Final Report

The Highway Construction Equity Gap

prepared for

Texas Department of Transportation
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Division

prepared by

Cambridge Systematics, Inc.

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Executive Summary

TxDOT created a methodology to determine whether the tax revenue and fees associated with or apportioned to specific road segments do or do not equal the construction and maintenance costs associated with the same road segment. The methodology includes calculations of the apportioned tax and fee revenues attributable to the road segment.

Legislative leadership questioned aspects of the accuracy of the methodology and instructed the State Auditor's Office to review and comment on the methodology.

Summary

- The Texas State Auditor's Office (SAO) identified a number of deficiencies in the methodology used by the Texas Department of Transportation (TxDOT) to calculate the "equity gap" of specific roadway segments (i.e., whether or not these segments pay for their construction and maintenance costs over their expected lifespan).
- Cambridge Systematics (CS) refined the existing methodology to address the SAO's recommendations. These refinements allow the methodology to better account for:
  - Roadway lifecycle and reconstruction costs;
  - Expected changes in fleet fuel efficiency (and motor fuel tax revenue impacts);
  - Construction and maintenance cost increases; and
  - Expected growth in vehicle registration fee revenues.
- TxDOT can use the revised equity gap methodology to more accurately estimate the total construction/maintenance costs and apportioned revenues attributed to particular roadways around the state and calculate:
  - The equity gap expressed as the difference between a roadway or roadway segment's revenues (R) and its costs (C);
  - The equity gap expressed as a ratio of revenues to costs (R/C), i.e., the Asset Value Index; and
  - The level of state fuel tax necessary for the roadway or roadway segment to "pay for itself," i.e., revenues equal costs (R = C).

Introduction

In 2005, TxDOT began to develop a methodology to determine whether the tax revenue associated with or apportioned to specific road segments do or do not equal the construction and maintenance costs associated with the road segments. This "equity gap" methodology calculates the difference between the revenue attributed to a particular roadway segment (i.e., federal and state motor fuel taxes, registration fees) and the costs associated with the roadway segment (i.e., initial construction and right-of-way costs, costs associated with preventative and routine maintenance, and roadway reconstruction costs).

In April, 2007, the SAO identified a number of deficiencies within the existing equity gap estimation methodology and made three key recommendations to TxDOT:

1. Determine an appropriate equity gap analysis period beyond the 40-year life of a roadway in order to more effectively capture road segment reconstruction costs;
2. Ensure that cost definitions correctly reflect all elements within the cost model, particularly reconstruction costs beyond the 40-year lifespan of a road segment; and
3. Conduct a formal review and approval process to ensure that assumptions used in the equity gap methodology are consistent throughout the Department.

To address these recommendations, TxDOT contracted with Cambridge Systematics (CS) to conduct a literature and data search to identify, evaluate, and revise key assumptions contained within the existing equity gap methodology. A revised TxDOT equity gap estimation spreadsheet model that reflects the key findings is attached.

Key Changes to the Equity gap Methodology

CS focused refinements to the existing equity gap methodology on several key elements, including:

- **Roadway lifecycle and reconstruction costs**, to help determine the appropriate lifecycle of road segment reconstruction costs as well as how reconstruction costs should be accounted for in equity gap calculations.
- **Fleet fuel efficiency**, to better account for future changes in fleet fuel efficiency and resulting changes in fuel tax revenue.
- **Construction and maintenance cost increases**, to better understand projected cost increases related to road reconstruction (i.e., concrete, steel, labor) and maintenance (i.e., crack and joint repair) to determine the appropriate inflation factors to use within the equity gap methodology.

- **Vehicle registration fee revenue growth**, to understand how expected changes in Texas population will impact revenues derived from vehicle registration fees.

Table ES.1 summarizes key changes to several key variables within the existing equity gap methodology. These changes are supported by existing data, research, and consensus of industry experts.

Sample Road Segments

CS applied the revised equity gap methodology to seven sample road segments. These samples include both rural and urban road segments from each of the following areas:

- Austin (US 183 South of US 290 to North of Bolm Road);
- Brownsville (US 277 Relief Route around Del Rio);
- Dallas-Ft. Worth (IH-820 from Southwestern Railroad [DART] to SH26);
- El Paso (IH-10, from LP 375 [Transmountain Road] to SH 20 [Mesa St]);
- Houston (Houston Pearland FM 865 from Beltway 8 South to FM 518);
- San Antonio(FM 3487 from IH-410 to FM 471; FM 2696 from Glade Crossing to West Oak Estates; and Spur 421 from Ligistrum to IH-10); and
- Longview (Tyler Loop 281, from 0.96 miles south of SH 300 to US 259)

Tables ES.2 through ES.8 summarize the results of each analysis, illustrating that revenues generated are not always sufficient to cover the costs incurred in construction, reconstruction, and routine maintenance.

Table ES.1. Summary of Key Changes to Equity Gap Methodology

Variable	Description	Original Assumption(s)	New Assumption(s)	Rationale/Source
Roadway Lifecycle	Point at which reconstruction is considered necessary	30 years (regardless of surface type)	26 years (concrete) 20 years (asphalt)	Average lifecycle as defined by several key sources: • Engineering System Analysis for Design at the Massachusetts Institute of Technology (MIT) • American Concrete Pavement Association • Arizona Department of Transportation • Federal Highway Administration (FHWA) • Personal interview with TxDOT Construction Division staff
Roadway Reconstruction Costs	How reconstruction costs should be accounted for over the lifespan of the roadway	Reconstruction costs included as a lump sum liability at 30-year mark No revenues calculated after 40 years	Reconstruction costs included at end of lifecycle Analysis period extended 10 years from reconstruction year Reconstruction costs spread over the next lifecycle	Consensus of CS pavement and transportation financing experts
Fleet Fuel Efficiency	Average fuel efficiency in miles-per-gallon	21-22 mpg (based on national data)	17.2 to 58.5 mpg	TxDOT Fleet Fuel Efficiency Model (revised November 2007)
Construction Cost Increase	Annual growth rate of construction costs	4% per year	4.8% per year	Producer price index (PPI) for highway and street construction from Bureau of Labor Statistics

Table ES.1. Summary of Key Changes to Equity gap Methodology (cont'd.)

Variable	Description	Original Assumption(s)	New Assumption(s)	Rationale/Source
Routine Maintenance Costs	Annual costs per lane mile	$4,400 per lane mile (2004 $) with 2% annual growth	$4,400 per lane mile (2004 $) with 6% annual growth	Texas-specific data contained in FHWA Highway Statistics
Vehicle Registration Revenues	Vehicle registration (VR) revenue per $1 of motor fuel tax (MFT) revenue	VR revenues increase at the same rate as MFT revenues	VR revenues increase in relation to population growth, at a rate of 1.65 (i.e., 1 % growth in population results in 1.65% growth in vehicle registrations)	TxDOT revenue forecast model for vehicle registrations (revised June 2006)

Table ES.2 "Equity Gap" Analysis Results

Austin – US 183 South of US 290 to North of Bolm Road

Estimated Total Construction Costs (2009-2044)	***$327,744,251***
Estimated Federal MFT Revenues	$31,130,698
Estimated State MFT Revenues	$33,506,394
Estimated Vehicle Registration Revenues	$40,620,515
Estimated Total Revenues (2009-2044)	***$105,257,607***
Revenues/Costs (R/C)	0.32
Total State MFT Rate required for R=C (per gallon)	**$1.85**
Incremental increase in state MFT Rate required for R=C (per gallon)	$1.65

Table ES.3 "Equity Gap" Analysis Results
Brownsville – US 277 Relief Route around Del Rio

Estimated Total Construction Costs (2009-2044)	***$218,048,025***
Estimated Federal MFT Revenues	$9,722,961
Estimated State MFT Revenues	$9,655,240
Estimated Vehicle Registration Revenues	$11,473,933
Estimated Total Revenues (2009-2044)	***$30,852,134***
Revenues/Costs (R/C)	0.14
Total State MFT Rate required for R=C (per gallon)	**$4.64**
Incremental increase in state MFT Rate required for R=C (per gallon)	$4.44

Table ES.4 "Equity Gap" Analysis Results
Dallas-Ft. Worth - IH-820 from Southwestern Railroad (DART) to SH26

Estimated Total Construction Costs (2009-2044)	***$293,849,644***
Estimated Federal MFT Revenues	$28,721,952
Estimated State MFT Revenues	$29,347,627
Estimated Vehicle Registration Revenues	$33,828,176
Estimated Total Revenues (2009-2044)	***$91,897,755***
Revenues/Costs (R/C)	0.31
Total State MFT Rate required for R=C (per gallon)	**$1.77**
Incremental increase in state MFT Rate required for R=C (per gallon)	$1.57

Table ES.5 "Equity Gap" Analysis Results
El Paso – IH-10, from LP 375 (Transmountain Road) to SH 20 (Mesa St)

Estimated Total Construction Costs (2009-2044)	***$126,954,619***
Estimated Federal MFT Revenues	$36,624,922
Estimated State MFT Revenues	$37,695,581
Estimated Vehicle Registration Revenues	$43,450,626
Estimated Total Revenues (2009-2044)	***$117,771,128***
Revenues/Costs (R/C)	0.93
Total State MFT Rate required for R=C (per gallon)	**$0.28**
Incremental increase in state MFT Rate required for R=C (per gallon)	$0.08

Table ES.6 "Equity Gap" Analysis Results
Houston- Harris Pearland FM 865 from Beltway 8 South to FM 518

Estimated Total Construction Costs (2009-2044)	***$109,147,076***
Estimated Federal MFT Revenues	$4,342,154
Estimated State MFT Revenues	$4,673,519
Estimated Vehicle Registration Revenues	$5,245,081
Estimated Total Revenues (2009-2044)	***$14,260,754***
Revenues/Costs (R/C)	0.13
Total State MFT Rate required for R=C (per gallon)	**$4.93**
Incremental increase in state MFT Rate required for R=C (per gallon)	$4.73

Table ES.7 "Equity Gap" Analysis Results

San Antonio – FM 3487 from IH-410 to FM 471
FM 2696 from Glade Crossing to West Oak Estates
Spur 421 from Ligistrum to IH-10

Estimated Total Construction Costs (2009-2044)	***$345,277,587***
Estimated Federal MFT Revenues	$38,457,944
Estimated State MFT Revenues	$40,573,098
Estimated Vehicle Registration Revenues	$50,422,291
Estimated Total Revenues (2009-2044)	***$129,453,333***
Revenues/Costs (R/C)	0.37
Total State MFT Rate required for R=C (per gallon)	**$1.50**
Incremental increase in state MFT Rate required for R=C (per gallon)	$1.30

Table ES.8 "Equity Gap" Analysis Results

Longview – Tyler Loop 281, from 0.96 miles south of SH 300 to US 259

Estimated Total Construction Costs (2009-2044)	***$97,467,132***
Estimated Federal MFT Revenues	$6,164,380
Estimated State MFT Revenues	$6,584,606
Estimated Vehicle Registration Revenues	$7,589,887
Estimated Total Revenues (2009-2044)	***$20,338,873***
Revenues/Costs (R/C)	0.21
Total State MFT Rate required for R=C (per gallon)	**$2.86**
Incremental increase in state MFT Rate required for R=C (per gallon)	$2.66

1.0 Introduction and Approach

In 2005, the Texas Department of Transportation (TxDOT) developed a methodology to determine whether specific road segments do or do not pay for their construction and maintenance costs. This "equity gap" methodology calculates the difference between the revenue attributed to a particular roadway segment (i.e., federal and state motor fuel taxes, registration fees) and the costs associated with the roadway segment (i.e., initial construction and right-of-way costs, costs associated with preventative and routine maintenance, and roadway reconstruction costs).

In April, 2007, the Texas State Auditor's Office (SAO) released an audit report (1)[1] that identified a number of deficiencies within the existing equity gap estimation methodology and made three key recommendations to TxDOT:

- Determine an appropriate equity gap analysis period beyond the 40-year life of a project to capture road segment reconstruction costs.
- Ensure that cost definitions in its equity gap calculation methodology correctly reflect all elements within the cost model. If reconstruction costs are to be included, the Department should extend the analysis period to ensure that expenses are associated with revenues.
- Conduct a formal review and approval process to ensure that assumptions used in its equity gap calculation are consistent throughout the Department.

TxDOT commissioned Cambridge Systematics (CS) to refine this existing methodology to address these deficiencies and provide the Department a more accurate means to estimate the construction/maintenance costs and potential revenues attributed to particular roadways around the state. A revised TxDOT equity gap estimation spreadsheet model is attached.

■ Approach

CS collected data and information to address SAO's recommendations and to make other functional and usability improvements to the existing equity gap methodology. These data and information were used to refine several key aspects of the methodology, including:

[1] All sources are noted and listed in Section 5.0

- **Roadway lifecycle and reconstruction costs**. The original equity gap methodology assumes a roadway lifecycle of 30 years, which is the time when reconstruction is expected to occur. However, there are contradictory assertions that the life of a roadway segment could be estimated at 40 years or more. We collected data and information to determine the most appropriate lifecycle for road reconstruction for Texas as well as how reconstruction costs can and should be accounted for in equity gap calculations.
- **Fleet fuel efficiency**. Fleet fuel efficiency is one of the key variables used to estimate fuel consumption and associated fuel tax revenues. The original equity gap methodology uses an overall average (in miles per gallon [mpg]) based on national data available from the U.S. Bureau of Transportation Statistics (BTS). Fuel efficiency, however, is expected to improve over the long term with the introduction of more fuel efficient vehicles and alternative fuel technologies, which would significantly affect the amount of fuel tax revenues collected. TxDOT has recently developed a spreadsheet model (2) to better account for changes in fleet fuel efficiency. We collected appropriate data and information from this model for inclusion in the revised equity gap methodology.
- **Construction and maintenance cost increases**. Costs related to road reconstruction (i.e., concrete, steel, labor) and maintenance (i.e., crack and joint repair) have been increasing at a faster rate than general inflation. The existing equity gap methodology assumes annual increases of four percent and two percent for construction and maintenance costs, respectively. We collected data and information to determine the appropriate inflation factors to use within the refined methodology.
- **Vehicle registration fee revenue growth**. The original equity gap methodology estimates future vehicle registration (VR) revenues by relating VR growth to motor fuel tax revenue growth, meaning that VR revenues are estimated to increase at the same rate as these fuel tax revenues. However, TxDOT's own VR model indicates that population growth may be a better indicator of future VR revenue than motor fuel taxes. We collected data and information to understand how expected changes in Texas population will impact revenues derived from vehicle registration fees (even if fee structures remain constant).

Following this data collection effort, CS developed a revised equity gap estimation methodology and associated equity gap estimation spreadsheet model. This revised methodology estimates the construction/maintenance costs and potential revenues of roadway segments. The spreadsheet model produces the following information:

- Equity gap expressed as the difference between the roadway or roadway segment's revenues (R), and its costs (C);
- Equity gap expressed as a ratio of revenues to costs (R/C), also known as the Asset Value Index; and
- Level of state fuel tax necessary for the roadway or roadway segment to "pay for itself," i.e., revenues equal costs (R = C).

We then applied the revised equity gap methodology to nine road segments to evaluate consistency with the SAO audit report.

The remainder of this technical report presents a summary of the revisions to the existing equity gap methodology. It is organized as follows:

- **Section 2.0, Key Changes to Equity gap Methodology**, summarizes the key changes to the existing equity gap methodology and provides background information and supporting documentation to support them.
- **Section 3.0, Equity gap Estimation Spreadsheet Structure and Use**, describes the key elements, input parameters, and assumptions included within the revised equity gap methodology. It also provides information that describes use of the equity gap estimation spreadsheet model.
- **Section 4.0, Case Study**, summarizes the results of the methodology as applied to a segment of Harris Pearland FM 865.
- **Section 5.0, Bibliography and Sources**, provides links to datasets, research reports, and other sources used to support the development of the revised equity gap methodology.

2.0 Key Changes to Equity Gap Methodology

CS focused changes and refinements to the existing equity gap methodology on several key elements, including:

- **Roadway lifecycle and reconstruction costs**, to help determine the appropriate lifecycle of road segment reconstruction costs as well as how reconstruction costs should be accounted for in equity gap calculations.
- **Fleet fuel efficiency**, to better account for changes in fleet fuel efficiency and resulting changes in fuel tax revenue.
- **Construction cost increases**, to better understand projected cost increases related to road reconstruction (i.e., concrete, steel, labor) and help determine the appropriate inflation factors to use within the equity gap methodology.
- **Vehicle registration fee revenue growth**, to understand how expected changes in Texas population will impact revenues derived from vehicle registration fees.

This section summarizes the key changes made to the methodology within these four areas and provides background information and supporting documentation to support them. Links to sources are provided in Section 5.

■ Roadway Lifecycle and Reconstruction Costs

The lifecycle of a highway, defined as the time when reconstruction activities are normally expected to occur, is a function of several factors, including pavement type (asphalt versus concrete), climate, traffic volumes, and truck/auto mix. The original equity gap methodology assumes a highway lifecycle of 30 years, regardless of pavement type, while the SAO recommends 40 years.

In addition to understanding the expected lifecycle of a roadway, it is also important to develop an appropriate method for accounting for reconstruction costs over this lifespan. The original equity gap methodology includes reconstruction costs at the end of the lifecycle (i.e., at the 30-year mark) as a lump-sum amount and does not calculate revenues after the 40-year analysis period. As a result, much of the revenue that would normally be expected to cover the reconstruction costs over the second lifecycle are excluded.

The following sections describe key findings of our literature and data collection effort and recommendations on how to more appropriately account for roadway lifecycle and reconstruction costs within the revised equity gap methodology.

Key Findings

Roadway Lifecycle

We reviewed four sources that describe the average lifecycle of roadways:

- **Massachusetts Institute of Technology (MIT), Engineering System Analysis for Design Division**, conducts research on a variety of topics, including pavement lifecycle. Recent research conducted indicates that asphalt roadway surface can be expected to last an average of 17 years, while concrete surface can be expected to last approximately 27 years (3).

- **American Concrete Pavement Association (ACPA)**, the national industry group representing the concrete pavement industry, recently completed a study to compare service life and lifecycle cost of both concrete and asphalt surfaces along segments of I-40 in Tennessee. The research indicated that the lifecycle of asphalt surface (in this region) is approximately 12 years, while the lifecycle of concrete surfaces is between 26 and 31 years (4).

- **Arizona Department of Transportation** recently conducted a comprehensive study to evaluate the performance characteristics and service life of pavement surfaces using sample road sections from across the state (5). Results indicated that the typical asphalt service life was approximately 13 to 28 years, and concrete service life was between 20 and 32 years.

- **Highway Economic Reporting System (HERS),** a simulation model that estimates the benefits and costs of highway investments on the Federal-aid highway system. It is also used by the U.S. DOT as the basis for its reports to the Congress on highway investment needs. The most recent version of HERS uses a service life for pavements of 20 years. The pavement deterioration model within HERS assumes pavement maximum life between 15-25 years for asphalt and 20-30 years for concrete. (6)

Table 2.1 presents the results from these sources.

Table 2.1 Lifecycle of Highway Surface by Pavement Type

Source	Asphalt	Concrete
Engineering System Analysis for Design (MIT)	17 years	27 years
American Concrete Pavement Association	12 years	26-31 years
Arizona Department of Transportation	13-28 years	20-32 years
FHWA HERS	15-20 years	20-30 years
Average	**20 years**	**26 years**

In addition to the sources described in Table 2.1, we also interviewed staff from the Materials and Pavement Section of TxDOT's Construction Division (7). For pavement design, TxDOT uses a 30-year design life for concrete pavement, and a 20-year lifecycle for flexible pavement (i.e., asphalt). According to TxDOT, flexible pavements are rehabilitated within the 20-year lifecycle, although that is not the case of concrete pavement. In very rare cases, concrete pavement could be designed with a lifecycle of 40 years but this is not standard TxDOT practice.

Roadway Reconstruction Costs

The SAO report recommended that reconstruction costs included within the equity gap methodology reflect the analysis period under consideration in order to avoid overstatement of these costs. Interviews with key experts in this field (8) indicate that in order to more accurately estimate the revenue that could reasonably be expected to cover the reconstruction costs over the second lifecycle of a roadway, the equity gap methodology should extend the analysis period from the reconstruction year and spread costs across the "next" lifecycle of the roadway using the following method:

- Include reconstruction costs at the end of the lifecycle, and extend the analysis period 10 years from reconstruction year (i.e., end year of analysis is Construction Year 1 + Lifecycle + 9); and
- Distribute reconstruction costs over the next lifecycle, to account for cumulative costs over 10 years.

Summary

To more appropriately account for roadway lifecycle and reconstruction costs, we made several changes to the equity gap methodology:

- Default values for roadway lifecycle were modified to more accurately reflect the differences between asphalt and concrete pavement life spans using an average of the sources described in Table 2.1 (i.e., 20 years for asphalt pavements and 26 years for concrete pavements). These values are consistent with both existing studies and current TxDOT practices for estimating roadway lifecycles.
- The analysis period for roadway reconstruction costs was extended 10 years from reconstruction year (i.e., end year of analysis is Construction Year 1 + Lifecycle + 9); and
- Additional calculations were developed to distributed reconstruction costs over the next lifecycle, allowing the methodology to account for cumulative costs over 10 years.

Fleet Fuel Efficiency

Fuel efficiency is one of the key variables used to calculate fuel consumption and technological improvements in fuel efficiency over the next several decades will have a major impact on these revenues. The original equity gap methodology uses an average fuel efficiency value (in miles per gallon or MPG) based on data from the U.S. Bureau of Transportation Statistics (BTS), which remains constant through the analysis period. This approach neglects the changes in fuel efficiency and changes in the state's vehicle fleet that are expected to occur over the next several decades.

The following sections describe key findings and recommendations on how to more appropriately account for fleet fuel efficiency changes within the revised equity gap methodology.

Key Findings

TxDOT recently commissioned CS to assess the assumptions of the existing Texas Motor Fleet Fuel Efficiency Model and revise the model to forecast Texas motor fleet fuel efficiency for the period of 2007 to 2031. We paid particular attention to refining the assumptions that influence both the overall composition of the State's motor fleet and its projected fuel efficiency. The refined Motor Fleet Fuel Efficiency Model (2) included several key changes:

- Diesel vehicles were included as an additional fuel efficient alternative to the current hybrid alternative, since among automotive analysts there is consensus that hybrid and diesel vehicles will be the main competitors to gasoline vehicles;
- Motor fleet composition was disaggregated to specifically identify cars, light trucks, and heavy trucks;
- Current mileage per gallon for gasoline, diesel, and hybrid vehicles was adjusted based on the Environmental Protection Agency's (EPA) latest revision on fuel efficiency labels given that its new estimates are 5 to 10 percent lower than today's labels;
- Future mileage per gallon for gasoline, diesel, and hybrid vehicles, disaggregated by type of vehicle, was adjusted based on historical data and literature review; and
- Future rate of growth of vehicle miles traveled by type of vehicle was adjusted based on historical data.

Scenario testing of the resulting model indicated that appropriate average MPG values for Texas range from 17.2 to 58.5, depending on vehicle type (passenger car, passenger truck, or heavy-duty truck), fuel type (gasoline, diesel, or hybrid), and year of analysis.

Summary

To more appropriately account for change in fleet fuel efficiency, we revised the equity gap methodology to include information contained in the revised Texas Motor Fleet Fuel Efficiency Model. This allows users to define a MPG value that more accurately reflects vehicle types and year of analysis on the roadway being analyzed.

■ Construction Cost Increases

Costs related to road construction (i.e., concrete, steel, labor) have been increasing faster than the general rate of inflation (6-8 percent vs. 5 percent) (9) over the last several years. The original equity gap methodology assumes that construction costs will increase at a rate of 4 percent per year. However, it is important to understand in more detail how construction costs are expected to change in the future so that they can be accurately accounted for within the methodology. The following sections describe the key findings of our literature and data collection effort and recommend a growth factor for reconstruction costs that is in line with historical experience in Texas and the U.S..

Key Findings

We reviewed historical data and forecasts on construction price indices from several sources, including:

- **Consumer Price Index (CPI)** –Bureau of Labor Statistics;
- **Producer Price Index (PPI), Highway and Street Construction** – Bureau of Labor Statistics;
- **Building Cost Index (BCI)** – Engineering News Record;
- **Construction Cost Index (CCI)** – Engineering News Record;
- **Bid Price Index (BPI) or Federal-aid Highway Construction Cost Index** –Federal Highway Administration (FHWA);
- **Turner Building Cost Index** – Turner Construction; and
- **Texas Highway Construction Index**- TxDOT

We analyzed historical data from the past 10 years, allowing us to cancel out effects of cyclical events, such as periods of high or low inflation due to changes in economic conditions.

Consumer Price Index (CPI)

The CPI (10) is published by the Bureau of Labor Statistics (BLS), and estimates monthly changes in prices paid by urban consumers for a representative sample of goods and services. The CPI is typically used to describe cost inflation in general. CPI data are published monthly and provide information on estimated price changes in the U.S. as a whole as well as in various large metropolitan areas, including Dallas-Fort Worth.

Table 2.2 summarizes the CPI data for years 1996 through 2006 (annual), and the monthly data for May (the last month of data available) through 2007. The 10-year compounded average growth rate is estimated at 2.5 percent in all cases, except for the U.S. CPI through May 2007, which is slightly higher (at 2.6 percent).

Table 2.2 Consumer Price Index (CPI) for U.S. City Average and Dallas-Fort Worth, TX
1996 – 2007, 1982-84 = 100

Year	CPI: U.S. Average (Annual)	CPI: U.S. Average (Jan-May)	CPI: Dallas-Fort Worth (Annual)	CPI: Dallas-Fort Worth (Jan-May)
1996	156.9	156.6	148.8	148.9*
1997	160.5	160.1	151.4	151.0*
1998	163.0	162.8	153.6	153.0
1999	166.6	166.2	158.0	157.2
2000	172.2	171.5	164.7	163.2
2001	177.1	177.7	170.4	169.4
2002	179.9	179.8	12.7	172.9
2003	184.0	183.5	176.2	176.9
2004	188.9	189.1	178.7	179.1
2005	195.3	194.4	184.7	183.5
2006	201.6	202.5	190.1	191.2
2007	N/A	207.9	N/A	192.8
10-yr Compound Growth	**2.5%**	**2.6%**	**2.5%**	**2.5%**

*Actual data not available for the month of May; CPI for the month of May in 1996 and 1997 estimated as the average CPI for the months of April and June.

Producer Price Index (PPI), Highway and Street Construction Index

The PPI (11) measures the average change over time in the selling prices received by domestic producers for their output. Price change is measured from the seller's perspective. The PPI is provided either by industry, commodity, or state of products (e.g., finished goods or crude materials). Highway and Street Construction is one of several industries for which PPI is estimated. The index includes the prices of materials and services used directly or indirectly in highway construction from more than 180 industries. It does not include the cost of labor or administration and is only available at the national level.

Annual PPI – Highway and Street Construction data are available through 2006, and monthly data are available through May 2007. Table 2.3 shows PPI data, annual change, and the compounded average growth rate for the last ten years. The ten-year annual growth is between 4.2 and 4.8 percent.

Table 2.3 Producer Price Index (PPI) – Highway and Street Construction Index
1996-2007

Year	PPI – Hwy/Street (Annual)	Annual Change	PPI – Hwy/Street (Jan-May)	Annual Change
1996	122.1	-	122.6	-
1997	124.6	2.0%	124.5	1.5
1998	123.5	-0.9%	124.0	-0.4%
1999	126.6	2.5%	125.9	1.5%
2000	136.5	7.8%	135.8	7.9%
2001	137.0	0.4%	139.9	3.0%
2002	133.7	-2.4%	133.8	-4.4%
2003	136.6	2.2%	137.0	2.4%
2004	148.2	8.5%	147.9	8.0%
2005	166.8	12.6%	162.4	9.8%
2006	184.8	10.8%	187.9	15.7%
2007	N/A		193.8	5.5%
10-yr Compound Growth		**4.2%**		**4.8%**

Building Cost Index (BCI) and Construction Cost Index (CCI) – Engineering News Record (ENR)

ENR (12) publishes the BCI and CCI monthly (with historical data available for purchase). The BCI is an index for construction projects that require more specialized labor than the CCI. The BCI and CCI includes the average costs of construction materials (steel, Portland cement, and lumber) and labor (skilled labor for BCI; common labor for CCI) in 20 U.S. cities (including Dallas).

Table 2.4 shows the annual series of the 20-city BCI and CCI. The latest cost index estimate is for July 2007. The 10-year compounded average growth rate is 3.1 percent for BCI and 2.9 percent for CCI for the period between July 1997 and July 2007. Table 2.4 also includes cost indices for the Dallas metropolitan area. Both CCI and BCI increased at an average annual growth rate of 2.5 percent, lower than the 20-city average.

Table 2.4 ENR's Building Construction Index and Construction Cost Index, U.S. and Dallas, TX, 1996-2007
Index 1913 = 100

Year	U.S. BCI	U.S. CCI	Dallas BCI	Dallas CCI
1996	5617	3190	2596	3871
1997	5863	3392	2662	3936
1998	5921	3382	2682	3960
1999	6076	3460	2691	3968
2000	6225	3545	2742	3986
2001	6404	3625	2677	3854
2002	6605	3652	2684	3895
2003	6695	3683	2809	4044
2004	7126	4013	3062	4343
2005	7422	4197	3186	4697
2006	7721	4356	3333	4934
2007 (through July)	7959	4493	N/A	N/A
10-yr Compound Growth	**3.1%**	**2.9%**	**2.5%**	**2.5%**

FHWA Bid Price Index (BPI)

FHWA develops the BPI (13) using cost data provided by states for National Highway System projects with a contract value of at least $500,000. The index includes several components/indicators, including: common excavation; Portland cement concrete pavement and bituminous concrete pavement (for surfacing); and reinforced steel, structural steel, and structural concrete (for structures).

Table 2.5 summarizes the BPI data from 1995 through 2005. The latest report available includes data for the second quarter of 2006. The BPI increased significantly between 2004 and 2005 (18.9 percent), as the individual indices for components increased between 16 to 24 percent. For the 1995-2005 period, the BPI increased at a compounded average growth rate of 4.2 percent, with surfacing costs increasing at a faster rate than excavation and structures.

Table 2.5 FHWA Bid Price Index, 1995-2005
1987 = 100

Year	BPI	Annual Change	Excavation	Surfacing	Structures
1995	121.9	-	112.8	127.9	119.5
1996	120.2	-1.4%	120.6	118.7	121.6
1997	130.6	8.7%	117.6	133.0	132.7
1998	126.9	-2.8%	124.3	120.8	133.4
1999	136.5	7.6%	120.9	140.3	138.3
2000	145.6	6.7%	124.1	152.2	146.9
2001	144.8	-0.5%	125.9	158.1	138.8
2002	147.9	2.1%	121.2	150.7	154.5
2003	149.8	1.3%	142.3	142.1	159.5
2004	154.4	3.1%	135.7	160.8	154.7
2005	183.6	18.9%	164.6	198.6	176.0
10-yr Compound Growth	**4.2%**		**3.8%**	**4.5%**	**3.9%**

Turner Building Cost Index

The Turner Building Cost Index (14) is produced by Turner Construction. The index considers factors such as labor rates and productivity, material prices, and the competitive conditions of the market place. Annual data are available through 2006. Table 2.6 presents the annual Turner Building Cost Index for the last decade, when the index increased at an average growth rate of 4.6 percent per year. Similar to other indices above, the Turner Building Cost Index has increased at a faster rate since 2004.

Table 2.6 Turner Building Cost Index, 1996-2006
1967=100

Year	Turner BCI	Annual Change
1995	505	
1996	525	4.0%
1997	549	4.6%
1998	570	3.8%
1999	595	4.4%
2000	613	3.0%
2001	619	1.0%
2002	621	0.3%
2003	655	5.5%
2004	717	9.5%
2005	793	10.6%
10-yr Compound Growth		**4.6%**

Texas Highway Construction Index

TxDOT also has a Highway Construction Index that tracks the growth in highway construction costs for different components, including: pavement materials, earthwork, structures, sub-grade, and surfacing. The most recent report (July 2007) shows how the index has increased significantly since 2004. In July 2003, the index was 118.3, and by July 2007, the index increased to 203.2, an average growth rate of 14 percent per year. Over the 1997-2006 period, the index grew at an average annual rate of 7.8 percent, which is a much higher growth rate compared to other national indices described above.

Summary

Figure 2.1 shows the growth rates from 1995 to 2006; and Table 2.7 summarizes the 10-year cumulative annual growth rates of the various construction indices described above. Clearly, after 2003 all indices have grown at a faster pace than previous years, with the Texas Highway Construction Index, FHWA BPI, Turner Building Construction Index, and PPI-Highway and Street Construction growing the fastest.

Figure 2.1 Summary of Construction Costs Indices, 1995-2006
1995=100

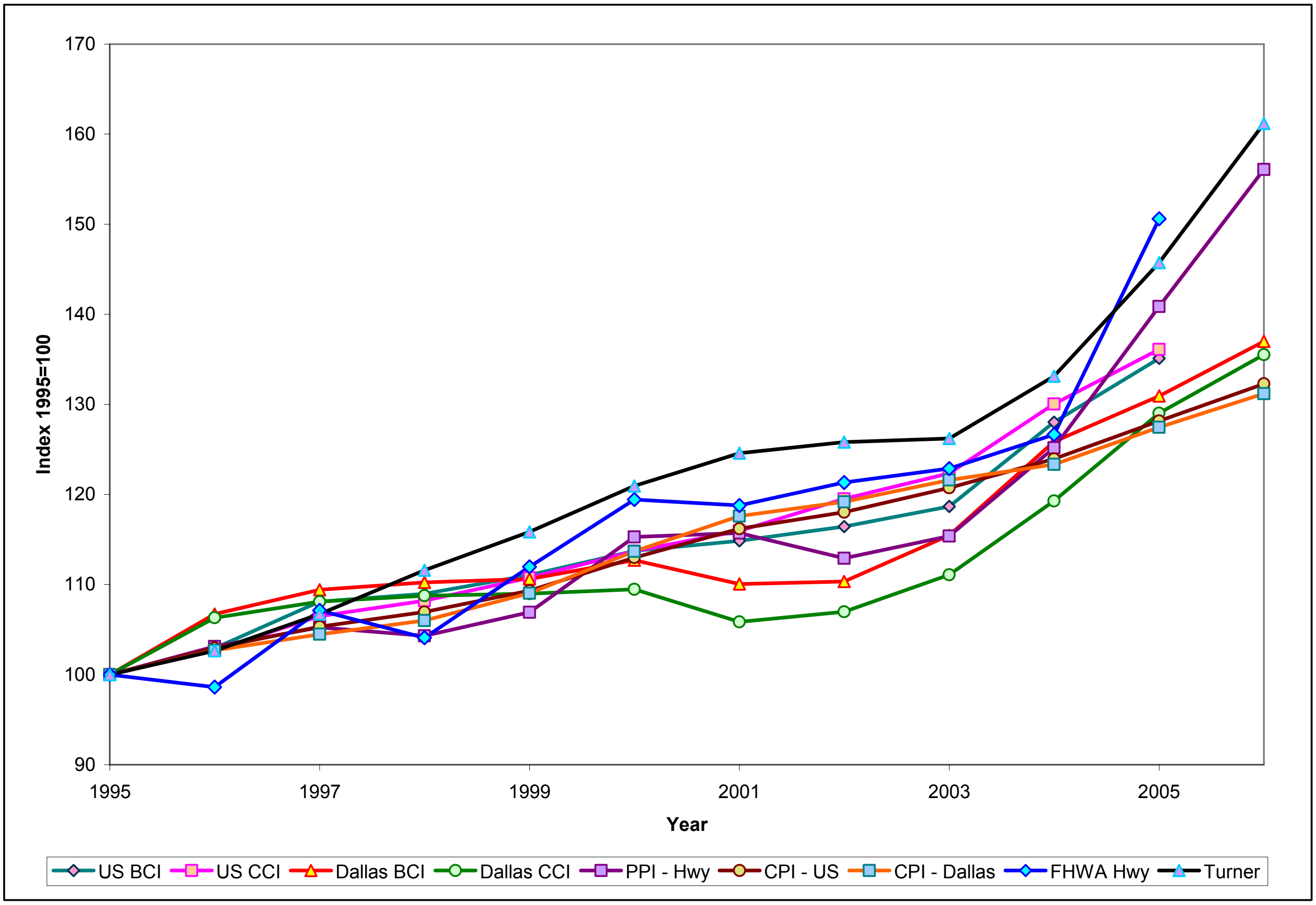


Table 2.7 Summary of Cost Indices

Cost Index (Period)	10-yr CAGR*
CPI – U.S. (May 1997/May 2007)	2.6%
CPI – Dallas/Ft. Worth (May 1997/May 2007)	2.5%
PPI – Hwy & Streets (May 1997/May 2007)	4.8%
BCI – U.S. (July 1997/July 2007)	3.1%
CCI – U.S. (July 1997/July 2007)	2.8%
BCI – Dallas (1996/2006)	2.5%
CCI – Dallas (1996/2006)	2.5%
FHWA BPI (1995/2005)	4.2%
Turner Construction Index (1996/2006)	4.6%
Texas Highway Construction Index (1997-2006)	7.8%

The use of the Texas Highway Construction Index (compounded annual growth rate [CAGR] 7.8 percent) to account for construction cost increases within the equity gap methodology would provide the most conservative (i.e., highest) estimate of future costs. However, it is unlikely that this rate of annual growth will be sustained in the longer term, and the current CAGR of 7.8 percent is being skewed by the rapid growth between 2003 and 2007 (CAGR of 14 percent).

When assessing construction cost increases, it is important to take a longer-term view, particularly since the typical lifespan of a given roadway segment is between 20 and 30 years. A broader look at the indices described in Table 2.7 indicates that while short-term trends (i.e., 5-year) show 4-10 percent annual growth in construction costs, the 20-year

CAGR averages between 2 and 4 percent.[2] The Texas Highway Construction Index will also show slower growth rate over the same period of time. As a result, the PPI (Highway and Streets) measure should be used to estimate the long-term rise in construction costs and we revised the equity gap methodology to use this measure (4.8% annual growth).

Routine Maintenance Costs

Costs related to routine maintenance activities, such as crack and joint repairs, have also been increasing over the last several years. The existing equity gap methodology describes routine maintenance costs per lane mile in constant 2004 dollars. The default value is $4,400 per lane-mile (2004 $). These costs are inflated to nominal/year-of-expenditure (YOE) dollars using a 2 percent inflation factor. The following sections describe the key findings and recommendations to determine the appropriate inflation factors to use within the refined methodology.

[2] 20-year CAGR not available for the Texas Highway Construction Index, which has a base year of 1997.

Key Findings

We collected and analyzed data from FHWA Highway Statistics on maintenance and services (15) and lane-miles (16) for Texas and the U.S. as a whole. These data show that TxDOT's average routine maintenance costs for 2004 and 2005 were $5,320 and $6,027 per lane-mile, respectively. Figure 2.2 shows how maintenance costs in Texas have grown compared to national maintenance costs, from 1930 through 2005. From 1980 to present, total maintenance costs have increased at a faster growth rate in Texas compared to the U.S., with this trend accelerating after 1995.

Figure 2.2 Annual Index of Maintenance Costs, Texas vs. U.S., 1930-2005 *Index 1930 = 100*

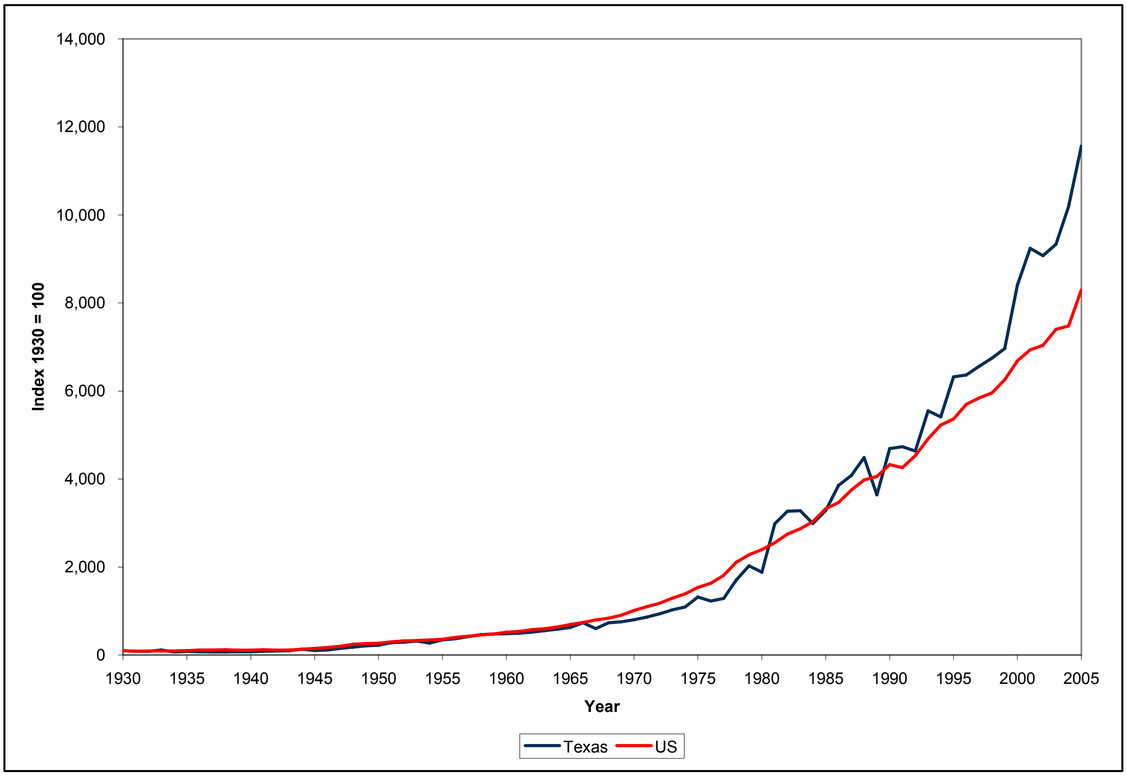
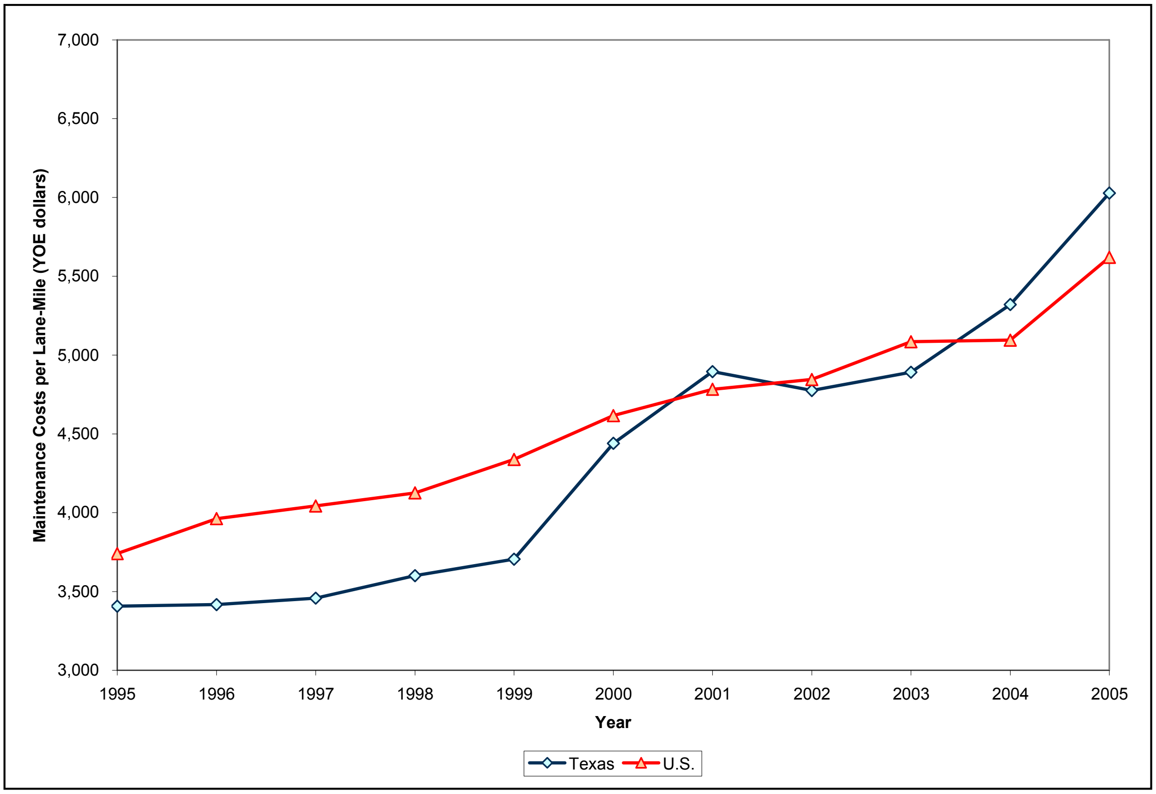


Figure 2.3 shows average maintenance costs per lane mile from 1995 through 2005 for Texas and the U.S. in nominal/YOE dollars. Prior to 2000, estimated U.S. average maintenance cost per lane mile was higher than Texas', but this changed in more recent years, with Texas exceeding the national average.

The 10-year compound average growth rate of maintenance costs in Texas is about 6 percent, compared to 4.2 percent in the U.S., both of which are higher than the 2 percent annual growth used in the original equity gap methodology

Figure 2.3 Average Maintenance Costs per Lane Mile, Texas vs. US, 1995-2005



Summary

As it provides the most conservative estimate of long-term growth in routine maintenance costs in the state, 6.0 percent annual growth rate should be used to estimate the long-term rise in routine maintenance cost. We revised the equity gap methodology to use 6.0 percent annual growth rate to convert existing maintenance costs ($4,400 per lane-mile [2004 $]) to YOE dollars.

Vehicle Registration Revenues

Vehicle registrations represent an important source of revenues that must be accurately accounted for in equity gap calculations. The original equity gap methodology incorporated vehicle registration (VR) revenues by using an adjustment factor that represented the amount of VR revenue generated per $1 of motor fuel tax (MFT) revenues. Using 2004 data on VR and state MFT revenues, this adjustment factor was estimated at 0.397, i.e., $1 in MFT revenue generates $0.397 in VR revenue.

Under this premise, VR revenues are assumed to increase at the same rate as state MFT revenues, neglecting the influence of population increases on overall VR growth. The following sections describe key findings of our literature and data collection effort and recommendations on how to more appropriately calculate VR revenues within the revised equity gap methodology.

Key Findings

TxDOT recently commissioned CS to develop forecast models for motor fuel tax and vehicle registration fee revenues over the next 25 years (17). The resulting Vehicle Registration Fee model uses population growth to estimate vehicle registration growth, noting that while either income or population growth is probably equally reasonable as an explanatory variable for future VR fees, population growth is a more accurate measure in the long term. Since continued growth in personal income is expected, and the highest income levels have already reached saturation of personal vehicles per person of driving age, forecasting of continued long-term growth past saturation levels may lead to overly optimistic revenue forecasts for forecasts that are based on personal income. Therefore, growth in vehicles in relation to population serves as a better long term explanatory variable as the society becomes more affluent.

As part of the VR revenue model development, CS assessed the relationship between population growth and VR revenue growth. A regression analysis of the relationship between population and vehicle registration revenues was used to predict the percentage change in vehicle registration revenues given a percentage change in population. The estimation involved the following regression equation:

log (Vehicle Registration Revenues) = a + log (Population)*b + error

The analysis determined that the ratio between population growth and vehicle registration revenue growth was 1.65 (i.e., a 1-percent growth in population will result in a 1.65-percent growth in vehicle registration revenues). This factor is applied to population growth forecast to calculate the VR revenue growth rate. For the purpose of the revised equity gap methodology, the adjusted VR revenue growth rates are used to forecast VR revenues after Year 1 of the analysis.

Summary

The Vehicle Registration Fee model shows that VR revenues increase in relation to population growth, at a rate of 1.65. To more appropriately account for change in VR revenues, the equity gap methodology was revised to link VR revenues with population growth, using a ratio of 1.65.

3.0 Equity Gap Estimation Spreadsheet Structure and Use

CS incorporated changes to the equity gap methodology within a Microsoft Excel equity gap estimation spreadsheet model, which is attached to this report. This spreadsheet model reflects the recommendations of the SAO's audit report, comprises changes to key parameters described in the previous section, and includes other usability improvements. The following sections describe the key elements, input parameters, and assumptions included within the revised equity gap methodology spreadsheet. It also provides "user information" to facilitate use by TxDOT staff.

Overall Spreadsheet Structure

The equity gap estimation spreadsheet is organized into several different worksheets, or tabs:

- Instruction Sheet;
- Summary Sheet;
- Data Input and Assumptions, or "Assumptions_Inputs";
- MPG data;
- Calculations-Cost;
- Calculations-Revenues (Average MPG);
- Revenue – Cost Analysis;
- Revenue Scenarios Summary;
- Calculations-Revenues (Low MPG); and
- Calculations-Revenues (High MPG).

Cells highlighted in green are those that require input from the user; those highlighted in blue represent calculations performed by the model; and those highlighted in yellow represent summary information. The following sections provide tab-by-tab information on assumptions, calculations, and use of the equity gap spreadsheet model.

Instruction Sheet

Page one of the equity gap estimation spreadsheet describes the overall purpose and structure of the spreadsheet.

Summary Sheet

Page 2 is the "Summary Sheet," which contains the results of the equity gap analysis in terms of R/C and state motor fuel tax increase required for R=C. This sheet also compares the equity gap default assumptions to the scenario assumptions.

Data Input and Assumptions

Pages 3-6 of the equity gap estimation spreadsheet, "Assumptions_ Input," require the user to input assumptions to be used in revenue calculations and provide details about the roadway segment being analyzed.

Revenue Assumptions

Table 3.1 summarizes the data and assumptions for revenue assumptions. Detailed explanations of these assumptions are also provided below.

Table 3.1 Summary of Revenue Assumptions in "Equity Gap" Estimation Spreadsheet

Data Input	Default Value	Source	Comments
State Highway Fund (SHF) share of MFT	72%	TxDOT	Current share of motor fuel tax revenues dedicated to transportation; remains constant through the analysis.
2007 Statewide Fuel Tax Rate	$0.20/gallon	Texas Tax Code, Section 162.102	Current state fuel tax rate
Federal Gasoline Tax Rate	$0.184/gallon	FHWA Highway Statistics	Current Federal gasoline tax rate; remains constant through the analysis. Adjusted to account for Mass Transit ($0.286/ gallon) and LUST accounts transfers ($0.001/gallon).
Federal Diesel Tax Rate	$0.244/gallon	FHWA Highway Statistics	Current Federal diesel tax rate; remains constant through the analysis. Adjusted to account for Mass Transit ($0.286/ gallon) and LUST accounts transfers ($0.001/gallon).
Federal Rate of Return	85%	TxDOT	Estimated share of Federal fuel tax revenues that are returned to the state.
Ratio of Vehicle Registration to State Motor Fuel Taxes	0.384	CS analysis of TxDOT data	Calculated as the average of VR Revenues/State MFT Revenues over a 9-yr period. Placeholders are provided for the years 2006-2009, should new or alterative VR or MFT values become available.
Population	Varies by year	Texas State Data Center	Population forecast through 2040 (Scenario 0.5), October 2006
Population Annual Growth Rate	1.11%-1.54%	Texas State Data Center	Population forecast through 2040 (Scenario 0.5), October 2006
Ratio of Vehicle Registration Revenue Growth to Population Growth	1.65	CS	Estimated ratio of change in vehicle registration revenues to change in population from 1987-2006
Fuel Efficiency Forecast	Varies by year and scenario; user-defined	TxDOT/CS	MPG forecast (through 2030) provided for several scenarios on a separate spreadsheet. Default scenarios are Low, Average and High MPG.

- **State Highway Fund (SHF) Share of State Motor Fuel Tax (MFT) Revenues.** Of the total state motor fuel tax revenues collected in Texas, **72 percent** is currently appropriated for use by TxDOT. Other state motor fuel tax revenues are dedicated to fund public schools and to pay for revenue collection expenses and tax reimbursements. This input value has been set to 72 percent in the spreadsheet and is assumed constant throughout the analysis horizon. The state fuel tax rate is adjusted by 72 percent to calculate the state motor fuel tax revenues that are appropriated to TxDOT.

- **2007 State Fuel Tax Rate.** The state motor fuel tax rate levied on roadway use of gasoline, ethanol and diesel is **20 cents per gallon**. The state motor fuel tax rate was last increased in October 1991, when it was increased by 5 cents per gallon to the current rate. The user has the option to use variable state fuel tax rates by year within the "Revenue" worksheets, as discussed in a subsequent section.
- **Federal Gasoline Tax Rate.** The current Federal gasoline tax rate is **18.4 cents per gallon**, of which 15.44 cents per gallon is dedicated to the Highway Account of the Highway Trust Fund (HTF). Transfers to other accounts include 2.86 cents per gallon dedicated to Mass Transit, and 0.1 cents per gallon going into the Leaking Underground Storage Tank (LUST) Trust Fund.
- **Federal Diesel Tax Rate.** Diesel fuels are taxed at **24.4 cents per gallon**, but only 21.44 cents per gallon are dedicated to the Highway Account of the HTF after accounting for transfers to the Mass Transit Account (2.86 cents per gallon) and LUST Trust Fund (0.1 cents per gallon).
- **Federal Rate of Return.** The average Federal fuel tax rate is adjusted by the rate of return to calculate the effective Federal fuel tax rate that will be applied in the calculation of the Federal MFT revenues. TxDOT currently receives back approximately **85 percent** of Federal fuel taxes it collects in the state for its highway program, making Texas a "donor" state. This parameter can be adjusted by the user.
- **Ratio of Vehicle Registration to State Motor Fuel Taxes.** As described earlier, a ratio of VR revenue to state MFT revenues was calculated based on historical data from 1997 to 2005. This ratio is only applied to the first year of state MFT to calculate the first year VR revenues. The model assumes that future VR revenues will increase based on population growth.
- **Population**. Population data are taken from the Texas 2040 population estimate developed from the Texas State Data Center (18) using Migration Scenario 0.5, i.e., it assumes rates of net migration one-half of those experienced in Texas during the 1990s.
- **Population Annual Growth Rate**. This is a calculated field that displays the annual population growth rate.
- **Ratio of Vehicle Registration Revenue Growth to Population.** As described earlier, population growth is used to estimate vehicle registration growth. The adjustment factor applied to population growth is **1.65** (i.e., a 1-percent growth in population will result in a 1.65-percent growth in vehicle registration revenues), based on previous research conducted by CS for TxDOT.
- **Fuel Efficiency Forecast.** As described earlier, TxDOT revised its Texas Fleet Fuel Efficiency model in November 2007, and developed a series of scenarios that varies the market penetration of alternative fuel efficient vehicles and average fuel efficiency.

The results of all scenarios are included on a separate worksheet, "MPG Data." Users should refer to these scenarios and copy the desired fuel efficiency forecasts into the "Assumptions_Inputs" worksheet. The base model has been developed using the low, average, and high MPG scenarios to provide a range of fuel tax rates to close funding gap. The MPG data is used to estimate fuel consumption, which is ultimately used to calculate both the state and Federal MFT revenues.

Roadway Parameter Assumptions

Table 3.2 summarizes the data and assumptions for roadway parameters. Detailed explanations of these assumptions are also provided below.

Table 3.2 Roadway Parameters Assumptions in "Equity Gap" Methodology Spreadsheet

Data Input	Default Value	Source	Comments
Average ADT (vehicles/day)	User-defined	TxDOT	Based on roadway segment to be evaluated
Section length (miles)	User-defined	TxDOT	Based on roadway segment to be evaluated
Average Percent of Trucks	User-defined	TxDOT	Based on roadway segment to be evaluated
Average Percent of Cars	User-defined	TxDOT	Based on roadway segment to be evaluated
Average number of lanes	User-defined	TxDOT	Based on roadway segment to be evaluated
Pavement type	Variable: Rigid, Flexible or User-defined	TxDOT	Based on roadway segment to be evaluated. Used to determine service life of pavement, and years to reconstruction.
Reconstruction/Lifecycle (years)	26 (Rigid); 20 (Flexible); or user-defined	Multiple sources (see pages 11-13)	Option to enter user-defined lifecycle, between 1 and 40 years.
Maintenance costs (2004 dollars, per lane-mile)	$4,400	TxDOT	Can be adjusted by user
Year of Maintenance Cost Estimates	2004	TxDOT	Can be adjusted by user
ADT annual growth rate	User-defined	TxDOT	Based on roadway segment to be evaluated
Construction base year	User-defined	TxDOT	Based on roadway segment to be evaluated

Table 3.2 Input and Data Assumptions for "Equity Gap" Methodology Roadway Parameters (cont'd.)

Data Input	Default Value	Source	Comments
Construction Cost Index	PPI	PPI (see pages 14-23)	Default is to PPI (4.8%), though option for users to enter other annual construction cost growth rate based on other sources.
Inflation factor for reconstruction costs	4.8%	PPI (see pages 14-23)	Depends on index selected; default is 4.8%
Administration indirect costs	6%	TxDOT	Can be adjusted by user
Inflation factor for Routine Maintenance	6%	CS analysis of FHWA data (see pages 23-25)	Can be adjusted by user
Right-of-way costs	User-defined	TxDOT	Based on roadway segment to be evaluated

- **Average Annual Daily Traffic (ADT).** Average ADT is used in the model to calculate vehicle-miles traveled (VMT). This input will vary depending on the roadway segment being analyzed, and must be provide by the user. This is a corridor-specific parameter.
- **Section length (miles).** The length of the roadway segment being analyzed must be provided by the user. This input is combined with the average ADT to estimate the segment VMT. This is a corridor-specific parameter.
- **Average Percent of Trucks.** The average percent of truck traffic is used to calculate the Average Federal Fuel Tax rate. The truck percentage is applied to the Federal diesel tax rate. This is a corridor-specific parameter.
- **Average Percent of Cars.** The average percent of passenger car traffic is used to calculate the Average Federal Fuel Tax rate. This is a corridor-specific parameter.
- **Average Number of Lanes.** The average number of lanes is used to calculate routine maintenance costs, which are expressed in $/lane-mile. This is a corridor-specific parameter.
- **Pavement Type.** Pavement type is either asphalt (flexible) or concrete (rigid), which determines the lifecycle for reconstruction of the roadway segment. The user can select from a pull-down menu on cell F144 the type of pavement from flexible, rigid or user-defined. The user-defined option allows the user to enter the lifecycle, from 1 to 40 years. The user-defined lifecycle is entered on cell J145. This is a corridor-specific parameter.

- **Reconstruction/Lifecycle (years).** This refers to the number of years after initial construction when reconstruction will occur. The default values are 20 and 26 years for flexible and rigid surface, respectively. The default values can be adjusted by the user through the "user-defined" option (see *Pavement Type* above).
- **Maintenance Costs (dollars per lane-mile) and Year of Maintenance Cost Estimate.** Default maintenance costs per lane-mile are provided by TxDOT. The default value is **$4,400 in 2004 dollars**. The model requires the input of the base year of maintenance costs to ensure that the cost estimates are properly adjusted for inflation in the equity gap analysis.
- **Year of Maintenance Cost Estimates**. The user enters the future year at which point maintenance costs are to be calculated.
- **ADT Annual Growth Rate**. This is defined by the user and should be based on historical data for the roadway being analyzed, if available.
- **Construction Base Year.** The user enters in this cell the year when construction of the facility begins. This value becomes Year 1 of the analysis period. This is a corridor-specific parameter.
- **Construction Cost Index.** There are several construction cost indices that could be applied to the base year construction costs in order to estimate reconstruction costs by Year 1 + Lifecycle (or Reconstruction Year). Cell F157 has a pull down menu that allows the user to select the preferred construction cost inflation factor. The options include CPI, PPI, BCI, CCI, FHWA, Turner, and user-defined.
- **Inflation factor for reconstruction (percent).** This value will change, depending on the cost index selected (see above). The default value is **4.8 percent** based on PPI – Highway and Street Construction's 10-year average.
- **Administration Indirect Costs.** Construction, reconstruction and routine maintenance are adjusted by **6 percent** to account for administration indirect costs, based on TxDOT experience.
- **Inflation factor for routine maintenance.** The default inflation factor to convert routine maintenance costs to YOE/nominal dollars is **6 percent**. The user can override the default value.
- **Right-of-Way (ROW) Costs (dollars).** This is a corridor-specific parameter; the user enters the ROW costs incurred in Year 1 of the analysis.

MPG Data

Page 7 of the equity gap estimation spreadsheet, "MPG Data," contains the MPG data developed as part of the Fleet Fuel Efficiency Model (2). Users should copy the MPG values to be tested into the "Assumption_Inputs" worksheet. The values associated with the "average" scenario are preferred.

Calculations – Costs

Pages 8 and 9 of the equity gap estimation spreadsheet, "Calculations-Costs" consists only of calculations- no user inputs are required. All formulations in the spreadsheet are tied to the parameters and variables that the user has entered in the "Assumptions_Inputs" sheet. The formulations and methodology used to calculate the Cost element of the equity gap analysis are summarized below. Please note that column and line letters (A through H) refer to column headings listed in the tax-gap estimation spreadsheet, not the row/column headings provided in Excel.

Column (A) – Year

This column is populated based on input of **Construction Base Year** in the "Assumptions_Inputs" worksheet, which represents Year 1 of the analysis. Although we recommend a lifecycle of 26 years (for concrete) and 20 years (for asphalt), the analysis period in this column allows for a maximum of 50 years (i.e., 10 years from reconstruction with a lifecycle of 40 years). This provides the user with some flexibility in the definition of the roadway lifecycle.

Columns (B) and (C) – Construction and Reconstruction (C&R) Costs

Column (B) – C&R Base Costs

This column is populated with the construction and reconstruction Costs in nominal/YOE (i.e., inflated) dollars. The methodology assumes that the **Year 1 Construction Costs** are entered in the "Assumptions_Inputs" worksheet in nominal/YOE dollars, and that the reconstruction costs will be estimated by inflating the **Year 1 Construction Costs** to the reconstruction year. The formula in column B calls on column A to determine what construction costs are applicable per year. That is,

- If Year = Year 1, then C&R Base = *Year 1 Construction Costs*,

Else,

- If Year = Reconstruction Year, then C&R Base = *Reconstruction Costs*,

Therefore,

- C&R Base = Year 1 Construction Costs x (1+Inflation Factor Reconstruction)$^{\text{Lifecycle}}$

Else,

- C&R Base = 0

Column (C) – C&R Adjusted (% Indirect Costs)

In column (C), construction and reconstruction costs are inflated to account for indirect administrative costs. As described above, the recommended (default) inflation factor is 6 percent, but can be modified by the user. In addition, reconstruction costs are spread over the lifecycle; the methodology will only account for the 10 years from reconstruction included in the worksheet.

Column (D) – Right-of-Way (ROW) Costs

This column is populated with ROW costs from "Assumptions_Inputs" worksheet. This value only applies to Year 1 of the analysis.

Column (E) & (F) – Routine Maintenance (RM)

Column (E) – Base RM

This column calculates the annual routine maintenance costs in nominal/YOE dollars, using inputs from the "Assumptions_Inputs" worksheet, specifically **Maintenance Costs, Year of Maintenance Costs,** and **Inflation Factor for Routine Maintenance**. The calculation for Year 1 of the analysis includes the adjustment of **Maintenance Costs** from constant to Year 1 dollars, and then adjust the cost annually. The formula in column E calls on column A to determine what construction costs are applicable per year. That is,

If Year = Year 1, then

- Base $RM_{\text{Construction Base Year}}$ = (Section Length x Average Number of Lanes) x Maintenance Costs x $(1 + \text{Inflation Factor for Routine Maintenance})^{(\text{Construction Base Year – Year of Maintenance Cost Estimate})}$

Else,

- Base $RM_{\text{Year n}}$ = Base $RM_{\text{Year n-1}}$ x (1 + Inflation Factor for Routine Maintenance)

For example, if Construction Base Year = 2009, Maintenance Costs = $4,400 per lane-mile in 2004 dollars, Section Length = 3 miles, Average Number of Lanes = 4, and Inflation Factor for Routine Maintenance = 6%

In Year 2009,

- Base $RM_{2009} = (3 \times 4) \times \$4{,}400 \times 1.06^{(2009-2004)}$ = ***$70,658***

In Year 2010,

- Base RM_{2010} = \$70,658 x 1.06 = ***\$74,897***

Column (F) – RM Adjusted (% Indirect Costs)

In column (F), base routine maintenance costs are inflated to account for indirect administrative costs. The recommended (default) inflation factor is 6 percent, but it can be modified by the user.

Column (G) – Total Construction (per year)

Total construction costs per year are estimated by adding C&R Adjusted, ROW and RM Adjusted.

Line (H) – Grand Total, (Analysis Period)

This line provides the total construction costs, including initial construction, reconstruction and routine maintenance, over the analysis period.

Calculations – Revenues (by MPG Scenario)

Pages 10-11 and 16-19 of the equity gap estimation spreadsheet are the “Calculations-Revs” by MPG scenario (low [pages 16-17], average [pages 10-11], and high [pages 18-19]). The average MPG scenario is the default selection; the other scenarios are provided for reference. These pages consist mostly of calculations. All formulations in the spreadsheet are tied to the parameters and variables that the user has entered in the “Assumptions_Inputs” worksheet. The formulations and methodology used to calculate the Revenue element of the equity gap analysis are described below. Again, note that column and line letters (A through H) refer to column headings listed in the tax-gap estimation spreadsheet, not the row/column headings provided in Excel.

Column (A) – Year

This column is populated based on input of **Construction Base Year** in the “Assumptions_Inputs” worksheet, which represents Year 1 of the analysis. The recommended (default) lifecycles of for concrete and asphalt are 26 and 20 years, respectively. However, the analysis period in this column allows for a maximum of 50 years (i.e., 10 years from reconstruction with a lifecycle of 40 years) to provide users with some flexibility in the definition of the roadway lifecycle.

Column (B) – Vehicle-miles Traveled (VMT)

The calculation of VMT is based in the following formula:

- VMT = 40-year average ADT x 365 x Section Length

VMT is assumed constant throughout the analysis period. For example, if the 40-year ADT Average = 30,000 vehicle per day and Section Length = 3 miles,

- VMT = 30,000 x 365 x 3 = ***32,850,000 vehicle-miles***

Note that the VMT calculation does not account for potential impacts of traffic diversions (due to lane closures) during the reconstruction year. This factor would reduced actual federal and state fuel tax revenues on that specific year.

Column (C) – MPG

Fuel efficiency (in miles per gallon) values are read from the "Assumptions_Inputs" worksheet. For the average MPG scenario, the value ranges from 17.23 miles per gallon in 2005 to 58.4miles per gallon by 2030. The formula in this column assumes that if the Year in Column (A) is greater than year 2030 (last year of fuel efficiency forecast), that the MPG value remains at the 2030 forecast value thereafter.

Column (D) – Fuel Consumption

Annual fuel consumption calculation is calculated by dividing VMT and fuel efficiency.

- Fuel Consumption (in gallons)$_{\text{Year n}}$ = VMT$_{\text{Year n}}$/MPG$_{\text{Year n}}$

For Construction Year = 2009, fuel consumption for the average MPG scenario is estimated at:

- Fuel Consumption$_{2009}$ = 32,850,000/19.48 = ***1,686,345 gallons***

Columns (E) and (F) – Calculation of Federal MFT

Column (E) – Federal Tax Rate

Column (E) reads the effective Federal fuel tax rate calculated in the "Assumptions_Input" worksheet.

Column (F) – Federal MFT Revenues

Federal MFT revenues are calculated using the following equation:

- Federal MFT Revenues$_{\text{Year n}}$ = Effective Federal Fuel Tax Rate$_{\text{Year n}}$ x Fuel Consumption$_{\text{Year n}}$

For Construction Year = 2009, and a effective Federal fuel tax rate of $0.134 per gallon:

- Federal MFT Revenues$_{2009}$ = \$0.134 x 1,686,345 = ***\$225,970***

Column (G) through (I) – Calculation of State MFT Revenues

Column (G) – Base Rate

Data in this column reflect input from the "Assumptions_Inputs" worksheet. .

Column (H) – Adjusted Rate

The base rate in column (G) is adjusted to calculate the effective state fuel tax rate appropriated to TxDOT. The default adjustment factor is **72 percent**.

Column (I) – State MFT Revenues

State MFT revenues dedicated to transportation for the roadway segment analyzed are estimated using the formula:

- State MFT Revenues$_{\text{Year n}}$ = Adjusted Rate$_{\text{Year n}}$ x Fuel Consumption$_{\text{Year n}}$

For Construction Year = 2009, assuming the current state fuel tax rate:

- State MFT Revenues$_{2009}$ = \$0.144 x 1, 686,345 = ***\$242, 834***

Columns (J) and (K) – State Vehicle Registration Revenues

Column (J) – Vehicle Revenue Registration Growth

The VR revenue growth is estimated using the adjustment factor of **1.65**, which is the recommended ratio of VR revenue growth to population growth (see Section 2.0).

The VR revenue growth is calculated using the formula:

- VR Revenue Growth$_{\text{Year n}}$ = Population Growth$_{\text{Year n}}$ x Adjustment Factor

For example, for 2010, the VR Revenue Growth is estimated at:

- VR Revenue Growth$_{2010}$ = 1.50% x 1.65 = ***2.47%***

Column (K) – VR Revenues

Column (K) contains two formulas to calculate VR Revenues:

If Year = Construction Year, then

- VR Revenues$_{\text{Construction Year}}$ = State MFT Revenue$_{\text{Construction Year}}$ x Ratio of VR Revenues to State MFT

Else,

- VR $\text{Revenues}_{\text{Year n}}$ = VR $\text{Revenues}_{\text{Year n-1}}$ x (1 + VR Revenue $\text{Growth}_{\text{Year n}}$)

For example, for Construction Year = 2009,

- VR Revenues_{2009} = $242,834 x 0.384 = ***$93,248***

And for Year = 2010,

- VR Revenues_{2010} = $93,248 x (1.0247) = ***$95,551***

Column (L) – Total Revenues (per year)

Total revenues per year are estimated by adding State MFT, Federal MFT revenues, and VR revenues.

Line (M) – Grand Total (Analysis Period)

In Line M, the following items are added over the analysis period:

- VMT;
- Average MPG;
- Federal MFT Revenues;
- State MFT Revenues;
- VR Revenues; and
- Grand Total of Revenues over the analysis period

Revenue-Cost Analysis

Pages 12-14 of the equity gap estimation spreadsheet, "Revenue-Cost Analysis," consists only of calculations, pulling data from the "Calculation-Costs" and "Calculation-Revenues" sheets. The "Revenue-Cost Analysis" sheet produces the following information:

- "Equity gap" expressed as the difference between the roadway or roadway segment's revenues (R) and its costs (C);
- "Equity gap" expressed as a ratio of revenues to costs (R/C), also known as the Asset Value Index; and
- Level of state fuel tax necessary for the roadway or roadway segment to "pay for itself," i.e., revenues equal costs (R = C).

The formulations and methodology used within this worksheet are described below.

Equity Gap = R-C

The equity gap is calculated as the difference between revenues and costs. If R-C is less than 0, there is a funding gap, and revenues are not sufficient to cover the costs of the roadway over the analysis period.

Asset Value Index = R/C

The asset value index is the Revenue/Cost ratio. If the R/C is less than 1.0, there is a funding gap.

Revenues = Costs

For the R = C analysis, the following formula was developed to estimate the fuel tax rate necessary for the roadway to "pay for itself":

- Costs = Federal MFT + VR Revenues + State MFT, where
  State MFT = (VMT/Average MPG) x Fuel Tax Rate$_{R=C}$

Therefore,

- Fuel Tax Rate$_{R=C}$ = (Costs – Federal MFT – VR Revenues) x (Average MPG/VMT)

The Fuel Tax Rate$_{R=C}$ is the fuel tax rate allocated to the State Highway Fund (SHF), and does not include the tax required to pay for public schools, as currently required by the Texas Constitution. To calculate the Total State MFT Rate required in the State of Texas to close the funding gap and pay for other non-SHF uses:

- Total State MFT Rate$_{R=C}$ = Fuel Tax Rate$_{R=C}$/0.72

The following example illustrates the R = C analysis. Assuming Costs = $60,000,000, Federal MFT Revenues = $15,000,000, and VR Revenues = $5,000,000. VMT is equal to 1.5 billion vehicle-miles and average fuel efficiency is 25 miles per gallon.

Fuel Tax Rate$_{R=C}$ = (60,000,000 – 15,000,000 – 5,000,000) x (25/1,500,000,000)

Fuel Tax Rate$_{R=C}$ = ***$0.67 per gallon***

Total State MFT Rate$_{R=C}$ = $0.67/0.72 = ***$0.93 per gallon***

Note that in this example, the $0.93 per gallon already includes the current fuel tax rate of $0.20 per gallon levied at the state level.

Revenues Scenario Summary Worksheet

Page 15 in the equity gap estimation spreadsheet summarizes the results from the "equity gap" analysis by showing in a graph the Total State MFT $Rate_{R=C}$ for the MPG scenarios by their statistical probability.

■ Case Study

This section summarizes the results of the revised equity gap methodology as applied to a segment of Harris Pearland FM 865, from Beltway 8 South to FM 518. This case study was selected to test the revised equity gap estimation spreadsheet and ensure that the formulations were working properly. Tables 4.1 and 4.2 summarize the revenue assumptions and roadway parameters used in this scenario.

Table 4.1 Revenue Assumptions
Harris Pearland FM 865 – from Beltway 8 South to FM 518

Data Input	Default Value
State Highway Fund (SHF) share of MFT	72%
2007 Statewide Fuel Tax Rate	$0.20/gallon
Federal Gasoline Tax Rate	$0.184/gallon
Federal Diesel Tax Rate	$0.244/gallon
Federal Rate of Return	85%
Ratio of Vehicle Registration to State Motor Fuel Taxes	0.384
Population Annual Growth Rate	1.11%-1.54%
Ratio of Vehicle Registration Revenue Growth to Population Growth	1.65

Table 4.2 Roadway Parameters
Harris Pearland FM 865 – from Beltway 8 South to FM 518

Data Input	Default Value
Roadway name	Harris Pearland FM 865 from Beltway 8 South to FM 518
40-year average ADT (vehicles/day)	34,400
Section length (miles)	2.72
Average Percent of Trucks	5%

Table 4.2 Roadway Parameters (cont'd.)
Harris Pearland FM 865 – from Beltway 8 South to FM 518

Data Input	Default Value
Average Percent of Cars	95%
Average number of lanes	3.90
Pavement type	Rigid
Reconstruction/Lifecycle (years)	26
Maintenance costs (2004 dollars, per lane-mile)	$4,400
Year of Maintenance Cost Estimates	2004
ADT annual growth rate	1.5%
Construction base year	2009
Construction Costs	$41,486,691
Construction Cost Index	PPI
Inflation factor for reconstruction costs	4.8%
Administration indirect costs	6%
Inflation factor for Routine Maintenance	6%
Right-of-way costs	$600,000

Table 4.3 summarizes the results from the equity gap analysis, based on these input data. The R/C was estimated at 0.13, and the total State MFT rate for R=C is estimated at $4.93 per gallon for this roadway segment.

Table 4.3 "Equity Gap" Analysis Results
Harris Pearland FM 865 – from Beltway 8 South to FM 518

Total Construction Costs (2009-2044)	***$109,147,076***
Revenues (Average MPG Scenario):	
Federal MFT Revenues	$4,342,154
State MFT Revenues	$4,673,519
Vehicle Registration Revenues	$5,245,081
Total Revenues (2009-2044)	***$14,260,754***
Revenues/Costs (R/C)	0.13
Total State MFT Rate required for R=C (per gallon)	**$4.93**
Additional State MFT Rate required for R=C (per gallon)	$4.73

The results shown above indicate that revenues generated in this roadway section are not sufficient to cover the costs incurred in construction, reconstruction and routine maintenance. These values are specific to this roadway segment and do not represent in any way a statewide fuel tax rate.

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