided in Table A6.

Table A6: Cost Estimation of Hempstead Tollway (Source: H-GAC's RTP)

	Preliminary Engineering	**Construction**	**Construction Engineering**	**Contingencies**	**Indirects**	**Total**
Mangum to 43rd St.	$12.3M	$250M	$10M	$25M	$12.7M	$297.7M
Gessner to 43rd St.	$13.7M	$280M	$11.2M	$28M	$14.2M	$347M
Jones Rd. to Gessner	$17.6M	$360M	$14.4M	$36M	$18.3M	$446.3M
Jones to W of Huffmeister*	$14.7M	$350M	$20.1M	$36.3M	$7.7M	$428.8M
W of Huffmeister to SH 99*	$47.6M	$565.6M	$39M	$97M	$49.4M	$798.7M
Total	$93.7M	$1.8B	$94.6M	$222.5M	$102.3M	$2.3B

*Specific task costs were estimated based on relative costs from other segments and total segment costs provided from a separate H-GAC source.

In addition to these costs, annual maintenance costs are estimated for all alternatives and the base case scenario. Total maintenance and operations estimates are based on a financial feasibility study of a managed lanes project on IH 35E in Dallas (TxDOT 2008). This proposed project is similar in length (28 miles) and scope (adding four to five managed lanes) to the Hempstead Tollway. Total operations and maintenance costs are estimated at $7.3M/year for managed lanes and $7.7M/year for GP lanes. The base case scenario considers only maintenance of GP lanes, while each scenario includes operation and maintenance for both facilities, for a total cost of $14.7M/year.

Alternative 2: High Occupancy Toll

This alignment's parameters are identical to Alternative 1 except for lane pricing. HOVs pay half-price tolls and busses travel free. SOVs pay the full toll of $0.50 per mile. Construction costs are identical to Alternative 1.

Alternative 3: Free High Occupancy Vehicle

This alternative is also identical to Alternative 1 and 2, but discounts HOVs with two or more occupants. All construction costs are similar across scenarios.

Results

The results indicate that all alternatives provide substantial traveler benefits that surpass the project costs. However, tolling revenues in all scenarios are not substantial enough to cover project costs. Many links indicate that toll lane capacities are about 40–60% of GP lanes in areas nearest major intersections like IH 610 and TX 8. Toll links furthest from congested areas, toward the northwestern-most parts of the city, show very little volume growth, thereby returning little in toll revenue. However, average traffic speeds along the US 290 increase considerably, which improves traveler welfare (and reduces emissions). In this case study, traveler benefits are very large relative to tolling revenues, as seen in Table A7.

Table A7: Project Financing Measures including Traveler Welfare, Reliability, and Crashes

Project Financing (Thousands $)	**No Buil**	**Hempstead Tollway Flat**	**Hempstead Tollway HOT**	**Hempstead Tollway Free**
NPV of New Tolling Revenues	$0	$940.4K	$817.6K	$136.2K
NPV of Initial and Future Project Costs	$0	$2.5M	$2.5M	$2.5M
Project Financing Perspective NPV	$0	-$1.6M	-$1.7M	-$2.4M
Project Financing Perspective IRR	N/A	0.6%	N/A	N/A
Project Financing Perspective PP	N/A	> 30 years	> 30 years	> 30 years

Clearly, tolling revenues are greatest for the flat-rate scenario, and lowest for HOV. Despite this, traveler benefits are highest for the flat rate scenario and lowest for HOV, shown in Table A8. Greater vehicle miles traveled (VMT) increases in the HOV scenario lead to reduced link performance relative to the other scenarios, thereby imparting fewer welfare and reliability benefits while collecting less toll revenue. Traveler benefits in general are quite high, ranging from nearly $15 billion to over $23 billion, which is five to eight times greater than construction costs.

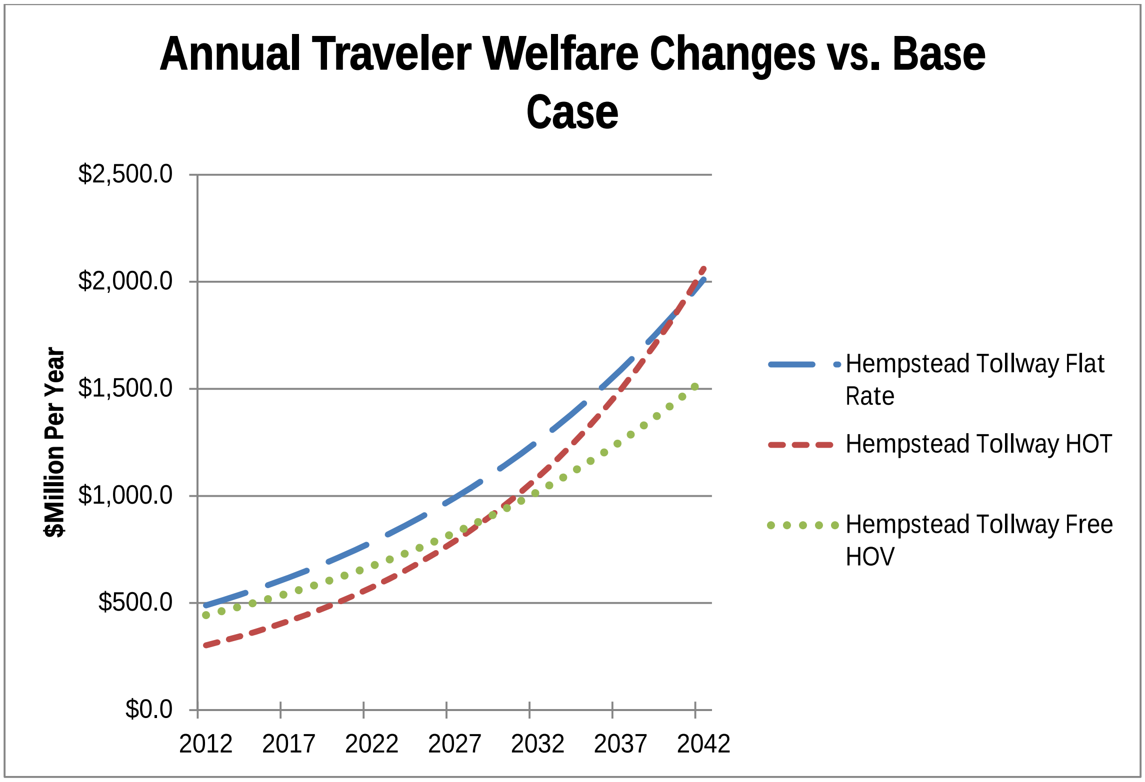
Table A8: Project Financing Measures Only from Agency Perspective (Only Tolling Revenues and Project Costs Used)

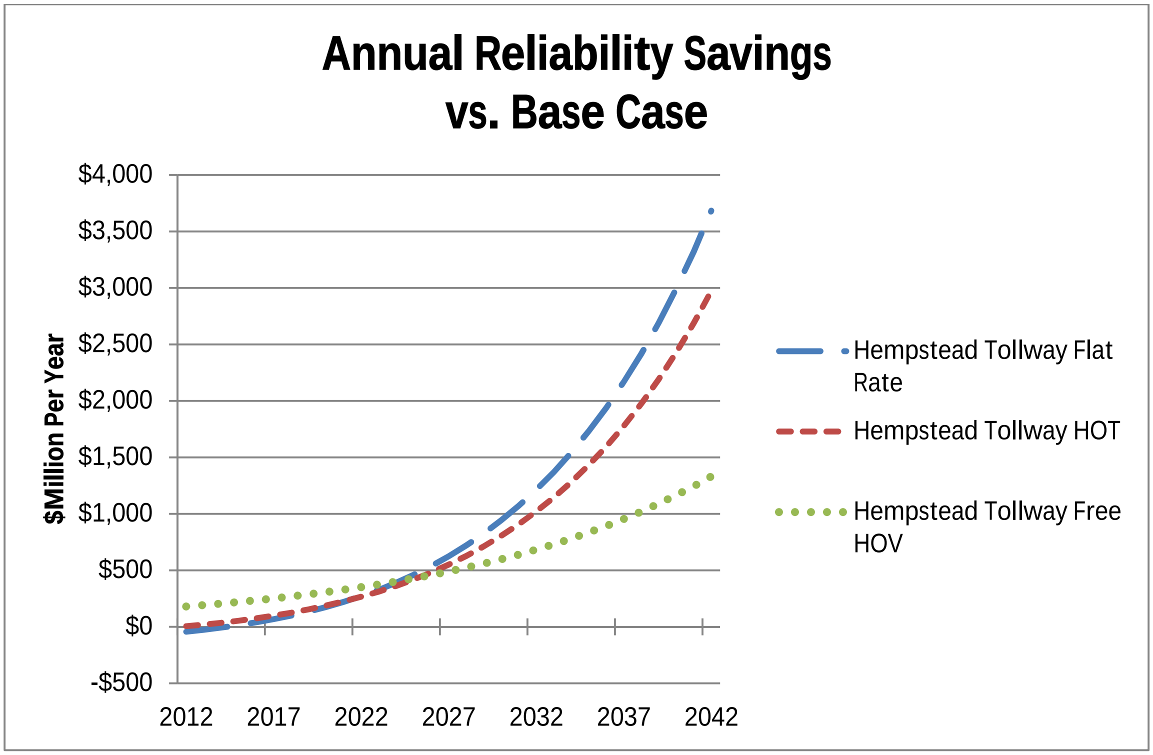
	No Build	**Hempstead Tollway Flat**	**Hempstead Tollway HOT**	**Hempstead Tollway Free HOV**
Net Present Value	$0	$23.32B	$19.39B	$14.82B
Internal Rate of	N/A	78.72%	58.23%	58.89%
Benefit/Cost Ratio	N/A	10.19	8.64	6.84
Payback Period	N/A	3.6	4.0	3.2

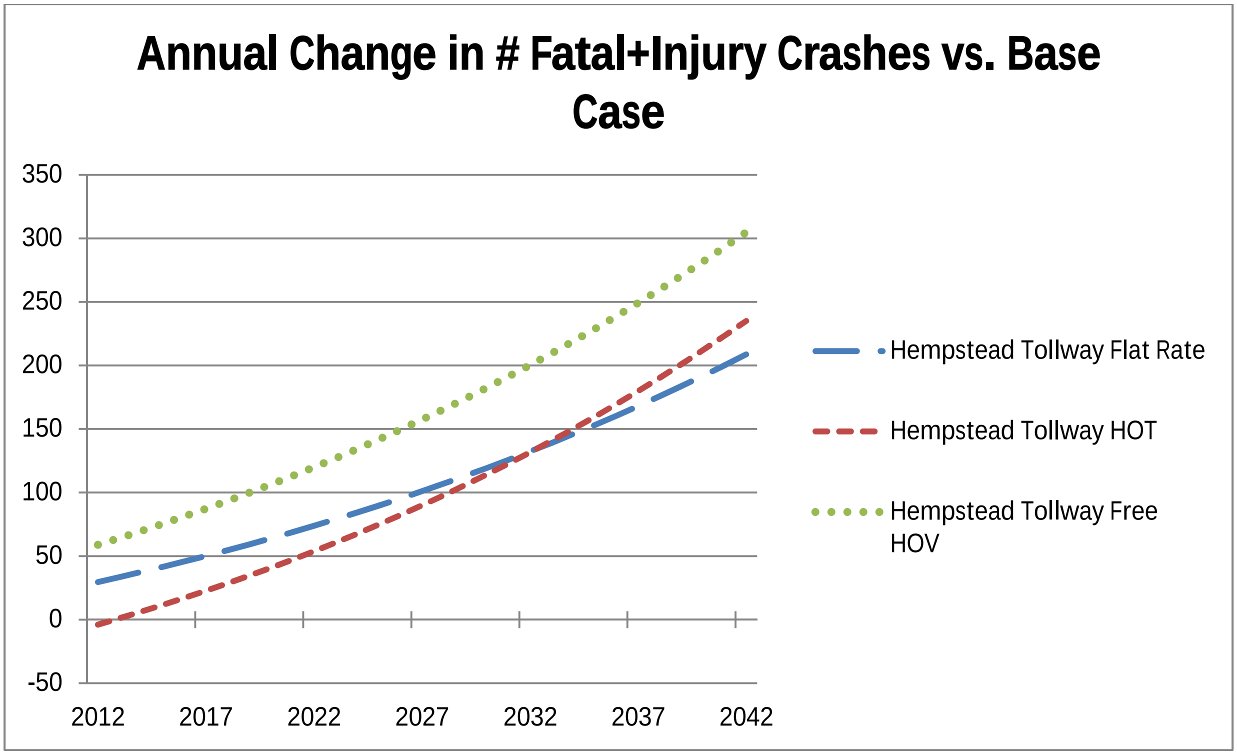
All traveler benefits are significant, but the flat-rate tolling option returns both the greatest traveler benefits and highest toll revenues. These results indicate that the Hempstead Tollway is a viable project that could be recommended for further study. Furthermore, preliminary results indicate that, while a variety of tolling options will provide returns on the project investment (in terms of user benefits), applying a flat-rate toll may improve functionality and return both the greatest benefits and highest direct toll revenue.

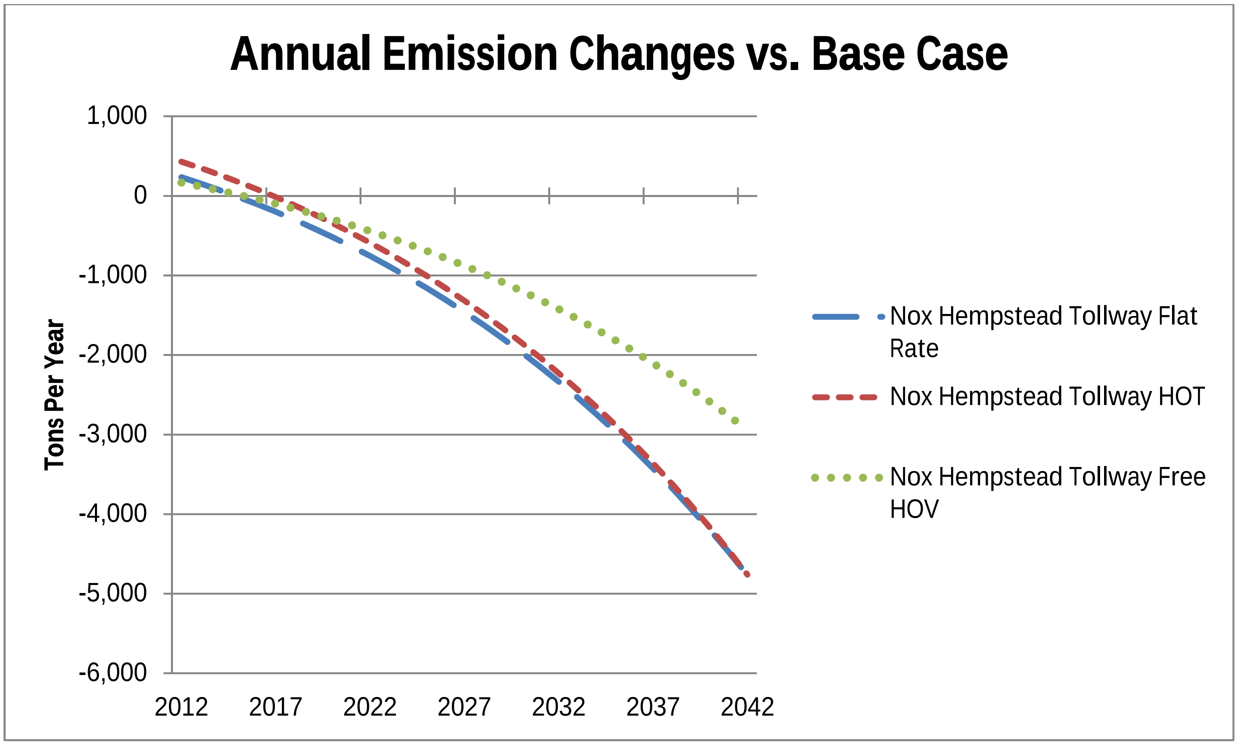
Charts

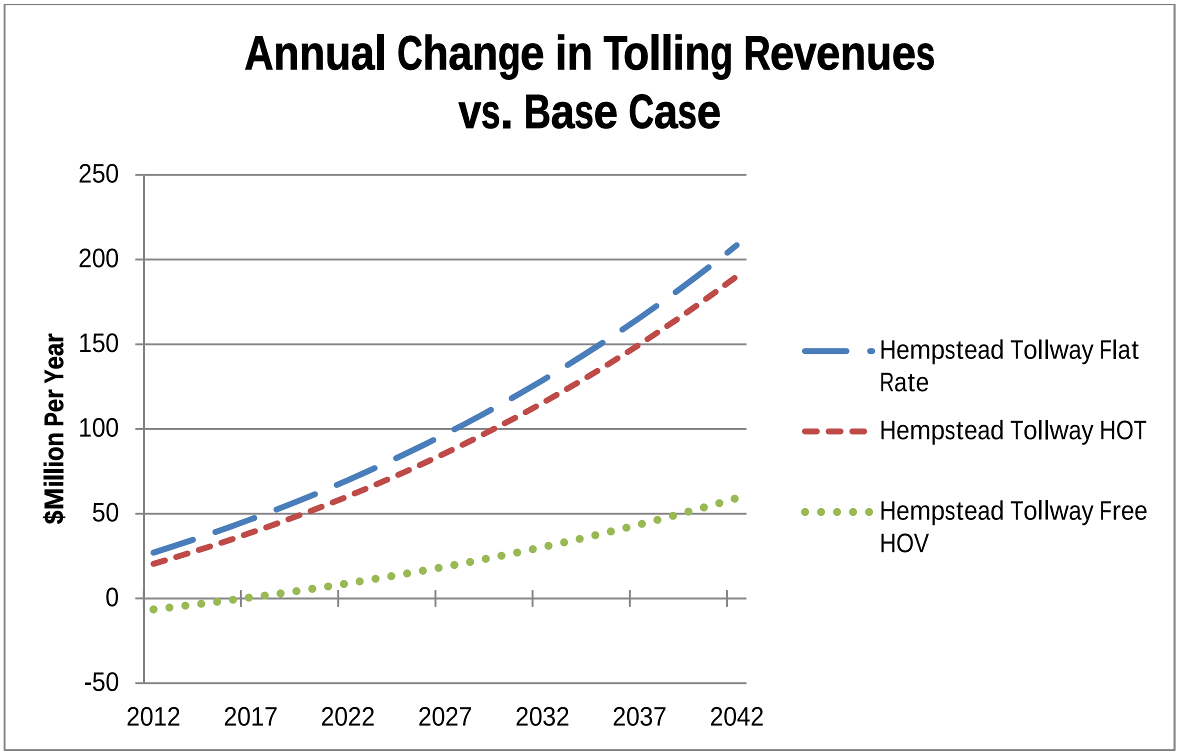
The following pages present several charts automatically created in PET for the **Hempstead Tollway** analysis. These charts provide an additional resource to analyze results and compare trends over time.

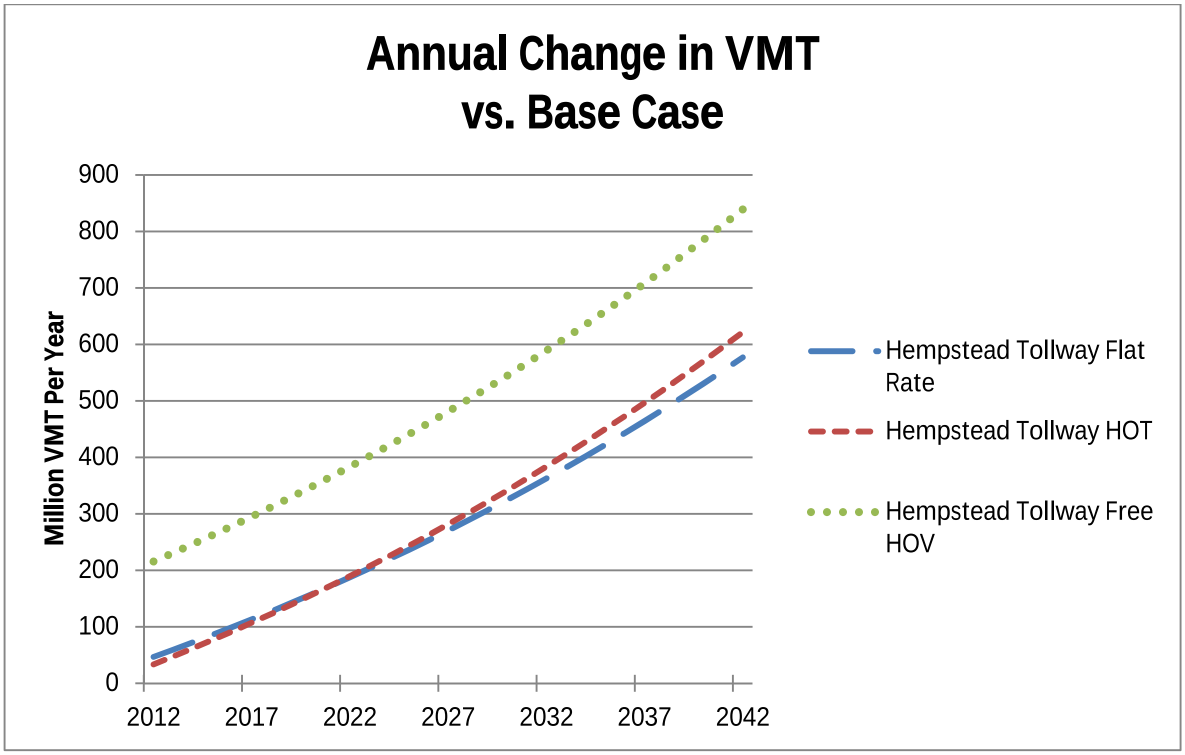

Annual Traveler Welfare Changes vs. Base Case
$Million Per Year
$2,500.0
$2,000.0
$1,500.0
$1,000.0
$500.0
$0.0
2012
2017
2022
2027
2032
2037
2042
Hempstead Tollway Flat Rate
Hempstead Tollway HOT
Hempstead Tollway Free HOV


Annual Reliability Savings vs. Base Case
$Million Per Year
$4,000
$3,500
$3,000
$2,500
$2,000
$1,500
$1,000
$500
$0
-$500
2012
2017
2022
2027
2032
2037
2042
Hempstead Tollway Flat Rate
Hempstead Tollway HOT
Hempstead Tollway Free HOV


Annual Change in # Fatal+Injury Crashes vs. Base Case
350
300
250
200
150
100
50
0
-50
2012
2017
2022
2027
2032
2037
2042
Hempstead Tollway Flat Rate
Hempstead Tollway HOT
Hempstead Tollway Free HOV


Annual Emission Changes vs. Base Case
Tons Per Year
1,000
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
2012
2017
2022
2027
2032
2037
2042
Nox Hempstead Tollway Flat Rate
Nox Hempstead Tollway HOT
Nox Hempstead Tollway Free HOV


Annual Change in Tolling Revenues
vs. Base Case
$Million Per Year
250
200
150
100
50
0
-50
2012
2017
2022
2027
2032
2037
2042
Hempstead Tollway Flat Rate
Hempstead Tollway HOT
Hempstead Tollway Free HOV


Annual Change in VMT
vs. Base Case
Million VMT Per Year
900
800
700
600
500
400
300
200
100
0
2012
2017
2022
2027
2032
2037
2042
Hempstead Tollway Flat Rate
Hempstead Tollway HOT
Hempstead Tollway Free HOV