I-5 NORTH COAST

MANAGED LANES VALUE PRICING STUDY

FROM LA JOLLA VILLAGE DRIVE TO VANDEGRIFT BOULEVARD

CONCEPT PLAN
VOLUME I

APRIL 2006

Submitted to:

Submitted by:

Table of Contents

EXECUTIVE SUMMARY

ES.1 PROJECT DESCRIPTION AND CORRIDOR OBJECTIVES ES-1
ES.2 STUDY DESCRIPTION AND CRITERIA ES-3
ES.3 FINDINGS ES-4
ES.3.1. Demand ES-4
ES.3.2. Access ES-5
ES.3.3. Pricing Strategy ES-5
ES.3.4. Technology and Performance Monitoring ES-7
ES.3.5. Revenue ES-8
ES.3.6. Public Attitudes and Equity ES-8
ES.4 RECOMMENDATIONS ES-9
ES.4.1. Timeline for Value Pricing ES-9
ES.4.2. Access ES-9
ES.4.3. Tolling Strategy ES-9
ES.4.4. Eligible Users ES-9
ES.4.5. Project Phasing ES-10
ES.4.6. Monitoring and Evaluation ES-10

CHAPTER 1 Introduction

1.1 PROJECT DESCRIPTION 1-3
1.1.1. Project Features 1-3
1.1.2. Project Need and Objectives 1-3
1.1.3. Other Corridor Projects 1-5
1.2 SCOPE OF STUDY 1-5
1.3 CRITERIA FOR FEASIBILITY 1-6
1.4 OUTLINE OF REPORT 1-7

CHAPTER 2 OPERATING PROFILE

2.1 HISTORICAL TRAFFIC TRENDS 2-1
2.2 2002 AVERAGE DAILY AND WEEKEND TRAFFIC 2-3
2.3 HOURLY TRAFFIC DISTRIBUTION 2-12
2.4 WEEKEND VS WEEKDAY VOLUMES 2-17
2.5 NORTHBOUND HOV LANE VOLUMES 2-21
2.6 VEHICLE OCCUPANCY DISTRIBUTION 2-24
2.7 VEHICLE CLASSIFICATION DISTRIBUTION 2-24
2.8 SECOND ROUND (FOCUS GROUPS #3 AND #4) 2-27
2.9 CURRENT PEAK HOUR OPERATING SPEEDS 2-28

CHAPTER 3 ALTERNATIVE PRICING STRATEGIES

3.1 PRICING GOALS AND STRATEGIES 3-1
3.1.1. Project Goals and Objectives 3-1

3.1.2. Toll Equity 3-2
3.1.3. Targeted Trips 3-2
3.1.4. User and System Complexity 3-3
3.2 PRICING OPTIONS 3-3
3.2.1. Strategy 1: Variable Fixed [time of day] 3-6
3.2.2. Strategy 2: Dynamic [real time per congestion level] 3-7
3.2.3. Strategy 3: Distance-based with reduced toll for HOV use 3-8
3.2.4. Strategy 4: Fixed [distance-based] 3-8
3.2.5. Strategy 5: Access Point-Based 3-9
3.2.6. Strategy 6: Fixed [time-based] 3-9
3.2.7. Strategy 7: Flat Toll 3-9
3.2.8. Strategy 8: Dynamic by Segment 3-9
3.2.9. Strategy 9: Time of Day, By Segment 3-10
3.2.10. Strategy 10: Dynamic, Skewed Toll 3-10
3.2.11. Comparative Summary among Scenarios 3-10
3.3 COMPARATIVE ATTRIBUTES 3-12
3.3.1. Toll Rates 3-12
3.3.2. Comparative Attributes 3-13
3.4 RECOMMENDATION 3-15

CHAPTER 4 TRAFFIC FORECASTS

4.1 METHODOLOGY 4-1
4.1.1. SANDAG Model Enhancement 4-1
4.1.2. Corridor Calibration 4-4
4.2 ANALYSIS YEARS 4-8
4.2.1. Intermediate Year Analysis (2015) 4-8
4.2.2. Design Year Analysis (2030) 4-8
4.3 ALTERNATIVES 4-8
4.3.1. No Build Alternative 4-9
4.3.2. Build Alternative 4-9
4.3.3. Scenario for Increasing HOVs to 3+ 4-9
4.3.4. Intermediate Access Scenarios 4-10
4.4 ASSUMPTIONS 4-12
4.4.1. Background Roadway Network 4-12
4.4.2. Land Use and Demographics 4-13
4.4.3. Managed Lane Configurations 4-13
4.4.4. Tolling 4-14

CHAPTER 5 FUTURE OPERATING CHARACTERISTICS

5.1 INTRODUCTION 5-1
5.2 METHODOLOGY 5-1
5.3 FORECAST RESULTS 5-1
5.3.1. Mainline Volumes 5-2
5.3.2. Ingress/Egress Volumes 5-5
5.3.3. Managed Lane Volumes 5-6
5.3.4. Comparison of Managed Lane Traffic Shares 5-20

5.4 RESULTS AND RECOMMENDATIONS 5-27

CHAPTER 6 REVENUE ANALYSIS

6.1 POTENTIAL PRICING CONCEPTS 6-1
6.1.1. Qualitative Forecasts of Traffic 6-1
6.1.2. Incorporating Rish in the Policy and Enterprise Strategy Development Process 6-3
6.2 METHODOLOGY 6-4
6.2.1. Model Output 6-4
6.2.2. Tolling Rates 6-7
6.2.3. Tolling Curves 6-9
6.3 ASSUMPTIONS 6-21
6.4 FORECASTED TOLL REVENUE 6-21
6.4.1. Intermediate Year 2015 6-21
6.4.2. Design Year 2030 6-30
6.5 FORECAST OF 2+ / 3+ HOV POLICY 6-39
6.6 SUMMARY 6-40

CHAPTER 7 TECHNOLOGY AND SYSTEMS OPERATION CONCEPT

7.1 INTRODUCTION 7-1
7.2 FACILITY DESIGN 7-1
7.2.1. Managed Lane Configurations 7-1
7.2.2. Managed Lane Entry/Exit Access Points and Toll Zones 7-2
7.3 TECHNOLOGY INFRASTRUCTURE 7-4
7.3.1. Standards 7-4
7.3.2. Electronic Toll Collection (ETC) System 7-7
7.3.3. ETC Violation Enforcement Systems (VES) 7-13
7.3.4. Traffic Management and Control Systems 7-19
7.3.5. Freeway Incident Response Provisions 7-33
7.4 CONCEPT OF OPERATIONS 7-34
7.4.1. System Overview 7-34
7.4.2. Development of Standards 7-37
7.4.3. Traffic Management: Assumed Operational Parameters 7-38
7.4.4. Back-End Office Operations 7-39
7.4.5. Staffing 7-43
7.5 EVALUATION AND CONTINUOUS IMPROVEMENT PROCESS 7-48
7.5.1. Performance Measures 7-48
7.5.2. Monitoring Program 7-49
7.6 POTENTIAL TIMELINE FOR TECHNOLOGY ADOPTION 7-50
7.7 PRELIMINARY COST ESTIMATE OF CURRENT TECHNOLOGY 7-51
7.7.1. Assumptions for Estimate 7-51
7.7.2. Annual Operating Expenditures 7-51

CHAPTER 8 MONITORING AND EVALUATION PLAN

8.1 PURPOSE OF MONITORING AND EVALUATION PLAN 8-1
8.2 EVALUATION OBJECTIVES 8-2
8.2.1. Project Need 8-2
8.2.2. Project Objectives 8-3
8.3 EVALUATION APPROACH 8-4
8.3.1. Measurement of Project Imapct 8-4
8.3.2. Measurement of Project Utilization 8-4
8.3.3. Measurement of Project Acceptance 8-4
8.3.4. Assessment of Project Operations 8-5
8.3.5. Summary of Evaluation Approach 8-5
8.4 KEY PERFORMANCE MEASURES 8-6
8.4.1. Level of Service 8-6
8.4.2. Changes in Travel Speed, Travel Time and Delay 8-7
8.4.3. Changes in Vehicle Occupancy 8-7
8.4.4. Changes in Mode Split 8-7
8.4.5. Change in Vehicle Classification 8-8
8.4.6. Changes in Travel Behavior 8-8
8.4.7. Toll Utilization 8-9
8.4.8. Park and Ride Utilization 8-9
8.4.9. Rate of Toll Evasion Violations 8-9
8.5 RECOMMENDED 'BEFORE' DATA SET 8-10
8.5.1. Project Imapct Data 8-10
8.5.2. Project Utilization Data 8-12
8.5.3. Project Acceptance Data 8-13
8.5.4. Project Operational Data 8-14
8.5.5. Summary of Before Data Set 8-15
8.6 RECOMMENDED 'AFTER' DATA SET 8-16
8.6.1. Project Imapct Data 8-16
8.6.2. Project Utilization Data 8-18
8.6.3. Project Acceptance Data 8-19
8.6.4. Project Operational Data 8-20
8.6.5. Summary of After Data Set 8-21
8.7 ONGOING MONITORING ACTIVITIES 8-23
8.8 SCHEDULE AND BUDGET 8-26
8.8.1. Schedule 8-26
8.8.2. Budget 8-27
8.9 CONTINUING IMPROVEMENT PROCESS 8-28
8.10 SUMMARY OF RECOMMENDED PLAN 8-29

List of Tables

Table ES-1: Comparison of Feasiblity Criteria to Study Subtasks Reports.....ES-4
Table ES-2: Comparable Attribute Matrix for Alternative Pricing Strategies ES-7
Table ES-3: Summary of Forecast Revenue ES-8
Table 1-1: Comparison of Feasibility Criteria to Study Subtasks Reports..... 1-7
Table 2-1: 1994-2003 7-Day Annual ADT Volume Trends 2-2
Table 2-2: Average Weekday Daily Volume Directional Split 2-4
Table 2-3: I-5 Southbound Mainline – Daily Volumes 2-18
Table 2-4: I-5 Northbound Mainline – Daily Volumes 2-19
Table 2-5: I-5 Northbound HOV Lane – Daily Volumes 2-20
Table 2-6: Vehicle Occupancy Distribution 2-25
Table 2-7: Vehicle Classigication Distribution 2-26
Table 2-8: Current 7-Day and Weekday Truck ADT 2-27
Table 3-1: Overview of I-5 ML Pricing Options..... 3-5
Table 3-2: Pricing Strategy Options Matrix 3-6
Table 3-3: Typical Per Mile Rates with Maximum Tolls 3-12
Table 3-4: Comparison of Toll Rates for Various Trip Types 3-13
Table 3-5: Comparative Attribute Matrix – Alternative Pricing Strategies 3-14
Table 4-1: I-15 Observed and Estimated Year 2000 HOV and FasTrak Demand 4-5
Table 4-2: Comparison of Year 2000 Volumes I-15 Main Lanes 4-5
Table 4-3: Year 2000 Southbound AM Peak Period Observed vs. Model Estimated Occupancy..... 4-6
Table 4-4: 2000 Model Assigned and Counted Volumes Comparison on I-5 4-7
Table 4-5: Southbound Intermediate Access Locations 4-11
Table 4-6: Northbound Intermediate Access Locations 4-12
Table 5-1: 2030 Daily Mainline Volumes 5-2
Table 5-2: 2015 Daily Mainline Volumes 5-3
Table 5-3: 2030 AM and PM Peak Hour 5-4
Table 5-4: 2015 AM and PM Peak Hour 5-5
Table 5-5: I-5 Managed Lane Traffic Volumes 5-14
Table 5-6: I-5 Managed Lane Traffic Volumes 5-15
Table 5-7: I-5 Managed Lane Traffic Volumes 5-16
Table 5-8: I-5 Managed Lane Traffic Volumes 5-17
Table 5-9: I-5 Managed Lane Daily Traffic Volumes 5-18
Table 5-10: I-5 Managed Lane Daily Traffic Volumes 5-19
Table 5-11: 2030 10+4 Managed Lane Shares SOV Toll Scenario 5-24
Table 5-12: 2030 10+4 Managed Lane Shares SOV/HOV-2 Toll Scenario 5-22
Table 5-13: 2030 8+4 Managed Lane Shares SOV Toll Scenario 5-23
Table 5-14: 2030 8+4 Managed Lane Shares SOV/HOV-2 Toll Scenario 5-24
Table 5-15: 2015 10+4 Managed Lane Shares SOV Toll Scenario 5-25
Table 5-16: 2015 8+4 Managed Lane Shares SOV Toll Scenario 5-26
Table 5-17: Peak Travel Time Savings from SR 76 to I-5/I-805 Split 5-28
Table 7-1: Facility Congestion Toll Levels..... 7-35
Table 7-2: Preliminary Cost Estimate for General Purpose Lanes 7-53
Table 7-3: Preliminary Cost Estimate for Managed Lanes 7-54
Table 8-1: Summary of Before Data Set 8-15
Table 8-2: Summary of After Data Set 8-22
Table 8-3: Summary of Ongoing Monitoring Activities 8-24

List of Figures

Figure ES-1: I-5 Study Limits ES-1
Figure ES-2: Alternative Managed Lane Cross Sections ES-2
Figure ES-3: Access Assumptions for I-5 Managed Lanes ES-6
Figure 1-1: I-5 Study Limits 1-2
Figure 2-1: 2002 AADT, AM Peak Hour Traffic and PM Peak Hour Traffic..... 2-5
Figure 2-2: 2003 Hourly Directional Traffic Distributions 2-13
Figure 2-3: 2003 Hourly Directional Traffic Distributions 2-14
Figure 2-4: 2003 Hourly Directional Traffic Distributions 2-15
Figure 2-5: 2003 Hourly Directional Traffic Distributions..... 2-16
Figure 2-6: I-5 Northbound hourly volumes - Wednesday 2-22
Figure 2-7: I-5 Northbound hourly volumes - Saturday 2-23
Figure 2-8: I-5 Southbound Mainline Speeds - Wednesday 2-30
Figure 2-9: I-5 Southbound Mainline Speeds - Saturday 2-31
Figure 2-10: I-5 Northbound Mainline Speeds - Wednesday 2-32
Figure 2-11: I-5 Northbound Mainline Speeds - Saturday 2-33
Figure 2-12: I-5 Northbound HOV Speeds 2-34
Figure 3-1: Example Cost Schedule from SR 91 in Orange County 3-7
Figure 3-2: Example Sign from I-15 Dynamically Changing Toll..... 3-8
Figure 4-1: Revised SANDAG Mode Choice Model Structure 4-2
Figure 5-1: 2030 AM Peak Period Volumes for 10+4 Alternative, Unlimited Access 5-8
Figure 5-2: 2030 PM Peak Period Volumes for 10+4 Alternative, Unlimited Access ... 5-9
Figure 5-3: 2030 AM Peak Period Volumes for 10+4 Alternative, Limited Access 5-10
Figure 5-4: 2030 PM Peak Period Volumes for 10+4 Alternative, Limited Access 5-11
Figure 5-5: 2030 AM Peak Hour Volume for 10+4 Alternative, Limited Access..... 5-12
Figure 5-6: 2030 PM Peak Hour Volume for 10+4 Alternative, Limited Access..... 5-13
Figure 6-1: Study Area and Tolling Locations 6-5
Figure 6-2: Sample Regional Model Output 6-6
Figure 6-3: Observed I-15 Data Points 6-7
Figure 6-4: Off-Peak Base Toll Rates 6-8
Figure 6-5: 2015 10+4 and 8+4 Configuration Toll Rates 6-8
Figure 6-6: I-15 Express Lane Market Share Curve 6-9
Figure 6-7: Sample Manged Lane Market Share Curve 6-10
Figure 6-8: 2030 10+4 FasTrak, HOV, and Total Market Share Curves by Location.. 6-11
Figure 6-9: 2030 8+4 FasTrak, HOV, and Total Market Share Curves by Location.... 6-16
Figure 6-10: 2015 Managed Lanes Hourly Traffic Volumes (8+4 Configuration) 6-22
Figure 6-11: 2015 Managed Lanes Hourly Traffic Volumes (10+4 Configuration) 6-26
Figure 6-12: 2015 Managed Lanes Annual Revenue 6-30
Figure 6-13: 2030 Managed Lanes Hourly Traffic Volumes (8+4 Configuration) 6-31
Figure 6-14: 2030 Managed Lanes Hourly Traffic Volumes (10+4 Configuration)..... 6-35
Figure 6-15: 2030 Managed Lanes Annual Revenue..... 6-39
Figure 6-16: 2030 10+4 HOV 2+/3+ Model Output 6-40
Figure 7-1: Buffer Separated 8+4 Arrangement..... 7-2
Figure 7-2: Lane Configuration 7-3
Figure 7-3: Electric Toll Collection (ETC) System 7-6
Figure 7-4: General Purpose Lane Gantry 7-9
Figure 7-5: Managed Lane Gantry 7-11
Figure 7-6: Violation Enforcement System Overview 7-14

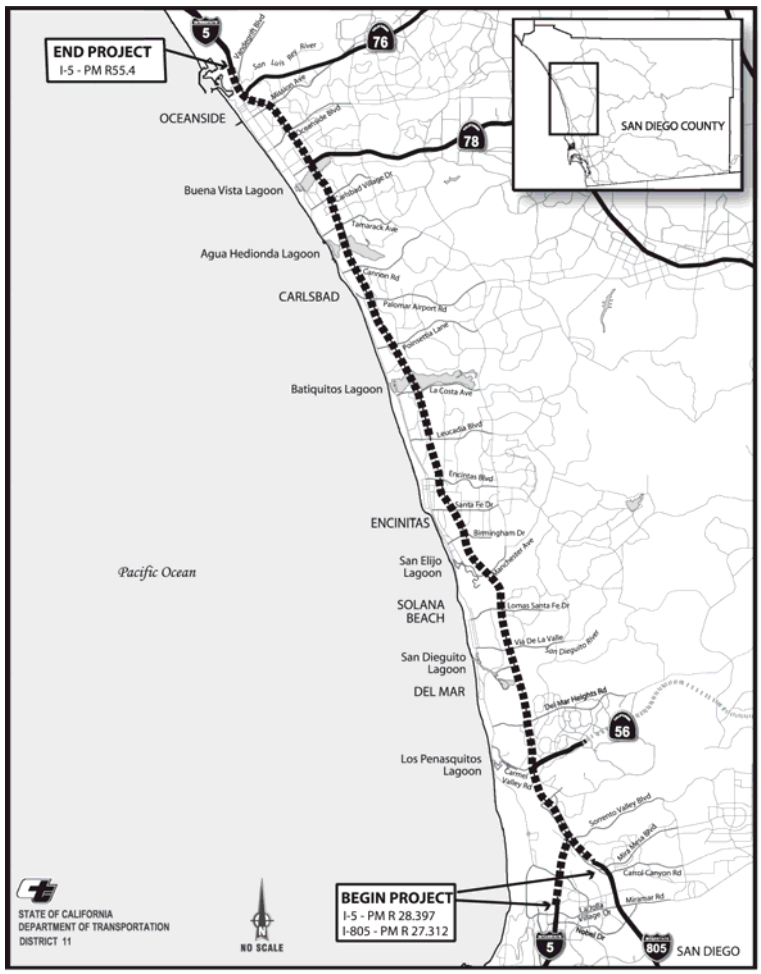
Figure 7-7: Automated Traffic Management System Diagram 7-19
Figure 7-8: Managed Lane Entry Signing 7-22
Figure 7-9: Managed Lane Exit Signing 7-23
Figure 7-10: Example Layout Entrance Signing 7-24
Figure 7-11: Example Layout Exit Signing 7-25
Figure 7-12: Example Signing for Direct Access from a Park & Ride Facility 7-26
Figure 7-13: Example Signing for Direct Access with a Local Street or a Park & Ride Facility 7-27
Figure 7-14: Maintenance Online management Systems (MOMS) 7-32
Figure 7-15: I-5 North Coast ETTM System Overview 7-35
Figure 7-16: Account Process Overview 7-37
Figure 7-17: Timeline for Technology Adoption 7-50

I-5 NORTH COAST MANAGED LANES VALUE PRICING PLANNING STUDY VOLUME I – EXECUTIVE SUMMARY

ES.1 PROJECT DESCRIPTION AND CORRIDOR OBJECTIVES

The I-5 North Coast managed lanes project in San Diego County represents the most extensive national application of managed lanes to date in a new corridor. Four express managed lanes are proposed in several build alternatives to extend 26 miles along the North Coast from La Jolla Village Drive to its northern limit at Vandegrift Boulevard, just south of Camp Pendleton (Figure ES-1). Alternatives being considered in this feasibility review include adding four managed lanes incorporating either four or five adjacent general purpose lanes in each direction, denoted as either an 8+4 alternative or 10+4 alternative. Managed lanes may be separated by barrier or buffer separation as shown in Figure ES-2.

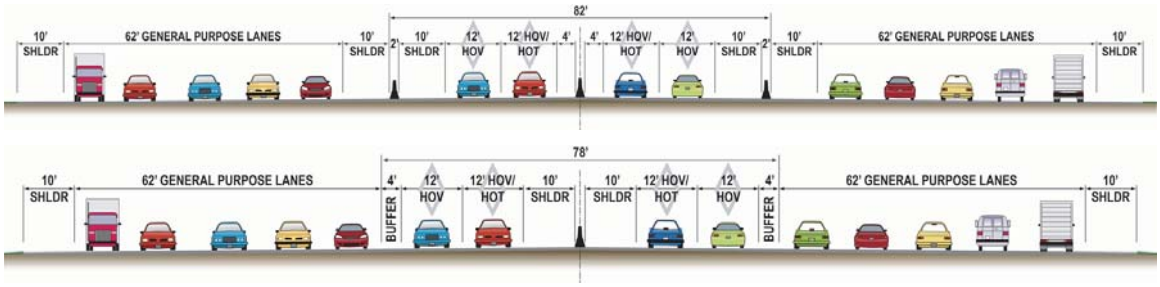
FIGURE ES-1: I-5 STUDY LIMITS



North Coast I-5 Corridor Project Location Map

This planning study is one of various parallel investigations involving an examination of the environmental, design and traffic benefits and impacts associated with the proposed project, which is partially funded under the countywide *TransNet* transportation program. Goals and objectives associated with this project include the ability to manage some of the added roadway capacity along I-5 to ensure that mobility to all stakeholders can be assured. Based on regional and state transportation policies, use of the managed lanes is given highest priority to transit and other high occupancy vehicles (vanpools and carpools) so as to promote more person movement in fewer vehicles. However, much if not all of this project will have available capacity for all potential users, at least during its early years of operation. To accommodate these users, value pricing is being considered as a means of managing demand so as to allow all potential stakeholders to equitability benefit.

FIGURE ES-2: ALTERNATIVE MANAGED LANE CROSS SECTIONS



The primary goal of the proposed I-5 North Coast Managed Lanes (ML) is to maintain mobility of four of the added lanes through roadway demand management. The I-5 Purpose and Need Report prepared as part of corridor NEPA studies identified the following objectives in addressing I-5 corridor mobility:

- Maintain or improve future traffic levels of service in 2030 over the existing levels of service;
- Maintain or improve travel times within the corridor;
- Provide a (roadway) facility that is compatible with future bus rapid transit and modal options; and
- Maintain I-5 as an effective link in the national Strategic Highway Network.

Pricing as a traffic management tool is considered in conjunction with access controls and eligibility to achieve real-time demand management of the ML during varying operating conditions. Access will be restricted to designated locations including openings to adjacent general purpose freeway lanes and direct access ramps (DARs) connecting to transit facilities and local streets. In keeping with regional policy which requires maintenance of a high level of service on HOV and managed lanes in San Diego, there will be a requirement to maintain this high level of service, defined as LOS C or better, at all times. This equates to about 1,650 vehicles per lane per hour, or 1,300 vehicles per hour directionally. Regionally, HOVs carrying two or more persons are allowed free use of managed lanes.

This technical summary provides findings supporting an assessment of value pricing feasibility for the subject I-5 corridor managed lane alternatives.

ES.2 STUDY DESCRIPTION AND CRITERIA

Corridor-wide demand now and in the future will greatly outpace available transportation infrastructure, based on available traffic data and traffic forecasts. Agency and public stakeholders are aware of this situation. The scope of this planning study is determining if pricing as a demand management tool is feasible on the four managed lanes (ML). Pricing is intended to be the primary tool to manage demand which maximizes the number of potential users who can use the I-5 managed lanes, thereby promoting mobility in an equitable manner to the greatest number of users. Pricing can be prescribed according to a preset schedule or applied dynamically to manage demand in real time for all segments of the corridor. Pricing can also generate revenue in support of operations and transit services.

This study examines various factors that influence value pricing feasibility. Study activities include both technical and public outreach investigations, in response to various measures. Evaluations conducted are representative and selective based on differentiating cross sections (i.e.,"10+4" to "8+4") or topic (i.e., buffer vs. barrier separation between general purpose and ML roadways)

These investigations address the following parameters and questions that reflect the various attributes influencing feasibility:

Demand:
- Is sufficient demand, in terms of AM and PM peak hour use, present in various time horizons to justify pricing managed lanes?

Access:
- Can access be provided to the managed lanes with sufficient frequency to adequately meet transit, HOV and priced demand?

Pricing Strategy:
- What is the most appropriate pricing strategy for the I-5 corridor and why?

Impacts to Adjacent Traffic:
- What are the impacts to adjacent traffic caused by managed lanes, and can these impacts be adequately mitigated?

Technology:
- What are the functional and performance monitoring needs to support a pricing strategy?

Revenue:
- What is the potential revenue generated from pricing the I-5 managed lanes?

Public Attitudes:
- Are public, agency and key stakeholder attitudes favorable toward pricing? What issues need to be addressed?

Equity:
- What equity issues, if any, are created by pricing the managed lanes?

The study began in June 2004. Study scope subtasks addressed each of these parameters according to specific subject areas. Table ES-1 provides a summary of the specific subtask reports, or elements within a subtask, that addressed each.

TABLE ES-1: COMPARISON OF FEASIBILITY CRITERIA TO STUDY SUBTASKS REPORTS

Parameter	Measure	Chapter Reference in Concept Plan
Demand	Sufficient demand	Chapter 4-5, (Subtasks 1-1, 1-2)
Access	Sufficient to meet demand	Chapter 4-5, (Subtask 1-2, Subtask 2-3)
Pricing strategy	Appropriate to manage demand	Chapter 2, (Subtask 2-1)
Impacts to adjacent traffic	Merges at access points	Chapter 4-5, (Subtask 1-2)
Technology	Pricing able to be installed and operated	Chapter 7, (Subtask 2-3)
Revenue	Adequate to cover operation	Chapter 6, (Subtask 2-2)
Public attitudes	Supportive of management goals and pricing	Concept Plan Volume 2 of 2,, (Subtask 2-4)
Equity (EJ)	• Pricing strategy • Public outreach feedback	Chapter 2 and Concept Plan Volume 2 of 2, (Subtasks 2-1 and 2-4)

This summary addresses technical investigations conducted, with specific evaluations and findings provided in an accompanying Volume 1 of the I-5 North Coast Managed Lanes Value Pricing Concept Plan. Public outreach activities addressing public perceptions and equity are contained in Volume 2.

ES.3 FINDINGS

ES.3.1. Demand

The existing I-5 corridor in 2002 had an average daily traffic (ADT) volume of 153,000 (north end) to 249,000 (south end). The traffic during peaks was not highly directional varying from 61/39 to 51/49 in the respective peak and off-peak directions. Annual growth rates are 2 to 5 percent, with most growth occurring in off-peak periods. Congestion is experienced in spot locations from 6 a.m. to 6 p.m., consistent with heavy congestion. In comparison to other congested corridors nationwide, a relatively high level of HOV formation already exists, with 16 percent 2-occupant vehicles and two percent 3+ occupant vehicles in the peak traffic streams. Averages nationally are 12 to 15 percent for 2+ HOVs. Truck volumes are moderate with seven percent heavy trucks and 15 percent light duty trucks in the traffic mix.

Forecast conditions for managed lanes were developed using two base pricing schemes--$0.25 per minute saved and $0.50 per minute saved. Both scenarios were calibrated in a “no-build” condition against the I-15 reversible express toll lanes in the SANDAG traffic model. Results showed that forecast volumes on I-5 managed lanes would be overloaded if continuous access was assumed. Successive tests with limited ingress/egress suggested that 4 to 5 mile spacing was needed, and by 2030 some portions of the managed lanes may have to price 2-occupant carpools to manage demand. Policy assumptions established by SANDAG for feasibility testing assumes that 2-occupant HOVs would be given a 50 percent discount for any prevailing HOV pricing rate once capacity is reached.

These findings indicate that the ML facility can be easily oversubscribed in both 2017 (shortly after opening) and 2030 (the design year) based on current values of time associated with I-15 and without applying access restrictions. Accordingly, the demand threshold for justifying pricing demand for I-5 was met for all segments. In a comparison of 8+4 and 10+4 alternatives, the added general purpose lanes on the north end beyond SR 78 distracted from potential demand, indicating that priority phasing this section would not be as critical to meeting current and forecast demand as other sections.

ES.3.2. Access

Results from demand forecast testing indicated that access alone cannot manage demand. Further, applying pricing in conjunction with a fairly restrictive access plan will be required. A restrictive access plan with 4 to 5 mile spacing was applied in conjunction with direct access ramps (DARs) at selected locations as highlighted in Figure ES-3. Arriving at this set of access assumptions was both dictated by NEPA activities involving the analysis of DAR locations and collaborated with Caltrans. A list of DARs were given assumptions. (Further evaluation of specific access locations will continue to be part of the NEPA process.)

Slip ramp access with the I-5 mainlanes showed a peak hour demand that ranged from 100 to 1,600 per hour (both directions). DAR demand varied from 100 to 2,400 per hour, indicating that both access features are needed and will be used. The provision of DARs helps lower demand for slip ramps, and reduces weaving that would otherwise occur across the I-5 mainlanes.

ES.3.3. Pricing Strategy

A wide universe of pricing strategies were identified and evaluated. Most pricing strategies could be applied to any of the I-5 ML alternatives, however, most were more easily applied to a barrier-separated alternative.

FIGURE ES-3: ACCESS ASSUMPTIONS FOR I-5 MANAGED LANES

Table ES-2 provides a brief summary of the various attributes associated with the major types of toll pricing strategies applicable to this corridor. Further investigations focused on comparative pricing benefits of a per-mile toll, segment toll and skewed per-mile toll. Most of the detailed model calibration and development of revenue forecasts were performed using a per-mile toll basis, since this was the best overall approach to managing traffic demand within a variety of variables, including different segment lengths, uneven demand and need for an equitable strategy. Two scenarios were tested for 2030, including SOV pricing and SOV pricing with HOV-2 pricing at a 50 percent discount, due to overloading of lane capacity. The SANDAG model appears to be overly sensitive to HOV-2 pricing, and further model refinement will be necessary to more fully explore HOV-2 pricing when this is needed in the future. Findings suggest that:

- SOV pricing allows for congestion free ML operations in 2015;,
- In 2030, some sections of ML exceed capacity during peak hours with pricing SOV only; and
- SOV/HOV-2 pricing appears to dramatically reduce ML demand.

TABLE ES-2: COMPARABLE ATTRIBUTE MATRIX FOR ALTERNATIVE PRICING STRATEGIES

			Demand Management Attributes			Public Acceptance		
Toll Strategy	Toll Variation	Trips Favored	Overall Effectiveness	Impacts on General Traffic	Revenue Generation	Public Perceptions	Equity	Signing
Flat Toll – Standard	Pre-set Dynamic	Long	Low-Medium Medium-High	High High	Medium Medium	High High	Low Low	Simple Medium
Flat Toll – Max. Trip	Pre-set Dynamic	Long	Low Medium	Medium Medium	Low Low	High High	Medium Medium	Simple Medium
Per Mile w/ Maximum	Pre-set Dynamic	Medium	Medium	Low Low	Low Low	Moderate Moderate	High High	Medium Complex
Per Mile no Maximum	Pre-set Dynamic	Medium	Medium High	Medium Medium	Medium Medium	Moderate Low	Medium Medium	Medium Complex
Per Mile-Skewed w Maximum	Pre-set Dynamic	Long	Medium High	Low Low	Medium Medium	Moderate Low	Medium Medium	Medium Complex
Per Mile-Skewed no Maximum	Pre-set Dynamic	Short	High High	Low Low	High High	Low Low	High High	Medium Medium
Segment Toll-Standard	Pre-set Dynamic	Short	Low Medium	Low Low	Medium Medium	Moderate Low	Medium Medium	Medium Complex
Segment Toll-Skewed	Pre-set Dynamic	Medium	Medium High	Medium Medium	High High	Low Low	Medium Medium	Medium Complex

ES.3.4. Technology and Performance Monitoring

A toll collection system and operation concept was evaluated and developed based on potential tolling strategies. A functional concept was provided since technology will change between now and the year of opening. The target implementation year was assumed to be 2012 to 2015. The concept plan looked at both current and future technology options across a wide array of topics integral to a tolling and traffic operations monitoring system. Key objectives of this plan were interoperability (Title 21) and affordability. Functional requirements were set as standards, with evolving technology decisions over time. Specific recommendations and include:

- Transponders:
  - Transition from Passive RFID toll tags to optical readers.
  - Plan for open road tolling using GPS based readers.
- Communication:
  - Plan for fiber link (hard wiring) along freeway and assume more wireless applications.
  - Dedicated short-range communication spectrum will be available.
  - Consider dynamic signing guidance developed which provides users both the price of the prevailing toll (price per mile) and travel time to a downstream destination to confirm benefits provided for the toll.
- New enforcement options:
  - Video and optical character recognition (OCR) of license tags
  - In-vehicle sensors
  - Front facing optics
- Improve ability for automated traffic management

- Development of a maintenance on-line management system
- Monitoring and evaluation
  - Responsive to corridor and traffic management goals and objectives
  - Supports future capital and operation policy decisions and management practice
  - Affordable and public friendly
- Monitoring and evaluation performance measures :
  - Level of service
  - Changes in speed and delay
  - Changes in average vehicle occupancies
  - Changes in mode splits and travel behavior

ES.3.5. Revenue

Revenue evaluations assumed a toll rate structure based on the I-15 managed lanes for calibration purposes, including variable pricing of managed lanes based on volume-to-capacity ratio. Findings indicated that a per-mile toll and revenues would be higher in the southern portion of the I-5 corridor due to higher demand in this section. In 2030 for the 8+4 alternative, there is no available capacity in the ML for SOV toll users in the southern portion during peak periods. With a 10+4 alternative, the base toll (uncongested) for entire length is $4.00 in 2015 ($0.16 per mile) and $6.00 in 2030 ($0.26 per mile), based on the derived validations from the SR 91 corridor. In 2015 the toll reaches almost $14 during congested conditions based on future year dollar values. In 2030 the toll is over $26 during congested conditions. A summary of forecast revenue is provided in Table ES-3.

ES.3.6. Public Attitudes and Equity

Refer to Public Outreach Executive Summary, Volume 2 of the I-5 Concept Plan.

TABLE ES-3: SUMMARY OF FORECAST REVENUE

I-5 Managed Lanes Estimated Annual Revenue (in millions)		
Location	**2030**	
	8+4	**10+4**
s/o SR 56	$6.656	$4.329
s/o Via de la Valle	$6.274	$3.983
s/o Manchester Ave	$2.076	$1.154
n/o Encinitas Blvd	$2.421	$1.478
s/o Palomar Airport Rd	$1.203	$0.837
n/o Carlsbad Village Dr	$0.882	$0.629
n/o SR 76	$0.227	$0.225
TOTAL	$19.739	$12.636

ES.4 RECOMMENDATIONS

Findings from this study have validated the feasibility of value pricing for the proposed I-5 North Coast managed lanes for both an 8+4 and 10+4 configuration, and for both barrier- and buffer-separated design treatments. Other factors in the ongoing NEPA and related traffic evaluations may result in findings that refute these conclusions and recommendations. The recommendations made below are solely based on evaluations conducted in the 2004-2005 time period for testing value pricing on managed lanes in the configurations indicated, and for the assumptions and variations specified. These findings suggest the following recommendations be considered as the project is further evaluated and implemented:

ES.4.1. Timeline for Value Pricing

The I-5 managed lanes will need value pricing to be applied in order to achieve effective traffic management during congested periods. These congested periods will exist both in the near and long term conditions, and will be prevalent when the added general purpose capacity is opened.

ES.4.2. Access

Access will need to be controlled through designated at-grade slip ramps with the I-5 mainlanes and direct access ramps with local streets and transit facilities. Slip ramps will need to incorporate weave lanes to safety and efficiently handle high volumes of entering and exiting traffic without adversely affecting levels-of-service in either roadway.

ES.4.3. Tolling Strategy

Based on the high level of forecast demand for I-5, likelihood that congestion will exist and grow in both direction and directionality, and similarity these attributes have to analyses conducted on the I-15 corridor, a dynamic, skewed per-mile pricing strategy is recommended for adoption on the I-5 managed lanes. The adoption of dynamic, skewed per mile pricing is feasible and consistent with the adopted pricing strategy on I-15, making marketing and communication of this tolling strategy easier regionally to perform.

Depending on the staged development of both I-15 and I-15 corridors, the recommended pricing strategy may not be needed for early segments of the I-5 corridor that are opened. Flat-based tolling may be possible for the first segments and pre-set, non-skewed per-mile tolling may be possible until such time that specific segments on the south end of the corridor overload. Assuming roadway construction is staged from south to north, these intermediate pricing stages may be appropriate for a number of years to simplify pricing as users become acquainted with the ML roadway and access system. Dynamic signing recommended in the technology chapter could work for this type of phased pricing approach.

ES.4.4. Eligible Users

Current regional, state and federal transportation policies appear to be generally consistent with findings from the value pricing evaluations, insofar as the preference given to potential users. HOVs comprising transit, vanpools, and carpools carrying two or more persons plus motorcycles are considered free according to local policy. Hybrid vehicles, although considered eligible by federal and state legislation, are currently

considered free users of managed lanes in San Diego County. I-5 demand forecasts indicate that 2-occupant HOVs may need to be priced in the future at a rate that represents a 50 percent discount off of the SOV prevailing toll.

ES.4.5. Project Phasing

Managed lanes can provide effective corridor relief and mobility to a variety of freeway users. Value pricing should be applied whenever managed lane capacity is added, whether the project is opened continuously throughout the 26-mile length or opened in phases. The highest demand and need to manage demand will occur on the south end of the project.

ES.4.6. Monitoring and Evaluation

A plan to measure and monitor performance of the managed lanes will be dependent on the need for collection of quality before and after data sets and methods. The following categories of data will be needed:

- Project impact data
- Project utilization and operation data
- Project acceptance data
- Costs and benefits

CHAPTER 1

INTRODUCTION

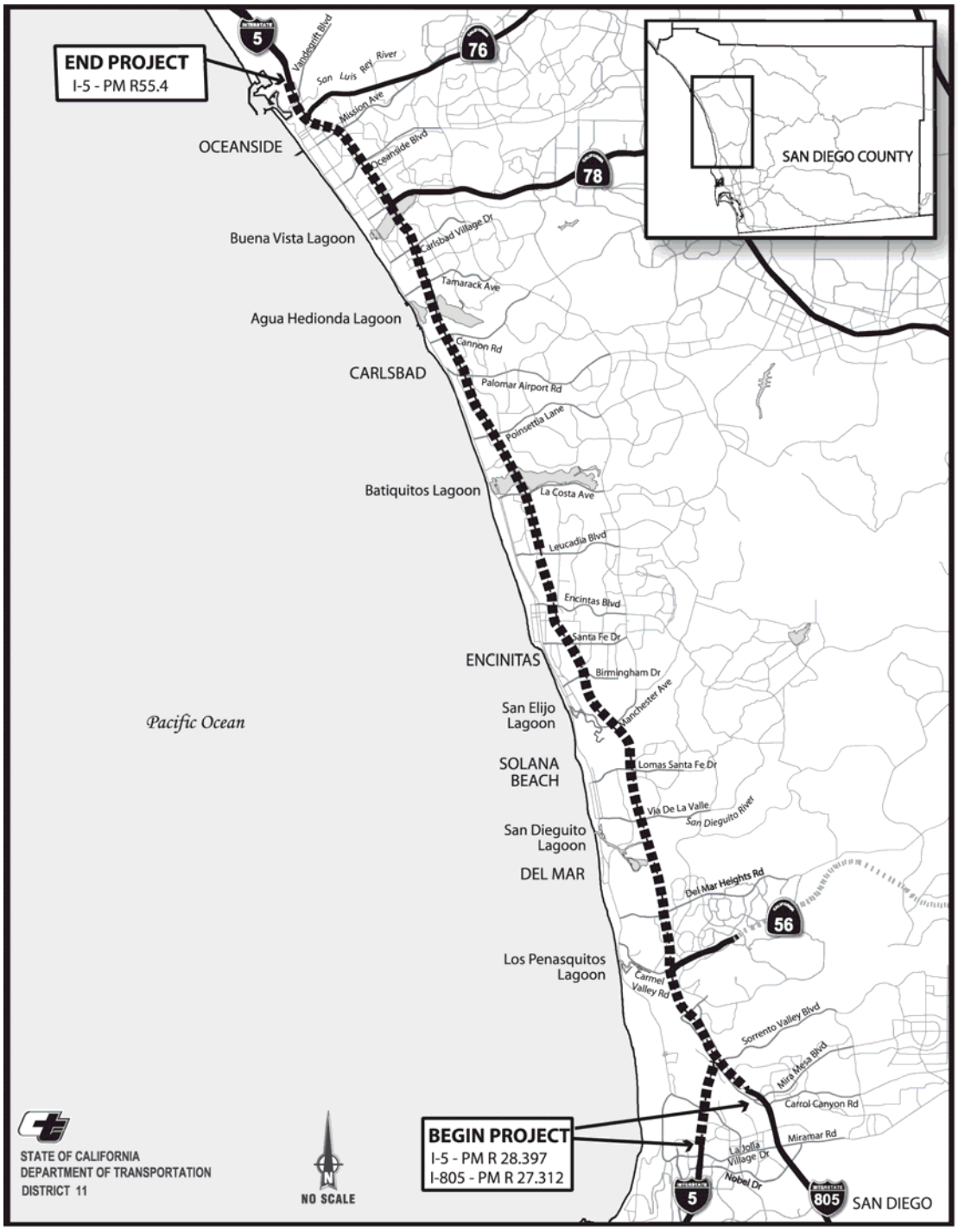
A network of connected and free-flowing HOV and managed lanes throughout the San Diego County region is a key strategy outlined in the 2030 Regional Transportation Plan (RTP), MOBILITY 2030. The I-5 North Coast Managed Lanes project will provide a key component of that network being on a heavily congested corridor providing a key lifeline for trade, commerce, commuting and recreation between the many cities clustered along this corridor from Oceanside to San Diego. The I-5 North Coast Managed Lanes project is part of an overall strategy to improve mobility along the North Coast corridor.

The 26 mile I-5 North Coast Managed Lanes (ML) project will add additional roadway capacity and provide mobility choices for motorists on I-5 in the northern San Diego region. As illustrated in Figure 1-1, the project extends from La Jolla Village Drive to Vandegrift Boulevard along I-5. A key feature of several of the alternatives being considered is four managed lanes—two in each direction—which will be located adjacent the median and operated at a high level of service for bus transit, vanpools, carpools and others regardless of the adjacent roadway traffic conditions. Lane management will depend largely on value pricing, and the purpose of this study is the evaluation of the feasibility of pricing to serve this function.

A study team headed by PB Consult conducted the I-5 North Coast Managed Lanes Value Pricing Planning Study to examine the technical, financial and attitudinal feasibility of HOV/managed lanes on the I-5 corridor. Tasks included an analysis of traffic operations, pricing strategies, electronic toll collection requirements, potential revenue, and performance monitoring requirements, in addition to a significant community outreach surveying program. The I-5 Value Pricing Concept Plan summarizes the results of the tasks of this study, presented in two volumes. Volume 1 addresses technical studies involving value pricing. Volume 2 addresses community outreach survey results and findings.

The next few sections provide a project description, study scope, basis for managed lanes, facility design, parallel studies, and organization of the remainder of this Concept Plan.

FIGURE 1-1: I-5 STUDY LIMITS



North Coast I-5 Corridor Project Location Map

1.1 PROJECT DESCRIPTION

1.1.1 Project Features

A primary feature of the I-5 North Coast Managed Lanes project is development of managed lanes in the median of I-5. The project may be implemented with or without added general purpose lanes. The defined improvements through this report evaluate and compare findings for both a project involving only the implementation of managed lanes, termed "8+4" to reflect the existing 8 lanes plus 4 managed lanes; or "10+4" to denote 10 general purpose lanes (the existing 8 plus 2 more) and 4 managed lanes. Additionally, the managed lanes may be separated from adjacent general purpose lanes by concrete barriers or a designated buffer. Both of these design features were also assessed for selected evaluations involving the application of pricing.

Several access features would support of the managed lanes including:

- Direct HOV-to-HOV connectors at the I-5/I-805 merge,
- Direct Access Ramps (DAR) at key local streets in various communities, and
- Designated slip ramps providing access between the managed lanes and general purpose lanes.

The project would include several additional features to improve general connectivity, capacity, and operating conditions on the project corridor:

- New connectors at SR 56,
- Additional general purpose lanes on I-5 from Del Mar Heights Road to Leucadia Boulevard, and
- Additional auxiliary lanes in heavy weave areas and local freeway interchange modifications added incrementally in key locations to improve traffic flow.

Features to integrate and upgrade the existing roadway facility so that it is compatible with the newly added roadway features, to mitigate environmental concerns, and to improve the final aesthetics of the corridor also will be included in the project. Some examples:

- Replacement of many existing bridges as a result of freeway widening,
- Construction of numerous retaining walls,
- Environmental enhancements (e.g. lagoon restoration) implemented early in the project development process to mitigate corridor highway, transit, and arterial impacts,
- Provision of noise barriers meeting federal requirements, and
- Corridor-wide replacement planting and other aesthetic treatments, termed "betterment" projects, that local communities select.

1.1.2 Project Need and Objectives

The I-5 North Coast corridor experiences recurrent traffic congestion during weekday rush hours and also is heavily traveled on weekends. Congestion on this corridor is a relevant issue because it is the major corridor connecting San Diego County, Los

Angeles County, Orange County, and Baja California, Mexico, regions and it is important for commuter, commercial, and recreational travel.

Without capacity improvements, the increases in traffic in the corridor will result in congestion throughout the entire day. Average daily traffic on I-5 is at 261,000 vehicles (near SR 56) and is projected to increase to 430,000 daily vehicles by the year 2030. Over 10,000 daily truck trips are made on I-5.

Improvements to I-5 are needed since I-5 will carry the burden of trips in the corridor which is also served by commuter and freight rail and arterial roadways. This need persists even with planned expansion of the Coaster commuter rail service. No new major parallel arterial roadways are planned throughout the corridor. Existing arterial roadways parallel to I-5 are segmented and do not provide a continuous north-south alternative route to the freeway

The primary goal of the proposed I-5 Managed Lanes is to maintain mobility of four of the added lanes through roadway demand management. The I-5 Purpose and Need Report prepared as part of corridor NEPA studies identified the following objectives in addressing I-5 corridor mobility among other objectives listed:

- Maintain or improve future traffic levels of service in 2030 over the existing levels of service;
- Maintain or improve travel times within the corridor;
- Provide a (roadway) facility that is compatible with future bus rapid transit and modal options; and
- Maintain I-5 as an effective link in the national Strategic Highway Network.

Pricing as a traffic management tool is considered in conjunction with access controls and eligibility to achieve real-time demand management of the managed lanes during varying operating conditions. Access will be restricted to designated locations including openings to adjacent general purpose freeway lanes and DARs connecting to transit facilities and local streets. In keeping with regional policy which requires maintenance of a high level of service on HOV and managed lanes in San Diego, there will be a requirement to maintain this high level of service (LOS), defined as LOS C or better, at all times. This LOS equates to about 1,650 vehicles per lane per hour, or 1300 vehicles per hour directionally. Regionally, HOVs carrying two or more persons are currently allowed free use of managed lanes unless demand exceeds the above threshold.

Consistent with the high volume of truck traffic existing and projected within the I-5 corridor, the possibility of trucks utilizing the proposed I-5 Managed Lanes has been identified as an issue during this study effort. Although there are traffic operations benefits to separating trucks from the general purpose traffic stream should the opportunity exist, the results of this study show that projected demand for eligible HOV and/or toll users of the proposed I-5 Managed Lanes severely limits the opportunities for trucks to use the lanes when sufficient capacity exists.

Furthermore, current California law prohibits trucks from operating outside of the right-most two lanes of freeways. The design concept for the I-5 Managed Lanes places the lanes toward the median of the freeway necessitating left access from the general purpose lanes at the project termini and intermediate access locations (except at the

DARs which would directly access arterial streets). This configuration would require trucks to weave across all lanes of the freeway to access the I-5 Managed Lanes, particularly at the termini of the facility. Trucks maneuvering in this manner would exacerbate congestion within the corridor and would present a potential collision hazard to the trucks and other freeway users alike. Additional direct access features at the lane termini or reconfiguration of the lanes to accommodate trucks access from the right lanes would be necessary to mitigate this situation. These mitigation measures would add considerable expense to the project for the limited benefit that could be realized by allowing trucks to utilize the lanes during the times of the day when HOV and/or toll user demand (along with general purpose demand) would be lowest.

1.1.3 Other Corridor Projects

The I-5 North Coast Managed Lanes project is one component of the overall strategy to improve mobility along the North Coast corridor. Recent projects include the Del Mar Heights Road northbound freeway auxiliary lane (open to traffic June 2004) and the I-5/I-805 Merge Widening project, currently under construction. Other planned projects in the corridor include:

- Interchange modifications at Genesee Avenue, Sorrento Valley Road, Lomas Santa Fe Avenue, and Manchester Avenue;
- Extending the existing northbound HOV lane to Manchester Avenue and providing a matching southbound HOV lane;
- Constructing the missing freeway-to-freeway connectors at the I-5/SR 78 interchange;
- Double tracking the coastal rail corridor;
- Bus rapid transit (BRT) on the El Camino Real corridor;
- Various arterial street improvement projects.

1.2 SCOPE OF STUDY

The technical work performed in this federal/state funded study was undertaken in two phases. Phase One included the development of the Traffic Operations Plan and the Traffic Forecast Report. Phase Two included development of a functional plan addressing technology, revenue analysis, pricing scenarios and a performance and monitoring plan. Community outreach surveying was conducted throughout the study process.

Phase One of the study produced the Traffic Operations Plan and the Traffic Forecast Report. The Traffic Operations Plan includes a discussion of signing/striping requirements, types and location of all traffic control features, safety issues, AM versus PM operations, peak versus off-peak operations, incident/emergency scenarios, and other issues related to traffic operations specific to the managed lanes. The Traffic Forecast Report provides both existing and projected traffic conditions. Its focus was determining the amount of excess capacity available on the managed lanes and the threshold for value pricing.

Phase Two is comprised of several subtasks including the development of this Concept Plan. As part of Subtask 2.1, Alternative Pricing Strategies, a number of potential alternative pricing strategies were identified and subjected to preliminary screening analysis. After initial review and screening of the pricing options, Subtask 2.2, Traffic

and Revenue Analysis, involved performing a traffic and revenue analysis for the managed lanes using the preferred pricing concepts and testing various toll rates.

Subtask 2.3, Technology and Operations System Concept, related specifically to the development of a draft Concept Plan. It incorporated all the elements of the design process short of the detailed design of the Electronic Toll Collection (ETC) system and access control/enforcement systems. It illustrated how each toll collection and access control scenario would operate. It included general physical descriptions and layouts of the facility including locations of ETC equipment, variable message signs, enforcement strategies, "back office" operating concepts, and customer service center concepts. Only a preliminary definition of the technology to be used was addressed. Preliminary estimates of the capital costs and operating costs were included.

Subtask 2.4 consisted of a community outreach program. Subtask 2.5, Project Monitoring and Evaluation Plan, involved development of the framework for monitoring and evaluating the project when in operation. Subtask 2.6, Presentation of Concept Plan, involved presentation of the draft Concept Plan to SANDAG's Transportation Committee and Board of Directors and incorporation of any revisions into the Final Concept Plan.

1.3 CRITERIA FOR FEASIBILITY

Corridor-wide demand now and in the future will greatly outpace available transportation infrastructure, based on available traffic data and traffic forecasts. Agency and public stakeholders are aware of this situation. Based on the scope of this planning study in determining if pricing as a demand management tool is feasible on the four managed lanes, criteria were established to be assessed in the various technical studies and public surveys. These investigations address the following parameters and questions that reflect the various attributes influencing value pricing feasibility:

- Demand:
  Is sufficient demand, in terms of AM and PM peak hour use, present in various time horizons to justify pricing managed lanes?
- Access:
  Can access be provided to the managed lanes with sufficient frequency to adequately meet transit, HOV and priced demand?
- Pricing Strategy:
  What is the most appropriate pricing strategy for the I-5 corridor and why?
- Impacts to Adjacent Traffic:
  What are the impacts to adjacent traffic caused by managed lanes, and can these impacts be adequately mitigated?
- Technology:
  What are the functional and performance monitoring needs to support a pricing strategy?
- Revenue:
  What is the potential revenue generated from pricing the I-5 managed lanes?
- Public Attitudes:

Are public, agency and key stakeholder attitudes favorable toward pricing? What issues need to be addressed?

- Equity:
  What equity issues, if any, are created by pricing the managed lanes?

The study began in June 2004 and concluded in December 2005. Study scope tasks addressed each of these parameters according to specific subject areas. Table 1-1 provides a reference for the specific subtask reports, or elements within a subtask, that addresses each.

1.4 OUTLINE OF REPORT

Chapter 2 addresses current operating characteristics of I-5. Chapter 3 identifies and evaluates a variety of different pricing strategies, making recommendations on a limited set of strategies to carry forward. Chapters 4 and 5 address traffic forecasts and future operating characteristics based on findings from SANDAG's regional model for 2015 and 2030, and simulations of the corridor, respectively. Chapter 6 provides findings from a revenue analysis using pricing assumptions from Chapter 3. Chapter 7 analyzes and presents findings for a ML toll collection system and operations concept. Chapter 8 provides guidance for a performance monitoring and evaluation program once the lanes open, to measure effectiveness to the project's management objectives. A separate companion volume of the Concept Plan addresses community outreach activities and findings.

TABLE 1-1: COMPARISON OF FEASIBILITY CRITERIA TO STUDY SUBTASK REPORTS

Parameter	Measure	Chapter Reference in Concept Plan
Demand	Sufficient demand	Chapters 4-5, (Subtasks 1-1, 1-2)
Access	Sufficient to meet demand	Chapters 4-5, (Subtask 1-2, 2-3)
Pricing strategy	Appropriate to manage demand	Chapter 2, (Subtask 2-1)
Impacts to adjacent traffic	Merges at access points	Chapters 4-5, (Subtask 1-2)
Technology	Pricing able to be installed and operated	Chapter 7, (Subtask 2-3)
Revenue	Adequate to cover operation	Chapter 6, (Subtask 2-2)
Public attitudes	Supportive of management goals and pricing	Concept Plan Volume 2 of 2,, (Subtask 2-4)
Equity (EJ)	• Pricing strategy • Public outreach feedback	Chapter 2 and Concept Plan Volume 2 of 2, (Subtasks 2-1 and 2-4)

CHAPTER 2

OPERATING PROFILE

This report develops a profile of existing operating conditions along the I-5 corridor as part of the I-5 North Coast Managed Lanes Value Pricing Planning Study. The study corridor's southern limits are at La Jolla Village Drive on I-5 and at Lusk Boulevard on I-805, just south of the I-5/I-805 merge. The study corridor extends 26 miles to its northern limit at Vandegrift Boulevard, just south of Camp Pendleton.

Traffic operating characteristics within the I-5 corridor were identified in terms of the traffic volumes, vehicle classifications, vehicle occupancy profiles, truck volumes, and operating speeds. Traffic data was obtained from SANDAG, Caltrans, and PeMS. The next few sections discuss historical traffic trends, 2002 average weekday and daily traffic, hourly and directional traffic distribution patterns, weekend versus weekday volume trends, northbound HOV lane volume trends, vehicle occupancy distribution, vehicle classification distribution, truck volumes, and current peak hour operating speeds along the I-5 study corridor.

2.1 HISTORICAL TRAFFIC TRENDS

Traffic trends at selected locations along the I-5 Managed Lanes study corridor are presented in terms of annual average daily traffic (AADT) and average weekday daily traffic (AWDT). Data was provided by Caltrans.

Table 2-1 summarizes AADT traffic trends at nine locations along the I-5 corridor for the ten-year period between 1994 and 2003. Also shown are the annual percent change (APC) and the average annual percent change (AAPC) for the ten-year period 1994–2003. It should be noted that year 1994, 1996, and 1998 traffic data were not available for the "I-805 south of Mira Mesa Boulevard" location.

As shown, the I-5 study corridor has experienced an average annual growth rate in the range of 1.88 percent to 3.82 percent between years 1994 and 2003. The highest rate of traffic growth, 3.82 percent, in the corridor has been experienced south of La Costa Avenue. The lowest overall rate of growth, 1.88 percent, has occurred at the southern end of the corridor, south of the I-5/I-805 merge.

TABLE 2-1: 1994-2003 7-DAY ANNUAL ADT VOLUME TRENDS

LOCATION	1994	1995	*APC*	1996	*APC*	1997	*APC*	1998	*APC*	1999	*APC*	2000	*APC*	2001	*APC*	2002	*APC*	2003	*APC*	*10-Year Average APC*
I-805 s/o Mira Mesa Blvd	N/A	134,000	*N/A*	N/A	*N/A*	172,000	*N/A*	N/A	*N/A*	182,000	*N/A*	177,000	*-2.75%*	190,000	*7.34%*	209,000	*10.00%*	200,000	*-4.31%*	***2.06****
I-5 s/o Genesee Ave	127,000	129,000	*1.57%*	131,000	*1.55%*	134,000	*2.29%*	133,000	*-0.75%*	140,000	*5.26%*	145,000	*3.57%*	145,000	*0.00%*	147,000	*1.38%*	150,000	*2.04%*	***1.88%***
I-5 s/o SR-56	210,000	213,000	*1.43%*	216,000	*1.41%*	226,000	*4.63%*	231,000	*2.21%*	245,000	*6.06%*	254,000	*3.67%*	261,000	*2.76%*	262,000	*0.38%*	263,000	*0.38%*	***2.55%***
I-5 s/o Villa de la Valle	192,000	194,000	*1.04%*	200,000	*3.09%*	210,000	*5.00%*	215,000	*2.38%*	227,000	*5.58%*	253,000	*11.45%*	241,000	*-4.74%*	241,000	*0.00%*	241,000	*0.00%*	***2.65%***
I-5 s/o La Costa	158,000	161,000	*1.90%*	166,000	*3.11%*	169,000	*1.81%*	164,000	*-2.96%*	182,000	*10.98%*	192,000	*5.49%*	206,000	*7.29%*	218,000	*5.83%*	220,000	*0.92%*	***3.82%***
I-5 s/o Cannon Rd	156,000	159,000	*1.92%*	163,000	*2.52%*	166,000	*1.84%*	162,000	*-2.41%*	181,000	*11.73%*	190,000	*4.97%*	195,000	*2.63%*	197,000	*1.03%*	199,000	*1.02%*	***2.80%***
I-5 s/o SR-78	162,000	165,000	*1.85%*	171,000	*3.64%*	180,000	*5.26%*	188,000	*4.44%*	192,000	*2.13%*	202,000	*5.21%*	210,000	*3.96%*	205,000	*-2.38%*	209,000	*1.95%*	***2.90%***
I-5 s/o Mission Ave	146,000	148,000	*1.37%*	153,000	*3.38%*	161,000	*5.23%*	183,000	*13.66%*	178,000	*-2.73%*	183,000	*2.81%*	184,000	*0.55%*	184,000	*0.00%*	189,000	*2.72%*	***3.00%***
I-5 s/o Harbor Drive	129,000	125,000	*-3.10%*	134,000	*7.20%*	139,000	*3.73%*	144,000	*3.60%*	147,000	*2.08%*	148,000	*0.68%*	163,000	*10.14%*	173,000	*6.13%*	171,000	*-1.16%*	***3.26%***

APC=Annual Percent Change

**=Average for 1999-2003*

The magnitude of AADT volume growth experienced along the corridor tells a slightly different story to that told by the average annual growth rate. AADT volume growth ranged from 23,000 to 66,000 along the length of the study corridor. The highest and lowest magnitudes, 23,000 and 66,000, both occurred south of the I-5/I-805 merge on the I-5 and I-805, respectively. Please note that because 1994 volumes were not available for the I-805 at this location, the 66,000 volume growth reflects growth between 1995 and 2003, rather than between 1994 and 2003. North of the I-5/I-805 merge, along the I-5, AADT volume growth ranged from 42,000 (south of Harbor Drive) to 62,000 (south of La Costa Avenue).

Table 2-2 summarizes annual weekday traffic trends at four locations along the I-5 corridor for years 2001, 2002, and 2003. The table shows daily volume, as well as AM and PM peak volumes. The AM and PM peaks were defined as the hours with highest combined (northbound plus southbound) volume occurring from midnight to noon (AM), or noon to midnight (PM). Year 2002 data was not available at the Harbor Drive location.

Also shown in Table 2-2 is the directional split (i.e. northbound versus southbound) during each of the three time periods. Several of the AM and PM peak counts show an even direction distribution of volume. For example, at the "I-5 south of Lomas Santa Fe" count location, PM peak volumes were split 51 percent northbound / 49 percent southbound in 2002, and nearly as closely in 2001 and 2003. At the "I-5 south of Leucadia Boulevard" count location AM peak volumes were split 49.1 percent northbound /50.9 percent southbound in 2002 and shifted to 51 percent northbound /49.0 percent southbound in 2003. However, 2001 counts at this location showed a more imbalanced directional split of 39.7 percent northbound /60.3 percent southbound. Similarly, during the AM peak, volumes at the "I-5 southbound Tamarack Avenue" count location were imbalanced in 2001 and 2002, but balanced in 2003 with a directional split of 50.9 percent northbound /49.1 percent southbound.

2.2 2002 AVERAGE DAILY AND WEEKDAY TRAFFIC

Year 2002 average weekday daily traffic (AWDT) and annual average daily traffic (AADT) volumes were obtained from Caltrans to establish baseline traffic conditions in the corridor. They are presented in Table 2-2 and Figure 2-1, respectively.

Figure 2-1 shows AADT to generally increase from north to south up to the I-5/I-805 merge. At the north end of the corridor, between SR 76 and Vandegrift Boulevard, daily traffic averages approximately 151,440 vehicles. At the south end, between Carmel Mountain Road and the I-5/I-805 merge, daily traffic volumes average 272,990 vehicles. In the middle segment, between Mission Avenue and Manchester Avenue, the daily traffic ranges from 191,450 to 211,470 vehicles.

South of the I-5/I-805 merge, on I-5 north of Roselle Street, daily traffic volumes average 129,990 vehicles. South of Roselle Street they average 147,990 vehicles. South of the I-5/I-805 merge, on I-805 north of Mira Mesa Boulevard volumes average 143,000 vehicles. The combined I-5 and I-805 volumes south of the I-5/I-805 merge average 272,990 (129,990 plus 143,000) vehicles.

TABLE 2-2: AVERAGE WEEKDAY DAILY VOLUME DIRECTIONAL SPLIT

	2001			2002			2003		
	NB	SB	TOTAL	NB	SB	TOTAL	NB	SB	TOTAL
I-5 s/o Lomas Santa Fe									
Average Weekday Daily Volume	112,000	112,000	224,000	114,000	115,000	229,000	115,000	116,000	231,000
Percent Split	*50.0%*	*50.0%*	*100.0%*	*49.8%*	*50.2%*	*100.0%*	*49.8%*	*50.2%*	*100.0%*
AM Peak	6,133	7,883	14,016	6,475	7,918	14,393	6,603	7,857	14,460
Percent Split	*43.8%*	*56.2%*	*100.0%*	*45.0%*	*55.0%*	*100.0%*	*45.7%*	*54.3%*	*100.0%*
PM Peak	7811	7286	15097	7719	7415	15134	7664	7320	14984
Percent Split	*51.7%*	*48.3%*	*100.0%*	*51.0%*	*49.0%*	*100.0%*	*51.1%*	*48.9%*	*100.0%*
I-5 s/o Leucadia Boulevard									
Average Weekday Daily Volume	105,000	103,000	208,000	108,000	104,000	212,000	107,000	104,000	211,000
Percent Split	*50.5%*	*49.5%*	*100.0%*	*50.9%*	*49.1%*	*100.0%*	*50.7%*	*49.3%*	*100.0%*
AM Peak	4,911	7,454	12,365	6,044	6,269	12,313	6,371	6,117	12,488
Percent Split	39.7%	60.3%	100.0%	49.1%	50.9%	100.0%	51.0%	49.0%	100.0%
PM Peak	7,665	6,955	14,620	7,645	6,934	14,579	7,591	6,848	14,439
Percent Split	*52.4%*	*47.6%*	*100.0%*	*52.4%*	*47.6%*	*100.0%*	*52.6%*	*47.4%*	*100.0%*
I-5 s/o Tamarack Avenue									
Average Weekday Daily Volume	102,000	103,000	205,000	104,000	105,000	209,000	106,000	107,000	213,000
Percent Split	*49.8%*	*50.2%*	*100.0%*	*49.8%*	*50.2%*	*100.0%*	*49.8%*	*50.2%*	*100.0%*
AM Peak	4,636	7,947	12,583	4,743	7,719	12,462	6,581	6,351	12,932
Percent Split	36.8%	63.2%	100.0%	38.1%	61.9%	100.0%	50.9%	49.1%	100.0%
PM Peak	7,798	6,318	14,116	7,775	6,498	14,273	7,843	6,498	14,341
Percent Split	*55.2%*	*44.8%*	*100.0%*	*54.5%*	*45.5%*	*100.0%*	*54.7%*	*45.3%*	*100.0%*
I-5 s/o Harbor Drive									
Average Weekday Daily Volume	68,000	68,000	136,000	N/A	N/A	N/A	74,000	76,000	150,000
Percent Split	*50.0%*	*50.0%*	*100.0%*	N/A	N/A	N/A	*49.3%*	*50.7%*	*100.0%*
AM Peak	3,837	3,988	7,825	N/A	N/A	N/A	4,799	3,669	8,468
Percent Split	49.0%	51.0%	100.0%	N/A	N/A	N/A	56.7%	43.3%	100.0%
PM Peak	3,937	5,368	9,305	N/A	N/A	N/A	4,160	6,455	10,615
Percent Split	*42.3%*	*57.7%*	*100.0%*	N/A	N/A	N/A	*39.2%*	*60.8%*	*100.0%*

Notes:

- All peak hours are defined as the hours with the highest combined (Northbound + Southbound) volume occurring within the designated period [Midnight-Noon (AM); Noon – Midnight (PM)]; and that for this reason, the directional splits may vary from year to year.
- Average Weekday Daily Volumes are rounded to the nearest thousand.

FIGURE 2-1: 2002 AADT, AM PEAK HOUR TRAFFIC, AND PM PEAK HOUR TRAFFIC

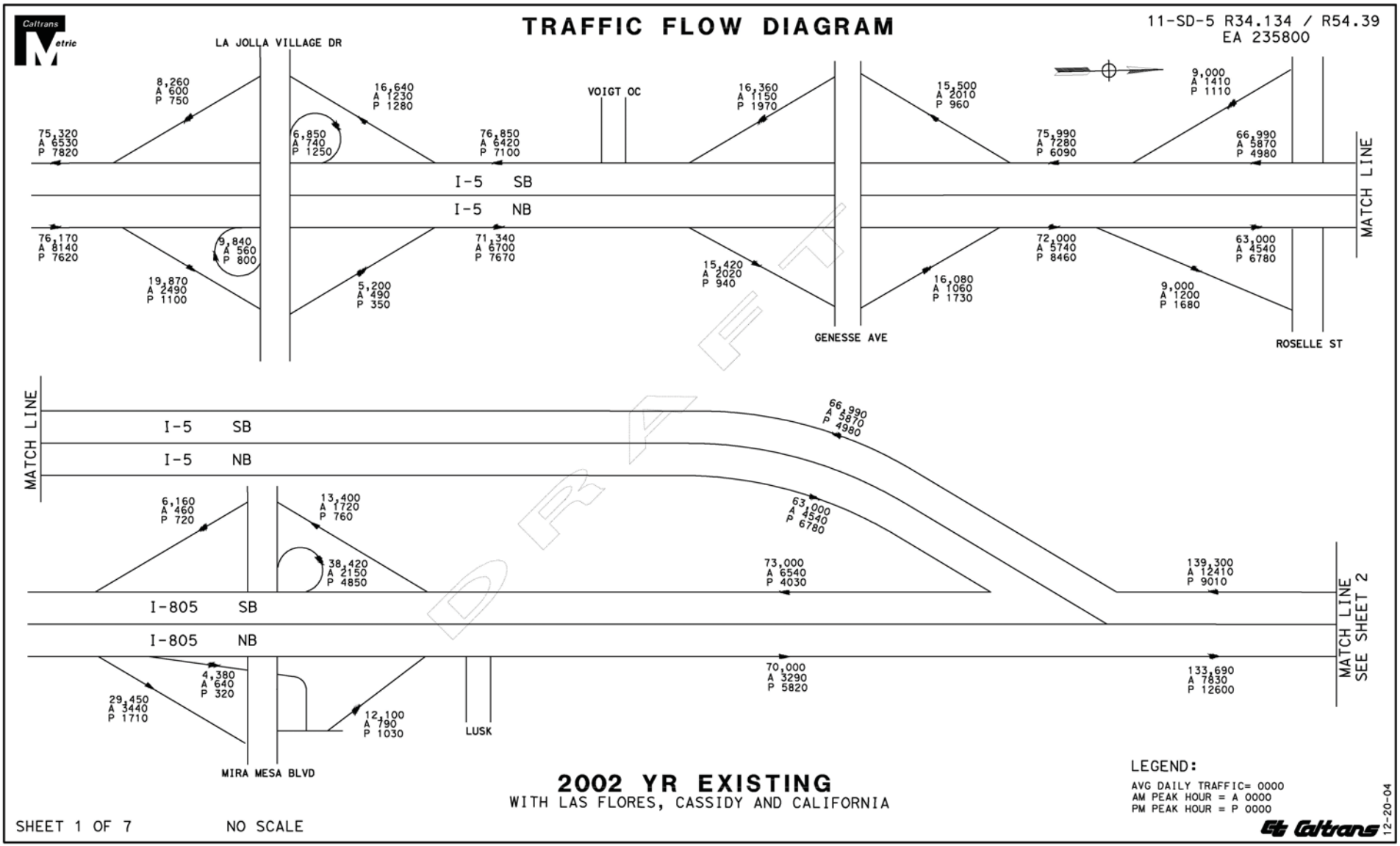


FIGURE 2-1: CONTINUED

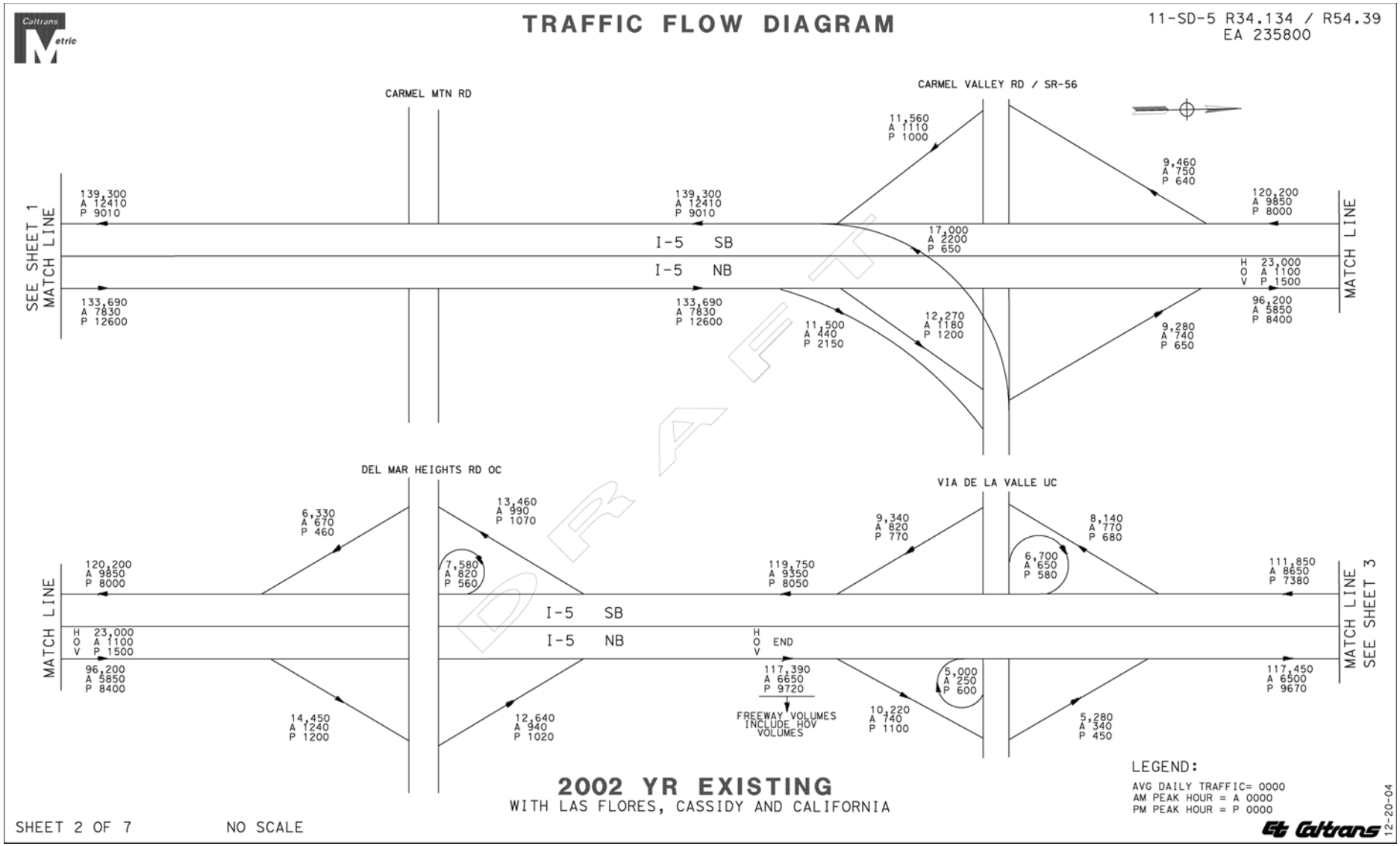


FIGURE 2-1: CONTINUED

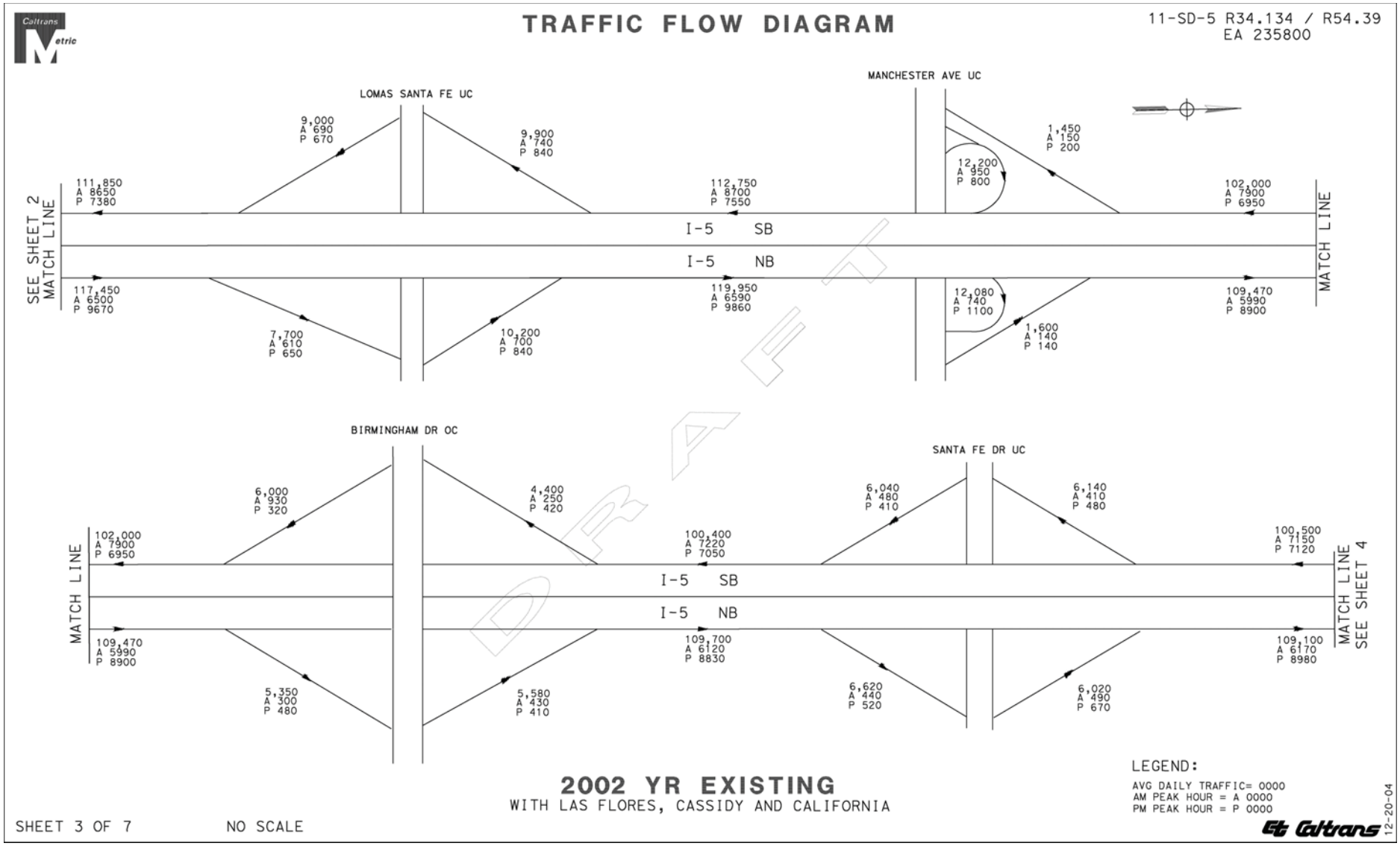


FIGURE 2-1: CONTINUED

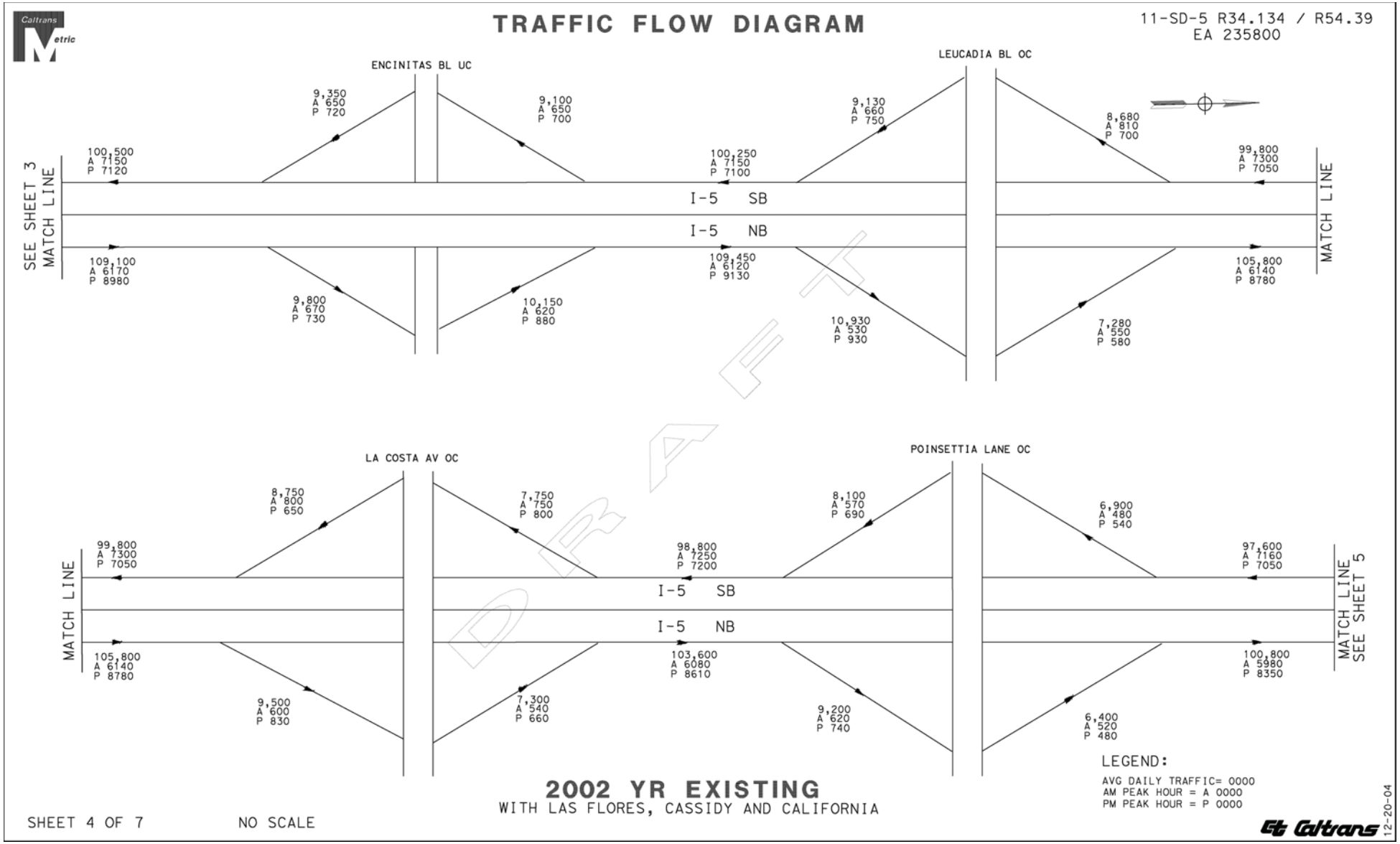


FIGURE 2-1: CONTINUED

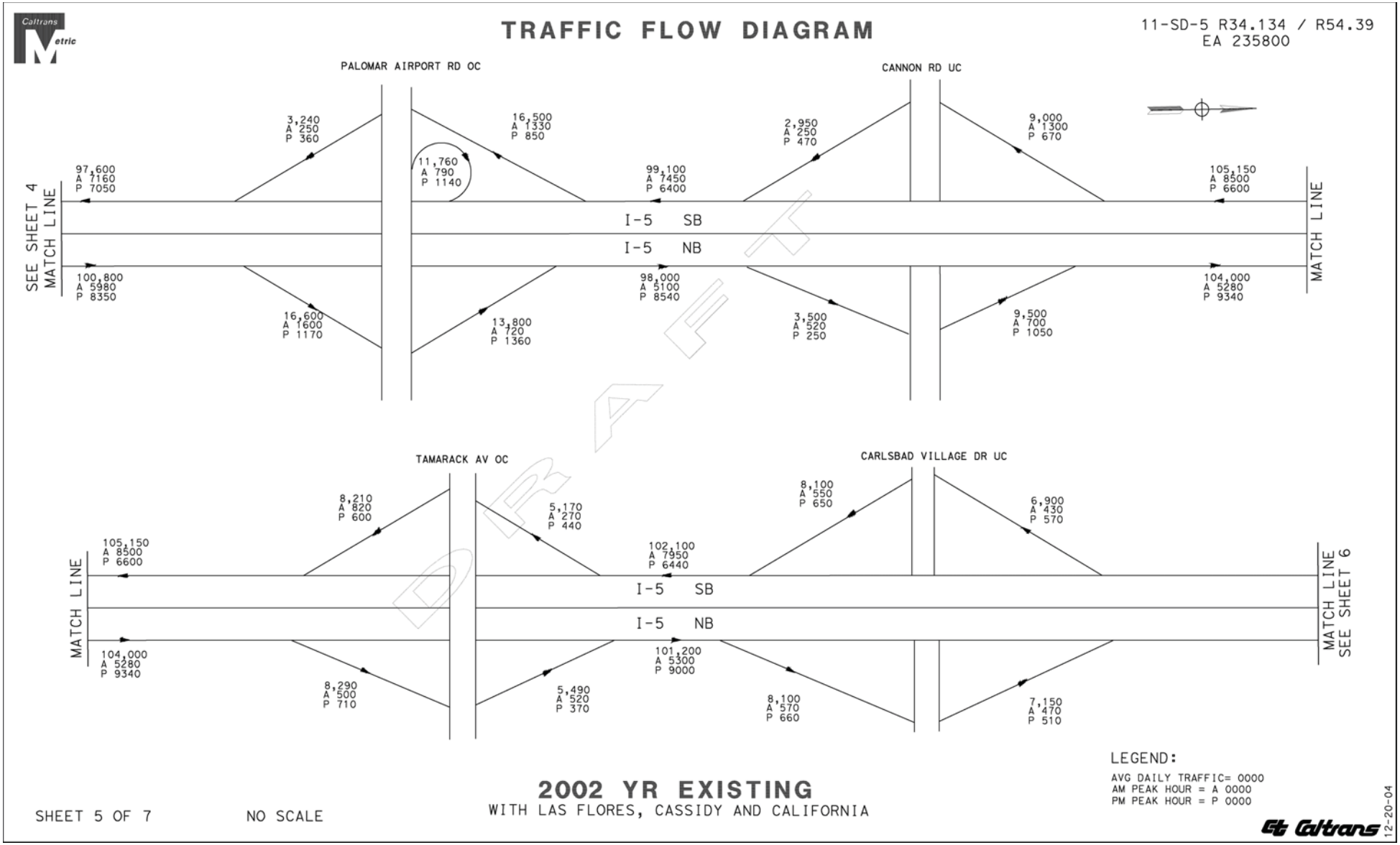


FIGURE 2-1: CONTINUED

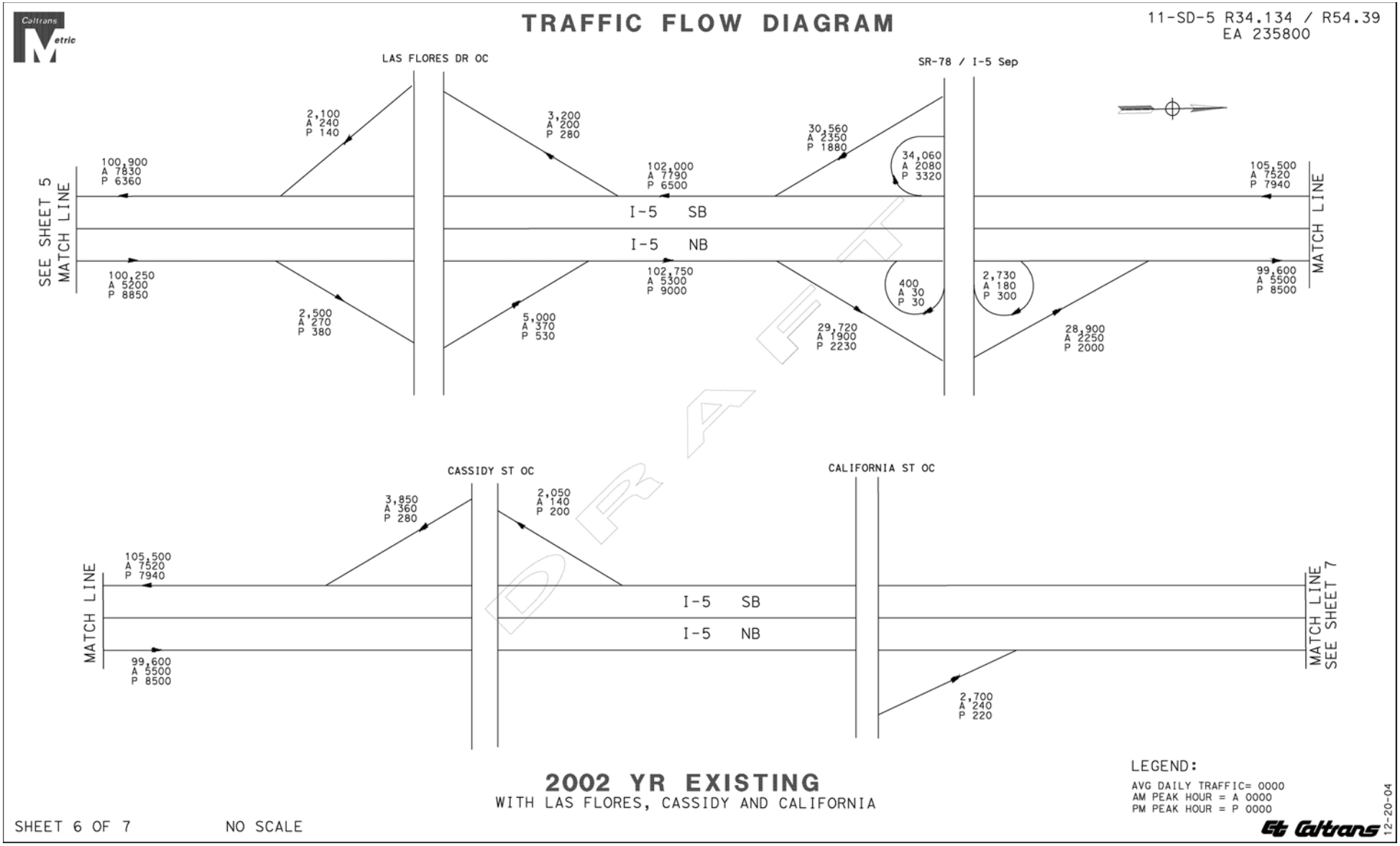
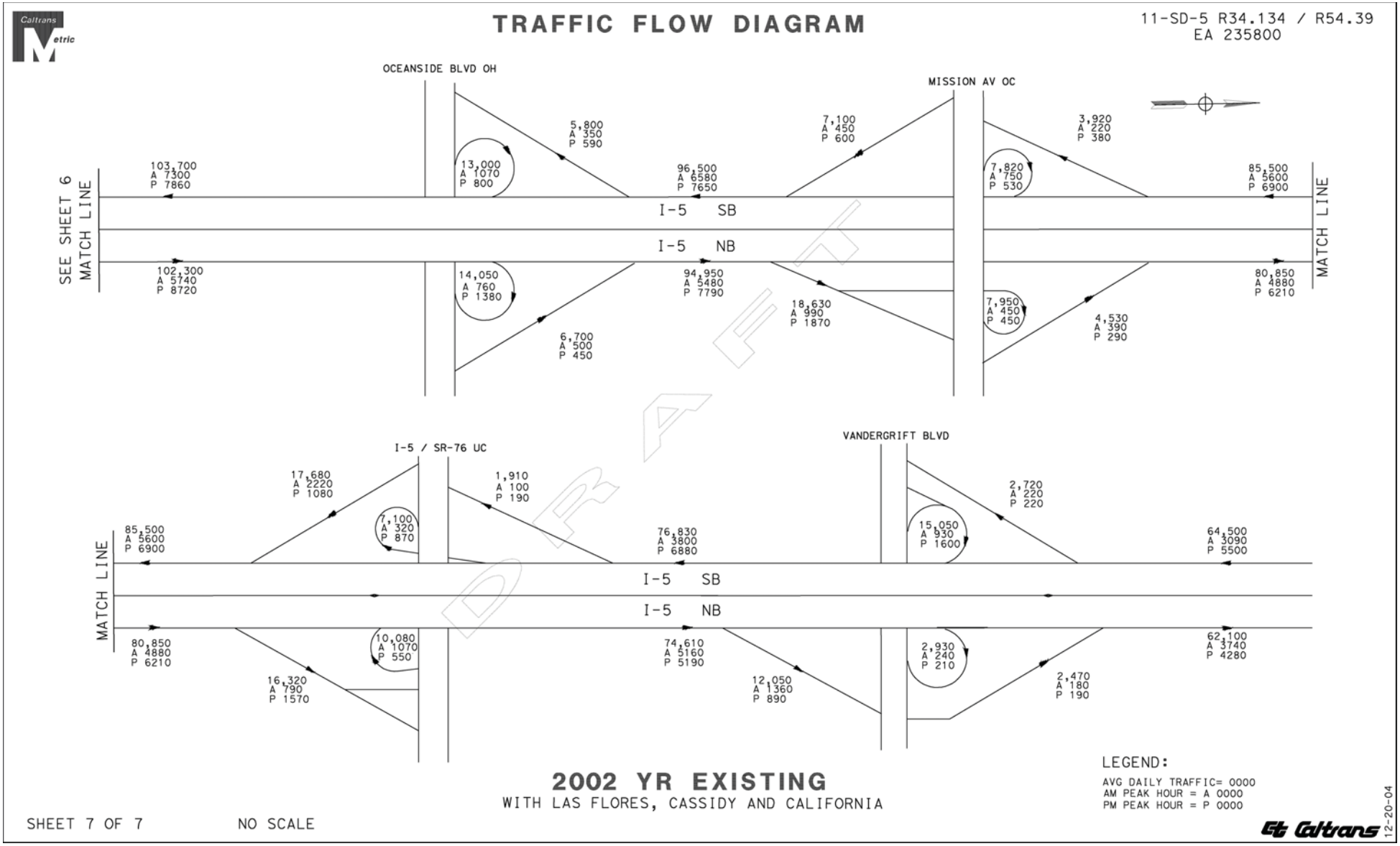


FIGURE 2-1: CONTINUED



2.3 HOURLY TRAFFIC DISTRIBUTION

Figure 2-1 and Table 2-2 present morning and evening peak hour traffic volumes provided by Caltrans. Figure 2-1 displays 2002 volumes on the mainline and ramps along the length of the corridor. Table 2-2 summarizes trends at four locations along the I-5 corridor for years 2001, 2002, and 2003.

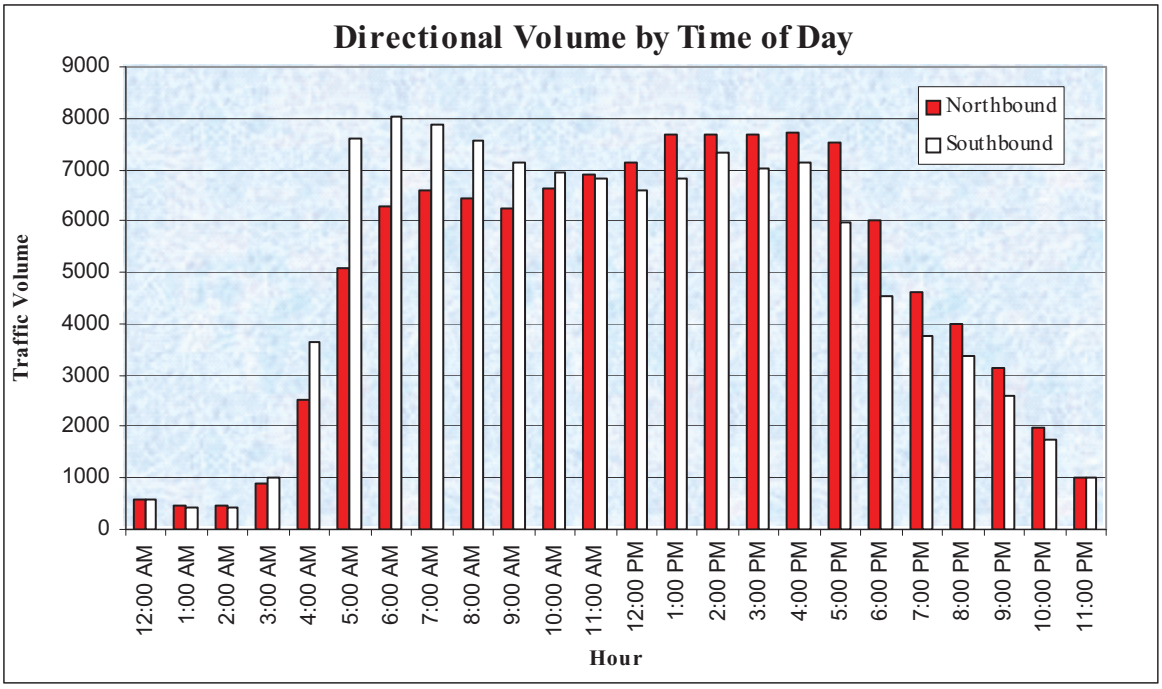
Hourly traffic distributions within the study corridor are graphically displayed in Figures 2-2 through 2-5 for four separate locations along the corridor. The locations from north to south are south of Harbor Drive, south of Tamarack Avenue, south of Encinitas Boulevard, and south of Lomas Santa Fe Drive. Each graphic displays both the directional traffic volume by time of day and the directional distribution, as a percent of the hourly traffic, by time of day.

The hourly distribution of traffic in the I-5 study corridor displays the typical morning and evening periods of increased traffic that are influenced by the work commute. The three southern locations show that the directional distribution of travel in the corridor is heavier southbound in the morning and northbound in the evening, as would be the expected influence of commuters traveling to/from work in the central San Diego area. This is most pronounced during the morning peak when 60 percent or more of the total volume is traveling southbound. The directional split is a more even 55 percent/45 percent during the evening peak.

The hourly distribution of traffic south of Harbor Drive has different characteristics than those exhibited by the other three locations. This location displays morning and evening periods of increased traffic as did the other three, however the periods occur earlier in the morning and evening than at the other three locations and they are less spread. Also, the directional distribution is reversed; there are heavier northbound flows during the morning peak, and heavier southbound flows during the evening peak. These patterns may be due to the generally lower volumes at the northern end of the study corridor, as well as to different work destinations. In particular, the heavy northbound flows occurring in the morning may be due to workers commuting to Camp Pendleton and Orange County, and the heavy southbound flows occurring in the evening may be due to workers returning home from these locations.

FIGURE 2-2: 2003 HOURLY DIRECTIONAL TRAFFIC DISTRIBUTIONS

SOUTH OF LOMAS SANTA FE



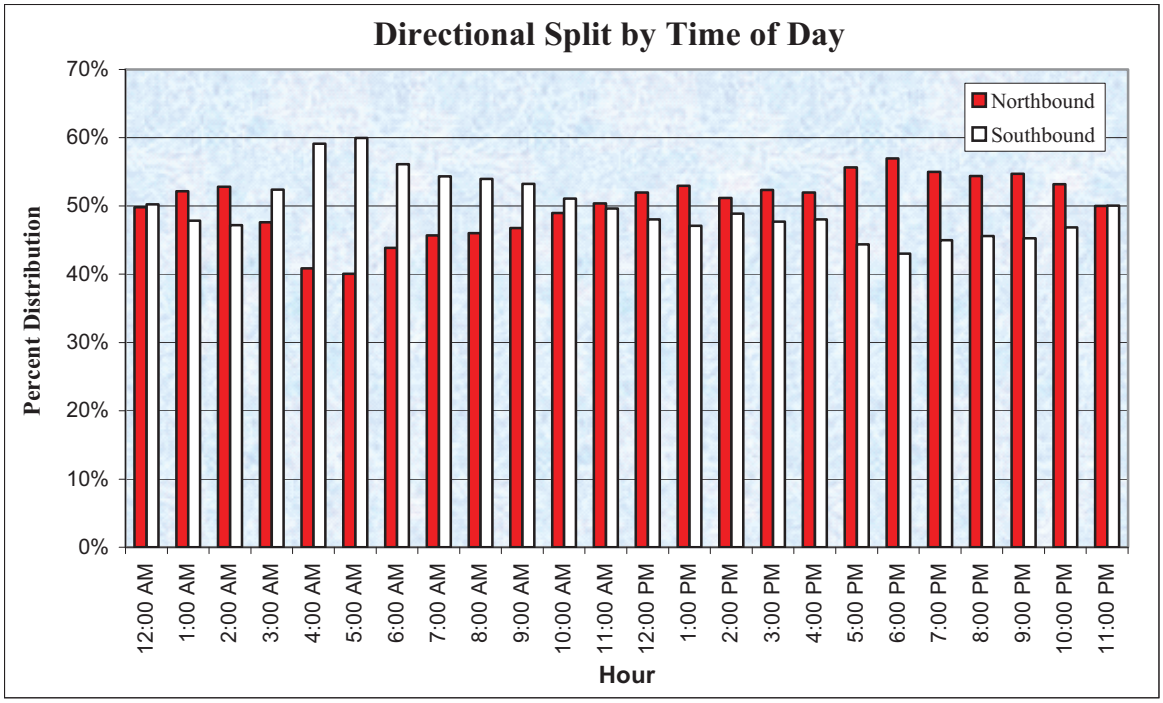
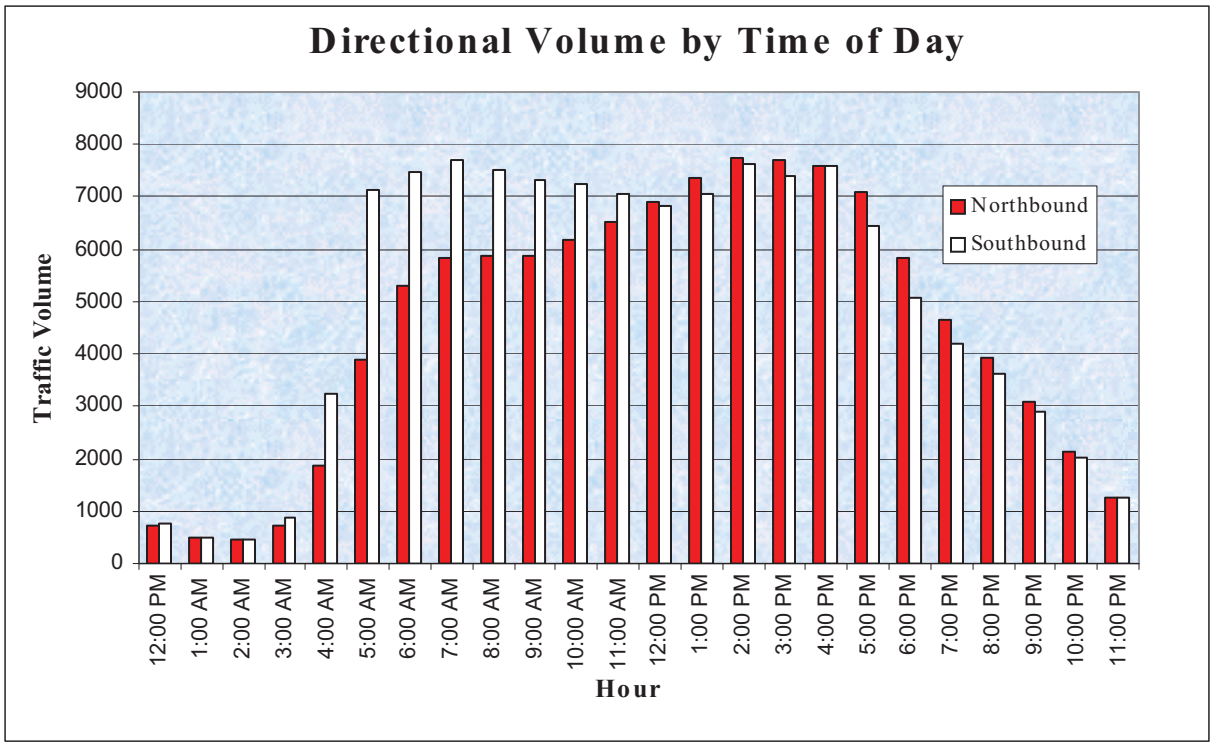


FIGURE 2-3: 2003 HOURLY DIRECTIONAL TRAFFIC DISTRIBUTIONS

SOUTH OF ENCINITAS BOULVARD



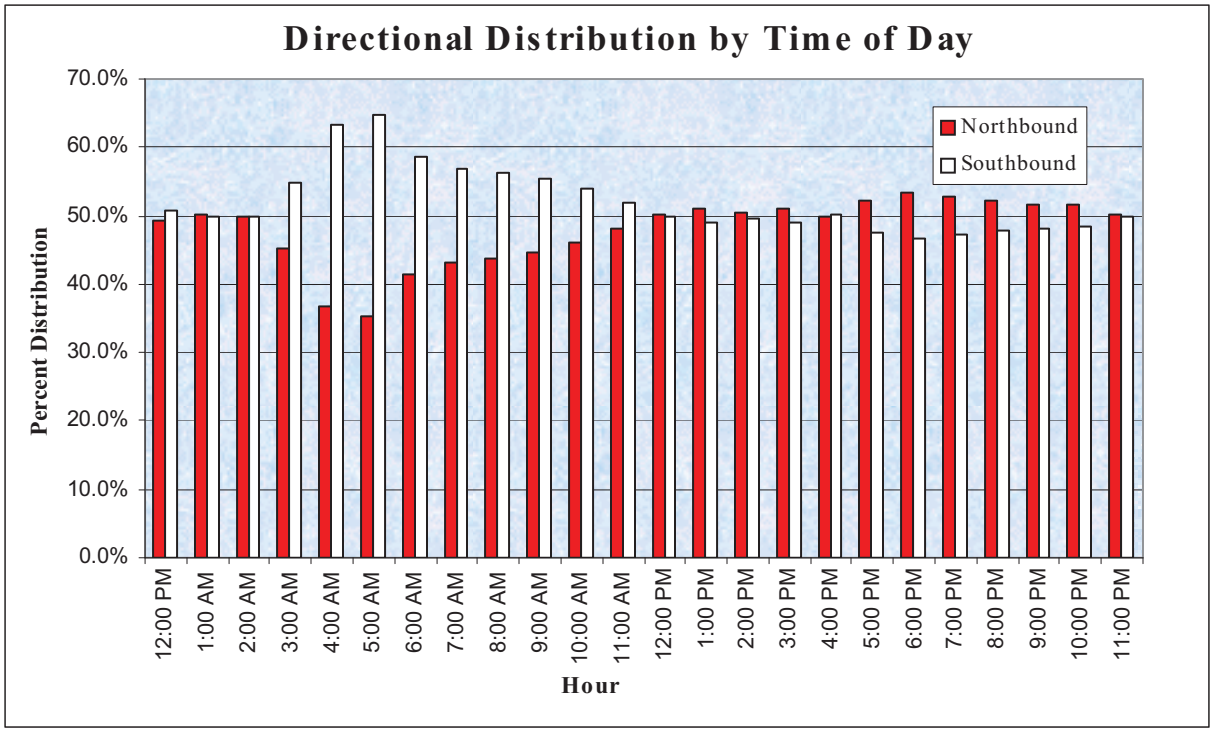
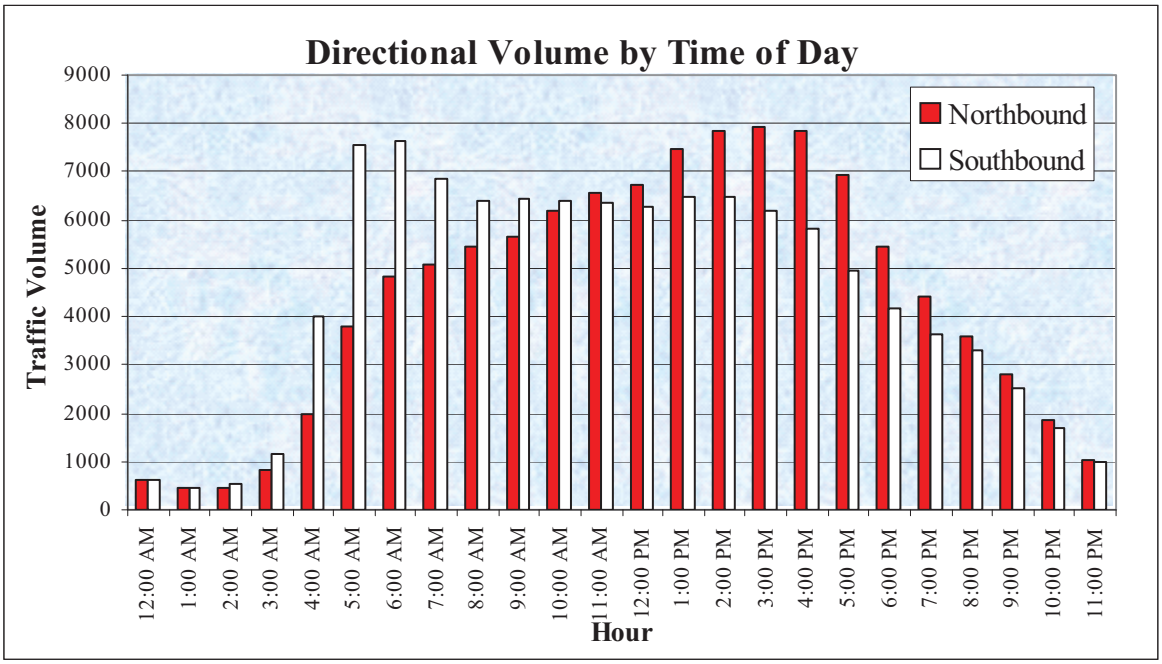


FIGURE 2-4: 2003 HOURLY DIRECTIONAL TRAFFIC DISTRIBUTIONS

SOUTH OF TAMARACK AVENUE



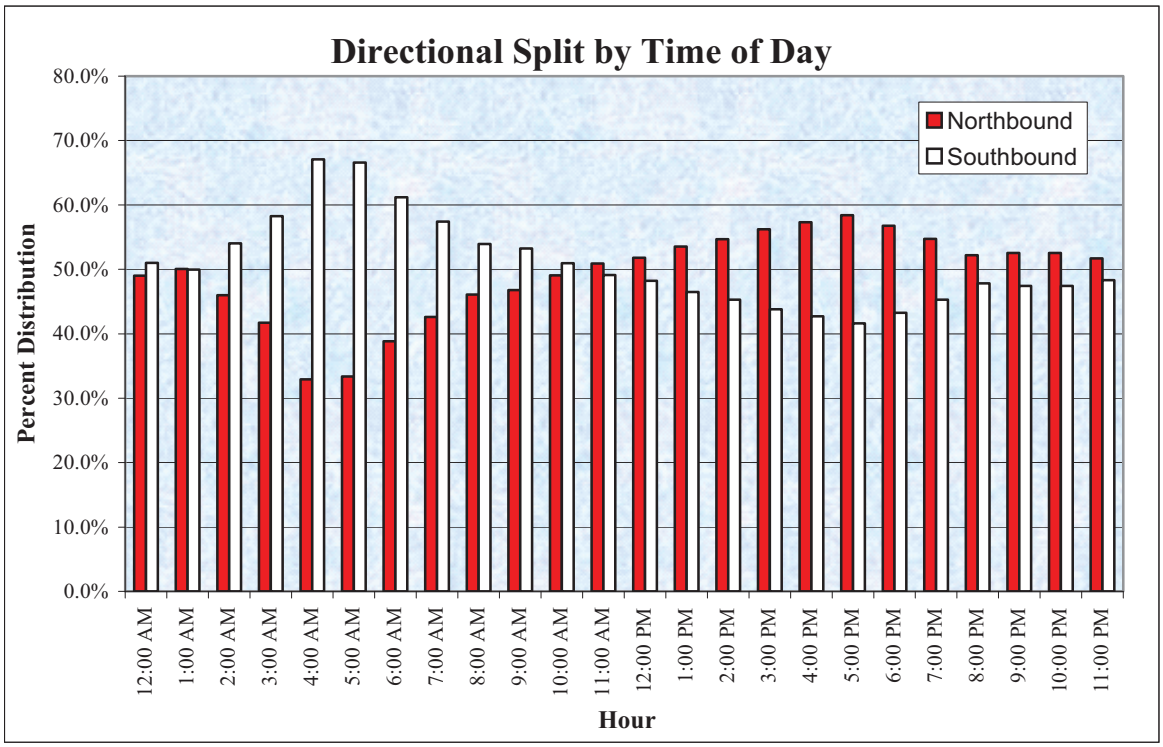
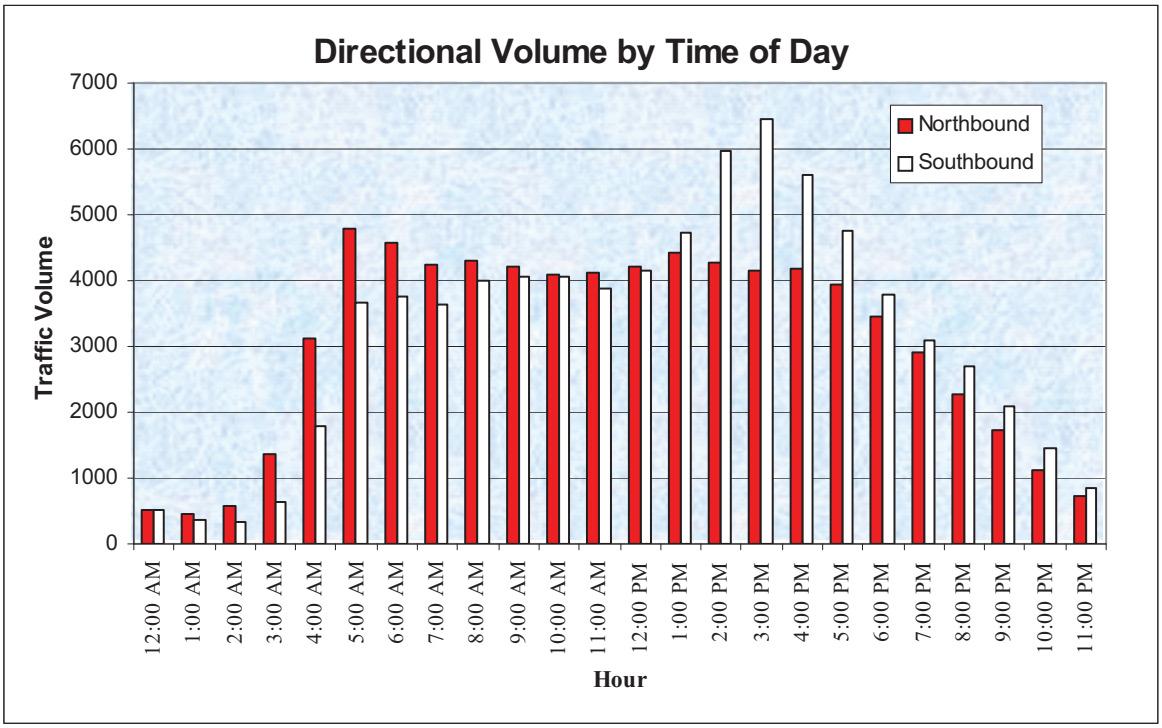
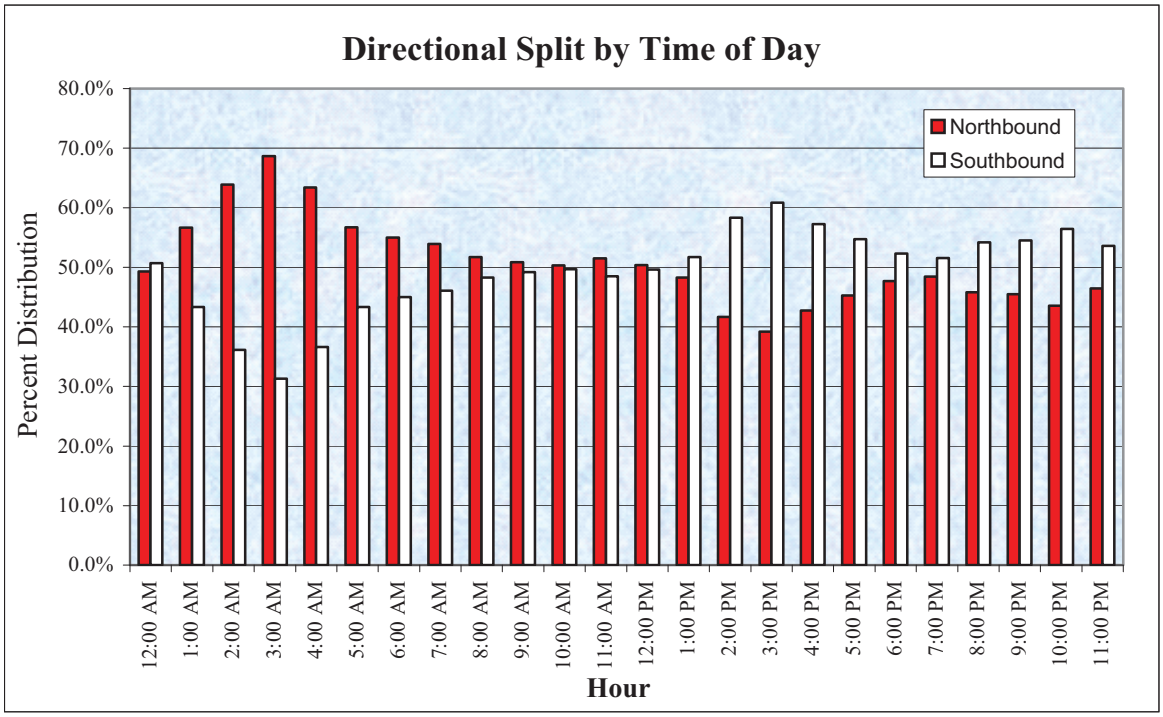


FIGURE 2-5: 2003 HOURLY DIRECTIONAL TRAFFIC DISTRIBUTIONS

SOUTH OF HARBOR DRIVE





2.4 WEEKEND VS WEEKDAY VOLUMES

Mainline and HOV lane I-5 volume data was extracted from PeMS for comparison of weekend and weekday volume trends. PeMS, short for Freeway Performance Measurement System, is a cooperative effort between UC Berkeley, California Partners for Advanced Transit and Highways (PATH), and Caltrans that makes processed data from Caltrans' loop detectors available online, amongst other activities. Daily volumes were extracted for typical spring, summer, and fall weeks in 2003.

Please note that because the data shown is for specific days within 2003, it should not exactly match the annual average volumes contained in this report. Its purpose is to enable a comparison of weekend and weekday volume trends, rather than to establish average annual conditions along the corridor.

Tables 2-3 through 2-5 summarize and compare weekend and weekday volume data for the southbound mainline, northbound mainline, and northbound HOV facilities, respectively. As can be seen in Table 2-3, average weekend volumes on the southbound mainline are one to 15 percent lower than average weekday volumes. The largest difference of 15 percent occurs at the southern end of the study corridor, near La Jolla Village Drive, while the lowest difference of one percent occurs farther north at Cannon Road. Observing each of the weeks individually reveals a broader range of weekend versus weekday volume differences. The smallest difference for an individual week occurs at Cannon Road during the summer when weekend volumes are less than one percent less than weekday volumes. The greatest difference occurs at La Jolla Village Drive during the spring when weekend volumes are 23 percent lower than weekday volumes. In general, weekend volumes more closely match weekday volumes in summer, relative to spring and fall.

Table 2-4 shows similar trends for the northbound mainline, except that weekend volumes on the northbound mainline are higher than weekday volumes in some cases. Average weekend volumes range from one percent higher to 13 percent lower than average weekday volumes. The largest difference of negative 13 percent occurs at the southern end of the study corridor, near La Jolla Village Drive, while the smallest difference of positive 1 percent occurs farther north at Cannon Road. Observing each of the weeks individually reveals a broader range of weekend versus weekday volume differences. The highest difference for an individual week occurs at Cannon Road during the summer when weekend volumes are actually six percent higher than weekday volumes. The lowest difference occurs at Carmel Valley Road during the spring when weekend volumes are 18 percent lower than weekday volumes. In general, weekend volumes more closely match, or even outpace, weekday volumes in summer, relative to spring and fall.

Table 2-5 shows volumes in the northbound HOV lane at one location, Carmel Valley Road. At this location, average weekend volumes are 25 percent lower than average weekday volumes, averaged over the three sample weeks in spring, summer, and fall. As was the case for the mainline volumes, observing the individual weeks reveals a broader range of weekend versus weekday volume differences. The smallest differences occur in spring and summer when weekend volumes are 15 and 14 percent less than weekday volumes, respectively. The largest difference of negative 47 percent occurs in fall.

TABLE 2-3: I-5 SOUTHBOUND MAINLINE – DAILY VOLUMES

	Location Description:		WB LA JOLLA VILLAGE (R28.454)	CARMEL VALLEY (R32.79)	LOMAS SANTA FE (R37.26)	CANNON (R47.834)
SPRING	03/03/2003	Monday	57,846	82,306	99,721	88,136
	03/04/2003	Tuesday	57,313	81,427	98,544	86,891
	03/05/2003	Wednesday	59,445	82,944	100,577	89,472
	03/06/2003	Thursday	62,488	86,032	104,924	93,046
	03/07/2003	Friday	63,891	90,804	112,919	103,455
	03/08/2003	Saturday	51,110	83,587	102,493	96,409
	03/09/2003	Sunday	42,182	70,453	84,405	81,767
	Weekday Average		*60,197*	*84,703*	*103,337*	*92,200*
	Weekend Average		*46,646*	*77,020*	*93,449*	*89,088*
	Percent Difference		*-23%*	*-9%*	*-10%*	*-3%*
SUMMER	07/14/2003	Monday	61,981	89,724	109,547	97,484
	07/15/2003	Tuesday	67,231	91,825	111,785	100,395
	07/16/2003	Wednesday	66,718	92,004	111,563	100,609
	07/17/2003	Thursday	68,636	89,778	114,858	102,938
	07/18/2003	Friday	74,334	98,632	117,516	95,838
	07/19/2003	Saturday	65,158	93,354	110,789	104,399
	07/20/2003	Sunday	53,380	79,989	97,035	94,371
	Weekday Average		*67,780*	*92,393*	*113,054*	*99,453*
	Weekend Average		*59,269*	*86,672*	*103,912*	*99,385*
	Percent Difference		*-13%*	*-6%*	*-8%*	*0%*
FALL	10/20/2003	Monday	59,504	82,718	102,705	91,725
	10/21/2003	Tuesday	60,932	83,232	102,729	91,191
	10/22/2003	Wednesday	61,529	83,593	102,116	92,592
	10/23/2003	Thursday	62,577	86,453	107,120	95,846
	10/24/2003	Friday	66,706	92,963	116,958	107,083
	10/25/2003	Saturday	53,568	84,279	109,034	104,109
	10/26/2003	Sunday	57,545	60,127	81,426	85,107
	Weekday Average		*62,250*	*85,792*	*106,326*	*95,687*
	Weekend Average		*55,557*	*72,203*	*95,230*	*94,608*
	Percent Difference		*-11%*	*-16%*	*-10%*	*-1%*
ALL SEASONS	*Weekday Average*		*63,409*	*87,629*	*107,572*	*95,780*
	Weekend Average		*53,824*	*78,632*	*97,530*	*94,360*
	Percent Difference		*-15%*	*-10%*	*-9%*	*-1%*

TABLE 2-4: I-5 NORTHBOUND MAINLINE – DAILY VOLUMES

	Location Description:		EB LA JOLLA VILLAGE (R28.402)	CARMEL VALLEY (R33.147)	LOMAS SANTA FE (R37.514)	CANNON (R48.138)
SPRING	03/03/2003	Monday	60,076	73,544	101,889	90,728
	03/04/2003	Tuesday	59,805	72,470	98,490	87,731
	03/05/2003	Wednesday	62,808	75,346	103,843	91,981
	03/06/2003	Thursday	63,713	59,618	104,653	92,474
	03/07/2003	Friday	66,552	62,763	109,428	99,827
	03/08/2003	Saturday	53,592	48,504	100,976	94,759
	03/09/2003	Sunday	49,762	63,948	93,230	88,973
	Weekday Average		*62,591*	*68,748*	*103,661*	*92,548*
	Weekend Average		*51,677*	*56,226*	*97,103*	*91,866*
	Percent Difference		*-17%*	*-18%*	*-6%*	*-1%*
SUMMER	07/14/2003	Monday	67,142	87,327	112,547	99,587
	07/15/2003	Tuesday	68,074	60,205	112,481	97,039
	07/16/2003	Wednesday	69,454	68,860	114,260	101,380
	07/17/2003	Thursday	70,863	63,261	116,333	102,487
	07/18/2003	Friday	72,119	53,805	118,617	107,179
	07/19/2003	Saturday	64,817	49,032	115,879	109,420
	07/20/2003	Sunday	62,055	85,062	108,880	104,846
	Weekday Average		*69,530*	*66,692*	*114,848*	*101,534*
	Weekend Average		*63,436*	*67,047*	*112,380*	*107,133*
	Percent Difference		*-9%*	*1%*	*-2%*	*6%*
FALL	10/20/2003	Monday	62,134	83,329	104,816	92,381
	10/21/2003	Tuesday	63,783	54,159	105,437	93,102
	10/22/2003	Wednesday	64,468	48,135	105,882	93,320
	10/23/2003	Thursday	65,407	55,366	107,884	95,378
	10/24/2003	Friday	67,441	49,926	112,363	102,548
	10/25/2003	Saturday	54,666	41,648	105,079	100,051
	10/26/2003	Sunday	57,701	71,115	89,753	89,446
	Weekday Average		*64,647*	*58,183*	*107,276*	*95,346*
	Weekend Average		*56,184*	*56,382*	*97,416*	*94,749*
	Percent Difference		*-13%*	*-3%*	*-9%*	*-1%*
ALL SEASONS	*Weekday Average*		*65,589*	*64,541*	*108,595*	*96,476*
	Weekend Average		*57,099*	*59,885*	*102,300*	*97,916*
	Percent Difference		*-13%*	*-7%*	*-6%*	*1%*

TABLE 2-5: I-5 NORTHBOUND HOV LANE – DAILY VOLUMES

Day	Spring (March 3-9)	Summer (July 14-20)	Fall (Oct. 20-26)
Monday	26,889	28,858	27,224
Tuesday	25,186	27,912	26,743
Wednesday	26,377	27,798	27,331
Thursday	26,708	28,762	27,106
Friday	26,189	29,164	28,110
Saturday	23,521	25,229	11,364
Sunday	21,287	23,776	17,704
Weekday Average	*26,270*	*28,499*	*27,303*
Weekend Average	*22,404*	*24,503*	*14,534*
Percent Difference	*-15%*	*-14%*	*-47%*

AVERAGE OF ALL SEASONS	
Weekday Average	***27,357***
Weekend Average	***20,480***
Percent Difference	***-25%***

2.5 NORTHBOUND HOV LANE VOLUMES

In addition to the daily volumes discussed in the previous section, hourly northbound mainline and HOV lane I-5 volume data was extracted from PeMS for observation of volume trends in the HOV lane. Hourly volumes were extracted for two Wednesdays, one in summer 2003 and one in fall 2003, to represent typical weekday conditions. To represent typical weekend conditions, hourly volumes were extracted for two Saturdays, in the same summer and fall 2003 weeks as the Wednesday data.

Please note that because the data shown is for specific days within 2003, it should not exactly match the annual average volumes contained in this report. Its purpose is to enable analysis of the northbound HOV lane volume trends.

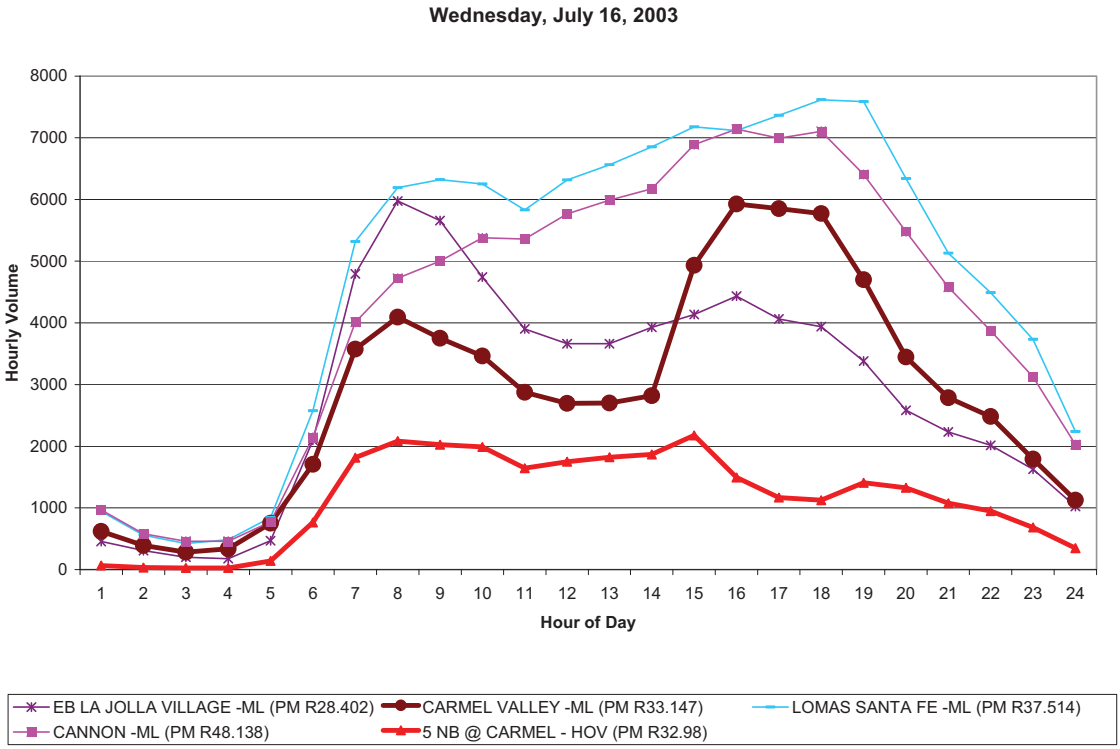
Figures 2-6 and 2-7 exhibit hourly volume data collected for two Wednesdays (July 16 and October 22, 2003) and two Saturdays (July 19 and October 25, 2003), respectively. Each figure shows the hourly volume trend at the same five count locations contained in Tables 2-4 and 2-5. These include one HOV lane count station near Carmel Valley Road, a nearby mainline count station at Carmel Valley Road, and three other mainline count stations.

As can be seen in Figure 2-6, weekday HOV lane volumes begin a steep climb at about 5:00 a.m. to a high of over 2,000 vehicles per hour around 7:00 a.m., remain above 1,500 vehicles per hour throughout the mid-day, and decline suddenly at around 3:00 p.m. Thus, HOV lane volumes are well above the ideal maximum rate of 1,650 vehicles per hour throughout much of the day. It has been determined through the Los Angeles MTA's HOV Performance Study and other HOV studies that single-lane HOV facilities do not function satisfactorily above 1,650 vehicles per hour. In fact, it is likely that the sudden decline in HOV volume which occurs around 3:00 p.m. is due to excessive demand for the HOV lane at this time and a resultant deterioration of conditions in the lane, rather than to diminishing demand.

Counts in the mainline lanes support this theory. As can be seen in Figure 2-6, northbound mainline volumes are highest during the PM peak period, roughly between 3:00 and 7:00 p.m., suggesting that HOV lane demand also likely reaches a high point during this time period. It is especially interesting to observe mainline volumes at Carmel Valley Road, near the HOV lane count station. The two Wednesday counts at this location are extremely different during the PM peak period. The Wednesday in July reaches a daily maximum of about 6,000 during the PM peak period, while volumes on the Wednesday in October begin a slow taper from about 3,000 during the PM peak period. This suggests that travel demand tends to exceed capacity at this location in the mainline, as well as HOV lanes, causing level of service to deteriorate and traffic flow rates to diminish during the PM peak period.

As can be seen in Figure 2-7, the two Saturday volume samples differ significantly in the HOV lane. The Saturday in July reaches a daily high of about 1,800 vehicles per hour, while the Saturday in October reaches a daily high of only about 1,000 vehicles per hour. The HOV lane volume is sustained close to this level throughout the mid-day and early evening, roughly 10:00 a.m. to 6:00 p.m. Mainline volumes also exhibit this sustained mid-day and early evening peaking. The mainline count station at Carmel Valley Road, near the HOV lane count station, shows similarly low volumes in July and October, reaching highs of about 3,000 and 2,700, respectively.

FIGURE 2-6: I-5 NORTHBOUND HOURLY VOLUMES - WEDNESDAY



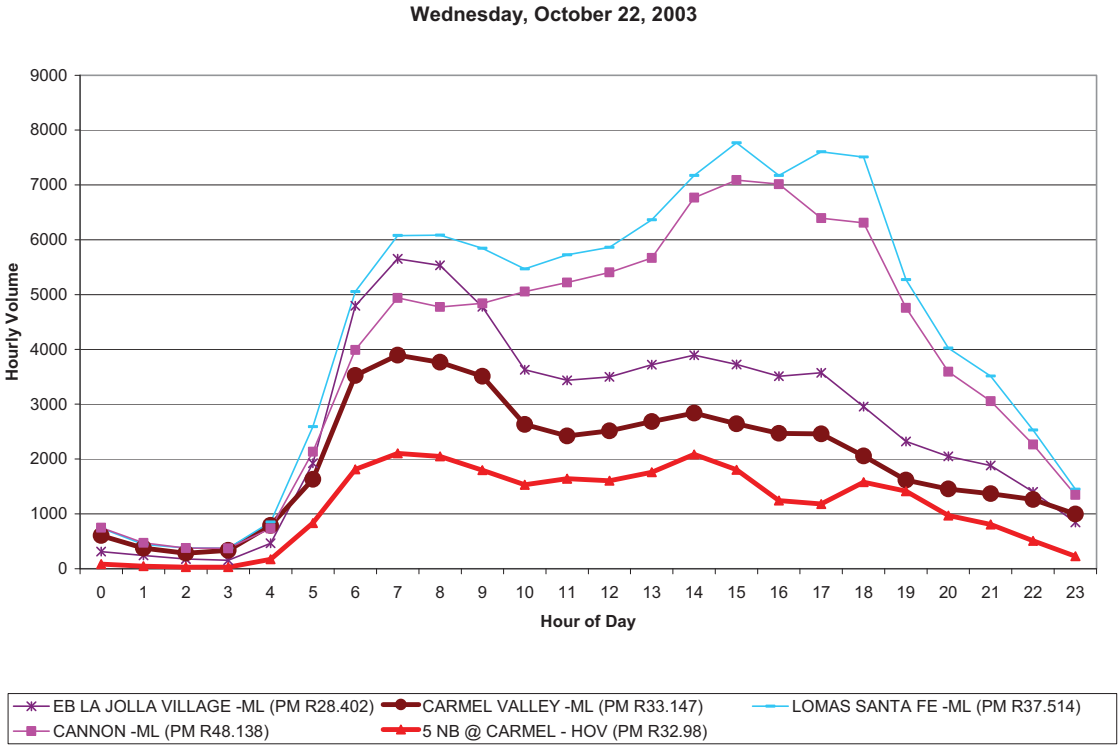
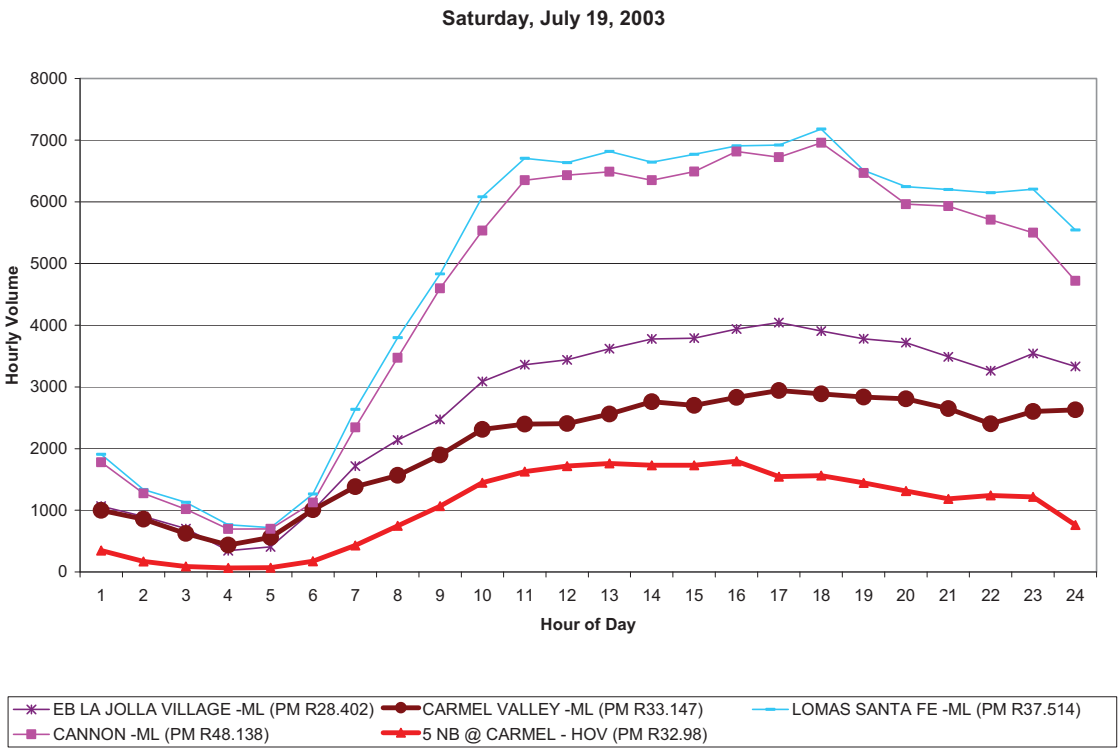
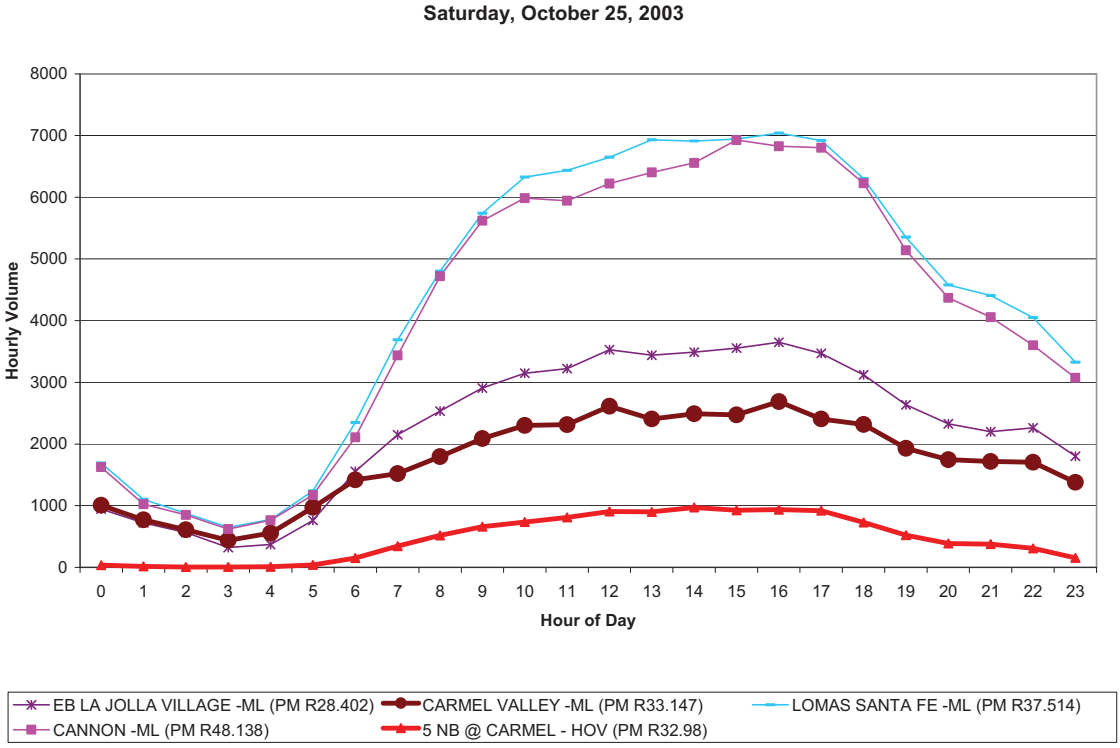


FIGURE 2-7: I-5 NORTHBOUND HOURLY VOLUMES – SATURDAY





2.6 VEHICLE OCCUPANCY DISTRIBUTION

Mainline I-5 vehicle occupancy counts were recorded in 2000 at one location along the study corridor for one direction: southbound I-5 north of Via de la Valle. Please note that these counts are a good source of information on the relative percentage of different vehicle occupancies, but not a good source for vehicle volume information since they were taken several years ago (Year 2000) using a manual counting methodology.

As shown in Table 2-6, at Via de la Valle occupancy counts for the morning peak period from 6:30 to 9:00 a.m. indicate that 87.5 percent of the southbound traffic was comprised of single occupant vehicles (SOV). The remaining southbound, morning peak period traffic consisted of 11.2 percent 2-person carpool vehicles and 1.3 percent 3+ person carpool vehicles. Average vehicle occupancy between 6:30 and 9:00 a.m. was approximately 1.14 persons per vehicle in the southbound direction.

The 7.5 hour traffic totals (6:30 a.m. to 2:00 p.m.) for southbound I-5 north of Via de la Valle indicate that 82.4 percent of traffic was composed of SOV, while 2-person HOV comprised 15.8 percent and 3+ person HOV comprised 1.8 percent. Average vehicle occupancy was approximately 1.19 persons per vehicle on I-5 southbound for the 7.5 hour period.

The percentage of SOV was higher during the morning peak period and lower during the mid-day hours. The lowest percentage of SOV, 77.1 percent, and the highest percentage of 2 and 3+ person carpools, 22.9 percent, occurred from 10 to 11 in the morning. Noon to 1 p.m. had the second lowest percentage of SOV, 77.3 percent. The highest percentage of SOV, 88.1 percent, occurred between 7:30 and 8:00 a.m. in the morning.

2.7 VEHICLE CLASSIFICATION DISTRIBUTION

Vehicle classification counts were conducted on I-5 southbound north of Via de la Valle in 2000. Please note that these counts are a good source of information on the relative percentage of different vehicle classes, but not a good source for vehicle volume information since they were taken several years ago (2000) using a manual counting methodology.

As shown in Table 2-7, autos at Via de la Valle comprised 76.6 percent of vehicular traffic in the southbound direction during the 7.5 hour period (6:30 a.m. to 2:00 p.m.) for which data was collected. Light-duty vehicles, motorcycles, buses, 2-3 axle heavy-duty trucks, and 4+ axle heavy-duty trucks comprised 15.2, 0.2, 0.7, 3.9, and 3.5 percent of the 7.5 hour traffic, respectively.

In the morning peak period (6:30 to 9:00 a.m.), 77.9 percent of southbound traffic at Via de la Valle was composed of autos. Light-duty vehicles, motorcycles, buses, 2-3 axle heavy-duty trucks, and 4+ axle heavy-duty trucks comprised 16.1, 0.2, 0.5, 2.7, and 2.5 percent of the southbound traffic, respectively.

Over the course of the 7.5 hour period counted, the percentage of passenger vehicles roughly followed a skewed bell curve, reaching its minimums in the early morning and mid-day, and reaching its maximum at the end of the morning peak period. The percentage of passenger vehicles peaked from 8:30 to 9 a.m., 82.8 percent. The lowest percentage of passenger vehicles, 73.2 percent occurred from noon to 1 p.m. in the afternoon, while the second lowest, 73.5, occurred from 6:30 to 7 a.m. in the morning.

TABLE 2-6: VEHICLE OCCUPANCY DISTRIBUTION

I-5 n/o Via de la Valle
Thursday (11/9/00)

	VEHICLE OCCUPANCY **Southbound**			
	1	**2**	**3+**	**Total**
6:30 - 7:00 a.m.	2,837	352	38	3,227
Percent	*87.9%*	*10.9%*	*1.2%*	*100.0%*
7:00 - 7:30 a.m.	2,651	332	39	3,022
Percent	*87.7%*	*11.0%*	*1.3%*	*100.0%*
7:30 - 8:00 a.m.	2,581	324	25	2,930
Percent	*88.1%*	*11.1%*	*0.9%*	*100.0%*
8:00 - 8:30 a.m.	2,334	309	42	2,685
Percent	*86.9%*	*11.5%*	*1.6%*	*100.0%*
8:30 - 9:00 a.m.	2,781	373	52	3,206
Percent	*86.7%*	*11.6%*	*1.6%*	*100.0%*
9:00 - 10:00 a.m.	3,736	661	70	4,467
Percent	*83.6%*	*14.8%*	*1.6%*	*100.0%*
10:00 - 11:00 a.m.	3,969	1,024	153	5,146
Percent	*77.1%*	*19.9%*	*3.0%*	*100.0%*
11:00 a.m. - 12:00 p.m.	3,669	924	102	4,695
Percent	*78.1%*	*19.7%*	*2.2%*	*100.0%*
12:00 - 1:00 p.m.	3,187	841	95	4,123
Percent	*77.3%*	*20.4%*	*2.3%*	*100.0%*
1:00 - 2:00 p.m.	3,246	789	62	4,097
Percent	79.2%	19.3%	1.5%	100.0%
TOTAL	***30,991***	***5,929***	***678***	***37,598***
Percent	***82.4%***	***15.8%***	***1.8%***	***100.0%***

Data Source: *2000 Vehicle Occupancy and Classification Study,* SANDAG

TABLE 2-7: VEHICLE CLASSIFICATION DISTRIBUTION

I-5 n/o Via de la Valle
Thursday (11/9/00)

VEHICLE CLASSIFICATION
Southbound

	Passenger Vehicle	Light Duty Vehicles	Motorcycle	Bus	Heavy Duty 2-3 Axle	Heavy Duty 4+ Axle	Total
6:30 - 7:00 a.m.	2,522	705	13	12	68	113	3,433
Percent	*73.5%*	*20.5%*	*0.4%*	*0.3%*	*2.0%*	*3.3%*	*100.0%*
7:00 - 7:30 a.m.	2,444	578	11	15	97	72	3,217
Percent	*76.0%*	*18.0%*	*0.3%*	*0.5%*	*3.0%*	*2.2%*	*100.0%*
7:30 - 8:00 a.m.	2,452	478	6	16	72	72	3,096
Percent	*79.2%*	*15.4%*	*0.2%*	*0.5%*	*2.3%*	*2.3%*	*100.0%*
8:00 - 8:30 a.m.	2,259	426	2	23	110	65	2,885
Percent	*78.3%*	*14.8%*	*0.1%*	*0.8%*	*3.8%*	*2.3%*	*100.0%*
8:30 - 9:00 a.m.	2,810	396	1	22	88	75	3,392
Percent	*82.8%*	*11.7%*	*0.0%*	*0.6%*	*2.6%*	*2.2%*	*100.0%*
9:00 - 10:00 a.m.	3,710	757	7	45	241	187	4,947
Percent	*75.0%*	*15.3%*	*0.1%*	*0.9%*	*4.9%*	*3.8%*	*100.0%*
10:00 - 11:00 a.m	4,448	698	2	49	208	233	5,638
Percent	*78.9%*	*12.4%*	*0.0%*	*0.9%*	*3.7%*	*4.1%*	*100.0%*
11:00 a.m. - 12:00 p.m.	3,973	722	7	23	236	223	5,184
Percent	*76.6%*	*13.9%*	*0.1%*	*0.4%*	*4.6%*	*4.3%*	*100.0%*
12:00 - 1:00 p.m.	3,369	754	5	41	238	197	4,604
Percent	*73.2%*	*16.4%*	*0.1%*	*0.9%*	*5.2%*	*4.3%*	*100.0%*
1:00 - 2:00 p.m.	3,368	729	12	32	223	191	4,555
Percent	*73.9%*	*16.0%*	*0.3%*	*0.7%*	*4.9%*	*4.2%*	*100.0%*
TOTAL	***31,355***	***6,243***	***66***	***278***	***1,581***	***1,428***	***40,951***
Percent	***76.6%***	***15.2%***	***0.2%***	***0.7%***	***3.9%***	***3.5%***	***100.0%***

Data Source: *2000 Vehicle Occupancy and Classification Study* , SANDAG

2.8 TRUCK VOLUMES

Table 2-7, which shows vehicle classification counts from 2000 on Southbound I-5 north of Via de la Valle for a 7.5 hour period, provides a snapshot of fluctuating truck percentages over the course of a day. As can be seen in the table, the percentage of heavy duty trucks (2-3 and 4+ axles) reached a low of 4.6 percent from 7:30 to 8:00 a.m. and a high of 9.5 percent from noon to 1 p.m. The percent of heavy duty trucks was consistently lower during the morning commute period than it was subsequently, from 9:00 a.m. to 2:00 p.m. The percentage of light duty vehicles also varied significantly, but followed a different pattern. The highest observed percentage of light duty trucks, 20.5 percent, occurred from 6:30 to 7:00 a.m. in the morning and the lowest percentage, 11.7 percent, occurred from 8:30 to 9:00 a.m. in the morning.

Truck volume trends along the I-5 study corridor can be seen in the 2002 7-day average daily traffic (ADT) and 2003 weekday (5-day) ADT contained in Table 2-8. The table shows that 7-day truck ADT was consistently lower than weekday truck ADT, at all five locations for which truck data was collected. Although the 7-day data was collected in 2002, and the weekday data was collected in 2003, the magnitude of difference between the two cannot be explained by typical growth rates observed along the corridor (shown in Table 2-1). Weekend truck volumes that are significantly lower than weekday truck volumes are the most likely cause of the consistently lower 7-day truck ADT. A second pattern displayed by the data, is that truck volumes on I-5 decrease from south to north. Both the 7-day and weekday ADT decrease by about nine percent, or 900-1200 trucks, between the southern-most count location and the northern-most one.

TABLE 2-8: CURRENT 7-DAY AND WEEKDAY TRUCK ADT

Location	2002 7-day Truck ADT	2003 Weekday Truck ADT
South of Del Mar Heights Road	10,500	13,700
South of Manchester Avenue	10,300	13,500
South of Palomar Airport Road	10,000	13,050
South of State Route 78	9,800	12,700
North of Oceanside Boulevard	9,600	12,500

Data Source: Caltrans District 11

2.9 CURRENT PEAK HOUR OPERATING SPEEDS

Speed data was extracted from PeMS for observation of weekday and weekend speed trends in the mainline and HOV lanes. The peak hours by direction were identified using the hourly volumes extracted for two Wednesdays and two Saturdays, in summer and fall 2003, described previously under "Northbound HOV Lane Volumes." Speeds were extracted from PeMS for the peak hours identified for the same days as the volume data:

- Wednesday, July 16, 2003
- Saturday, July 19, 2003
- Wednesday, October 22, 2003
- Saturday, October 25, 2003

Speeds at eleven count stations, located at roughly the same locations in the northbound and southbound directions, were tabulated. The eleven count stations are spread across about 20 miles of the 26 mile study corridor, providing reasonably good coverage.

Figures 2-8 and 2-9 illustrate the speed data collected for the southbound I-5 mainline during the weekday and weekend peaks, respectively. It was determined that the weekday peak hour in the southbound direction occurred from 7:00 to 8:00 a.m while the weekend peak hour occurred from 11:00 a.m to 12:00 p.m. based on hourly volume data for the sample days. As can be seen in Figure 2-8, speed reached a minimum of 22 to 24 mph near La Costa Avenue, on both sample weekdays. Slow speeds extended across 2-3 count stations, covering roughly five miles. Speeds of 30 mph or less were observed near Manchester Avenue, Leucadia Boulevard, and La Costa Avenue on the Wednesday in July, and only at Leucadia Boulevard and La Costa Avenue on the Wednesday in October.

As can be seen in Figure 2-9, southbound traffic slows at a similar location during the Saturday peak hour, but not as markedly. A minimum speed of 26 mph was observed at Leucadia Boulevard on the Saturday in July, while a minimum speed of 51 mph was observed at Manchester Avenue on the Saturday in October.

Figures 2-10 and 2-11 illustrate the speed data collected for the northbound I-5 mainline during the weekday and weekend peaks, respectively. It was determined that the weekday peak hour in the northbound direction occurred from 5:00 to 6:00 p.m. , while the weekend peak hour occurred from 4:00 to 5:00 p.m. based on hourly volume data for the sample days. As can be seen in Figure 2-10, during the two sample Wednesdays, northbound mainline speeds reach a minimum at two defined locations. Speeds ranging from 17 to 36 mph were observed at the neighboring stations of Del Mar Heights Road and Via de la Valle. Slow speeds ranging from 24 to 34 mph were also observed further north along the corridor at the adjacent stations at Poinsettia Lane, Palomar Airport Road, and Cannon Road.

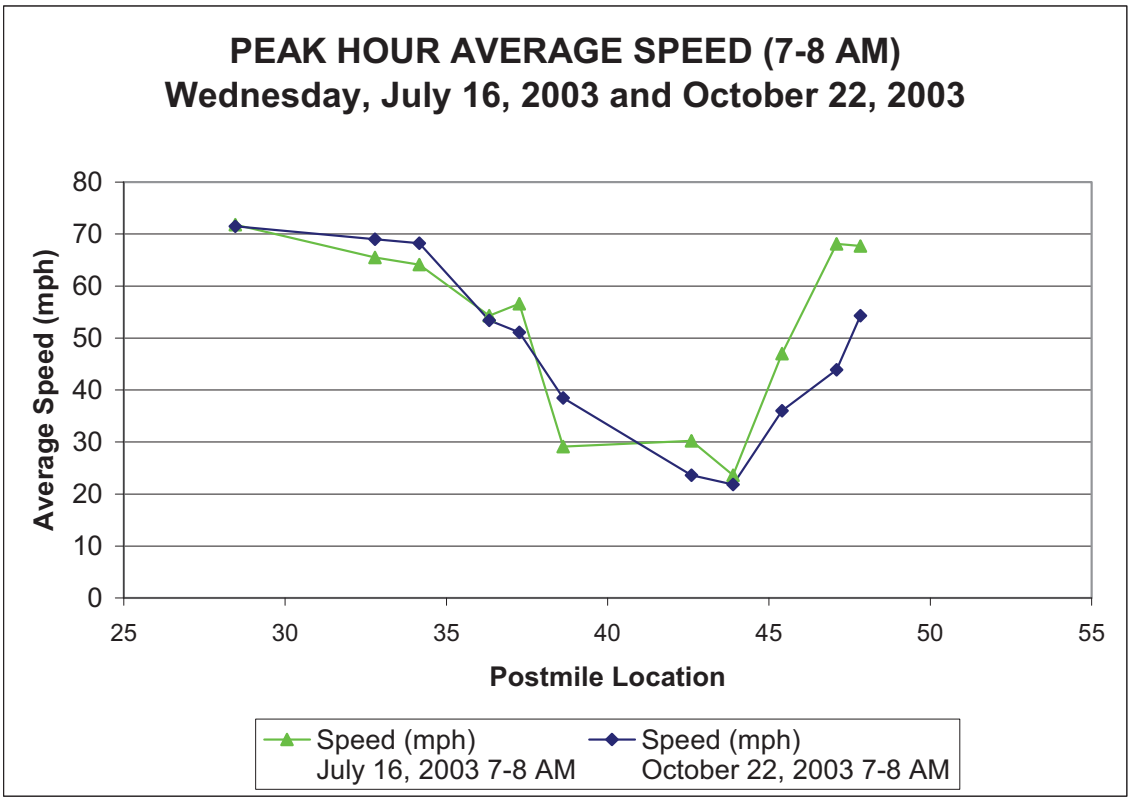
As can be seen in Figure 2-11, slow speeds were only observed in one of the two areas during the sample Saturday peaks. Minimum speeds of 20 and 21 mph were observed at Del Mar Heights Road on the Saturday in July and the Saturday in October, respectively.

Figure 2-12 illustrates speeds in the northbound HOV lane at Carmel Valley Road on the 4 sample days (two Wednesdays and two Saturdays) during their respective peak hours (5:00 to 6:00 p.m. and 4:00 to 5:00 p.m.). As can be seen in the figure, speeds in the

HOV lane range from 11 to 16 mph on the two sample Wednesdays, during the 5:00 to 6:00 p.m. peak hour, suggesting congested conditions. This corresponds with the volume trends observed in the HOV lane discussed previously and illustrated in Figure 2-6.

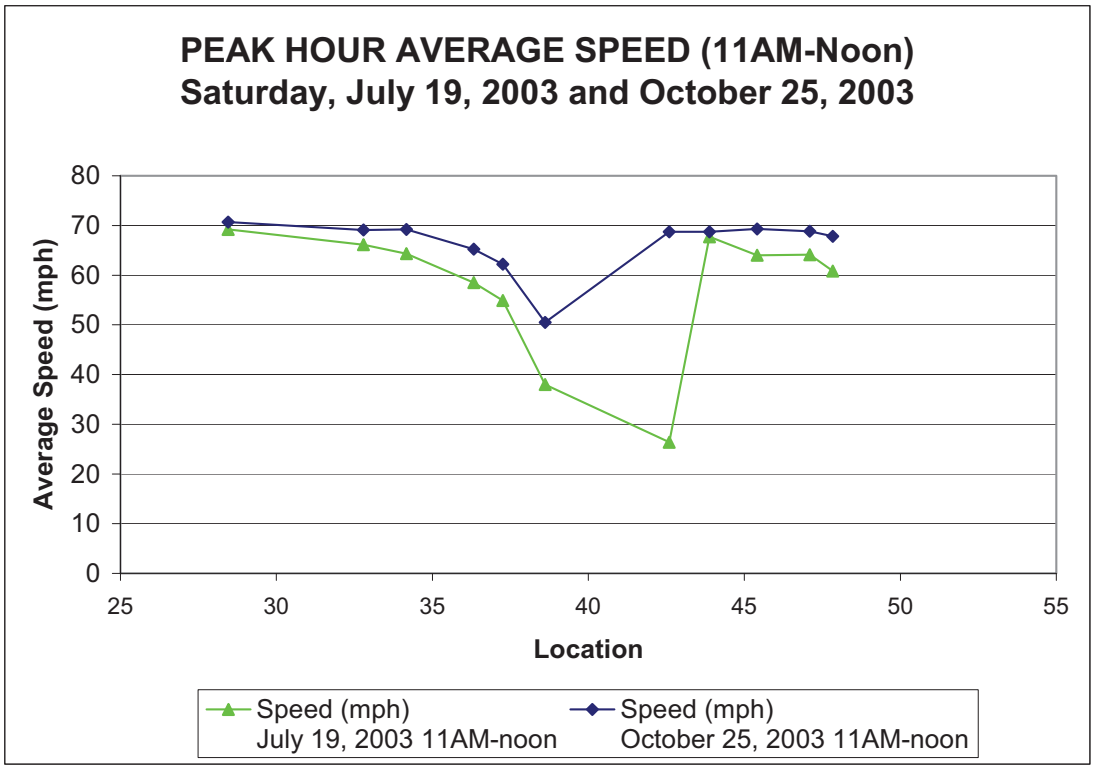
In contrast, Saturday speeds range from a fair 56 mph to a clearly free-flowing 72 mph. Once again, this correlates with the volumes observed in the HOV lane on these same two Saturdays, illustrated in Figure 2-7 and discussed previously. Hourly volumes of approximately 1,800 and 1,550 were observed from 4:00 to 5:00 and 5:00 to 6:00 p.m. on the Saturday in July, respectively, both of which are either above or near the 1,650 vehicle per hour capacity of a single-lane HOV facility. This correlates to the slightly reduced speed of 56 mph observed in the HOV lane from 5:00 to 6:00 p.m. on the Saturday in July. On the other hand, volumes in the HOV lane were well below 1,650 on the Saturday in October, corresponding to the clearly free-flowing speed of 72 mph which was observed.

FIGURE 2-8: I-5 SOUTHBOUND MAINLINE SPEEDS – WEDNESDAY



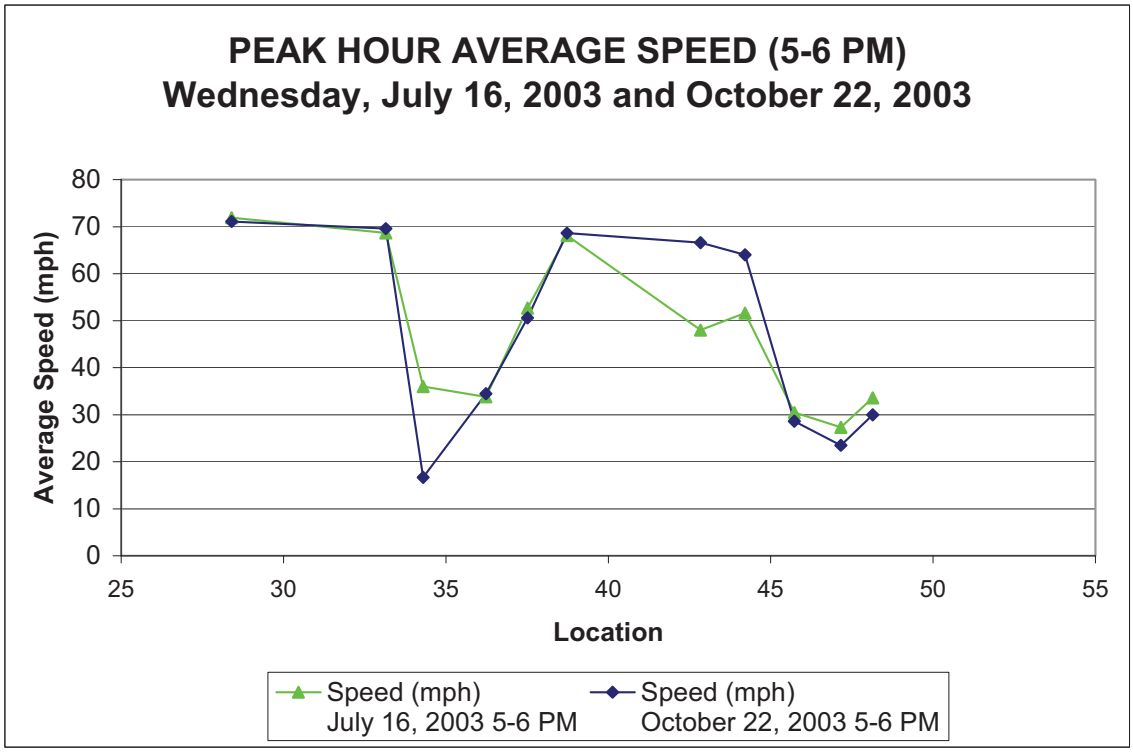
Location Description	CA Postmile	Speed (mph) July 16, 2003 7-8 AM	Speed (mph) October 22, 2003 7-8 AM
WB LA JOLLA VILLAGE	28.454	72	72
CARMEL VALLEY	32.79	66	69
WB DEL MAR HEIGHTS	34.164	64	68
WB VIA DE LA VALLE	36.326	54	53
LOMAS SANTA FE	37.26	57	51
MANCHESTER	38.617	29	39
LEUCADIA	42.591	30	24
LA COSTA	43.885	24	22
POINSETTIA	45.409	47	36
WB PALOMAR AIRPORT	47.097	68	44
CANNON	47.834	68	54

FIGURE 2-9: I-5 SOUTHBOUND MAINLINE SPEEDS – SATURDAY



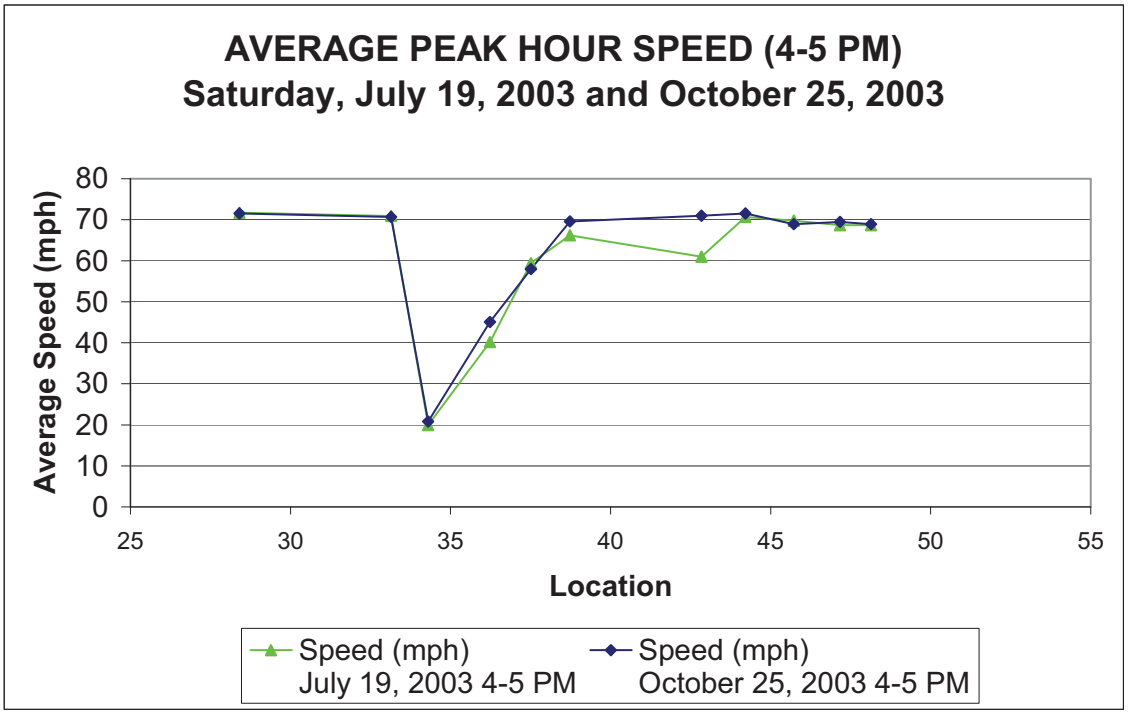
Location Description	CA Postmile	Speed (mph) July 19, 2003 11AM-noon	Speed (mph) October 25, 2003 11AM-noon
WB LA JOLLA VILLAGE	28.454	69	71
CARMEL VALLEY	32.79	66	69
WB DEL MAR HEIGHTS	34.164	64	69
WB VIA DE LA VALLE	36.326	59	65
LOMAS SANTA FE	37.26	55	62
MANCHESTER	38.617	38	51
LEUCADIA	42.591	26	69
LA COSTA	43.885	68	69
POINSETTIA	45.409	64	69
WB PALOMAR AIRPORT	47.097	64	69
CANNON	47.834	61	68

FIGURE 2-10: I-5 NORTHBOUND MAINLINE SPEEDS – WEDNESDAY



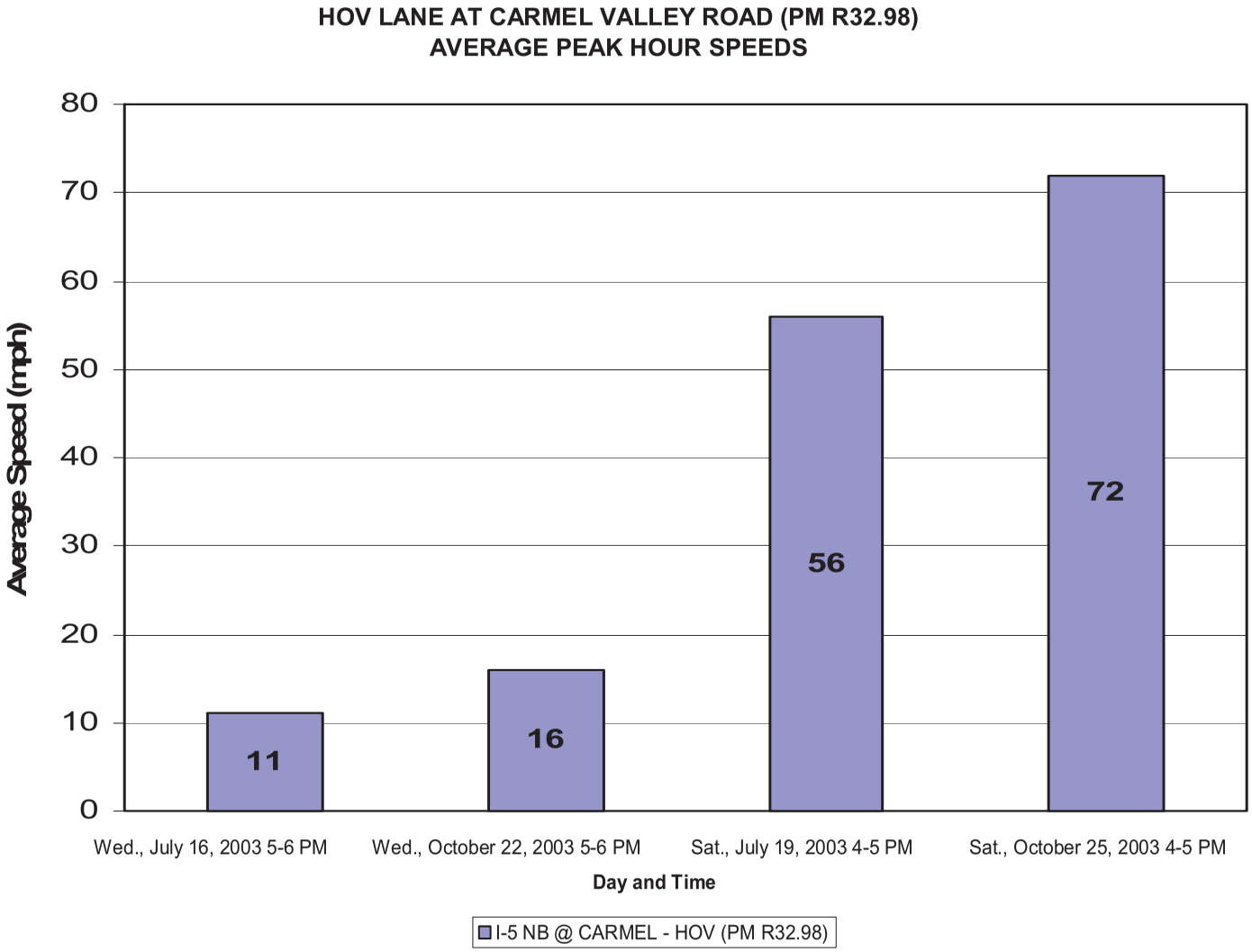
Location Description	CA Postmile	Speed (mph) July 16, 2003 5-6 PM	Speed (mph) October 22, 2003 5-6 PM
EB LA JOLLA VILLAGE	28.402	72	71
CARMEL VALLEY	33.147	69	70
DEL MAR HEIGHTS	34.296	36	17
EB VIA DE LA VALLE	36.23	34	35
LOMAS SANTA FE	37.514	53	51
MANCHESTER	38.728	68	69
LEUCADIA	42.838	48	67
LA COSTA	44.21	52	64
POINSETTIA	45.724	31	29
PALOMAR AIRPORT	47.165	27	24
CANNON	48.138	34	30

FIGURE 2-11: I-5 NORTHBOUND MAINLINE SPEEDS – SATURDAY



Location Description	CA Postmile	Speed (mph) July 19, 2003 4-5 PM	Speed (mph) October 25, 2003 4-5 PM
EB LA JOLLA VILLAGE	28.402	72	72
CARMEL VALLEY	33.147	71	71
DEL MAR HEIGHTS	34.296	20	21
EB VIA DE LA VALLE	36.23	40	45
LOMAS SANTA FE	37.514	59	58
MANCHESTER	38.728	66	70
LEUCADIA	42.838	61	71
LA COSTA	44.21	71	72
POINSETTIA	45.724	70	69
PALOMAR AIRPORT	47.165	69	70
CANNON	48.138	69	69

FIGURE 2-12: I-5 NORTHBOUND HOV SPEEDS



CHAPTER 3
ALTERNATIVE PRICING STRATEGIES

The purpose of this chapter is to identify and review a number of potential pricing strategies suitable to employ on I-5 North Coast Managed Lanes Study. Each pricing strategy details how the tolling mechanism would work, typical potential user fees, and conceptually how the price information would be communicated to the user. It is intended that each of these pricing alternatives be evaluated against feasibility criteria in order to find the one that is best suited for use on the I-5 corridor. The price values listed in each of these alternatives are very preliminary and are only intended for the purposes of the feasibility study. Price values are based on current I-15 toll experience and will be determined at the time of implementation and opening.

3.1 PRICING GOALS AND STRATEGIES

This section discusses pricing goals, toll equity, and targeted trips in an effort to take into consideration the goals and possible issues created by various pricing strategies for the proposed facility.

3.1.1. Project Goals and Objectives

The primary goal of the proposed I-5 North Coast Managed Lanes (ML) is to maintain mobility of four of the added lanes through roadway demand management. This goal is addressed in this section and is reflected in many of the mobility objectives found in the I-5 Purpose and Need report. Specifically, objectives addressing I-5 corridor mobility in this companion report include:

- Maintain or improve future traffic levels of service in 2030 over the existing levels of service;
- Maintain or improve travel times within the corridor;
- Provide a (roadway) facility that is compatible with future bus rapid transit and modal options; and
- Maintain I-5 as an effective link in the national Strategic Highway Network.

The scope of this study is determining if pricing as a demand management tool is feasible on the managed lanes. Pricing needs to be applied in conjunction with access controls and eligibility to achieve real-time demand management of the ML during varying operating conditions. In keeping with regional policy, a high level of service (LOS) on managed lanes in San Diego will need to be maintained.

Pricing can also generate revenue, and various pricing scenarios may optimize revenue generation while managing traffic.

Multiple access points along the roadway in the form of slip ramps with main lanes and direct access ramps (DARs) with major streets and transit facilities make managing traffic through access features a challenge. Users (HOVs or tolled SOVs) may elect to travel only in selected sections of the roadway and create a challenge to lane management. SANDAG and Caltrans also have regional and statewide goals that encourage the use of transit and formation of carpools and vanpools. These modes are

given preference in the form of free use of a managed lane roadway. They may have an adverse impact on mobility if HOV demand exceeds ML capacity. Value pricing may be the only tool to actively manage specific roadway sections, whether this demand is generated from single occupant vehicles (SOVs) or HOVs.

Current commute experience on the I-15 ML facility is based on allowing all traffic to enter at one end and exit at the other. A single toll price is displayed for entering vehicles that can change dynamically. However, multiple access locations make this approach complicated but feasible.

Multiple bottleneck locations within the ML and adjacent lanes may focus demand. Some tolling strategies, such as flat or distance based tolling, may either encourage users to travel a longer portion of the ML while others, e.g., dynamic, may encourage frequent transfers in and out of the ML, causing unnecessary weaving and increased safety and operational hazards. These issues should be recognized in the project's demand management goals and objectives.

Net revenue generated from the ML may be applied to a variety of purposes, including recovery of capital costs or operation costs associated with transit services, as is done on I-15. Toll revenue may become a more important issue on an expansive facility like I-5.

3.1.2. Toll Equity

An equitable toll system is needed since users of the ML will include short trips and long trips, but the possibility of toll rates being adjusted to reflect distance traveled may be needed to manage the ML. This section discusses the advantages and disadvantages of a distance-based system and flat toll system in meeting the management goal.

The traditional views on equity related to tolling rates are designed around mile based pricing plans. To achieve equity in those types of plans, toll rates should be adjusted to reflect the distance traveled. However, the more equitable the toll rates are, the less influence rate adjustments have on demand management. In an optimally managed distance-based system, short trips would have low tolls, which would provide relatively little disincentive to using the ML.

A flat-based toll system charging the same rate to all vehicles regardless of trip length would have low levels of toll equity, but would discourage frequent shifts between ML and general purpose (GP) lanes.

A segmentedly-skewed, time-of-day pricing system would have its equity based in delivering a constant value/cost of time saved. While this measure may be non traditional, it has seen acceptance in the marketplace as a fair way to price accessibility and mobility and it is very much at the heart of the utility derived by the driver.

3.1.3. Targeted Trips

Since different pricing strategies will encourage a variety of trips, it may be appropriate as a regional policy to consider targeting specific trips. For example, longer distance trips may be targeted versus shorter trips, or targeting frequent users who are typically commuters versus discretionary or recreational users who may not be averse to the price of a toll.

3.1.4. User and System Complexity

In selecting the optimum strategy, consideration must be given to complexity of the tolling system and customer interface. Complexity is harder to communicate on roadside signing and harder for users, particularly infrequent users, from making informed decisions. Regional policies and consistency between tolling strategies for I-5 may outweigh other objectives in addressing this need.

3.2 PRICING OPTIONS

A variety of potential pricing options exist. In general, there appear to be three basic options with respect to time variance, including:

- **Fixed Schedule Pricing:** No variability by time of day. Most traditional toll facilities follow this strategy because it is simple to understand and easily applied.
- **Preset Variable Rate Pricing:** Toll rates are varied by time of day or direction of travel, but on a preset fixed schedule. State Route (SR) 91 in Orange/Riverside County operates using this strategy.
- **Dynamic Variable Pricing:** Prices vary based on actual levels of demand or congestion and are not tied to a fixed schedule. This approach is currently applied on I-15.

The ML designs being studied for I-5, including a buffer- or barrier-separated roadway with multiple access points both with the adjacent GP lanes and DARs to arterials and transit facilities, suggest a need for some type of variable toll. Demand management will not be able to be achieved based on a fixed toll schedule. A non-variable toll might be possible for peak periods, but would generate virtually no traffic or revenue in the off-peak periods. Value pricing as defined and applied on the demonstration project on I-15 was based on the premise that toll rates were adjusted in proportion to the "value" motorists receive in traveling the express lanes in terms of time savings and reliability. The price is adjusted to reflect this. However, in off-peak periods when GP lanes operate well, the price is adjusted lower to attract traffic. A fixed rate schedule would neither satisfy demand management nor revenue generation goals.

Preset and dynamic pricing both offer potential for the I-5 ML project. The use of dynamic pricing will increase the ability to manage demand. The trade-offs associated with each relate to the level of complexity assigned. Both of these options are equivalent for any revenue analysis since one can be made to mimic the other in any modeling efforts. This is because modeling assignments for revenue are based on "static" trip tables reflecting regional demand for each period of the day. Ultimately, the decision between preset and dynamic pricing may be a function of the available technology, desire for regional toll policy consistency and ability to address changing conditions on the ML on a more real-time basis.

Within each of these two remaining options, tolling can be prescribed in three more potential strategies:

Flat Tolls: A single rate is charged from a specific entry, regardless of the point of exit. The rate can be different for each entry and different by time of day.

Per-Mile Tolls: A toll rate at any given time is based on the distance traveled, regardless of which entry is used.

Segment Tolls: A specific toll is charged for each segment between each of the major access locations with the GP lanes. For simplicity, DARs would not be considered major access locations, but this possibility also exists.

Each of these strategies can address pricing on lanes in a manner that helps regulate demand. All can vary either by time of day or dynamically based on travel demand. A key factor in determining the effectiveness or appropriateness of each is how the information provided to each user correctly corresponds to the value actually charged. The complexity of the toll design may also discourage use or encourage erratic use among the various access features. Current technology identified in this study limits some of the potential ways such information could be presented to potential users. Sign requirements need to be as simple and as understandable as possible, regardless of whether the signing information is through conventional means or as may be possible in the future, through heads up displays or on board voice over information. A summary of these options is provided in Table 3-1.

TABLE 3-1: OVERVIEW OF I-5 ML PRICING OPTIONS

Basic Options	Description	Optional Strategies	Other Variations
Flat Tolls	Single rate charged from entry regardless of trip length in the ML	• Standard rate at all entries • Rate based on maximum length trips from each entry point	• Time of day
Per Mile Tolls	Toll rate based on distance traveled in the ML	• Standard per mile rates at all entry points • Standard per mile rates depending on entry point	• With and without minimum toll • With minimum and maximum toll • Time of Day
Segment Tolls	Toll charged by segment between each major access point	• Standard rate per segment regardless of entry • Skewed segment rate at different points of entry	• Time of Day

Other variables affect the appropriateness of different toll structures, including the ability to use this toll for differing conditions as demand grows and how the toll policy will affect, or be affected by, pricing on other freeway corridors. Traffic forecasts for I-5 suggest that between 2015 and 2030 HOV demand will exceed the I-5 ML roadway capacity during peak periods. This condition will require tolling some of the HOVs to maintain an acceptable level of service. Variable, dynamic pricing already exists on the I-15 express lanes, and this pricing strategy will have changed to a skewed per mile toll basis by the time the I-5 project opens. These events further complicate potential tolling strategies that may be considered for I-5. Table 3-2 provides a matrix of options that encompasses these other corridor-specific and regional influences. Each of these strategies is then discussed regarding their potential benefits and impacts to forecast I-5 ML use.

TABLE 3-2: PRICING STRATEGY OPTIONS MATRIX

Pricing Strategies Comparison

Pricing Factors								
	Time of Day	Infrequent User	Travel Time	Travel Distance	Maintain LOS C	HOV-2+ free	HOV-3+ free, 2s tolled	Regional Consistency
Strategy								
1. Variable Fixed	X	X			X	X	X	
2. Dynamic	X				X	X	X	X
3. Distance Based		X		X		X	X	
4. Fixed Distance-Based	X	X		X				
5. Fixed by Access Point		X		X				
6. Fixed Time Based	X	X	X					
7. Flat Toll						OPTION	OPTION	
8. Dynamic by Segment						OPTION	OPTION	
9. Time of Day/Segment	X	X		X		OPTION	OPTION	
10. Dynamic, Skewed	X		X	X	X	OPTION	OPTION	X

3.2.1. Strategy 1: Variable Fixed [time of day]

This strategy charges users a variable toll depending on which hour of the day/day of the week they use the managed lanes. The rate schedule might peak in the morning in the southbound direction towards San Diego and in the northbound direction in the late afternoon. However, over time, the price during peaks may be the same for both directions if congestion is evidenced in northbound and southbound directions. Toll charges are independent of distance traveled, and the rate structure is fixed. A distinction could be made between an HOV and SOV as is done on SR 91 to allow HOVs with a certain requisite occupancy free use. A user can expect to pay a maximum toll rate if traveling between peak time of perhaps 7:00 a.m. to 8:00 a.m. and 5:00 to 6:00 p.m.in one or both directions, depending on levels of congestion typically experienced. Lower fees at other times of the day and on the weekend would be in effect. Given the constant change of this user fee throughout the day, a hybrid static-dynamic message sign would be needed to communicate the current price to the user. This sign would be mounted over the roadway at various locations. Assuming all tolled vehicles are equipped with a transponder, a current price schedule could be mailed along with the initial transponder purchase and/or updates mailed and posted to a website to provide the most current price structure (Figure 3-1).

FIGURE 3-1: EXAMPLE COST SCHEDULE FROM SR 91 IN ORANGE COUNTY

SOUTHBOUND

	Sun	M	Tu	W	Th	F	Sat
12:00 AM				$1.00			
1:00 AM				$1.00			
2:00 AM				$1.00			
3:00 AM				$1.00			
4:00 AM				$2.00			
5:00 AM				$3.00			
6:00 AM				$4.00			$1.00
7:00 AM				$5.00			
8:00 AM	$1.00			$4.00			$2.00
9:00 AM				$3.00			
10:00 AM				$2.00			
11:00 AM	$2.00			$2.00			
12:00 PM				$2.00			$3.00
1:00 PM				$2.00			
2:00 PM	$3.00			$2.00			$4.00
3:00 PM	$4.00			$2.00			
4:00 PM	$4.00			$2.00			$3.00
5:00 PM	$3.00			$2.00			
6:00 PM				$2.00			
7:00 PM				$1.00			
8:00 PM	$2.00			$1.00			$2.00
9:00 PM				$1.00			
10:00 PM	$1.00			$1.00			$1.00
11:00 PM				$1.00			

NORTHBOUND

	Sun	M	Tu	W	Th	F	Sat
12:00 AM				$1.00			
1:00 AM				$1.00			
2:00 AM				$1.00			
3:00 AM				$1.00			
4:00 AM				$1.00			
5:00 AM				$1.00			
6:00 AM				$2.00			$1.00
7:00 AM				$2.00			
8:00 AM	$1.00			$2.00			$2.00
9:00 AM				$2.00			
10:00 AM				$2.00			
11:00 AM	$2.00			$2.00			
12:00 PM				$2.00			$3.00
1:00 PM				$2.00			
2:00 PM	$3.00			$2.00			$4.00
3:00 PM	$4.00			$3.00			
4:00 PM	$4.00			$4.00			$3.00
5:00 PM	$3.00			$5.00			
6:00 PM				$4.00			
7:00 PM				$3.00			
8:00 PM	$2.00			$2.00			$2.00
9:00 PM				$1.00			
10:00 PM	$1.00			$1.00			$1.00
11:00 PM				$1.00			

Note: Prices are for illustrative purposes only.

3.2.2. Strategy 2: Dynamic [real time per congestion level]

The rate schedule in Figure 3-1 represents the baseline price structure with actual rates varying (higher or lower) depending on real time traffic volumes and traffic conditions. A distinction could be made between SOV and HOV as is done on the I-15 express lanes to allow HOVs free use. The per-trip fee varies dynamically in response to traffic conditions on the managed lanes and/or general purpose lanes. If calculation of rates involves comparative travel time with the general use lanes, this information would be displayed in advance on dynamic signs. Fees are set to maintain an acceptable LOS C or better assuming 1,650 vehicles/lane/hour as a threshold for this condition. In general, the per-trip fee to use the managed lanes is higher during peak periods when there is more demand and less available capacity. During off-peak periods, the per-trip fee is lower. Traffic volume data, collected from real-time loop detectors in the tolling zone, are used to determine when fees should be changed and to what level. This variable pricing information, again, would be communicated through a hybrid static-changeable message sign (Figure 3-2). This sign would mount over the roadway and be colored differently from the rest of the general purpose signs to indicate the presence of the managed lane(s).

FIGURE 3-2: EXAMPLE SIGN FROM I-15 DYNAMICALLY CHANGING TOLL

3.2.3. Strategy 3: Distance-based with reduced toll for HOV use

This strategy contains various possible scenarios:

- Restrict free access to HOV-3+ vehicles and charge all others
- Restrict free access to HOV-3+ vehicles and charge 2-occupant vehicles a reduced rate that might be a 50 percent discount of the SOV rate.

This strategy allows a certain category of HOVs to use the managed lanes free of charge while all other HOVs pay a toll that is distance based. Given this distinction of vehicles, proper signing and enforcement needs of the managed lanes is made more complex. The first sign a user would see as they approach the facility would be a static sign defining what HOV group is free and which must pay. If SOVs are also allowed, this distinction would also need to be made. As they approach the beginning of the toll zone, an overhead hybrid static-changeable message sign would indicate to the user the current rate for each of the two categories.

3.2.4. Strategy 4: Fixed [distance-based]

This strategy combines elements of distance-based and time-based tolling. Again, a variable toll by schedule is charged depending on the hour of the day/day of the week the facility is used. This variable toll also takes into account the distance traveled during that particular block of time (see previous Figure 3-1). No distinction is made between SOVs and HOVs. The rate schedule peaks in the morning in the southbound direction towards San Diego and in the northbound direction in the late afternoon. Lower rates at other times of the day and on the weekend are indicated. Given the constant change of

this user fee throughout the day, a hybrid static-changeable message sign could be used to communicate the current price to the user. This sign would mount over the roadway and be colored differently from the rest of the general purpose signs to indicate the presence of the managed lane(s). Assuming vehicles equipped with a transponder is a prerequisite for utilizing the facility, a current price schedule could be mailed along with the initial transponder purchase and/or updates posted to a website would provide the most current price structure.

3.2.5. Strategy 5: Access Point Based

This pricing strategy resembles that of certain mass transit lines. Each direct access point along the managed lane facility is treated like a "boarding station" and charges are based on the pairing of entrance points with exit points. The farther the two direct access points are located from each other, the higher the toll. This structure could be maintained at other times using lower point-to-point charges. In addition the point-to-point charges could be modified to account for the variation in distances between access points. For example, instead of charging a constant fee of $0.50 from one access point to the next adjacent one, a $0.30 fee would be charged for those adjacent pairs with a relatively shorter distance and a $0.50 fee would be charged for those pairs with a relatively longer distance. This type of pricing schedule is not conducive for display on overhead signs. Therefore, a price schedule would be mailed along with the initial transponder purchase and updates to the price structure would be posted to a website or mailed to transponder owners with active accounts.

3.2.6. Strategy 6: Fixed [time-based]

This strategy combines two elements of time-based tolling. A variable toll is charged depending on the hour of the day/day of the week the facility is used. This variable toll however also takes into account the number of minutes spent traveling in the facility during that particular block of time. No distinction is made between SOV and HOV. The rate at a particular time would be displayed on a hybrid static-changeable message sign, mounted overhead before the entrance to the facility. Price schedules could also be mailed to transponder owners or posted to a website. A potential drawback to this scenario is that users may have the tendency to speed excessively while in the managed lanes, in order to reduce the fee charged to them.

3.2.7. Strategy 7: Flat Toll

This strategy consists of a flat charge independent of occupancy, travel time, or distance. An option would be to offer a reduced flat rate for either HOV-2+ or HOV-3+. Static signs would be sufficient at entry locations to convey the flat user fee to drivers approaching the facility.

3.2.8. Strategy 8: Dynamic by Segment

This strategy consists of dynamically charging a toll by segment depending on real-time demand for each segment, or time savings generated by each segment if traffic density is obtained from adjacent lanes. In either case, the downstream toll would not be known for an upstream user, and display of toll rates could only be made for no more than the next two or three downstream toll zones. HOVs would be free and not be affected by the SOV toll rates.

3.2.9. Strategy 9: Time of Day, By Segment

This strategy sets a time of day toll by segment, which mirrors the typical traffic conditions experienced in Strategy 8 according to a preset schedule of tolls. Tolls would be able to be known in advance by users, but not necessarily displayed for all downstream segments. Again, signing would be confusing. HOVs would be free and not be affected by the SOV toll rates.

3.2.10. Strategy 10: Dynamic, Skewed Toll

This strategy consists of dynamic toll rate that is set at per mile level within each segment, and skewed or weighted along the corridor to account for demand for specific segments from south to north. The southerly segments would have a higher toll per mile at any time during the peak period than segments further to the north, mirroring demand and congestion characteristics. Some segments would carry the same rate per mile, while others would be higher. A maximum toll rate might be established to discourage users from arbitrarily exiting the ML in the southerly segments.

3.2.11. Comparative Summary among Scenarios

Strategies 1, 2 and 7 propose the same toll for the full length of the ML facility. Travel distance or time is not used as a basis for pricing. While this might work as an interim pricing mechanism for a short initial segment, it would be difficult to justify for the full 26-mile facility and be hard to communicate. With differing levels of congestion along the corridor, a single toll for the entire corridor would not optimize revenue and result in the efficient use of this corridor as noted earlier.

In Strategy 2 if congestion varies widely throughout the corridor, the toll will need to be set to maintain traffic flow in the most congested area. As noted above, this will have negative revenue and efficiency impacts.

In Strategy 3, without time of day or congestion included as pricing factors, the per-mile price would need to be set to handle the peak demand at the peak location. This will reduce revenue and result in inefficient use of the ML facility.

In Strategy 4 adding time of day to Strategy 3 allows for peak period pricing and improves the efficiency of the facility. It does not, however, allow differential pricing along the corridor.

In Strategy 5, this is a variation distance based pricing in Strategy 3. Weekend schedules and peak-period schedules could be added.

In Strategy 6, if free-flow is maintained on the ML, then travel time should be directly proportional to travel distance. As the report notes, speeding could be a problem.

In Strategy 7, a flat toll was included for comparison purposes, but is not practicable as a traffic management tool. This is the simplest of all the strategies and probably the least efficient and effective to meet the ML goals.

Strategies 8, 9 and 10 would divide the corridor into defined segments with each segment having relatively uniform levels of main lane congestion. In Strategy 8 the price, which would reflect the length of the segment, would vary in response to traffic conditions on each ML segment. Strategy 8 is a segmented version of Strategy 2 designed to overcome the problems resulting from differing levels of congestion along the corridor. Strategy 9 is simply a segmented version of Strategy 4. “Management by segment" in Strategy 10 is an approach that appears most appropriate for I-5 because it

allows for the greatest latitude in managing the roadway based on differing traffic conditions. Explaining this tolling scenario would be difficult unless the tolling value is assessed on a "per mile" basis and known at the point of entry. This strategy was also adopted for the I-15 corridor, meaning that its adoption on I-5 would represent regional consistency in how toll rates are applied and understood by the public. The only difference on I-5 is that over time, tolling may eventually have to include pricing the HOV-2 occupant users when they overwhelm the ML capacity. This approach to pricing would also be appropriate for staging the project, where toll rates per mile might start quite low and grow over time.

Minimum and Maximum Tolls

Previous analysis on I-15 raised concerns over the need to apply minimum and maximum tolls to better regulate trip desires and avoid overloading the ML at specific bottlenecks. The parallel analyses conducted on I-5 indicate that recurring ML bottlenecks, focused on the south end of the corridor, will be more likely than randomly occurring along the corridor. Further, the likelihood of weaving in and out of the ML is only related to slip ramp locations with the main lanes, since electing to use a DAR will impose a much greater time penalty of users and eliminate them from being able to quickly traverse the corridor. The spacing of slip ramps is recommended to be quite limited, with up to six intermediate slip ramp sites over the 26-mile project length. Spacing of these access openings will range from under three miles to five miles. Accordingly, the ability for tolled traffic to weave into and out of the ML is very limited. The I-15 toll feasibility recommendations suggested a five-mile minimum trip, and this minimum distance threshold is within the range that would otherwise occur between some successive at-grade slip ramps based on the current I-5 design.

These design characteristics for the I-5 ML suggest that setting a minimum toll may not be required. A minimum toll during rush hours, based on current modeling results using $0.26/mile from I-15 averages, will be above $0.75 per trip and more likely close to $2.00 per trip in the most heavily used sections to the south were costs per mile may be increased to manage demand. Setting a minimum toll would not appear to improve traffic management capability, but may have advantages related to corridor equity when compared to I-15. The complexities of establishing a minimum toll do not appear to merit separate signing and motorist communication.

Setting a maximum toll may be desirable for a variety of reasons. To effectively manage demand during certain hours, tolls will need to be raised to a very high level, based on I-15 and SR 91 experiences. If the same level of per-mile toll applied to I-15 at the current $4.00 for eight miles were needed to manage demand on I-5, at least on the southern sections of the project, this would result in an equivalent through trip toll of at least $12.00. Pricing and behavioral instability could result without the application of some form of maximum toll, since the per mile rates which might be needed to manage demand on certain sections of the project could result in high through trip tolls which are so high as to discourage them. Demand forecasts for I-5 suggest that few users will be through trips for the entire 26 miles. Most enter and exit at various access locations and traverse a portion of the corridor, with a higher demand concentrated in the southern seven miles of the project. Based on this demand profile, there are several rationales that might be applied to establish a policy for a maximum toll. Social equity suggests that the maximum toll be kept rather low, but not so low as to prevent effective lane management. A maximum toll might need to be up to $1.00 per mile based on current

experience. If so, then the maximum toll applied to the section from Manchester south could incur the same value as traveling the entire 26-mile corridor, or a value of about $7.00. Setting a maximum value in this fashion would provide more financial equity to both long and short distance trips and not penalize users who enter at the north and travel through to the south. Typical per mile rates applying a maximum toll are shown in this example in Table 3-3.

TABLE 3-3: TYPICAL PER MILE RATES WITH MAXIMUM TOLLS

Per Mile Rate	Typical Maximum Toll (1)	Through Trip Toll without Maximum (2)
$ 0.20	$ 1.40	$ 5.00
0.40	2.80	10.00
0.60	4.20	15.00
0.80	5.60	20.00
1.00	7.00	25.00

(1) Maximum is based on a 7-mile trip.
(2) Through trip is 26 miles.

3.3 COMPARATIVE ATTRIBUTES

This section provides a comparison among the different scenarios and their effects on system application. Both toll rates and comparative attributes are discussed.

3.3.1. Toll Rates

Different types of trips, which would result from the various pricing options, may result in different toll rates. This section provides a cursory comparison for possible toll rates for sample trips using the different toll scenarios.

TABLE 3-4: COMPARISION OF TOLL RATES FOR VARIOUS TRIP TYPES

(Based on $0.30 per mile equivalents)

Toll Concept	7-Mile Trip South End	5-Mile Trip North End	12-Mile Trip	Through Trip (26 Miles)
Flat Toll –Standard	$ 4.50	$4.50	$4.50	$4.50
Flat Toll –Max. Trip	2.10	1.50	2.10	2.10
Per Mile w/ Maximum	2.10	1.50	2.10	2.10
Per Mile no Maximum	2.10	1.50	3.60	7.50
Per Mile-Skewed w Maximum	4.20	1.50	4.20	4.20
Per Mile-Skewed no Maximum	4.20	1.50	4.20-5.70	9.60
Segment Toll-Standard	2.16	2.16	4.32	7.56
Segment Toll-Skewed	4.32	2.16	4.32-6.48	9.72

- Maximum toll is based on 7-mile trip.
- Standard flat rate is based on a nominal 15-mile trip.
- Average segment length is 3.6 miles.
- For this example, the south two segments are assumed to be more congested than the north segments and assumed for skewed tolling.
- Skewed toll rate multiplier is 2 times the standard toll rate per mile.

3.3.2. Comparative Attributes

This section compares the pricing strategies in regards to the various attributes and evaluation criteria which both reflect the feasibility and on differentiators that help influence selection. Table 3-5 presents a useful comparison for each of the major pricing strategies with respect to a number of attributes and criteria. In each case, the strategy is generally rated for preset versus dynamic pricing. The table suggests that as real-time demand management characteristics are improved, the level of complexity can grow and potentially adversely affect its implementation and acceptability. This level of complexity needs to be weighed against public perceptions of how understandable the tolling strategy is to the end user. Trade-offs are involved in recommending the most appropriate tolling strategy and its acceptance by corridor users and stakeholders.

TABLE 3-5: COMPARATIVE ATTRIBUTE MATRIX – ALTERNATIVE PRICING STRATEGIES

			Demand Management Attributes			Public Acceptance		
Toll Strategy	**Toll Variation**	**Trips Favored**	**Overall Effectiveness**	**Impacts on General Traffic**	**Revenue Generation**	**Public Perceptions**	**Equity**	**Signing/ Communication**
Flat Toll – Standard	Pre-set Dynamic	Long	Low-Medium Medium-High	High High	Medium Medium	High High	Low Low	Simple Medium
Flat Toll –Max. Trip	Pre-set Dynamic	Long	Low Medium	Medium Medium	Low Low	High High	Medium Medium	Simple Medium
Per Mile w/ Maximum	Pre-set Dynamic	Medium	Medium	Low Low	Low Low	Moderate Moderate	High High	Medium Complex
Per Mile no Maximum	Pre-set Dynamic	Medium	Medium High	Medium Medium	Medium Medium	Moderate Low	Medium Medium	Medium Complex
Per Mile-Skewed w Maximum	Pre-set Dynamic	Long	Medium High	Low Low	Medium Medium	Moderate Low	Medium Medium	Medium Complex
Per Mile-Skewed no Maximum	Pre-set Dynamic	Short	High High	Low Low	High High	Low Low	High High	Medium Medium
Segment Toll-Standard	Pre-set Dynamic	Short	Low Medium	Low Low	Medium Medium	Moderate	Medium Medium	Medium Complex
Segment Toll-Skewed	Pre-set Dynamic	Medium	Medium High	Medium Medium	High High	Low	Medium Medium	Medium Complex

Toll equity is best achieved for per mile rates, while flat tolls would have the lowest equity. But flat tolls will encourage longer trips, as would tolls that have maximum caps. The introduction of maximum tolls would moderate some of the potential weaving and discretionary travel that would be less than trip desires require.

As noted in the goals and objectives discussion, managing demand in the ML facility is key to maintaining mobility and acceptable level of service. Table 3-5 provides a ranking for overall effectiveness of each toll strategy, impacts on general traffic (based on the level of weaving likely to occur at specific ingress/egress locations.

3.4 RECOMMENDATION

Based on the high level of forecast demand for I-5, likelihood that congestion will exist and grow in both direction and directionality, and similarity these attributes have to analyses conducted on the I-15 corridor, a dynamic, skewed pricing strategy is recommended for adoption on the I-5 North Coast managed lanes. Additional tolling scenarios such as flat, segment, and per-mile tolls are considered in revenue analysis (Chapter 6). Additional analysis on the toll structure and algorithm will be needed as the project moves into the design phase.

CHAPTER 4

TRAFFIC FORECASTS

4.1 METHODOLOGY

An enhanced version of the SANDAG regional travel model was used to develop traffic estimates and forecasts for the I-5 North Coast corridor. The enhancements involved extending the ability of the model set to appropriately analyze high occupancy (HOV) and high occupancy toll (HOT) demand in the San Diego region. Specifically, the mode choice model has been enhanced to account for the attributes which affect HOV and HOT demand in a more state-of-the-practice manner. The mode choice model enhancements were calibrated to the extent possible against observed data. Existing traffic data is separately presented in Chapter 2.

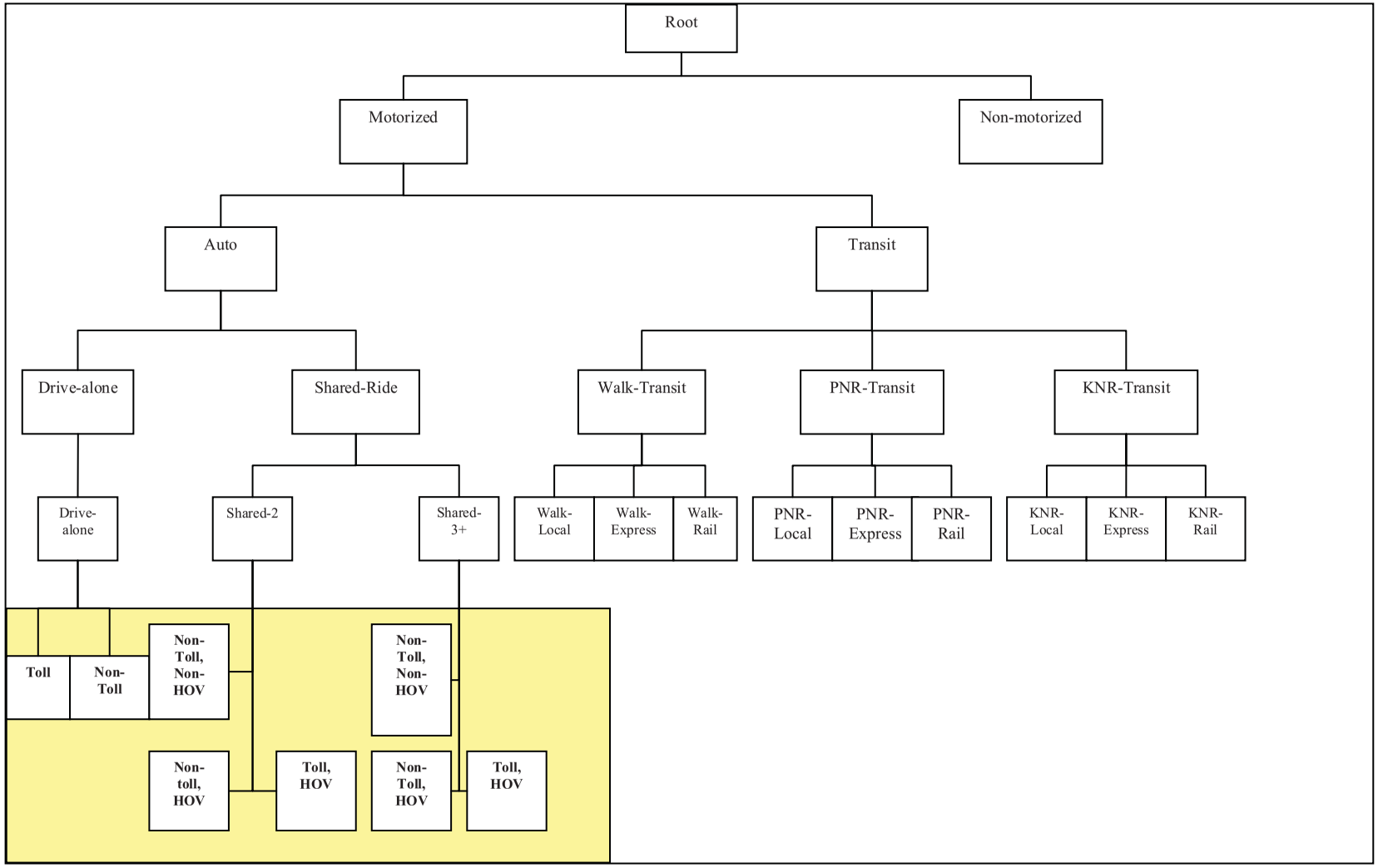
4.1.1. SANDAG Model Enhancement

The SANDAG regional travel demand model was enhanced to allow explicit representation of HOV and toll trips. This enhancement was performed by extending the SANDAG logit mode choice model to consider toll and HOV highway travel separately from general purpose lane highway travel. This is similar to the model's method for differentiating between local, express, and premium transit modes. Figure 4-1 shows the revised model nesting structure. The new modal alternatives for the model, in bold, are nested under the drive-alone, shared-ride (two occupants) and shared-ride (three or more occupant [3+]) auto alternatives. The new modal alternatives for the model are:

- Drive Alone Non-Toll
- Drive Alone Toll
- Shared Ride 2, Non-Toll, Non-HOV
- Shared Ride 2, Non-Toll, HOV
- Shared Ride 2, Toll
- Shared Ride 3+, Non-Toll, Non-HOV
- Shared Ride 3+, Non-Toll, HOV
- Shared Ride 3+, Toll

This structure allows the mode choice model to explicitly trade-off the time and costs associated with each of the highway paths. The model is segmented by household income; thus, low-income travelers are more sensitive to cost, while high-income travelers are less sensitive to cost and therefore more willing to pay to use toll facilities. The model predicts the number of trips that can use each mode. Each mode's trips are then assigned to the highway network, with the appropriate highway links available (for example, drive-alone non-toll trips are prohibited from using toll lanes).

FIGURE 4-1: REVISED SANDAG MODE CHOICE MODEL STRUCTURE



The implementation of this enhancement involved a number of changes to the SANDAG model system:

1) Highway networks applied a specific code identifying whether the link is general purpose or managed lane. The codes are stored in LINK GROUP 3 and have the following values:

LINK GROUP CODE	DESCRIPTION
1	General Purpose Lane
2	HOV-2+ (no toll)
3	HOV-3+ (no toll)
4	General Toll (all occupancies)
5	HOT-1 (DA Pay. HOV-2, 3+ Free)
6	HOT-2 (DA, HOV-2 Pay. HOV-3+ FREE)

2) A set of TRANPLAN procedures were written to build level of service (LOS) matrices (termed "skims") for all highway modes. Each highway mode skim includes time and distance. In addition, HOV and toll lane skims include the time and distance traveled on the managed lane only.

The following table indicates what links are available to each mode for building LOS matrices and for trip table assignment:

	Facility*	General Purpose	HOV-2+ (no toll)	HOV-3+ (no toll)	Toll (all)	HOT-1 (HOV-2, 3+ Free)	HOT-2 (HOV-3+ Free)
	Link Group 3 Code	**1**	**2**	**3**	**4**	**5**	**6**
Modes	Drive-Alone Non-Toll	X					
	Drive-Alone Toll	X			X	X	X
	Shared-Ride 2, Non-Toll, Non-HOV	X					
	Shared-Ride 2, Non-Toll, HOV	X	X			X	
	Shared-Ride 2, Toll (w or wo HOV)	X	X		X	X	X
	Shared-Ride 3+, Non-Toll, Non-HOV	X					
	Shared-Ride 3+, Non-Toll, HOV	X	X	X		X	X
	Shared-Ride 3+, Toll (w or wo HOV)	X	X	X	X	X	X

* X Indicates Availability to Mode

3) The FORTRAN program used to combine AM peak period and PM peak period LOS matrices into peak period level of service matrices for mode choice was revised to process the new highway matrices.

4) The FORTRAN mode choice application program was revised to implement the new nesting structure, as well as restructuring to allow income-specific cost coefficients and peak and off-peak alternative-specific constants by mode. The program was also

modified to produce trip tables in origin-destination format for all of the new highway modes. A number of other changes were implemented as part of this process.

5) A set of TRANPLAN procedures was developed to assign the new trip tables to the highway network using an equilibrium capacity-restraint multi-class assignment algorithm. This functionality is only available in the PC version of TRANPLAN. Therefore, part of the model application process involves porting Unix-based trip tables and highway networks to the PC computer environment, assigning trip tables manually on the PC, and then uploading results back to Unix. Much of this is automated within batch files developed specifically for this study.

4.1.2. Corridor Calibration

The model enhancements were calibrated to observed data collected from users of the existing HOT lanes in the parallel I-15 corridor in San Diego. This project is two reversible managed lanes that parallel the I-15 general purpose lanes for approximately eight miles between State Routes (SR) 56 to the north and SR 163 and SR 52 to the south. The I-15 managed lanes operate in the inbound direction (south to San Diego) in the AM peak period, and outbound in the PM period. It also operates in the off-peak mid-day period, switching between inbound and outbound between 11:00 a.m. and 1:00 p.m. In 2000, the lane operated between 5:30 a.m. and 7:30 p.m., except for the two hours between 11:00 a.m. and 1:00 p.m. Users of the reversible lanes include solo drivers, who pay a variable toll that is determined by traffic density in the reversible lanes, and carpoolers (two or more occupants) can use the roadway for free.

SANDAG provided a summary of number of vehicles observed using the I-15 managed lanes for 2000, broken out by FasTrak™ toll users (drive-alone toll), and HOV users, in one-half hour increments, along with the average toll paid by the FasTrak users for each increment. This data was averaged across the month of October to develop observed target values of number of HOV and toll vehicles on the lane and average toll paid in the peak period (6:00 to 9:00 a.m. and 3:00 to 6:00 p.m.) and the off-peak period. According to the data, the average toll paid in the peak period was $2.00, and the average toll paid in the off-peak period was $0.75.

In addition data were compiled from the I-15 users panel survey conducted by the University of California at Irvine between Fall 1997 and Fall 1999. The data were summarized to determine the number of FasTrak trips by income group and trip purpose, consistent with those used in the travel demand model. These data were used to compute calibration target values for mode choice alternative-specific constants for each of the modes in the enhanced model. The mode choice models were then calibrated to match these values by purpose, period and income group.

I-15 Corridor Validation Results

Validation of model results in the I-15 Corridor focused on two areas. The first tests involved a comparison of model estimated HOV and HOT (or FasTrak) vehicle demand to observed HOV and FasTrak vehicle demand in the I-15 corridor. Although the I-15 corridor is not the subject of the I-5 managed lane study, the presence of managed lanes in the I-15 corridor provides an opportunity to check model performance against locally observed data. If the model is successful in reasonably matching observed HOV/HOT demand in the I-15 corridor, then forecasts of HOV/HOT demand in the I-5 North Coast corridor can be made with increased confidence. Table 4-1 presents a

comparison of observed and model estimated HOV and FasTrak (HOT) demand in the I-15 corridor.

TABLE 4-1: I-15 OBSERVED AND ESTIMATED 2000 HOV AND FASTRAK DEMAND

TIME PERIOD	DIRECTION		HOV	FASTRAK	TOTAL
AM Peak	Inbound	*Observed*	4,094	1,846	5,940
		Model Estimated	2,992	1,799	4,791
PM Peak	Outbound	*Observed*	5,123	1,618	6,741
		Model Estimated	3,960	1,306	5,266
Off Peak	Inbound	*Observed*	1,154	364	1,518
		Model Estimated	2,032	442	2,474
	Outbound	*Observed*	2,623	604	3,226
		Model Estimated	2,046	434	2,480

Source: PB – 10/2004

In addition to a comparison of HOV/HOT modal volumes in the corridor, the model's ability to reasonably replicate observed traffic volumes for all modes is an important aspect of the model validation. Table 4-2 contains a comparison of counted and model assigned volumes at three different locations in the I-15 corridor.

TABLE 4-2 COMPARISON OF 2000 VOLUMES* I-15 MAIN LANES

Count Location	Time Period			
	AM Peak	Off-Peak	PM Peak	Daily
Station 935 - Lake Hodges				
Count	42,505	125,981	48,040	216,526
Assigned	52,507	141,298	62,483	256,288
% difference	24%	12%	30%	18%
Station 980 - Carmel Mountain Road				
Count	47,054	135,064	47,879	229,997
Assigned	44,078	112,805	49,366	206,249
% difference	-6%	-16%	3%	-10%
Station 999 - Carroll Canyon Road				
Count	61,956	168,190	64,383	294,529
Assigned	47,510	137,017	58,001	242,528
% difference	-23%	-19%	-10%	-18%

* unadjusted volumes
Source: PB – October 2004

For all observed count locations and for all times of day, the level of agreement between the counted and assigned traffic volume is within generally accepted error tolerances, particularly those for the time of day periods. The level of agreement in observed and model assigned traffic volumes on a daily basis is, however, at the outer edge of acceptable level of error.

I-5 North Coast Corridor

In addition to validating model performance in the region's existing managed lane corridor, it is important to evaluate model performance in the corridor that is the subject of the managed lane study. Occupancy characteristics of drivers in the I-5 North Coast corridor are a critical element to the level of demand for a managed lane facility in the corridor. Therefore, an appropriate measure of model performance in the I-5 North Coast corridor is a comparison of the model's estimate of trips by occupancy against observed occupancy levels. Table 4-3 contains a comparison of observed and model-estimated traffic volumes by occupancy level at a specific representative location in the I-5 North Coast corridor.

TABLE 4-3 2000 SOUTHBOUND AM PEAK PERIOD OBSERVED VS. MODEL ESTIMATED OCCUPANCY

I-5 @ Via Del Valle				
Mode	Observed Volume	Share	Model-Estimated Volume	Share
Drive-Alone	14,049	87.7%	18,777	88.0%
2-person	1,690	10.5%	1,957	9.2%
3-person	284	1.8%	609	2.8%

Source: PB – October 2004

The model estimated occupancy data compares very favorably with data collected in the I-5 North Coast corridor. Based on this comparison, the model should be expected to reasonably estimate corridor occupancy characteristics and responses by those using the corridor to changes in LOS for the different occupancy modes.

A comparison of total assigned traffic on I-5 to observed traffic counts also provides a means to determine the adequacy of the model's performance in the corridor. Using traffic counts from 2001 through 2003, estimated 2000 traffic counts were developed. These estimated counts are presented in Table 4-4 along with the model assigned daily traffic volumes at five locations in the I-5 North Coast.

The data in Table 4-4 indicates that the model appears to be under-estimating traffic in the corridor other than in the far northern end of the corridor near Camp Pendleton. The traffic assignment results are within generally accepted error margins in the southern and northern ends of the I-5 North Coast corridor. Assignment results appear a bit low in the central portion of the corridor. Further analysis involving screenlines would be necessary to determine whether this is a trip distribution problem or one related to highway assignment.

TABLE 4-4: 2000 MODEL ASSIGNED AND COUNTED VOLUMES COMPARISON ON I-5

	2000						
	Estimate of Counted Weekday Volume			Model Assigned Weekday Volume			% Difference - Assigned vs. Counted
Count Location	NB	SB	TOTAL	NB	SB	TOTAL	TOTAL
I-5 s/o Lomas Santa Fe	109,871	110,499	220,369	96,426	93,708	190,134	-13.7%
I-5 s/o Encinitas Boulevard	104,881	111,806	216,687	79,955	77,115	157,070	-27.5%
I-5 s/o Leucadia Boulevard	104,473	101,903	206,376	81,878	76,276	158,154	-23.4%
I-5 s/o Tamarack Avenue	99,604	100,814	200,418	78,638	79,373	158,011	-21.2%
I-5 n/o Camp Pendleton	64,234	65,046	129,280	78,893	79,593	158,486	22.6%

Source: PB – October 2004

4.2 ANALYSIS YEARS

To evaluate the long term impact of a managed lane facility on the I-5 North Coast corridor as well as the potential near term demand for a managed facility, travel forecasts were developed for a horizon year as well as an intermediate year. The years chosen as the horizon and design year were those for which provided appropriate time frames to evaluate the effect of a managed lane on travel in the I-5 North Coast corridor as well as those for which travel model inputs were readily available. The long term evaluation of the various alternatives was done for the same year as of horizon year for SANDAG's Regional Transportation Plan (RTP) which is currently 2030. The year chosen for intermediate year analysis was 2015 because the current I-5 North Coast project anticipates that most if not all of the project along this corridor will be operational by then.

For both analysis years, data developed and analyzed included daily and peak hour traffic volumes on the managed facility as well as the general purpose lanes. Additionally, peak hour managed lane demand by vehicle occupancy level was developed and reviewed along with level of that demand relative to the assumed LOS policies of the managed lane. An evaluation of the share of I-5 North Coast corridor traffic demand accommodated in the managed lanes both on a daily and peak hour basis was also performed.

4.2.1. Intermediate Year Analysis (2015)

In order to evaluate the performance of the Build alternatives in a near term year prior to the design year, analysis was performed for 2015. This analysis was done to develop data that would provide the opportunity to evaluate phased implementation of the Build alternatives in the context of expected 2015 travel demand and the expected 2015 regional transportation system. Demographic and network assumptions used in this analysis were consistent with SANDAG's RTP phasing. Additional detail regarding demographic and network assumptions are provided in Chapter 5 of this report.

4.2.2. Design Year Analysis (2030)

Analysis of the No Build and Build alternatives was performed for the horizon year of SANDAG's RTP. Analysis of the alternatives in 2030 allowed for evaluation with respect to the expected growth in the region and development of the transportation system over the course of the MTP time frame. The 2030 analysis also was used a mechanism to evaluate an issue related to the configuration of a potential managed facility in the I-5 North Coast corridor. Specifically, 2030 analysis was used to evaluate intermediate access options of the managed facility along the corridor.

4.3 ALTERNATIVES

Along with a No Build alternative, two different Build alternatives were evaluated. The only variation among the two Build alternatives was in the assumed number of general purpose lanes on I-5. Although the operational details of the Build alternatives included options for buffer and barrier-separated managed lanes, the nature of the separation between I-5 general purpose lanes and I-5 managed lanes is such that there would be no difference in the context of regional travel demand analysis. The No Build alternative was analyzed only for 2030 for comparison purposes in the analysis.

The transportation networks used to represent the Build alternatives were based on networks developed by SANDAG and/or Caltrans as a starting point. The proposed I-5 Build alternatives were then added to these networks.

4.3.1. No Build Alternative

The No Build alternative makes use of the same network that was developed by Caltrans for a prior I-5 North Coast corridor modeling effort but with the added feature of braided local general purpose access ramps at Genesee. The No Build network includes an HOV lane in the I-5 North Coast corridor from the I-5/I-805 interchange to Manchester at the northern terminus. The No Build alternative also includes the I-5/SR 78 and I-5/SR 56 freeway-to-freeway connectors.

4.3.2. Build Alternatives

”8+4” Alternative

This includes four managed lanes and eight general purpose lanes (a total of six in each direction) in the I-5 North Coast corridor. For purposes of lane balancing at particular interchanges, short sections include ten general purpose lanes (counting auxiliary lanes). Also included are the I-5/SR 78 and I-5/SR 56 freeway-to-freeway connectors Full direct access (i.e., all movements) to the I-5 managed lanes is assumed via Direct Access Ramps (DARs) at Oceanside, SR 78 HOV, Cannon, Manchester, Voigt and at Lusk on I-805 south of the I-5/I-805 split. This alternative also assumes that ramps to the general purpose lanes at California Street, Cassidy Street, and Las Flores Drive remain open.

For the intermediate year analysis, the DARs were modified, with one exception, to be half-DARs under the logic that demand would such that full-DARs would not be needed in the year 2015. The DARs at Oceanside, Cannon, Manchester are south-facing DARs and provided access for movements to and from I-5 to the south. The DARs at Voigt and Lusk are north-facing and provide access for movements to and from I-5 AND I-805 (in the case of Lusk). The I-5/SR 78 DAR is assumed to all full access DAR

“10+4” Alternative

This alternative is identical to the 8+4 alternative except for the configuration of the general purpose lanes which expands from eight lanes to ten lanes, from the I-5/I-805 split to SR 78 (a total of seven lanes in each direction). Access to and from the managed lanes are identical to those of the 8+4 alternative. This alternative was also used to evaluate intermediate managed lane access through the analysis of an unlimited access scenario as described in Section 4.4 below.

For the intermediate year analysis, the DARs were modified, with one exception, to be half-DARs under the logic that demand would such that full-DARs would not be needed in the year 2015. The DARs at Oceanside, Cannon, Manchester are south-facing DARs and provided access for movements to and from I-5 to the south. The DARs at Voigt and Lusk are north-facing and provide access for movements to and from I-5 AND I-805 (in the case of Lusk). The I-5/SR 78 DAR is assumed to all full access DAR.

4.3.3. Scenario for Increasing HOVs to 3+

At the outset of the modeling effort, it was initially assumed that the pricing policy under which the managed lanes would be operated would charge only drive-alone vehicles

(SOVs). Upon completion of some initial analysis of the Build alternatives for 2030, a desire to understand the impact of a HOV-2+ pricing strategy on managed lane demand came about because this demand was so large in 2030 that it overwhelmed four managed lanes, and in effect, indicated that the lanes could not be effectively managed without raising the occupancy requirements during the peak hours.

For this reason, two tolling scenarios were evaluated for the Build alternatives in the horizon year of 2030. The first scenario involved pricing of SOV vehicles only and no pricing of shared ride vehicles. Under this scenario SOV vehicles were priced on a per mile basis in an amount equivalent to that currently experienced on the I-15 managed lanes – an amount of $0.26 per mile in the peak period and $0.10 per mile in the off-peak period. The second tolling scenario assumed that HOV vehicles with 2 persons would be tolled at half of the rate of SOV vehicles and that 3+ person HOV vehicles would be free.

The purpose for this additional testing was to analyze the level of demand in the managed lane in association of different tolling policies that may be necessitated by excessive HOV demand. The determination of the most appropriate tolling policy given the goals of implementation of the managed lanes is not addressed in this report, but is addressed in the overall study recommendations. Further evaluation of revenue impacts of this same set of scenarios also was conducted in conjunction with the Revenue Analysis (Chapter 6) and is discussed in that respective document.

4.3.4. Intermediate Access Scenarios

Restricting access can both help manage lane demand and also provide for means of collecting and distributing demand at locations where it can best be accommodated with the adjacent mainlanes and local street network through DARs. The Build alternatives include DARs at five selected cross streets along the corridor. Access points along the I-5 North Coast corridor with the adjacent main lanes, referred to in this analysis as intermediate access locations, were the subject of study and evaluation through selected traffic simulations created for the two Build alternatives from forecast demand.

Modeling of both the 8+4 and 10+4 alternatives for 2030 was conducted for a scenario which provided virtually unlimited access between the general purpose lanes and the managed lanes. The unlimited intermediate access scenario was not considered a realistic scenario, but rather was used as a benchmark to evaluate locations where intermediate access might or might not be viable from a demand perspective.

Intermediate HOV/ML access points and the constrained and restricted fatal flaw analyses were developed by Caltrans staff. Decision-making on the final intermediate access points that were carried into modeling for the limited intermediate access scenarios also was driven by operational, environmental, and physical limitations (those areas with “fatal flaws”), as identified in Caltrans separate analysis activities as part of the project’s parallel environmental process.

Unlimited Intermediate Access Scenario

Unlimited intermediate access points, virtually unlimited access between the general purpose lanes and the managed lanes, were tested for Build alternative model runs with DAR locations to determine appropriate access points between the managed lanes and the general purpose lanes. This effort was to assist in decision-making for intermediate access locations, as it was anticipated to determine the sensitivity of demand for managed lanes. The result, further discussed in the Section 6 below, identified no effect

on managed lane volume. For this reason, the decisions on limiting intermediate access locations could be done in accordance with other issues associated with limiting the number of toll zones, minimizing operational conflicts with right-side access locations and environmental constraints.

Limited Intermediate Access Scenario

Based upon the knowledge that travel demand was not influenced in a substantial way by the location of intermediate access locations, the locations were deemed feasible and located based upon other controlling criteria and provided to Caltrans for evaluation in their environmental work. The intermediate access locations are defined in Tables 4-5 and 4-6. The traffic volumes generated from these model runs served as the basis for the analysis and evaluation as presented in the results section.

TABLE 4-5: SOUTHBOUND INTERMEDIATE ACCESS LOCATIONS

Southbound Access Point		
Name	**Entrance from**	**Exit to**
Pendleton	I-5 South	Harbor/Vandegrift, SR 76, Mission
Oceanside	Harbor/Vandegrift, SR 76	Cassidy, Las Flores, Carlsbad Village, Tamarack
Carlsbad	Cassidy, Las Flores, Carlsbad Village, Tamarack	Cannon, Palomar Airport, Poinsettia
Batiquitos	Tamarack, Cannon, Palomar Airport	La Costa, Leucadia, Encinitas
Encinitas	Palomar Airport, Poinsettia, La Costa, Leucadia	Santa Fe, Birmingham, Viewpoint, Manchester, Lomas Santa Fe
Solana Beach	Encinitas, Santa Fe, Birmingham, Manchester	Via de la Valle, Del Mar Heights, SR 56 East, Carmel Mountain, Carmel Valley
Carmel Valley	Lomas Santa Fe, Via de la Valle	I-805 South, I-805/Mira Mesa, Genesee
After the split, along I-805		
Sorrento	Del Mar Heights, Carmel Valley, SR 56 West, Carmel Mountain	I-805 South
After the split, along I-5		
University	Carmel Valley, SR 56 West, Carmel Mountain, Sorrento Valley, Genesee	I-5 South

Source: PB

TABLE 4-6: NORTHBOUND INTERMEDIATE ACCESS LOCATIONS

Northbound Access Point		
Name	**Entrance from**	**Exit to**
Pendleton	California, Oceanside, Mission, SR 76, Harbor/Vandegrift	I-5 North
Oceanside	Cannon, Tamarack, Carlsbad Village, Las Flores, SR 78/Vista, California	Harbor/Vandegrift, SR 76
Carlsbad	La Costa, Poinsettia	Tamarack, Carlsbad Village, Las Flores, Mission
Batiquitos	Santa Fe, Encinitas, Leucadia	Poinsettia, Palomar Airport, Cannon
Encinitas	Santa Fe, Birmingham, Viewpoint, Manchester, Lomas Santa Fe	Encinitas, La Costa, Leucadia
Solana Beach	Via de la Valle, Del Mar Heights, SR 56 West, Carmel Mountain, Carmel Valley	Encinitas, Santa Fe, Birmingham, Manchester
Carmel Valley	I-805 North, I-805/Mira Mesa, Genesee	Lomas Santa Fe, Via de la Valle
After the split, along I-805		
Sorrento	I-805 North, Mira/Mesa Sorrento Valley	Del Mar Heights, Carmel Valley, SR 56 East, Carmel Mountain, Via de la Valle
After the split, along I-5		
University	I-5 North	SR 56 East, Carmel Mountain, Del Mar Heights, Sorrento Valley, Genesee

4.4 ASSUMPTIONS

The following sections detail the basic input assumptions that were used and in some cases varied to create different scenarios among the two Build alternatives. All assumptions used are taken directly from the standard SANDAG model assumptions or were developed in consultation with SANDAG and Caltrans staff.

4.4.1. Background Roadway Network

The Design Year network outside the I-5 North Coast corridor represents SANDAG's MOBILITY 2030 RTP "Reasonably Expected" network. This network is based upon the No Build network, which is the same network developed by Caltrans for a prior I-5 North Coast corridor modeling effort. For this study, the No Build network also included the following: the feature of braided local general purpose access ramps at Genesee; an HOV lane in the I-5 North Coast corridor from the I-5/I-805 interchange to Manchester at

the northern terminus; and the I-5/SR 78 and I-5/SR 56 freeway-to-freeway connectors. This background roadway network also includes both priced and HOV lane facilities in other corridors. There are assumed priced managed lanes on I-805 between I-5 and SR 905, I-15 between SR 78 and SR 163 and SR 52 between SR 125 and I-15 in the background roadway network. The background network includes HOV lanes on I-5 between I-805 and SR 905, I-15 between SR 163 and SR 94, SR 125 between I-8 and SR 54, SR 54 between SR 125 and I-5, SR 94 between SR 125 and I-5, I-8, between El Cajon and SR 125, SR 56 between I-15 and I-5, and SR 78 between I-15 and I-5.

The Intermediate Year network outside the I-5 North Coast corridor assumes all regional freeway, arterial, and transit system improvements anticipated by 2015. This network assumed priced facilities on I-15 between SR 78 and SR 163, on I-805 between I-5 and SR 52 and I-805 between SR 94 and SR 905. The background network assumed HOV lanes on SR 56 between I-15 and I-5, SR 125 between SR 94 and SR 54, SR 54 between SR 125 and I-805, and I-5 between downtown and SR 54.

4.4.2. Land Use and Demographics

The land use and demographic assumptions used in both the Design Year and the Intermediate Year analysis represent the SANDAG's adopted and approved forecasts for the year of analysis.

4.4.3. Managed Lane Configurations

All Build alternatives included direct access ramps (DARs) at the following locations: Oceanside, SR 78 HOV, Cannon, Manchester, Lusk, and Voigt. The evaluation of managed lane demand was performed relative to an assumed LOS C capacity of 1,650 per hour per lane. LOS worse than C (i.e., LOS D, E and F) are characterized by traffic flowing at less than free-flow rates and by stop-and-go traffic conditions. Based on discussions with SANDAG staff, it was assumed that the operational policies of the managed lanes would be such that the lanes would be allowed to operate at no worse than LOS C conditions during the peak periods.

Design Year

In the Design Year (2030) the DARs are assumed to be full DARs providing for all movements at each of the DAR locations.

Intermediate Year

In the Intermediate Year (2015) all DARs are assumed to be are "half-DARs" in this study meaning that they only provide for two respective movements oriented in one direction at the access point. The movements for which direct access is provided vary among the locations. The Oceanside, Cannon, Manchester DARs are south-facing half DARs while the Lusk and Voigt half-DARs are north-facing.

In the initial analysis of the 10+4 alternative, access to the managed lane was virtually continuous between the general purpose lanes and the managed lanes. This scenario was tested to initially identify the locations of highest demand for access to/from the managed lanes. This analysis would allow for the identification of those access points which would be carried forward into the limited access analysis where all movements are designated. Chapter 5 discusses ingress/egress volumes, which contains volumes on the unlimited access scenario analysis.

4.4.4. Tolling

Two alternative tolling assumptions were tested for both of the Build alternatives for the travel demand model. The first and most widely tested among the alternatives was a $0.26 per mile peak period SOV toll and a $0.10 per mile off-peak period SOV toll. Under this set of tolling assumptions, vehicles with two or more occupants are allowed to use the managed lane without being charged a toll. These tolling assumptions were used for the travel demand forecast modeling. The two analyses (demand forecast and revenue forecast) came from different control corridors. The tolling assumptions described above were derived from the I-15 average peak toll cost and distance traveled on the existing I-15 facility. Revenue forecasts assumed a toll based on SR 91, which actually hold lower assumed tolls than currently exist on I-15 in the peak period.

CHAPTER 5

FUTURE OPERATING CHARACTERISTICS

5.1 INTRODUCTION

This chapter summarizes forecast demand for various alternatives and future conditions associated with the I-5 managed lanes. These forecasts served as the basis for evaluating various pricing strategies for the managed lanes and for analyzing revenue associated with pricing the managed lanes. A traffic forecast analysis was performed based on the alternative pricing strategies. This analysis estimated traffic by time period and direction to determine expected use of the I-5 managed lanes. Forecasts were developed for single occupancy vehicles (SOV) use on managed lanes (ML), high occupancy vehicles (HOV), and general purpose traffic demand on I-5. This report also presents an overview of the methodology used in developing these forecasts. Traffic forecasts are included for each alternative for different horizon years.

The traffic volumes developed for this study are for the purposes of evaluating the viability of the HOV/ML as a concept toll facility for the I-5 corridor. Traffic volumes for design, operation analysis, and related environmental studies for the Project Report and Environmental Documentation are still being developed as part of the project development process.

5.2 METHODOLOGY

The enhanced SANDAG model, as described in Chapter 4, was used to develop forecasts for a No Build alternative and two Build alternatives: eight general purpose lanes plus four managed lanes (8+4) and 10 general purpose lanes and four managed lanes (10+4). Among the Build alternatives, two different pricing scenarios were tested using the enhanced SANDAG model. Although many other pricing scenarios are possible and could have been tested, it was felt that modeling of two scenarios offered sufficient information to determine feasibility – which was the primary goal of the study. The model was created by Caltrans staff using networks already developed by Caltrans and modified to be consistent with managed lane configurations and access locations collectively chosen by the project team.

The enhanced model was applied to develop peak period traffic forecasts, including separate forecasts for general purpose lanes and managed lanes. The model application also included development of forecasted traffic volume by occupancy level and toll usage.

The forecast was finalized by post-processing the peak period volumes using standard SANDAG procedures to develop peak hour traffic volumes. The peak hour and peak period forecasts were then later used for revenue analysis and traffic simulation along the project corridor, as described in Chapter 6, Revenue Analysis.

5.3 FORECAST RESULTS

The results of traffic forecasting for both the 8+4 and 10+4 alternatives for both analysis years and each of the access and tolling scenarios are presented in the following

sections. SANDAG's modeling procedures typically include the post-assignment adjustment of volumes to account for variations between model-predicted volumes and traffic counts in the Base Year as well as to account for the effects of future travel demand management programs on peak travel. These adjustments when applied to the forecasted managed lane traffic volumes predicted directly by the models, resulted in illogical relationships among peak hour, peak period and daily traffic forecasts. For this reason, traffic forecasts for the managed lanes were developed both with and without the post-assignment adjustments. The managed lane traffic forecasts used in revenue analysis were not taken through this adjustment process and are presented as "unadjusted" traffic volumes.

So as to adhere to local practice of presenting model forecasted volumes that have been adjusted through the post-assignment process, the mainlane volumes and managed lane share data presented below represent volumes that have been adjusted to account for variations between model-predicted volumes and traffic counts in the Base Year as well as to account for the effects of future travel demand management programs on peak travel. They are, therefore, presented as "adjusted" traffic volumes.

5.3.1. Mainline Volumes

Table 5-1 presents daily traffic volumes at seven different locations along the corridor for the No Build and Build alternatives for 2030. For the Build alternatives, forecasted mainlane volumes are presented for both managed lane pricing scenarios. As would be expected, the 8+4 alternative is forecasted to have lower main lane volumes that the 10+4 alternative. The HOV-2/SOV toll scenarios have higher main lane volumes that the SOV toll scenarios. This is due to the HOT lane being less attractive to HOV vehicles as a result of the tolling of HOV-2, albeit at a lower rate than SOV vehicles. The No Build scenario is forecasted to have higher main lane volumes that the 8+4 scenario under the SOV toll scenario throughout the entire corridor. This result is due to the No Build alternative containing the same number of general purpose lanes as the 8+4 alternative, but a managed facility that allows only HOV-2+ vehicles. Under the No Build alternative, SOV vehicles must use the general purpose lanes of the freeway.

TABLE 5-1: 2030 DAILY MAINLANE VOLUMES

LOCATION	No Build	10+4		8+4	
		SOV Toll	HOV-2 & SOV Toll	SOV Toll	HOV-2 & SOV Toll
North of SR 76	204,800	196,800	208,600	195,300	207,200
North of Carlsbad Village Dr.	237,000	234,500	242,500	224,000	231,500
South of Palomar Airport	227,000	228,500	236,300	216,000	223,800
North of Encinitas Blvd.	241,500	242,500	250,000	228,500	238,300
South of Manchester	272,500	284,500	294,100	269,500	284,200
South of Via De La Valle	292,000	304,000	312,200	292,500	304,500
North of SR 56	310,000	318,000	329,300	314,000	324,500

*adjusted volumes
Source: PB, November 2005

Table 5-2 presents daily traffic volumes for the Build alternatives for 2015 under the SOV toll scenario. As expected, the 10+4 alternative is forecasted to have more traffic in the general purpose lanes than the 8+4 alternative.

TABLE 5-2: 2015 DAILY MAINLANE VOLUMES*

BUILD ALTERNATIVES – SOV TOLL

LOCATION	10+4	8+4
North of SR 76	172,100	172,200
North of Carlsbad Village Dr.	203,000	194,800
South of Palomar Airport	196,900	187,100
North of Encinitas Blvd.	218,600	207,800
South of Manchester	252,500	242,400
South of Via De La Valle	261,400	256,400
North of SR 56	265,200	263,300

* adjusted volumes
Source: PB, November 2005

AM and PM Hour Traffic

Table 5-3 presents AM and PM peak hour traffic volumes for the I-5 main lanes at various points along the corridor for the No Build and Build alternatives for 2030. Data is presented for both tolling scenarios of the Build alternatives. The relationship of the alternatives among the peak hour data resembles very closely that of the daily traffic data. Generally speaking, the PM peak hour volumes are higher than the AM peak hour volumes.

TABLE 5-3: 2030 AM AND PM PEAK HOUR
GENERAL PURPOSE LANE VOLUMES*

	AM PEAK HOUR					PM PEAK HOUR				
		10+4		8+4			10+4		8+4	
LOCATION	No Build	SOV Toll	SOV/HOV-2 Toll	SOV Toll	SOV/HOV-2 Toll	No Build	SOV Toll	SOV/HOV-2 Toll	SOV Toll	SOV/HOV-2 Toll
North of SR 76	13,800	10,400	10,500	10,200	10,200	17,700	14,100	15,300	13,900	15,100
North of Carlsbad Village Dr.	15,100	14,800	14,300	13,500	12,900	14,700	15,100	15,700	12,800	13,700
South of Palomar Airport	14,000	15,000	13,900	12,200	11,900	14,403	14,700	14,900	12,400	12,900
North of Encinitas Blvd.	14,700	14,800	14,500	12,300	12,700	14,675	15,000	15,200	13,200	13,300
South of Manchester	15,470	18,200	17,300	15,400	15,600	16,260	17,500	18,300	15,700	16,900
South of Via De La Valle	17,041	19,700	18,200	17,600	17,000	18,685	19,600	20,200	18,300	19,100
North of SR 56	20,164	21,000	20,600	20,700	20,300	20,560	22,000	22,500	21,000	21,400

* - adjusted volumes

Source: PB, November 2005

Table 5-4 presents AM and PM peak hour mainlane volumes for the two Build alternatives for 2015. The results are from the SOV toll pricing scenario. As with the 2030 data, the 2015 data shows that PM peak hour volumes are higher than AM peak hour volumes and that the 10+4 alternative has higher general purpose lane volumes than the 8+4 alternative.

TABLE 5-4: 2015 AM AND PM PEAK HOUR GENERAL PURPOSE LANE VOLUMES

LOCATION	AM PEAK HOUR		PM PEAK HOUR	
	10+4	8+4	10+4	8+4
North of SR 76	9,100	9,100	13,800	13,900
North of Carlsbad Village Dr.	12,600	11,800	14,800	13,300
South of Palomar Airport	11,800	10,600	14,000	12,000
North of Encinitas Blvd.	13,300	11,900	15,200	13,200
South of Manchester	15,600	14,300	17,000	15,100
South of Via De La Valle	16,000	15,900	17,800	16,400
North of SR 56	16,900	16,700	18,100	17,500

* adjusted volumes

Source: PB, November 2005

5.3.2. Ingress/Egress Volumes

Figure 5-1 and 5-2 present managed lane ingress and egress Design Year AM and PM peak period volumes along the corridor for the 10+4 unlimited access scenario. Based on an analysis of these volumes, candidate intermediate access points between the managed lanes and adjacent general purpose lanes (i.e. non-DAR) were identified corresponding to the highest ingress and egress demand locations. These candidate locations were subsequently reviewed by Caltrans design staff to determine the suitability for intermediate ingress and egress at these locations based on potential design limitations such as limited right-of-way availability, proximity to adjacent interchange locations and sight distance limitations. A refined set of nine intermediate access points were identified and recommended for further evaluation. Figure 5-3 and 5-4 present AM and PM peak period volumes for the 10+4 scenario limited access alternative for the Design Year.

Based on the analysis of the two access scenarios, it was decided that analysis of the two Build alternatives should include only the limited access locations for both the Intermediate and Design Year. All analysis results presented in this document deal with the limited access scenario.

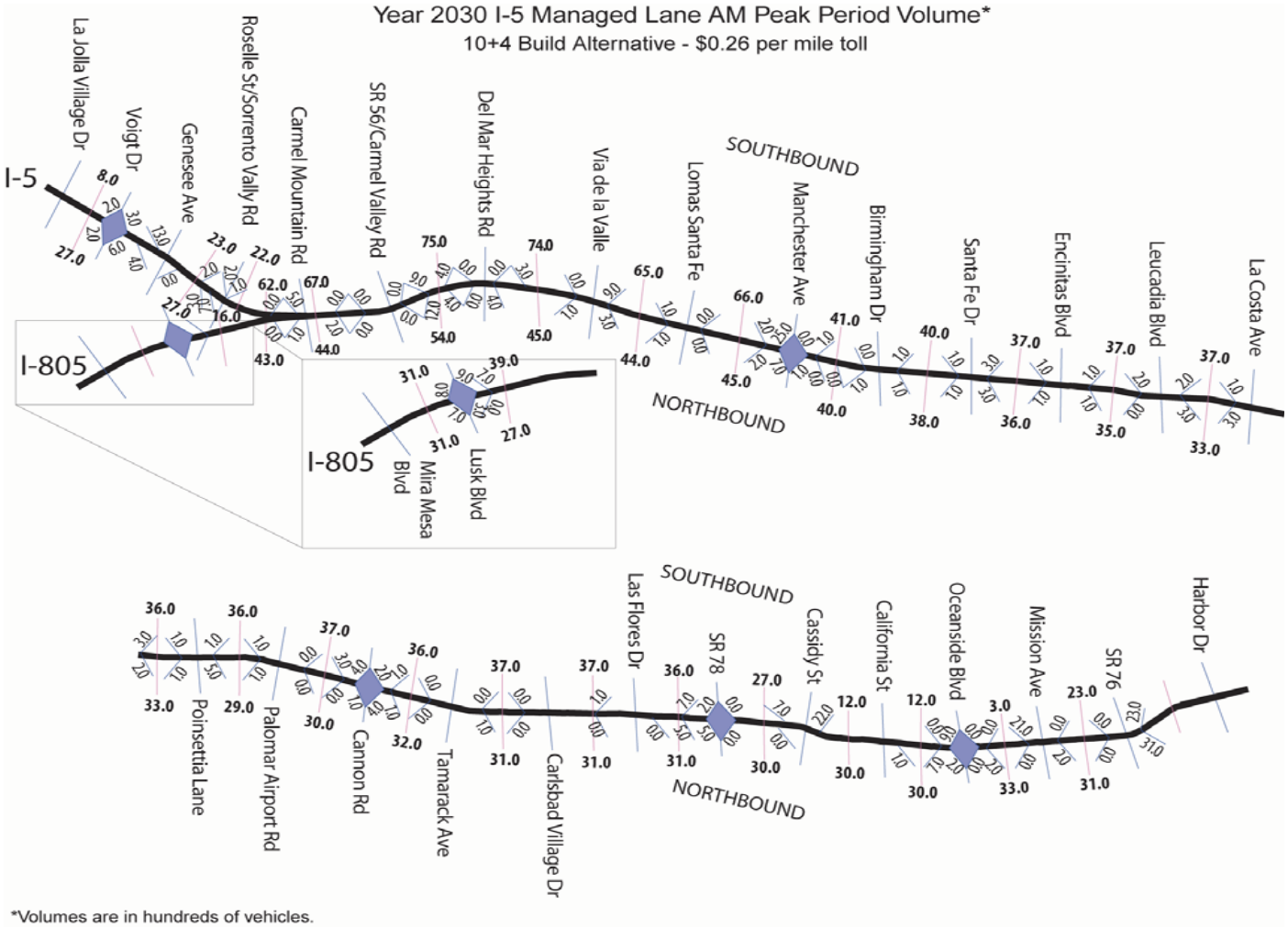
5.3.3. Managed Lane Volumes

Tables 5-5 and 5-6 present 2030 AM and PM peak hour and daily traffic volume summaries for four locations along the I-5 North Coast Managed Lanes under the SOV toll scenario of the two Build alternatives. Table 5-5 presents traffic volume data by occupancy level, total volume and proportion of that peak volume to the peak capacity. Table 5-6 presents similar data for the 8+4 alternative. As would be expected, managed lane traffic volumes increase from north to south and the level of use relative to capacity of the managed lane increases from north to south. These data show that in the southern section of the corridor, the managed lane is operating near or at LOS C in the PM peak hour in the 8+4 alternative and somewhat near capacity in the 10+4 alternative. This level of use was in part the reason behind the decision to test a second tolling scenario among the two Build alternatives for 2030.

The managed lane volume results for the AM and PM peak hours as well as daily traffic volumes for the second tolling scenario are presented in Tables 5-7 and 5-8. The 2030 data for the 10+4 and 8+4 alternatives, respectively for the tolling scenario under which HOV-2 vehicles were tolled at one-half the rate of SOV vehicles. As would be expected, the effect of this tolling policy was the substantial decrease in the amount of HOV-2 vehicles in the managed lane. The results indicated that the amount of SOV and HOV-3+ vehicles increased somewhat, but not substantially enough to offset the decrease in HOV-2 vehicles. The net result is that the managed lanes were forecasted to have much lower volumes of peak hour and daily traffic, which was, in part, the desired effect. A comparison of the proportion of volume to the LOS C capacity reveals that the managed lanes are operating at levels no higher than 45 percent of capacity in 2030 under this tolling scenario.

Tables 5-9 and 5-10 present 2015 AM and PM peak hour and daily managed lane traffic volumes for the two Build alternatives. Both sets of data are for the SOV toll scenario. Although the levels of managed lane demand are lower than in 2030, as would be expected, it is noteworthy that the managed lane volumes approach 75 percent of LOS C capacity in the southern part of the corridor in the PM peak hour.

FIGURE 5-1: 2030 AM PEAK PERIOD VOLUMES FOR 10+4 ALTERNATIVE, UNLIMITED ACCESS



*Volumes are in hundreds of vehicles.

FIGURE 5-2: 2030 PM PEAK PERIOD VOLUMES FOR 10+4 ALTERNATIVE, UNLIMITED ACCESS

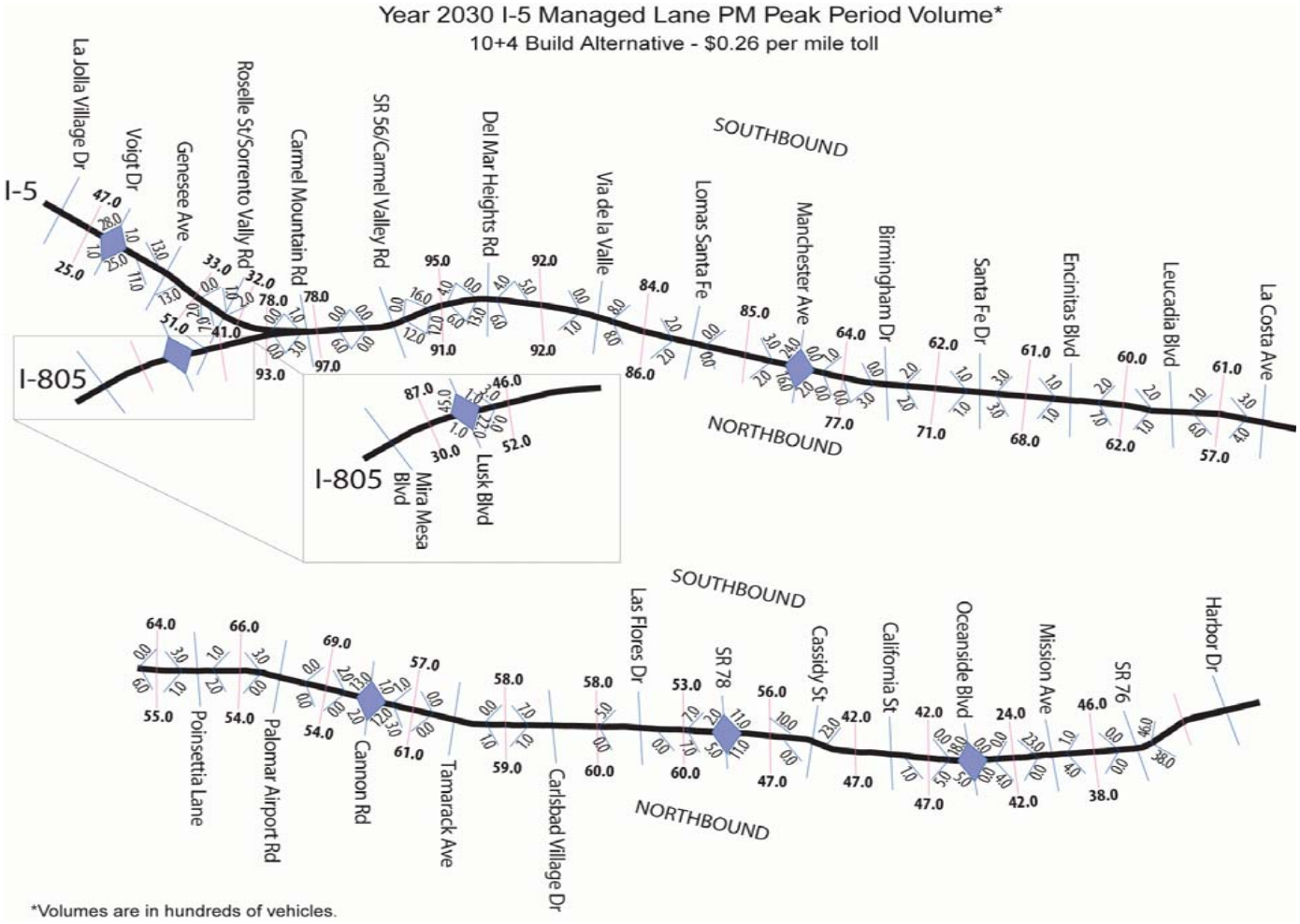


FIGURE 5-3: 2030 AM PEAK PERIOD VOLUMES FOR 10+4 ALTERNATIVE, LIMITED ACCESS

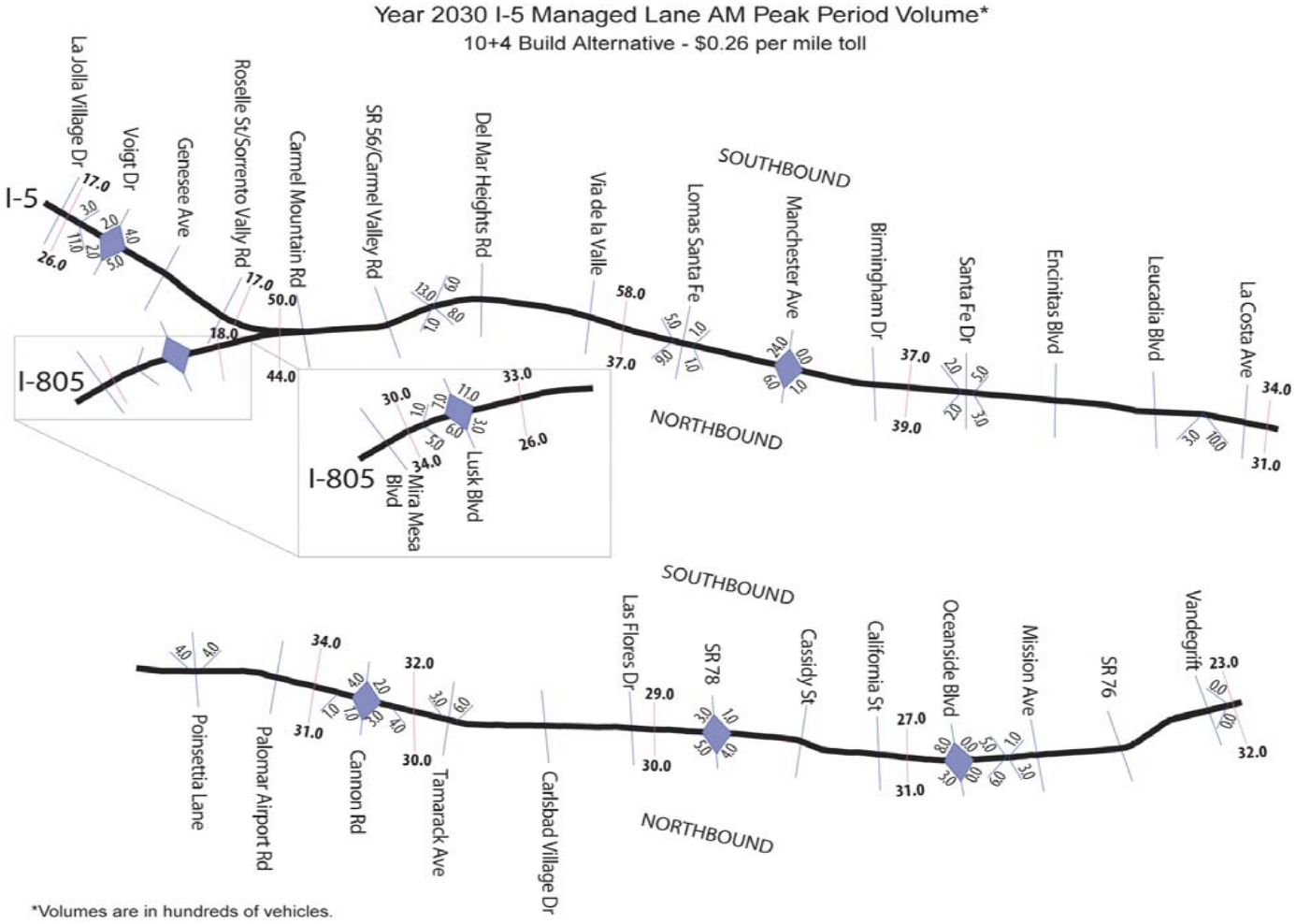


FIGURE 5-4: 2030 PM PEAK PERIOD VOLUMES FOR 10+4 ALTERNATIVE, LIMITED ACCESS

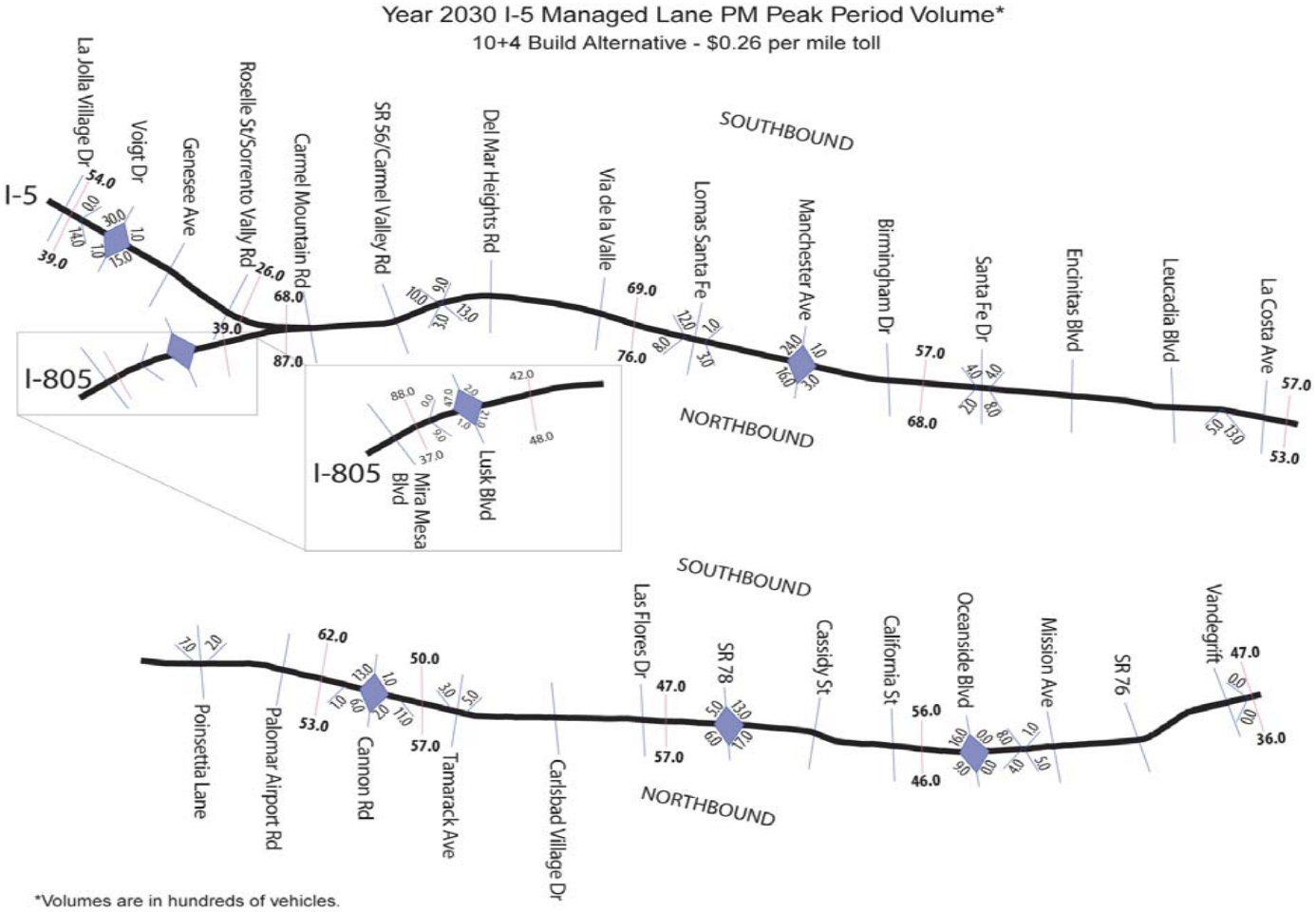
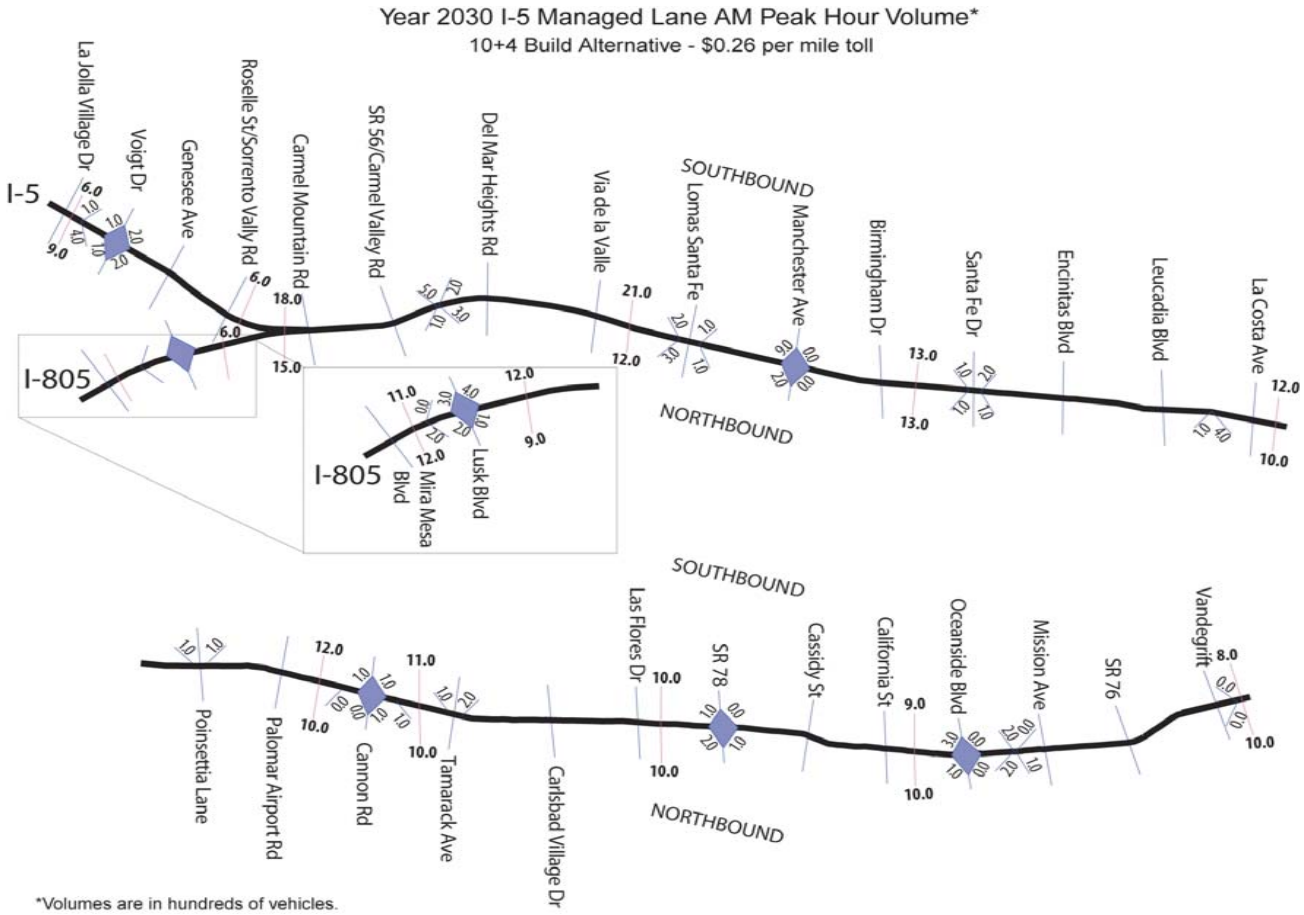
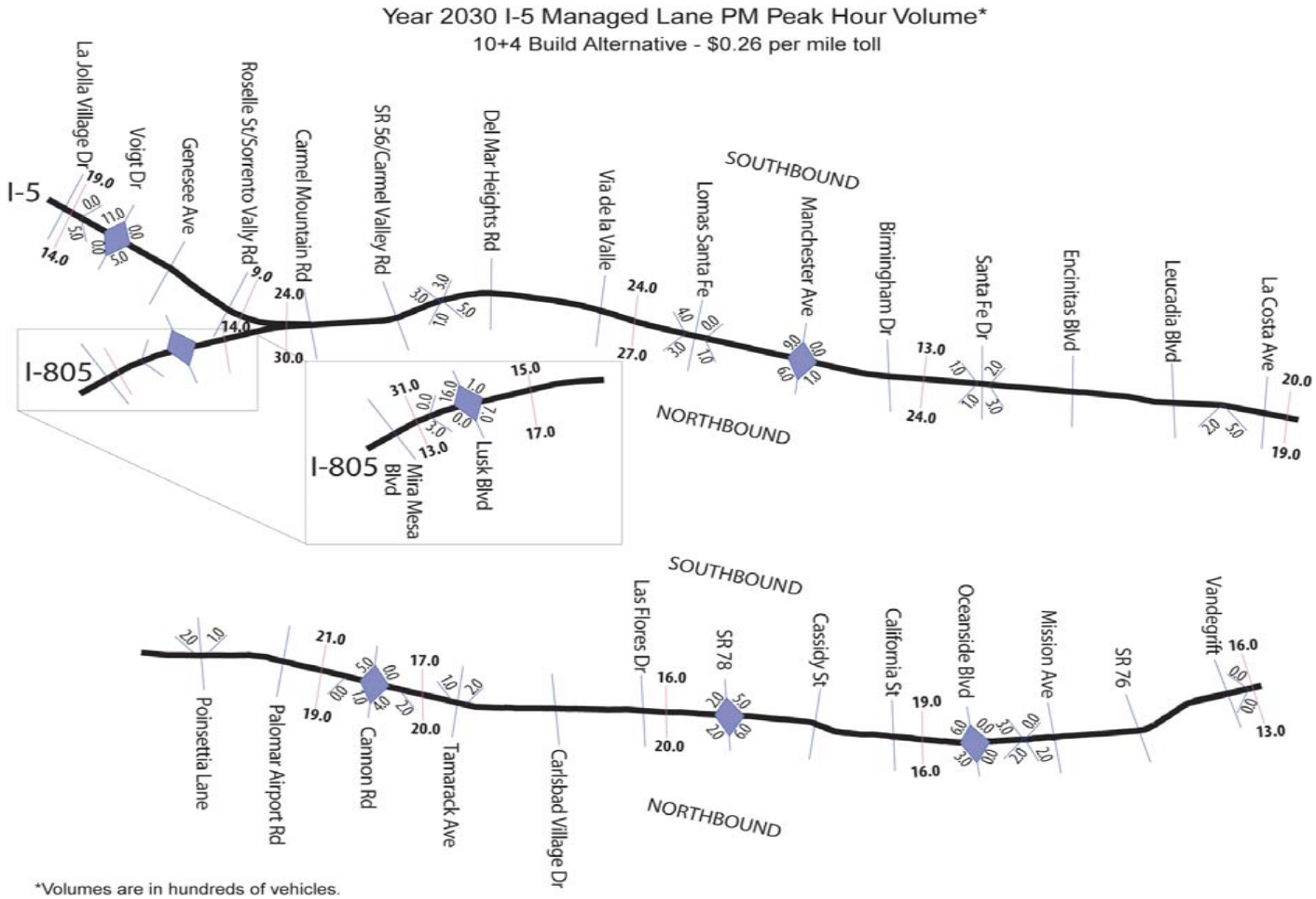


FIGURE 5-5: 2030 AM PEAK HOUR VOLUME FOR 10+4, LIMITED ACCESS**



** Peak Hour data was used for limited access scenario only.

FIGURE 5-6: 2030 PM PEAK HOUR VOLUME FOR 10+4, LIMITED ACCESS**



** Peak Hour data was used for limited access scenario only.

TABLE 5-5: I-5 MANAGED LANE TRAFFIC VOLUMES*

2030 10+4 ALTERNATIVE
SOV TOLL SCENARIO

Location		Drive Alone	Shared Ride - 2 Person	Shared Ride - 3+ Person	Total	Percent of LOS C Capacity
North of SR 76	AM Peak Hour Inbound	100	600	200	**900**	28%
	AM Peak Hour Outbound	100	800	300	**1,200**	38%
	Total AM Peak Hour	200	1,400	500	**2,100**	33%
	PM Peak Hour Inbound	0	1,200	400	**1,600**	50%
	PM Peak Hour Outbound	0	900	300	**1,200**	38%
	Total PM Peak Hour	0	2,100	700	**2,800**	44%
	Daily Inbound	400	7,200	2,400	**10,000**	--
	Daily Outbound	400	6,900	2,300	**9,600**	--
	Total Daily	800	14,100	4,700	**19,600**	--
South of Palomar Airport	AM Peak Hour Inbound	100	900	200	**1,200**	38%
	AM Peak Hour Outbound	100	900	200	**1,200**	38%
	Total AM Peak Hour	200	1,800	400	**2,400**	38%
	PM Peak Hour Inbound	100	1,500	500	**2,100**	66%
	PM Peak Hour Outbound	100	1,300	400	**1,800**	56%
	Total PM Peak Hour	200	2,800	900	**3,900**	61%
	Daily Inbound	800	9,600	3,000	**13,400**	--
	Daily Outbound	700	8,900	2,900	**12,500**	--
	Total Daily	1,500	18,500	5,900	**25,900**	--
South of Manchester	AM Peak Hour Inbound	500	1,400	400	**2,300**	72%
	AM Peak Hour Outbound	100	1,300	300	**1,700**	53%
	Total AM Peak Hour	600	2,700	700	**4,000**	63%
	PM Peak Hour Inbound	100	1,900	600	**2,600**	81%
	PM Peak Hour Outbound	400	1,800	500	**2,700**	84%
	Total PM Peak Hour	500	3,700	1,100	**5,300**	83%
	Daily Inbound	2,200	13,200	4,200	**19,600**	--
	Daily Outbound	2,100	12,300	3,900	**18,300**	--
	Total Daily	4,300	25,500	8,100	**37,900**	--
North of SR 56	AM Peak Hour Inbound	600	1,400	400	**2,400**	75%
	AM Peak Hour Outbound	100	1,400	400	**1,900**	59%
	Total AM Peak Hour	700	2,800	800	**4,300**	67%
	PM Peak Hour Inbound	0	2,200	700	**2,900**	91%
	PM Peak Hour Outbound	500	2,100	600	**3,200**	100%
	Total PM Peak Hour	500	4,300	1,300	**6,100**	95%
	Daily Inbound	2,300	13,900	4,400	**20,600**	--
	Daily Outbound	2,200	13,600	4,400	**20,200**	--
	Total Daily	4,500	27,500	8,800	**40,800**	--

* unadjusted volumes

Source: PB, November 2005

TABLE 5-6: I-5 MANAGED LANE TRAFFIC VOLUMES*

2030 8+4 ALTERNATIVE
SOV TOLL SCENARIO

Location		Drive Alone	Shared Ride - 2 Person	Shared Ride - 3+ Person	Total	Percent of LOS C Capacity
North of SR 76	AM Peak Hour Inbound	100	700	200	**1,000**	31%
	AM Peak Hour Outbound	100	900	300	**1,300**	41%
	Total AM Peak Hour	200	1,600	500	**2,300**	36%
	PM Peak Hour Inbound	0	1,300	400	**1,700**	53%
	PM Peak Hour Outbound	100	1,000	300	**1,400**	44%
	Total PM Peak Hour	100	2,300	700	**3,100**	48%
	Daily Inbound	500	7,800	2,600	**10,900**	--
	Daily Outbound	500	7,500	2,500	**10,500**	--
	Total Daily	1,000	15,300	5,100	**21,400**	--
South of Palomar Airport	AM Peak Hour Inbound	100	1,000	300	**1,400**	44%
	AM Peak Hour Outbound	100	1,000	300	**1,400**	44%
	Total AM Peak Hour	200	2,000	600	**2,800**	44%
	PM Peak Hour Inbound	100	1,600	500	**2,200**	69%
	PM Peak Hour Outbound	100	1,400	500	**2,000**	63%
	Total PM Peak Hour	200	3,000	1,000	**4,200**	66%
	Daily Inbound	1,100	10,500	3,300	**14,900**	--
	Daily Outbound	900	9,800	3,200	**13,900**	--
	Total Daily	2,000	20,300	6,500	**28,800**	--
South of Manchester	AM Peak Hour Inbound	700	1,400	400	**2,500**	78%
	AM Peak Hour Outbound	100	1,300	400	**1,800**	56%
	Total AM Peak Hour	800	2,700	800	**4,300**	67%
	PM Peak Hour Inbound	100	2,200	700	**3,000**	94%
	PM Peak Hour Outbound	500	2,000	600	**3,100**	97%
	Total PM Peak Hour	600	4,200	1,300	**6,100**	95%
	Daily Inbound	2,800	14,200	4,500	**21,500**	--
	Daily Outbound	2,600	13,300	4,300	**20,200**	--
	Total Daily	5,400	27,500	8,800	**41,700**	--
North of SR 56	AM Peak Hour Inbound	700	1,500	500	**2,700**	84%
	AM Peak Hour Outbound	200	1,500	400	**2,100**	66%
	Total AM Peak Hour	900	3,000	900	**4,800**	75%
	PM Peak Hour Inbound	100	2,200	700	**3,000**	94%
	PM Peak Hour Outbound	600	2,200	700	**3,500**	109%
	Total PM Peak Hour	700	4,400	1,400	**6,500**	102%
	Daily Inbound	2,800	14,900	4,800	**22,500**	--
	Daily Outbound	2,700	14,300	4,600	**21,600**	--
	Total Daily	5,500	29,200	9,400	**44,100**	--

* unadjusted volumes

Source: PB, November 2005

TABLE 5-7: I-5 MANAGED LANE TRAFFIC VOLUMES*

2030 10+4 ALTERNATIVE
HOV-2/SOV TOLL SCENARIO

Location		Drive Alone	Shared Ride - 2 Person	Shared Ride - 3+ Person	Total	Percent of LOS C Capacity
North of SR 76	AM Peak Hour Inbound	100	0	200	**300**	9%
	AM Peak Hour Outbound	100	0	300	**400**	13%
	Total AM Peak Hour	200	0	500	**700**	11%
	PM Peak Hour Inbound	100	0	500	**600**	19%
	PM Peak Hour Outbound	0	0	400	**400**	13%
	Total PM Peak Hour	100	0	900	**1,000**	16%
	Daily Inbound	500	100	2,800	**3,400**	--
	Daily Outbound	500	100	2,700	**3,300**	--
	Total Daily	1,000	200	5,500	**6,700**	--
South of Palomar Airport	AM Peak Hour Inbound	100	0	300	**400**	13%
	AM Peak Hour Outbound	100	0	300	**400**	13%
	Total AM Peak Hour	200	0	600	**800**	13%
	PM Peak Hour Inbound	100	0	600	**700**	22%
	PM Peak Hour Outbound	100	0	600	**700**	22%
	Total PM Peak Hour	200	0	1,200	**1,400**	22%
	Daily Inbound	900	200	3,800	**4,900**	--
	Daily Outbound	700	200	3,500	**4,400**	--
	Total Daily	1,600	400	7,300	**9,300**	--
South of Manchester	AM Peak Hour Inbound	600	100	500	**1,200**	38%
	AM Peak Hour Outbound	100	0	400	**500**	16%
	Total AM Peak Hour	700	100	900	**1,700**	27%
	PM Peak Hour Inbound	100	0	800	**900**	28%
	PM Peak Hour Outbound	400	100	800	**1,300**	41%
	Total PM Peak Hour	500	100	1,600	**2,200**	34%
	Daily Inbound	2,400	500	5,100	**8,000**	--
	Daily Outbound	2,200	500	4,800	**7,500**	--
	Total Daily	4,600	1,000	9,900	**15,500**	--
North of SR 56	AM Peak Hour Inbound	700	100	600	**1,400**	44%
	AM Peak Hour Outbound	200	0	500	**700**	22%
	Total AM Peak Hour	900	100	1,100	**2,100**	33%
	PM Peak Hour Inbound	100	0	800	**900**	28%
	PM Peak Hour Outbound	500	100	900	**1,500**	47%
	Total PM Peak Hour	600	100	1,700	**2,400**	38%
	Daily Inbound	2,500	600	5,200	**8,300**	--
	Daily Outbound	2,300	500	5,400	**8,200**	--
	Total Daily	4,800	1,100	10,600	**16,500**	--

* unadjusted volumes

Source: PB, November 2005

TABLE 5-8: I-5 MANAGED LANE TRAFFIC VOLUMES*

2030 8+4 ALTERNATIVE
HOV-2/SOV TOLL SCENARIO

Location		Drive Alone	Shared Ride - 2 Person	Shared Ride - 3+ Person	Total	Percent of LOS C Capacity
North of SR 76	AM Peak Hour Inbound	100	0	300	**400**	13%
	AM Peak Hour Outbound	100	0	300	**400**	13%
	Total AM Peak Hour	200	0	600	**800**	13%
	PM Peak Hour Inbound	100	0	500	**600**	19%
	PM Peak Hour Outbound	100	0	400	**500**	16%
	Total PM Peak Hour	200	0	900	**1,100**	17%
	Daily Inbound	600	100	3,000	**3,700**	--
	Daily Outbound	500	100	2,900	**3,500**	--
	Total Daily	1,100	200	5,900	**7,200**	--
South of Palomar Airport	AM Peak Hour Inbound	200	100	400	**700**	22%
	AM Peak Hour Outbound	100	0	300	**400**	13%
	Total AM Peak Hour	300	100	700	**1,100**	17%
	PM Peak Hour Inbound	100	0	700	**800**	25%
	PM Peak Hour Outbound	100	0	600	**700**	22%
	Total PM Peak Hour	200	0	1,300	**1,500**	23%
	Daily Inbound	1,100	300	4,100	**5,500**	--
	Daily Outbound	900	300	4,000	**5,200**	--
	Total Daily	2,000	600	8,100	**10,700**	--
South of Manchester	AM Peak Hour Inbound	700	200	500	**1,400**	44%
	AM Peak Hour Outbound	100	0	500	**600**	19%
	Total AM Peak Hour	800	200	1,000	**2,000**	31%
	PM Peak Hour Inbound	100	0	900	**1,000**	31%
	PM Peak Hour Outbound	600	100	900	**1,600**	50%
	Total PM Peak Hour	700	100	1,800	**2,600**	41%
	Daily Inbound	3,000	600	5,600	**9,200**	--
	Daily Outbound	2,700	500	5,300	**8,500**	--
	Total Daily	5,700	1,100	10,900	**17,700**	--
North of SR 56	AM Peak Hour Inbound	800	200	600	**1,600**	50%
	AM Peak Hour Outbound	200	0	500	**700**	22%
	Total AM Peak Hour	1,000	200	1,100	**2,300**	36%
	PM Peak Hour Inbound	100	0	900	**1,000**	31%
	PM Peak Hour Outbound	600	100	1,000	**1,700**	53%
	Total PM Peak Hour	700	100	1,900	**2,700**	42%
	Daily Inbound	3,000	600	5,700	**9,300**	--
	Daily Outbound	2,800	600	5,700	**9,100**	--
	Total Daily	5,800	1,200	11,400	**18,400**	--

* unadjusted volumes

Source: PB, November 2005

TABLE 5-9: I-5 MANAGED LANE DAILY TRAFFIC VOLUMES*

2015 10+4 ALTERNATIVE
SOV TOLL SCENARIO

Location		Drive Alone	Shared Ride - 2 Person	Shared Ride - 3+ Person	Total	Percent of LOS C Capacity
North of SR 76	AM Peak Hour Inbound	0	300	100	**400**	13%
	AM Peak Hour Outbound	0	400	100	**500**	16%
	Total AM Peak Hour	0	700	200	**900**	14%
	PM Peak Hour Inbound	0	600	200	**800**	25%
	PM Peak Hour Outbound	0	500	200	**700**	22%
	Total PM Peak Hour	0	1,100	400	**1,500**	23%
	Daily Inbound	200	3,600	1,200	**5,000**	--
	Daily Outbound	300	4,700	1,600	**6,600**	--
	Total Daily	500	8,300	2,800	**11,600**	--
South of Palomar Airport	AM Peak Hour Inbound	100	600	200	**900**	28%
	AM Peak Hour Outbound	0	600	200	**800**	25%
	Total AM Peak Hour	100	1,200	400	**1,700**	27%
	PM Peak Hour Inbound	100	1,100	300	**1,500**	47%
	PM Peak Hour Outbound	0	1,000	300	**1,300**	41%
	Total PM Peak Hour	100	2,100	600	**2,800**	44%
	Daily Inbound	600	6,900	2,300	**9,800**	--
	Daily Outbound	500	6,500	2,200	**9,200**	--
	Total Daily	1,100	13,400	4,500	**19,000**	--
South of Manchester	AM Peak Hour Inbound	700	1,100	300	**2,100**	66%
	AM Peak Hour Outbound	100	800	200	**1,100**	34%
	Total AM Peak Hour	800	1,900	500	**3,200**	50%
	PM Peak Hour Inbound	100	1,400	400	**1,900**	59%
	PM Peak Hour Outbound	500	1,500	400	**2,400**	75%
	Total PM Peak Hour	600	2,900	800	**4,300**	67%
	Daily Inbound	4,100	10,000	3,200	**17,300**	--
	Daily Outbound	900	8,900	3,000	**12,800**	--
	Total Daily	5,000	18,900	6,200	**30,100**	--
North of SR 56	AM Peak Hour Inbound	700	1,100	300	**2,100**	66%
	AM Peak Hour Outbound	0	900	300	**1,200**	38%
	Total AM Peak Hour	700	2,000	600	**3,300**	52%
	PM Peak Hour Inbound	0	1,400	500	**1,900**	59%
	PM Peak Hour Outbound	600	1,700	500	**2,800**	88%
	Total PM Peak Hour	600	3,100	1,000	**4,700**	73%
	Daily Inbound	2,700	9,800	3,200	**15,700**	--
	Daily Outbound	2,400	9,600	3,200	**15,200**	--
	Total Daily	5,100	19,400	6,400	**30,900**	--

* unadjusted volumes

Source: PB, November 2005

TABLE 5-10: I-5 MANAGED LANE DAILY TRAFFIC VOLUMES*

2015 8+4 ALTERNATIVE
SOV TOLL SCENARIO

Location		Drive Alone	Shared Ride - 2 Person	Shared Ride - 3+ Person	Total	Percent of LOS C Capacity
North of SR 76	AM Peak Hour Inbound	0	400	100	**500**	16%
	AM Peak Hour Outbound	0	400	100	**500**	16%
	Total AM Peak Hour	0	800	200	**1,000**	16%
	PM Peak Hour Inbound	0	600	200	**800**	25%
	PM Peak Hour Outbound	0	500	200	**700**	22%
	Total PM Peak Hour	0	1,100	400	**1,500**	23%
	Daily Inbound	200	3,900	1,300	**5,400**	--
	Daily Outbound	200	3,700	1,300	**5,200**	--
	Total Daily	400	7,600	2,600	**10,600**	--
South of Palomar Airport	AM Peak Hour Inbound	100	700	200	**1,000**	31%
	AM Peak Hour Outbound	0	700	200	**900**	28%
	Total AM Peak Hour	100	1,400	400	**1,900**	30%
	PM Peak Hour Inbound	100	1,100	400	**1,600**	50%
	PM Peak Hour Outbound	100	1,000	300	**1,400**	44%
	Total PM Peak Hour	200	2,100	700	**3,000**	47%
	Daily Inbound	700	7,400	2,500	**10,600**	--
	Daily Outbound	500	7,000	2,300	**9,800**	--
	Total Daily	1,200	14,400	4,800	**20,400**	--
South of Manchester	AM Peak Hour Inbound	700	1,100	300	**2,100**	66%
	AM Peak Hour Outbound	100	900	300	**1,300**	41%
	Total AM Peak Hour	800	2,000	600	**3,400**	53%
	PM Peak Hour Inbound	100	1,500	500	**2,100**	66%
	PM Peak Hour Outbound	500	1,600	500	**2,600**	81%
	Total PM Peak Hour	600	3,100	1,000	**4,700**	73%
	Daily Inbound	2,500	10,400	3,400	**16,300**	--
	Daily Outbound	2,200	9,700	3,200	**15,100**	--
	Total Daily	4,700	20,100	6,600	**31,400**	--
North of SR 56	AM Peak Hour Inbound	700	1,200	300	**2,200**	69%
	AM Peak Hour Outbound	0	900	300	**1,200**	38%
	Total AM Peak Hour	700	2,100	600	**3,400**	53%
	PM Peak Hour Inbound	0	1,500	500	**2,000**	63%
	PM Peak Hour Outbound	500	1,600	500	**2,600**	81%
	Total PM Peak Hour	500	3,100	1,000	**4,600**	72%
	Daily Inbound	2,500	10,400	3,400	**16,300**	--
	Daily Outbound	2,200	9,900	3,200	**15,300**	--
	Total Daily	4,700	20,300	6,600	**31,600**	--

* unadjusted volumes

Source: PB, November 2005

The time of day managed lane volumes relationship to LOS C operations varies along the corridor in both 2030 and 2015. The variation is somewhat more dramatic in 2015. These results would provide support to the idea of differential tolling rates in the corridor given the different levels of demand relative to the managed lane's maximum vehicle operational threshold of 1,650 vehicles per lane.

5.3.4. Comparison of Managed Lane Traffic Shares

One method of analyzing the effectiveness of the I-5 managed lanes is to compare the relative amount of traffic volume that is accommodated by the managed lanes in each of the scenarios. Tables 5-11 through 5-14 present this data as shares of the total corridor volume for the 2030 AM and PM peak hours as well as for the entire day at four locations along the I-5 North Coast corridor. Data are presented for both Build alternatives and both tolling scenarios.

These data show that under the SOV tolling scenario of the Build alternatives, the managed lane carries a higher share of corridor traffic and that the 8+4 alternative carries a higher share than the 10+4 alternative. The managed lane share of I-5 North Coast corridor traffic is highest in the middle section of the corridor.

Tables 5-15 and 5-16 present the managed lane share of total corridor traffic in 2015 for the SOV toll scenario of each of the two Build alternatives. Similar to the 2030 data, the 8+4 alternative accommodates a larger share of corridor traffic than the 10+4 alternative.

TABLE 5-11: 2030 10+4 MANAGED LANE SHARES SOV TOLL SCENARIO

Location		Managed Lane Volume	General Purpose Lane Volume	Managed Lane Share of Corridor Volume
North of SR 76	AM Peak Hour Inbound	900	5,300	15%
	AM Peak Hour Outbound	1,200	7,800	13%
	Total AM Peak Hour	2,100	13,100	14%
	PM Peak Hour Inbound	1,600	9,000	15%
	PM Peak Hour Outbound	1,200	6,200	16%
	Total PM Peak Hour	2,800	15,200	16%
	Daily Inbound	10,000	108,900	8%
	Daily Outbound	9,600	103,200	9%
	Total Daily	19,600	212,100	8%
South of Palomar Airport	AM Peak Hour Inbound	1,200	7,900	13%
	AM Peak Hour Outbound	1,200	7,100	14%
	Total AM Peak Hour	2,400	15,000	14%
	PM Peak Hour Inbound	2,100	8,000	21%
	PM Peak Hour Outbound	1,800	7,200	20%
	Total PM Peak Hour	3,900	15,200	20%
	Daily Inbound	13,400	105,700	11%
	Daily Outbound	12,500	101,400	11%
	Total Daily	25,900	207,100	11%
South of Manchester	AM Peak Hour Inbound	2,300	9,500	19%
	AM Peak Hour Outbound	1,700	8,800	16%
	Total AM Peak Hour	4,000	18,300	18%
	PM Peak Hour Inbound	2,600	10,100	20%
	PM Peak Hour Outbound	2,700	9,800	22%
	Total PM Peak Hour	5,300	19,900	21%
	Daily Inbound	19,600	133,900	13%
	Daily Outbound	18,300	133,000	12%
	Total Daily	37,900	266,900	12%
North of SR 56	AM Peak Hour Inbound	2,400	11,500	17%
	AM Peak Hour Outbound	1,900	9,500	17%
	Total AM Peak Hour	4,300	21,000	17%
	PM Peak Hour Inbound	2,900	11,000	21%
	PM Peak Hour Outbound	3,200	11,500	22%
	Total PM Peak Hour	6,100	22,500	21%
	Daily Inbound	20,600	153,100	12%
	Daily Outbound	20,200	147,600	12%
	Total Daily	40,800	300,700	12%

* unadjusted volumes

Source: PB, November 2005

TABLE 5-12: 2030 10+4 MANAGED LANE SHARES SOV/HOV- 2 TOLL SCENARIO

Location		Managed Lane Volume	General Purpose Lane Volume	Managed Lane Share of Corridor Volume
North of SR 76	AM Peak Hour Inbound	300	6,000	5%
	AM Peak Hour Outbound	400	8,700	4%
	Total AM Peak Hour	700	14,700	5%
	PM Peak Hour Inbound	600	10,100	6%
	PM Peak Hour Outbound	400	6,900	5%
	Total PM Peak Hour	1,000	17,000	6%
	Daily Inbound	3,400	115,700	3%
	Daily Outbound	3,300	109,400	3%
	Total Daily	6,700	225,100	3%
South of Palomar Airport	AM Peak Hour Inbound	400	8,200	5%
	AM Peak Hour Outbound	400	7,500	5%
	Total AM Peak Hour	800	15,700	5%
	PM Peak Hour Inbound	700	8,400	8%
	PM Peak Hour Outbound	700	7,400	9%
	Total PM Peak Hour	1,400	15,800	8%
	Daily Inbound	4,900	109,900	4%
	Daily Outbound	4,400	105,000	4%
	Total Daily	9,300	214,900	4%
South of Manchester	AM Peak Hour Inbound	1,200	9,200	12%
	AM Peak Hour Outbound	500	9,300	5%
	Total AM Peak Hour	1,700	18,500	8%
	PM Peak Hour Inbound	900	9,600	9%
	PM Peak Hour Outbound	1,300	9,400	12%
	Total PM Peak Hour	2,200	19,000	10%
	Daily Inbound	8,000	137,800	5%
	Daily Outbound	7,500	138,500	5%
	Total Daily	15,500	276,300	5%
North of SR 56	AM Peak Hour Inbound	1,400	12,300	10%
	AM Peak Hour Outbound	700	10,000	7%
	Total AM Peak Hour	2,100	22,300	9%
	PM Peak Hour Inbound	900	11,200	7%
	PM Peak Hour Outbound	1,500	11,500	12%
	Total PM Peak Hour	2,400	22,700	10%
	Daily Inbound	8,300	160,100	5%
	Daily Outbound	8,200	151,400	5%
	Total Daily	16,500	311,500	5%

* unadjusted volumes

Source: PB, November 2005

TABLE 5-13: 2030 8+4 MANAGED LANE SHARES SOV TOLL SCENARIO

Location		Managed Lane Volume	General Purpose Lane Volume	Managed Lane Share of Corridor Volume
North of SR 76	AM Peak Hour Inbound	1,000	5,300	16%
	AM Peak Hour Outbound	1,300	7,800	14%
	Total AM Peak Hour	2,300	13,100	15%
	PM Peak Hour Inbound	1,700	8,900	16%
	PM Peak Hour Outbound	1,400	6,100	19%
	Total PM Peak Hour	3,100	15,000	17%
	Daily Inbound	10,900	108,000	9%
	Daily Outbound	10,500	102,200	9%
	Total Daily	21,400	210,200	9%
South of Palomar Airport	AM Peak Hour Inbound	1,400	6,800	17%
	AM Peak Hour Outbound	1,400	6,500	18%
	Total AM Peak Hour	2,800	13,300	17%
	PM Peak Hour Inbound	2,200	6,900	24%
	PM Peak Hour Outbound	2,000	6,000	25%
	Total PM Peak Hour	4,200	12,900	25%
	Daily Inbound	14,900	99,400	13%
	Daily Outbound	13,900	95,500	13%
	Total Daily	28,800	194,900	13%
South of Manchester	AM Peak Hour Inbound	2,500	7,900	24%
	AM Peak Hour Outbound	1,800	7,600	19%
	Total AM Peak Hour	4,300	15,500	22%
	PM Peak Hour Inbound	3,000	8,000	27%
	PM Peak Hour Outbound	3,100	8,000	28%
	Total PM Peak Hour	6,100	16,000	28%
	Daily Inbound	21,500	126,300	15%
	Daily Outbound	20,200	125,800	14%
	Total Daily	41,700	252,100	14%
North of SR 56	AM Peak Hour Inbound	2,700	12,200	18%
	AM Peak Hour Outbound	2,100	8,700	19%
	Total AM Peak Hour	4,800	20,900	19%
	PM Peak Hour Inbound	3,000	10,400	22%
	PM Peak Hour Outbound	3,500	10,900	24%
	Total PM Peak Hour	6,500	21,300	23%
	Daily Inbound	22,500	153,500	13%
	Daily Outbound	21,600	143,000	13%
	Total Daily	44,100	296,500	13%

* unadjusted volumes

Source: PB, November 2005

TABLE 5-14: 2030 8+4 MANAGED LANE SHARES SOV/HOV-2 TOLL SCENARIO

Location		Managed Lane Volume	General Purpose Lane Volume	Managed Lane Share of Corridor Volume
North of SR 76	AM Peak Hour Inbound	400	5,900	6%
	AM Peak Hour Outbound	400	8,500	4%
	Total AM Peak Hour	800	14,400	5%
	PM Peak Hour Inbound	600	10,000	6%
	PM Peak Hour Outbound	500	6,800	7%
	Total PM Peak Hour	1,100	16,800	6%
	Daily Inbound	3,700	115,000	3%
	Daily Outbound	3,500	108,700	3%
	Total Daily	7,200	223,700	3%
South of Palomar Airport	AM Peak Hour Inbound	700	7,100	9%
	AM Peak Hour Outbound	400	6,600	6%
	Total AM Peak Hour	1,100	13,700	7%
	PM Peak Hour Inbound	800	7,300	10%
	PM Peak Hour Outbound	700	6,300	10%
	Total PM Peak Hour	1,500	13,600	10%
	Daily Inbound	5,500	103,300	5%
	Daily Outbound	5,200	98,800	5%
	Total Daily	10,700	202,100	5%
South of Manchester	AM Peak Hour Inbound	1,400	8,700	14%
	AM Peak Hour Outbound	600	8,000	7%
	Total AM Peak Hour	2,000	16,700	11%
	PM Peak Hour Inbound	1,000	7,300	12%
	PM Peak Hour Outbound	1,600	6,300	20%
	Total PM Peak Hour	2,600	17,600	13%
	Daily Inbound	9,200	133,500	6%
	Daily Outbound	8,500	133,000	6%
	Total Daily	17,700	266,500	6%
North of SR 56	AM Peak Hour Inbound	1,600	12,700	11%
	AM Peak Hour Outbound	700	9,200	7%
	Total AM Peak Hour	2,300	21,900	10%
	PM Peak Hour Inbound	1,000	11,100	8%
	PM Peak Hour Outbound	1,700	11,100	13%
	Total PM Peak Hour	2,700	22,200	11%
	Daily Inbound	9,300	159,300	6%
	Daily Outbound	9,100	147,400	6%
	Total Daily	18,400	306,700	6%

* unadjusted volumes

Source: PB, November 2005

TABLE 5-15: 2015 10+4 MANAGED LANE SHARES SOV TOLL SCENARIO

Location		Managed Lane Volume	General Purpose Lane Volume	Managed Lane Share of Corridor Volume
North of SR 76	AM Peak Hour Inbound	400	4,700	8%
	AM Peak Hour Outbound	500	7,500	6%
	Total AM Peak Hour	900	12,200	7%
	PM Peak Hour Inbound	800	9,600	8%
	PM Peak Hour Outbound	700	5,400	11%
	Total PM Peak Hour	1,500	15,000	9%
	Daily Inbound	5,000	98,500	5%
	Daily Outbound	6,600	89,400	7%
	Total Daily	11,600	187,900	6%
South of Palomar Airport	AM Peak Hour Inbound	900	6,400	12%
	AM Peak Hour Outbound	800	6,600	11%
	Total AM Peak Hour	1,700	13,000	12%
	PM Peak Hour Inbound	1,500	7,400	17%
	PM Peak Hour Outbound	1,300	7,100	15%
	Total PM Peak Hour	2,800	14,500	16%
	Daily Inbound	9,800	87,200	10%
	Daily Outbound	9,200	89,400	9%
	Total Daily	19,000	176,600	10%
South of Manchester	AM Peak Hour Inbound	2,100	8,300	20%
	AM Peak Hour Outbound	1,100	7,400	13%
	Total AM Peak Hour	3,200	15,700	17%
	PM Peak Hour Inbound	1,900	8,200	19%
	PM Peak Hour Outbound	2,400	9,000	21%
	Total PM Peak Hour	4,300	17,200	20%
	Daily Inbound	17,300	116,600	13%
	Daily Outbound	12,800	118,600	10%
	Total Daily	30,100	235,200	11%
North of SR 56	AM Peak Hour Inbound	2,100	9,700	18%
	AM Peak Hour Outbound	1,200	7,400	14%
	Total AM Peak Hour	3,300	17,100	16%
	PM Peak Hour Inbound	1,900	8,300	19%
	PM Peak Hour Outbound	2,800	10,100	22%
	Total PM Peak Hour	4,700	18,400	20%
	Daily Inbound	15,700	124,700	11%
	Daily Outbound	15,200	123,900	11%
	Total Daily	30,900	248,600	11%

* unadjusted volumes

Source: PB, November 2005

TABLE 5-16: 2015 8+4 MANAGED LANE SHARES SOV TOLL SCENARIO

Location		Managed Lane Volume	General Purpose Lane Volume	Managed Lane Share of Corridor Volume
North of SR 76	AM Peak Hour Inbound	500	4,600	10%
	AM Peak Hour Outbound	500	7,000	7%
	Total AM Peak Hour	1,000	11,600	8%
	PM Peak Hour Inbound	800	8,900	8%
	PM Peak Hour Outbound	700	5,400	11%
	Total PM Peak Hour	1,500	14,300	9%
	Daily Inbound	5,400	98,600	5%
	Daily Outbound	5,200	89,700	5%
	Total Daily	10,600	188,300	5%
South of Palomar Airport	AM Peak Hour Inbound	1,000	5,600	15%
	AM Peak Hour Outbound	900	5,600	14%
	Total AM Peak Hour	1,900	11,200	15%
	PM Peak Hour Inbound	1,600	6,300	20%
	PM Peak Hour Outbound	1,400	5,800	19%
	Total PM Peak Hour	3,000	12,100	20%
	Daily Inbound	10,600	82,300	11%
	Daily Outbound	9,800	84,500	10%
	Total Daily	20,400	166,800	11%
South of Manchester	AM Peak Hour Inbound	2,100	7,100	23%
	AM Peak Hour Outbound	1,300	6,200	17%
	Total AM Peak Hour	3,400	13,300	20%
	PM Peak Hour Inbound	2,100	6,900	23%
	PM Peak Hour Outbound	2,600	7,800	25%
	Total PM Peak Hour	4,700	14,700	24%
	Daily Inbound	16,300	110,800	13%
	Daily Outbound	15,100	114,400	12%
	Total Daily	31,400	225,200	12%
North of SR 56	AM Peak Hour Inbound	2,200	9,300	19%
	AM Peak Hour Outbound	1,200	6,100	16%
	Total AM Peak Hour	3,400	15,400	18%
	PM Peak Hour Inbound	2,000	6,900	22%
	PM Peak Hour Outbound	2,600	9,600	21%
	Total PM Peak Hour	4,600	16,500	22%
	Daily Inbound	16,300	122,400	12%
	Daily Outbound	15,300	123,700	11%
	Total Daily	31,600	246,100	11%

* unadjusted volumes

Source: PB, November 2005

5.4 RESULTS AND RECOMMENDATIONS

Traffic analyses conducted on the I-5 North Coast corridor validated feasibility of value pricing for both of the Build alternatives assuming either a buffer or barrier separation.

As shown in the data above, the proposed managed lanes, when operated as a priced facility, carry a substantial amount of traffic and do seem to reduce traffic levels on the I-5 general purpose lanes as compared to a scenario in which no managed lane exists. In terms of traffic on the general purpose lanes, the most direct comparison is between the No Build and the 8+4 alternative. In the 2030, the general purpose lane volumes of the 8+4 alternative under the SOV toll scenario are forecasted to be somewhat lower than volumes for the No Build alternative. The same is true with respect to general purpose volumes in the AM and PM peak hours. General purpose lane volumes for the 10+4 alternative in 2030 are higher than those of the No Build alternative, but this is most likely due to the increased general purpose lane capacity. Despite the higher volumes of the general purpose lanes of the Build alternatives, performance of the corridor is improved over the No Build condition.

In terms of level of use, the managed lanes are forecasted in 2030 under the SOV toll scenario to operate near or above 90 percent of the desired operation threshold (1,650 vph/lane) in the peak hours, with certain sections in the south approaching full use. With the more robust HOV-2/SOV tolling policy, demand levels drop by more than half. These results suggest that the HOV-2/SOV tolling policy might be more aggressive than necessary, and the SOV toll policy not aggressive enough. A variable tolling policy is probably the most feasible. In 2015, levels of managed lane uses approach 75 percent of maximum desired levels, demonstrating that there is a market for managed lanes in the corridor in the near term. The nature of demand by occupancy level in 2015 is different than that in 2030. The 2015 managed lane demand has a higher proportion of SOV vehicles than does 2030 managed lane demand. This is probably due to higher levels of corridor congestion in 2030 which encourage higher levels of carpooling in the corridor.

A review of the managed lane share of corridor traffic among the Build alternatives demonstrates that the managed lanes carry the highest percentage of corridor vehicle traffic when adjacent lanes are most congested. The 8+4 alternative is the most congested alternative in both analysis years, and correspondingly, has the highest managed lane share of traffic. This data demonstrate that the share of traffic carried on the managed lanes drops off dramatically under the HOV-2/SOV tolling policy as compared to the SOV tolling policy.

A summary of findings are highlighted below:

- Using calibration to experiences on I-15, the I-5 managed lanes will generate significant demand based on toll rate currently applied. The rates applied were $0.26 per mile during the peak period and $0.10 per mile in the off-peak.
- Results from the forecast traffic conditions indicate that the 8+4 alternative carries a proportionately higher share of overall corridor traffic than when compared to the 10+4 alternative. In the southern portion of the I-5 corridor, both alternatives operate at or near LOS C capacity in the design year. This would suggest that more restrictive occupancy requirements than a HOV-2+ will eventually be necessary.

- Peak travel time savings for managed lane trips traversing the I-5 North Coast corridor between SR 76 and the I-5/I-805 split is at least 12 minutes for the 8+4 alternative and at least eight minutes for the 10+4 alternative in 2030. These figures suggest a travel time savings rate approaching a minimum of one-half minute per mile, a value which represents substantial time savings. In 2015, as would be expected, these travel time savings figures decrease to a minimum of seven minutes for the 8+4 alternative and at least five minutes for the 10+4 alternative. This is shown in Table 5-19.

TABLE 5-17: PEAK TRAVEL TIME SAVINGS FROM SR 76 TO I-5/I-805 SPLIT*

	2015	2030
8+4 Alternative	12 minutes	7 minutes
10+4 Alternative	8 minutes	5 minutes

*Minimum travel time savings.

- Designated intermediate access locations with the I-5 general purpose lanes are feasible in the locations selected and minimize the number of toll zones required to effectively manage lanes.

CHAPTER 6

REVENUE ANALYSIS

6.1 POTENTIAL PRICING CONCEPTS

In Chapter 3, a wide variety of toll pricing scenarios were identified and reviewed for the purpose of managing traffic in the I-5 North Coast managed lanes. Findings suggested that flat pricing was not as practicable for lane management, and dynamic pricing had the greatest potential for flexibly addressing pricing needs based on real-time changes in roadway operating conditions. Per mile and segment tolls had greater potential for pricing, and skewed has perhaps the greatest potential because not all sections of the I-5 managed lanes have the same levels of forecast demand. Three pricing strategies were considered for further comparative study—flat rate tolls, segment tolls, and per mile tolls with focus on skewed rates where demand is heaviest. This chapter briefly analyzes these shortlisted strategies, with an in-depth analysis of revenue for one specific strategy.

6.1.1. Qualitative Forecasts of Traffic

The process of selecting pricing policies to forecast diversions to tolled facilities is difficult even when one has undertaken detailed computer simulations. In situations where qualitative estimates of future tolled travel are needed, one must bear in mind that many variables are involved that influence outcomes.

However, in order to support discussions of policies related to facility feasibility the study team has prepared just such qualitatively estimated impacts/adjustments to the base forecast for three other pricing strategies. Of necessity, the rigor supporting these estimates will be far lower that that of the scenarios that were actually modeled on computers.

The three pricing strategies to be evaluated are;

- Flat rate
- Segment rates
- Skewed toll per mile

To inform this estimation process, it is useful to look at the results of the base line forecast. Traffic levels in the northern areas of the ML facility as shown in Table 5-6, Chapter 5, indicate that in 2030 there is considerable room for added toll paying traffic that is not utilized due to the toll rate being too high. The percent of capacity within the LOS C volume level only reaches 66 percent in the peak direction of the peak hour in 2030. This not only reduces income, but also sub-optimizes performance of the ML facility on the basis of objectives established at the outset for maximizing vehicle trips through the corridor and on the managed lanes.

Even in the highly traveled sections in the southern portions in the non-peak direction, traffic levels are not forecast to exceed 75 percent of the LOS C levels. This clearly

demonstrates that even under a very simplistic tolling/pricing strategy that was structured around the performance of I-15; there is room for improving the management of the system to achieve the objectives established for maximizing throughput at the outset.

This is a natural outcome for traffic and revenue forecasting and price setting that serves as the basis of this assessment, (i.e., it was not meant to be an investment grade forecasting process, and one should not/can not usefully apply those performance standards post hoc). However, this assessment of the forecast was made to inform the process of making the qualitative estimation effort and not made as a post hoc critique of the forecasts that have been prepared within the understood constraints.

Another dimension of the operational performance of the ML facility shown in Table 5-6 also is informative to this effort to make the qualitative forecasts enumerated above, and that is the percent of toll-paying vehicles as compared to the non-toll-paying fraction of HOV vehicles. On a daily basis in the northern reaches of the ML facility, one realizes that only five to seven percent toll paying utilization of the MLs in 2030, while in the more highly traveled southern section toll payers do not even comprise 15 percent of the traffic.

While there is little room in 2030 in the peak direction to add toll payers under the base forecast, there is anywhere from 25 to 35 percent of the capacity that is unused in the non-peak direction during the peak period that could be utilized if tolls were lower.

Taking this information and applying it to the three tolling scenarios shown above, the following conclusions can be made:

- A flat rate toll/pricing plan would only exacerbate the under-utilization identified above. It would surely reduce off-peak use, if not eliminate it entirely. If one tried to secure a portion of that traffic by reducing the flat rate from the base line forecast's peak price level, by 2030, it would come at the expense of creating significant delays in the southern portion of the ML facility since the demand would surely exceed that which would be compatible with LOS C volumes in peak direction peak periods.
- Segment rates, meaning two segments: northern and southern segments, would increase traffic volumes and revenues since use of the currently under-utilized capacity could be optimized. If one further refined the notion of segment rate pricing to be directionally differentiated as well segmentally differentiated, one could further improve performance in terms of increased vehicle traffic and increase revenues
- Skewed per-mile rates, meaning rates that were differentiated for each tolled segment, would further improve upon the performance of the "segment rate" strategy. Of course, if one further differentiated rates by direction, one would see even further improvements.

The HOV percentages of vehicle composition in Table 5-6, one is presented with a policy and income-based issues if one chooses to pursue higher toll paying objectives:

- Financial returns from tolling could be improved by increasing the free HOV requirement to HOV-3+ at some point in the forecast period.

- This transition comes at the expense of person-trip accommodation on the ML facility insofar that for every SOV vehicle that replaces an HOV-2 vehicle, one is reducing the average person carrying capacity.
- One also would incur a reduction in market demand to support joint development revenue planning/real estate ventures from this impact. This could result in some economic/financial reduction/impacts. Bus rapid transit (BRT) are the main sources of demand for joint development strategies, and they would not be affected by moving up to an HOV-3+ free policy with potential discounts to lower occupancy carpools.

Tables 5-3 and 5-4 in Chapter 5 show that growth in travel is low in the north and comparatively higher in the south. Demand on the southern portions of the corridor challenges the view that the facility may have more than enough capacity to meet needs over the forecast period.

Regarding the spatial dimensions of the travel scenario that was used in the baseline forecast in this report and its impact on the three qualitative forecasts being described in this section, the traffic levels should be impacted as shown below:

- Assuming reasonable rate levels chosen to attempt to optimize traffic and revenues, the flat rate toll pricing plan would see congestion at higher levels in the southern sections than that of the base line forecasts. Depending on the toll levels chosen, congestion could occur earlier in the forecasts as well.
- Segmented tolling as described above would be designed to accommodate this spatial distinction, so no other impacts would be seen.
- Skewed per-mile tolling as described above would be designed to accommodate this spatial distinction, so no other impacts would be seen.

6.1.2 Incorporating Risk in the Policy and Enterprise Strategy Development Process

It is important to remember when looking at these forecasts as well as that of the baseline forecast that one is looking at events that are over 10 to 20 years into the future, and many factors will affect their realization which are not imbedded into the forecasts. Aside from growth rate fluctuations, variables like recessions, inflation, a fall in real wage rates, oil price rises and the like could occur, and all have the potential to reduce traffic on the toll road or in the corridor.

A reduction in traffic has implications for many other dimensions of public and private life as well as the success and performance of the ML facility. It may be that the results of a detailed risk based assessment may be more informative than a computer-based assessment of a traditional normative forecast.

For example, a price rise in fuel costs would likely pressure motorists to choose transit modes if they were available and if they serviced the destinations that motorists desired. By making this choice available, one is enabling the public and the regional economy to better manage the economic and financial impacts of such a price rise. One does not need a forecast to accommodate this highly probable event; one needs a management strategy based on a financially weighted risk assessment.

A managed lane facility can have the ability to incorporate not only transit modes to enable the choice by motorists to make more readily in times when modal competitiveness is shifting, it can also incorporate development activities on parcels adjoining the transit stations which could be influenced by BRT services. This will have the effect of enabling the region's policy makers and the public to better manage changes in its competitive production capabilities. A risk analysis can also enable the ML facility to be phased in response to a better understanding of these variables.

For purposes of more detailed revenue forecast investigations, the study team recommended a focused application of per-mile tolling, using I-15 for calibration purposes. In obtaining a conservative "ballpark" estimate of revenue, no other aspects of risk or variables related to value capture for access locations or adjoining land parcels were applied in this feasibility study. Such a study may be warranted in the future. The remainder of this chapter addresses a revenue comparison assuming per-mile tolling for the different 8+4 and 10+4 roadway configurations for 2015 and 2030.

6.2 METHODOLOGY

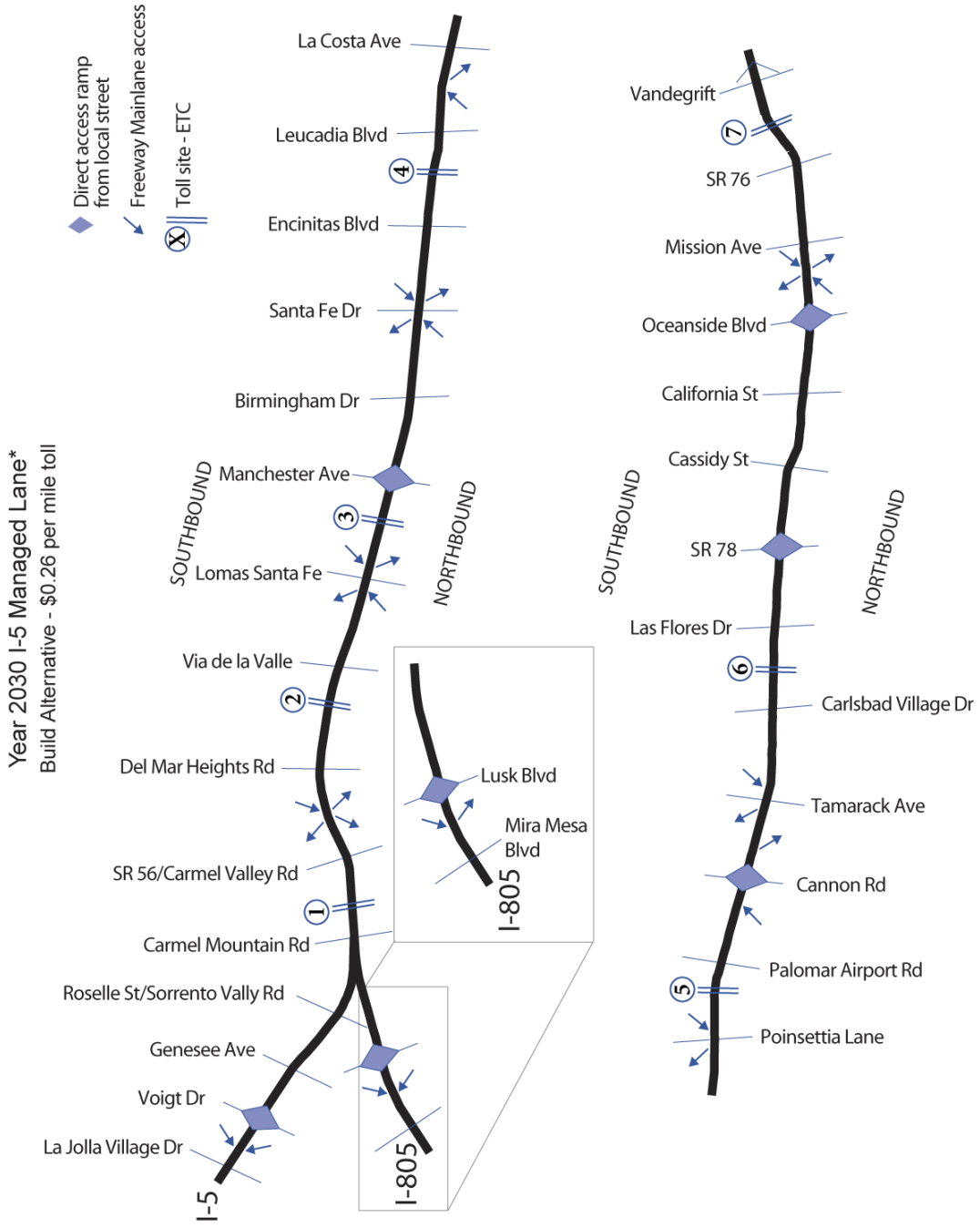
The revenue analysis for the I-5 North Coast Managed Lanes was performed using unadjusted output from the SANDAG regional model at seven mainline tolling locations along the study corridor. The model output provided peak, off-peak and daily traffic volumes segmented into general purpose lane and managed lane trips by vehicle occupancy. These volumes were then broken down into hourly volumes, and hourly toll rates were estimated based on the volume/capacity ratio in the managed lanes based on a throughput goal of no more than 1,650 vehicles/hour/lane. The toll rate structure was based on the structure used on the I-15 Express Lanes in San Diego. Finally, the estimated revenues for each of the seven locations were summed to provide annual revenue estimates for 2015 and 2030 scenarios with "8+4" and "10+4" lane configurations. It is important to note that in the "8+4" configuration, there are three of the seven tolling locations where there are more than eight general purpose lanes (auxiliary lanes have been excluded for this analysis); North of SR 76, I-5 is proposed to have 10 general purpose lanes; south of Via de la Valle I-5 is proposed to have nine general purpose lanes (5SB/4NB); and south of SR 56 I-5 is proposed to have 10 general purpose lanes.

6.2.1. Model Output

The regional model output was used without any adjustments in order to determine the split between managed lane and general purpose lane use. The tolling location and managed lane access points assumed are shown in Figure 6-1. The model assumed a toll cost of $0.10 per mile during off-peak periods and up $0.24 per mile during peak periods (all costs are valued in the base year of 2000).[1] Figure 6-2 is a sample of the model output that was used in the revenue analysis. Model output for the 10+4 and 8+4 configurations was used for 2015 and 2030 at each of the seven tolling locations. A complete set of model outputs can be found in the appendix.

[1] The demand forecast model used tolling assumptions of $0.26 per mile; however, the revenue analysis assumed a toll rate of $0.24 per mile for the 2030 Build Alternative, based on SR 91 validations.

FIGURE 6-1: STUDY AREA AND TOLLING LOCATIONS[2]



[2] The demand forecast model used tolling assumptions of $0.26 per mile; however, the revenue analysis assumed a toll rate of $0.24 per mile.

FIGURE 6-2: SAMPLE REGIONAL MODEL OUTPUT

	Drive Alone		Shared Ride - 2 Person		Shared Ride - 3+ Person			V/C*	Percent of
	Non-Toll	Toll	Non-Toll, Non-HOV	Non-Toll, HOV	Non-Toll, Non-HOV	Non-Toll, HOV	Total	Ratio	LOS C Capacity
AM Peak Period Inbound									
General Purpose Lanes	*30,700*	*200*	*700*	*600*	*200*	*200*	***32,600***	***0.97***	*n/a*
Managed Lanes	*0*	*1,400*	*0*	*3,400*	*0*	*900*	***5,700***	***0.48***	*n/a*
Total Demand of Managed Lane Modes	*--*	*1,600*	*--*	*4,000*	*--*	*1,100*	***6,700***		70%
AM Peak Period Outbound									
General Purpose Lanes	*23,500*	*200*	*800*	*1,000*	*300*	*300*	***26,100***	***0.70***	*n/a*
Managed Lane	*0*	*100*	*0*	*2,800*	*0*	*800*	***3,700***	***0.31***	*n/a*
Total Demand of Managed Lane Modes	*--*	*300*	*--*	*3,800*	*--*	*1,100*	***5,200***		54%
Total AM Peak Period									
General Purpose Lanes	*54,200*	*400*	*1,500*	*1,600*	*500*	*500*	***58,700***	***0.83***	*n/a*
Managed Lanes	*0*	*1,500*	*0*	*6,200*	*0*	*1,700*	***9,400***	***0.39***	*n/a*
Total Demand of Managed Lane Modes	*--*	*1,900*	*--*	*7,800*	*--*	*2,200*	***11,900***		62%

* - modeling capacity

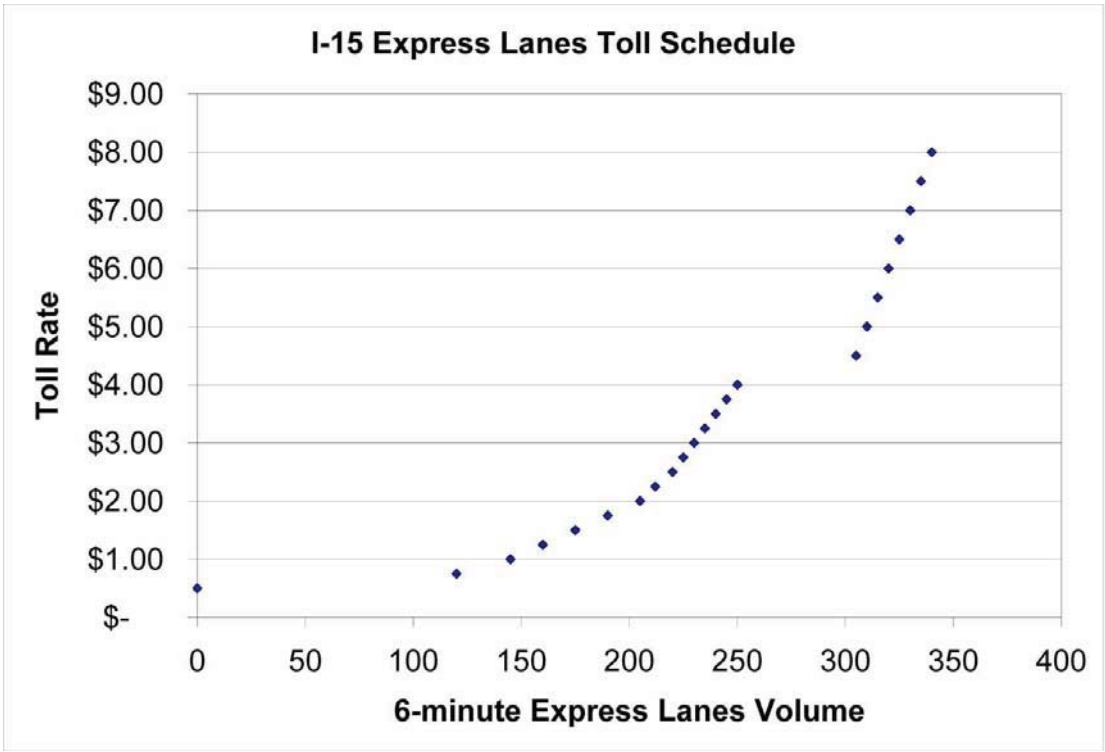
	Drive Alone		Shared Ride - 2 Person		Shared Ride - 3+ Person			V/C*	Percent of
	Non-Toll	Toll	Non-Toll, Non-HOV	Non-Toll, HOV	Non-Toll, Non-HOV	Non-Toll, HOV	Total	Ratio	LOS C Capacity
AM Peak Period Inbound									
General Purpose Lanes	*32,500*	*200*	*800*	*700*	*300*	*200*	***34,700***	***1.03***	*n/a*
Managed Lanes	*0*	*1,800*	*0*	*3,700*	*0*	*1,000*	***6,500***	***0.54***	*n/a*
Total Demand of Managed Lane Modes	*--*	*2,000*	*--*	*4,400*	*--*	*1,200*	***7,600***		79%
AM Peak Period Outbound									
General Purpose Lanes	*21,600*	*200*	*700*	*1,000*	*200*	*300*	***24,000***	***0.65***	*n/a*
Managed Lane	*0*	*100*	*0*	*2,900*	*0*	*900*	***3,900***	***0.33***	*n/a*
Total Demand of Managed Lane Modes	*--*	*300*	*--*	*3,900*	*--*	*1,200*	***5,400***		56%
Total AM Peak Period									
General Purpose Lanes	*54,100*	*400*	*1,500*	*1,700*	*500*	*500*	***58,700***	***0.83***	*n/a*
Managed Lanes	*0*	*1,900*	*0*	*6,600*	*0*	*1,900*	***10,400***	***0.43***	*n/a*
Total Demand of Managed Lane Modes	*--*	*2,300*	*--*	*8,300*	*--*	*2,400*	***13,000***		68%

* - modeling capacity

6.2.2. Tolling Rates

The I-15 Express Lanes in San Diego were used as a basis for generating the tolling curves and the toll rate relationships factored to percent capacity on the toll facility. The I-15 Express Lanes toll rates are monitored based on the volume over capacity (v/c) ratio in the lanes. Figure 6-3 shows the relationship between six-minute average volumes on the I-15 Express Lanes and the toll rates that are charged to single occupancy vehicles (SOV).

FIGURE 6-3: OBSERVED I-15 DATA POINTS



This relationship between managed lane v/c rates and toll rates were then translated to apply to the I-5 North Coast managed lanes assuming variable pricing of these lanes. Base (off-peak) tolls were calculated based on the distance between tolling locations using the $0.10 per mile rate assumed in the model. The following figure shows the off-peak SOV toll rates for 2000, 2015, and 2030, rounding tolls to the nearest 25-cent increment and assuming a three percent annual inflation rate.

FIGURE 6-4: OFF-PEAK BASE TOLL RATES

Location	**Mileage** (miles)	**2000** 10¢/mile	**2015** 16¢/mile	**2030** 24¢/mile
s/o SR 56	4.5	$0.50	$0.75	$1.00
s/o Via de la Valle	3.9	$0.50	$0.50	$1.00
s/o Manchester Ave	1.2	$0.25	$0.25	$0.25
n/o Encinitas Blvd	5.5	$0.50	$1.00	$1.25
s/o Palomar Airport Rd	3.9	$0.50	$0.50	$1.00
n/o Carlsbad Village Dr	3.8	$0.50	$0.50	$1.00
n/o SR 76	2.6	$0.25	$0.50	$0.50
TOTAL	25.4	$3.00	$4.00	$6.00

These base toll rates were used during times of very low use on the managed lanes (corresponding to 0-100 vehicles per hour using Figure 6-3). As volumes in the corridor increase, the managed lane volumes also increase, and the toll rates are adjusted upward based on the relationship shown in Figure 6-3. Figure 6-5 shows the resulting average hourly toll rates that were used during the peak hour (northbound) in 2015 (10+4 and 8+4 configurations). Each hour's toll rate structure varies based on the level of congestion in the managed lanes. Portions of the project with higher congestion, such as the southern section near SR 56, have a higher toll rate per mile. These rates are only charged to customers who are driving alone; all vehicles carrying two or more people travel in the managed lanes for free based on current occupancy policies.

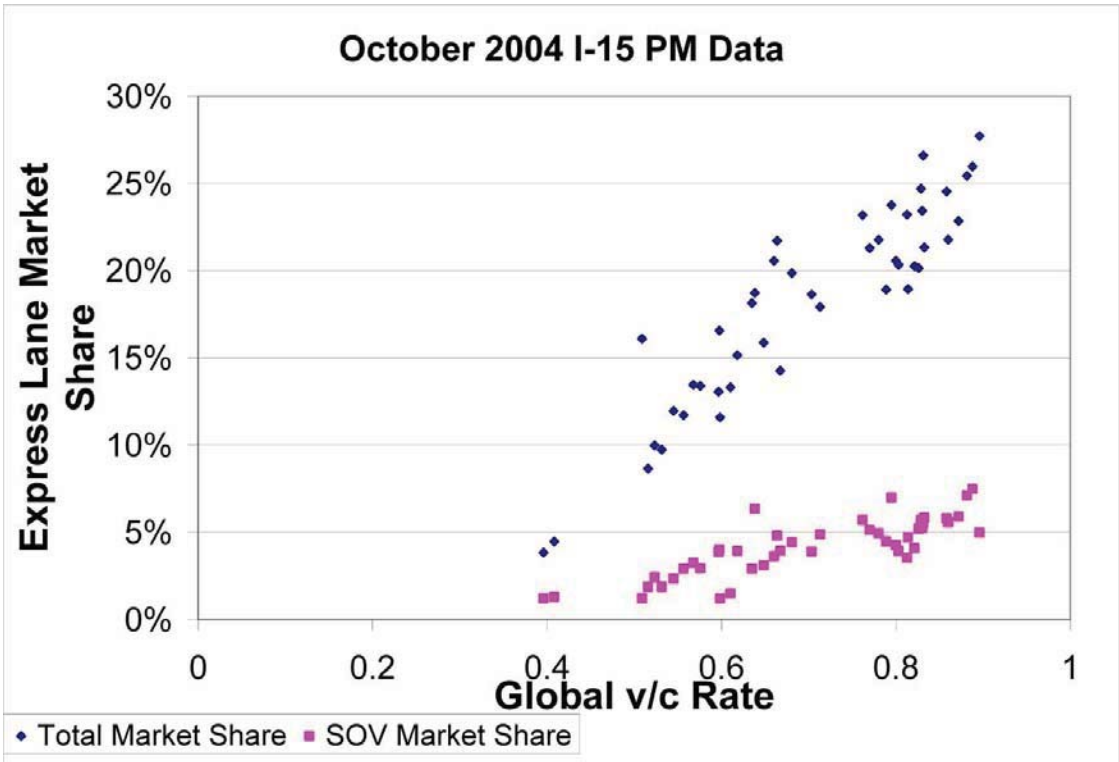
FIGURE 6-5: 2015 10+4 AND 8+4 CONFIGURATION TOLL RATES

	10+4		**8+4**	
	2015		**2015**	
Location	Off-peak	NB Peak	Off-peak	NB Peak
s/o SR 56	$0.75	$4.90	$0.75	$5.50
s/o Via de la Valle	$0.50	$3.25	$0.50	$3.25
s/o Manchester Ave	$0.25	$1.50	$0.25	$2.00
n/o Encinitas Blvd	$1.00	$2.50	$1.00	$2.50
s/o Palomar Airport Rd	$0.50	$0.75	$0.50	$0.75
n/o Carlsbad Village Dr	$0.50	$0.50	$0.50	$0.50
n/o SR 76	$0.50	$0.50	$0.50	$0.50
TOTAL	$4.00	$13.90	$4.00	$15.00

6.2.3. Tolling Curves

The volume of traffic using the managed lanes is determined by using the regional model output. However, since the revenue model requires hourly volume input (rather than by period), tolling curves must be generated to develop a relationship between total corridor v/c rates and the use of the managed lanes by both SOV and HOV trips. The basis of these curves is application of observed market share rates and global v/c data from the I-15 Express Lanes, as shown in Figure 6-6. As the overall (global) volume in the corridor increases, the share of total traffic using the managed lanes increases. Since managed lanes are intended to benefit carpools, the majority of the users will be HOVs, and a smaller share will pay the toll to use as an SOV.

FIGURE 6-6: I-15 EXPRESS LANE MARKET SHARE CURVE



The basic shape of total market share, as shown below in Figure 6-7, was applied to each of the tolling locations on the I-5 corridor. The total market share curve for each location is slightly different, depending on the mix of HOV and SOV managed lane use that was projected by the regional model. Figure 6-7 shows a generic total market share curve, and the curves in Figures 6-8 and 6-9 show the varying curve types by time of day and location for FasTrak™ (paying) customers, HOV, and total market share. While each year and configuration have similar curves, each are unique in order to match the regional model output.

FIGURE 6-7: SAMPLE MANAGED LANE MARKET SHARE CURVE

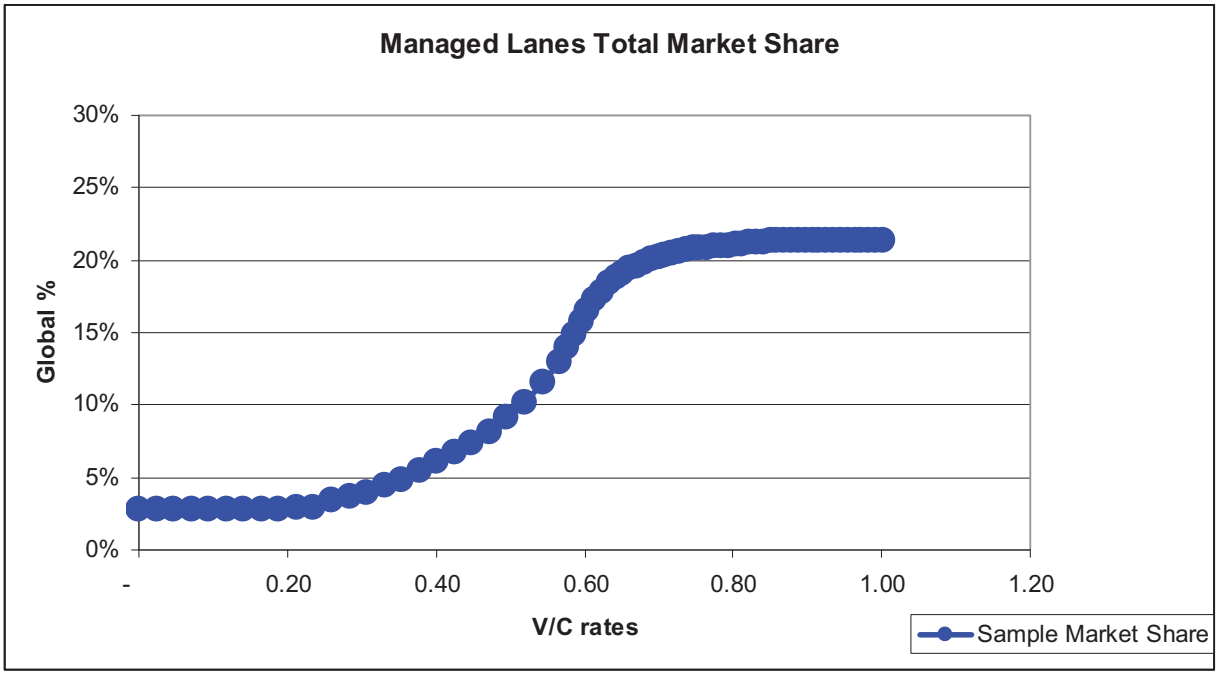
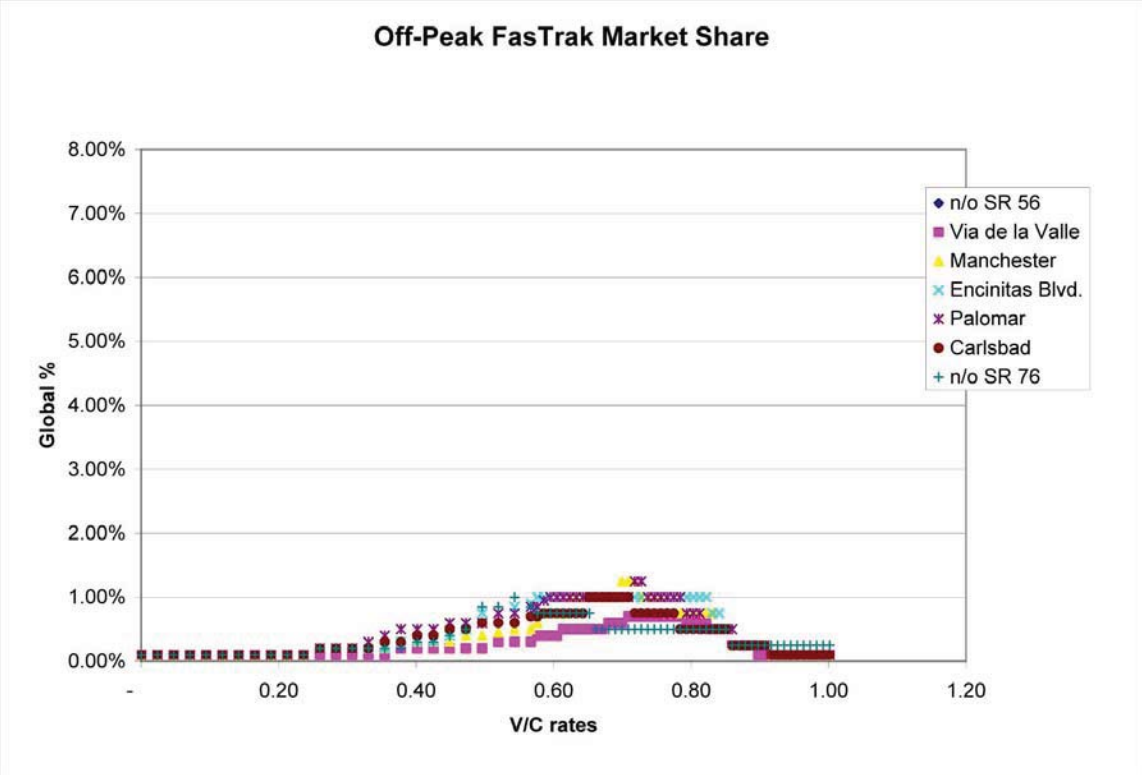
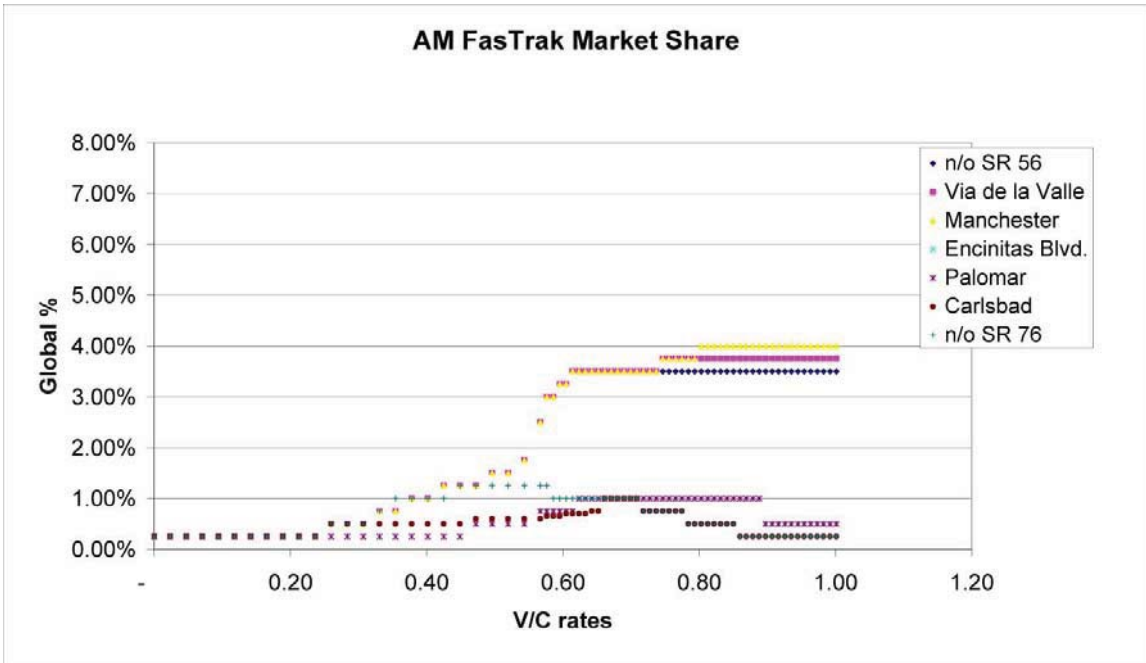
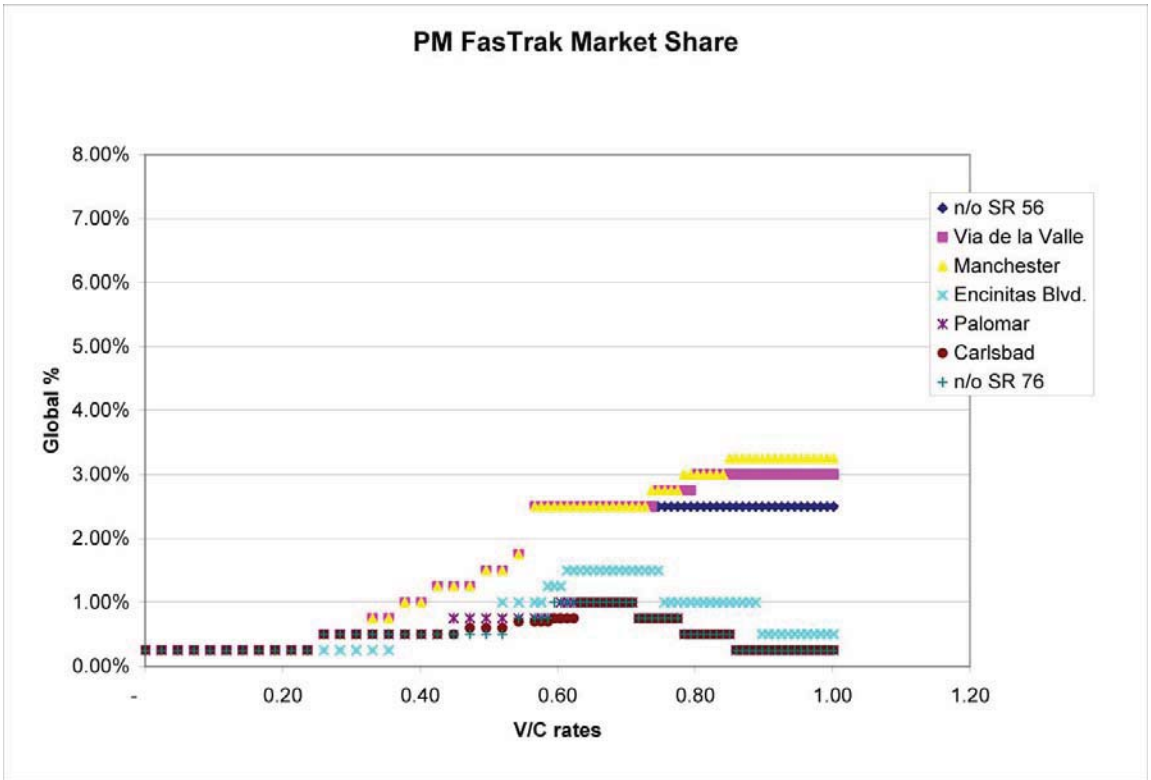
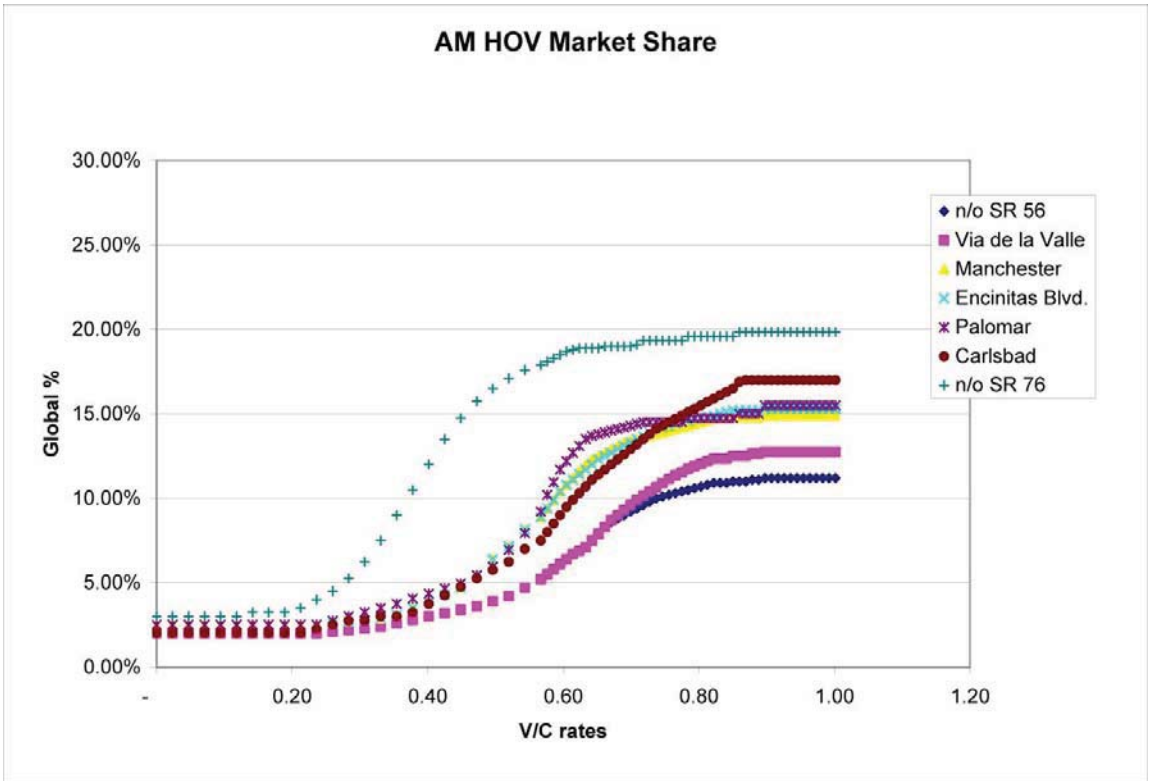


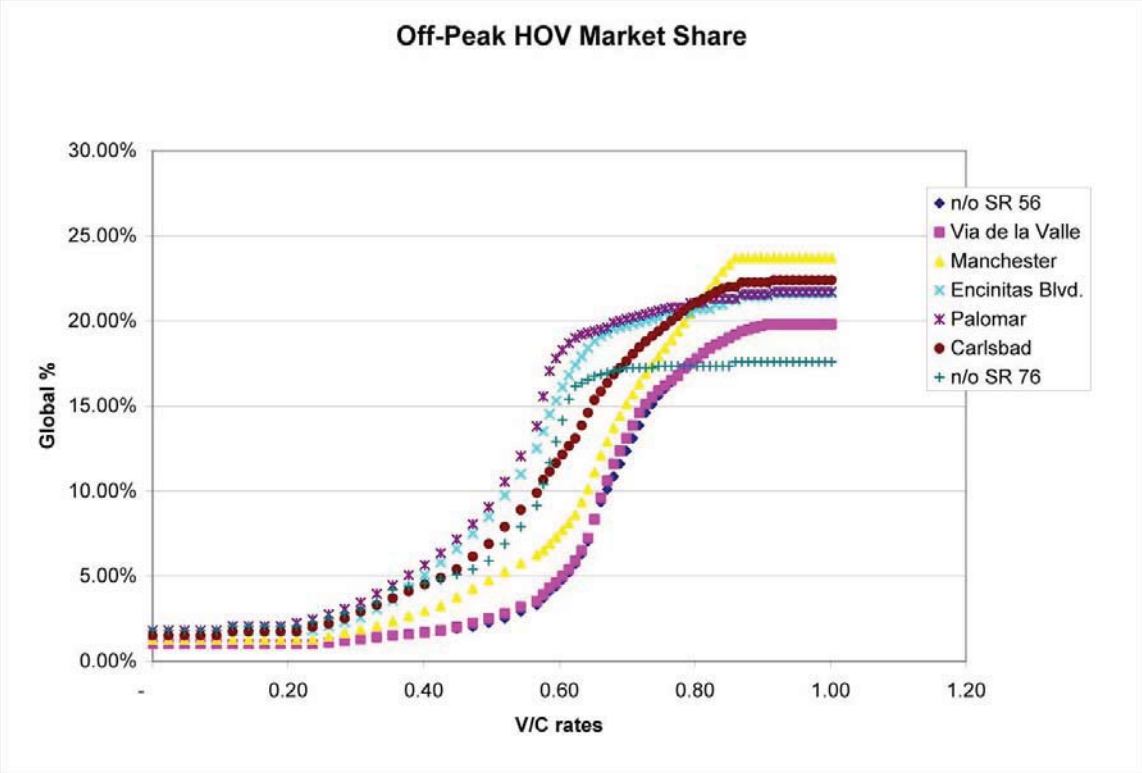
FIGURE 6-8: 2030 10+4 FASTRAK, HOV, AND TOTAL MARKET SHARE CURVES BY LOCATION

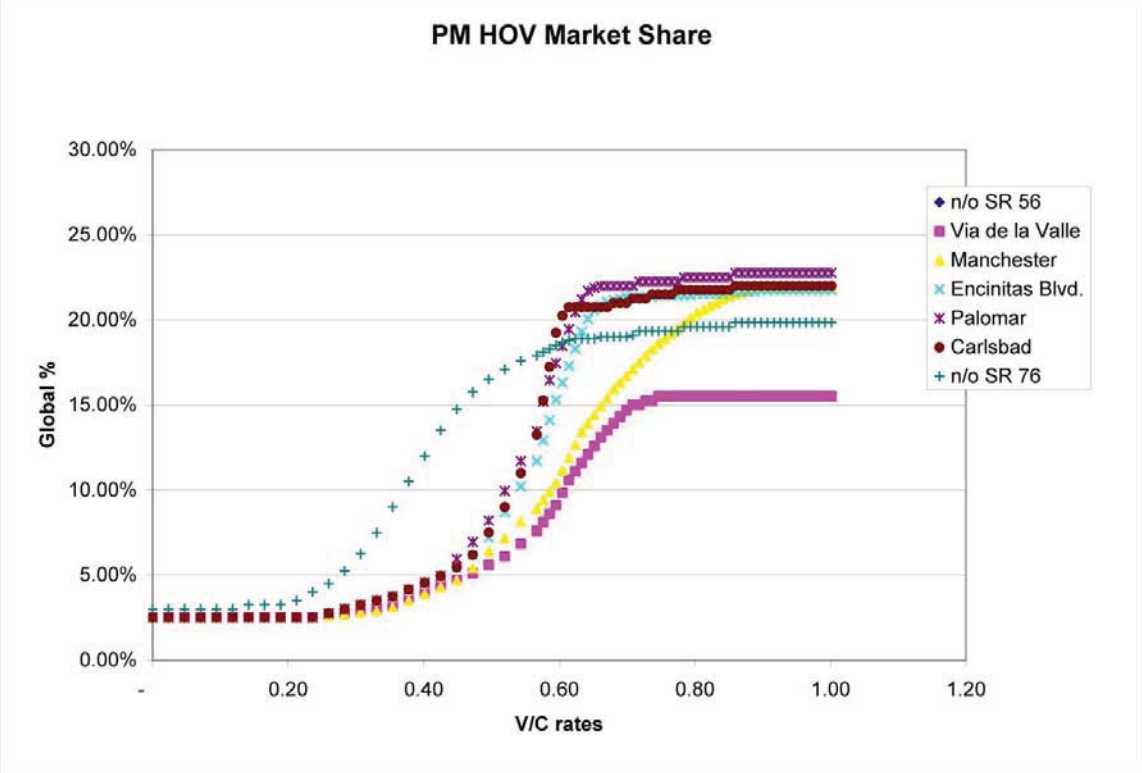


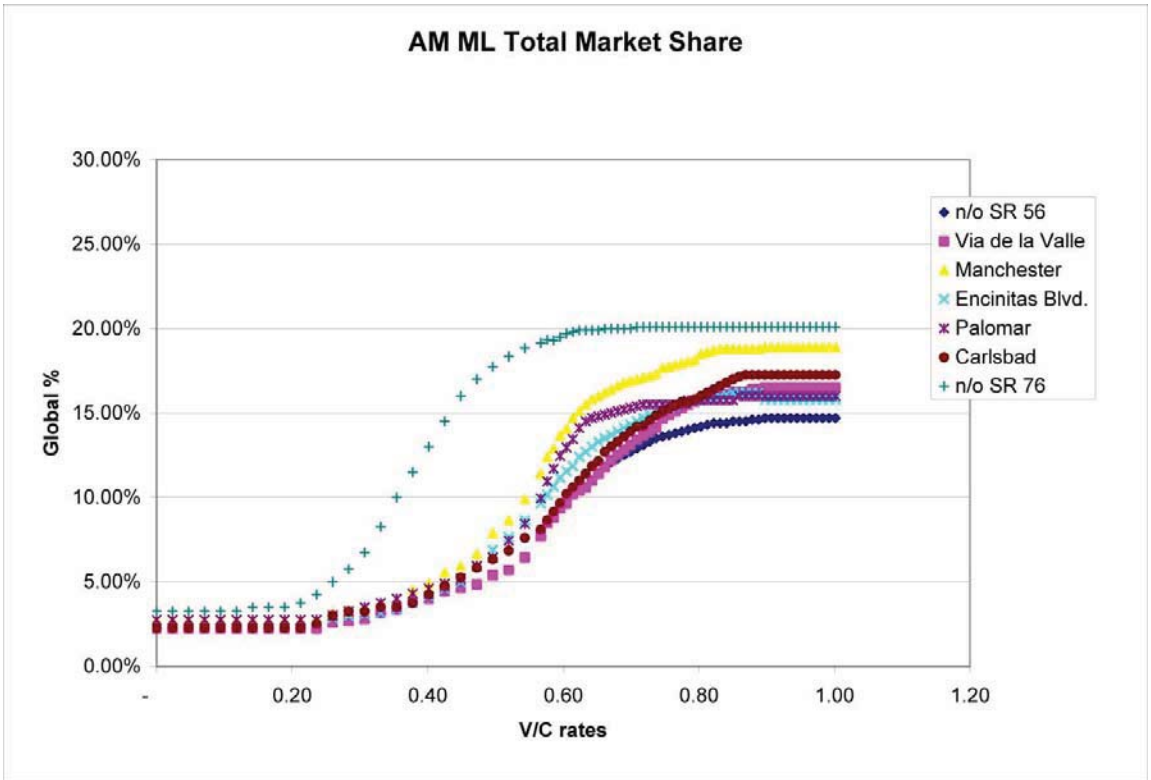


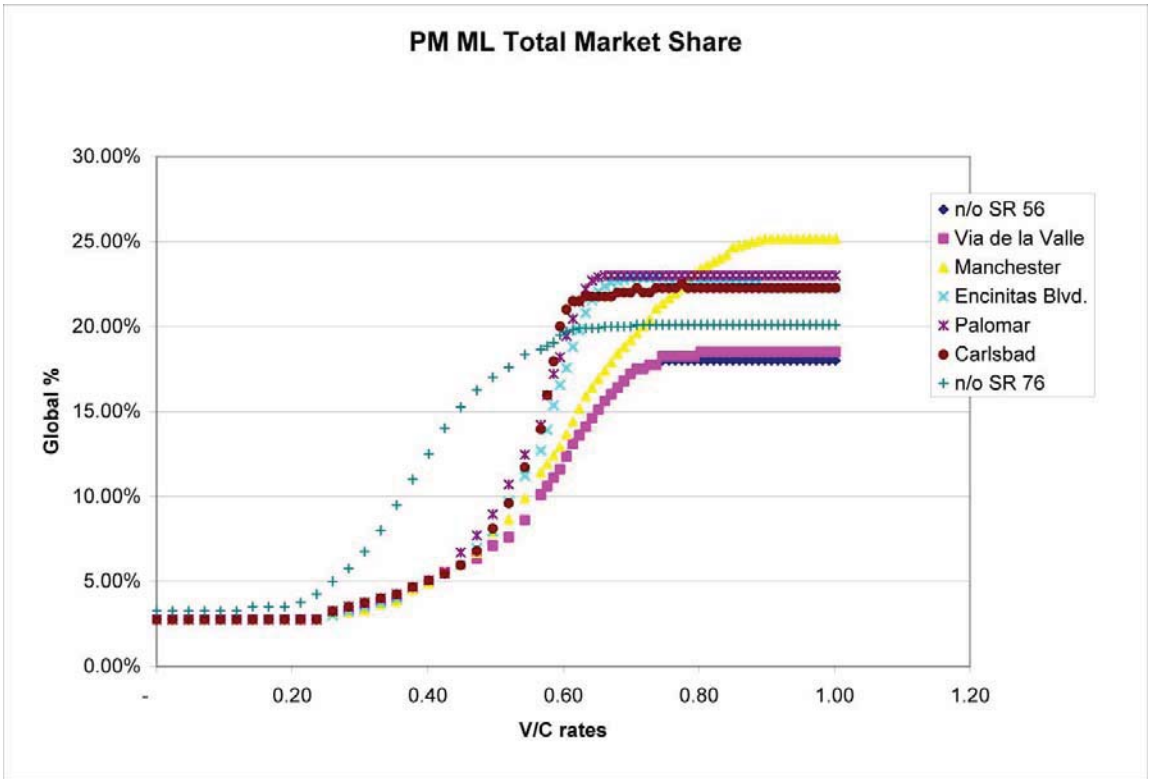

PM FasTrak Market Share
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


AM HOV Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


Off-Peak HOV Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


PM HOV Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


AM ML Total Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


PM ML Total Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76

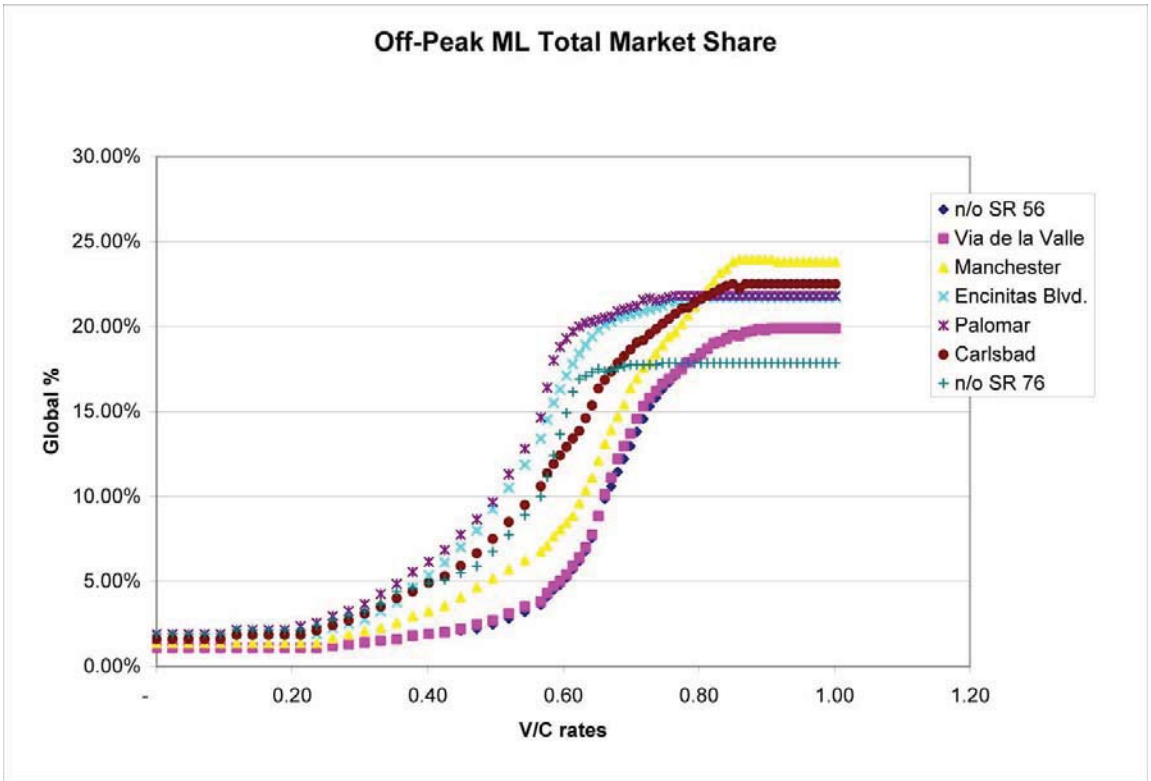
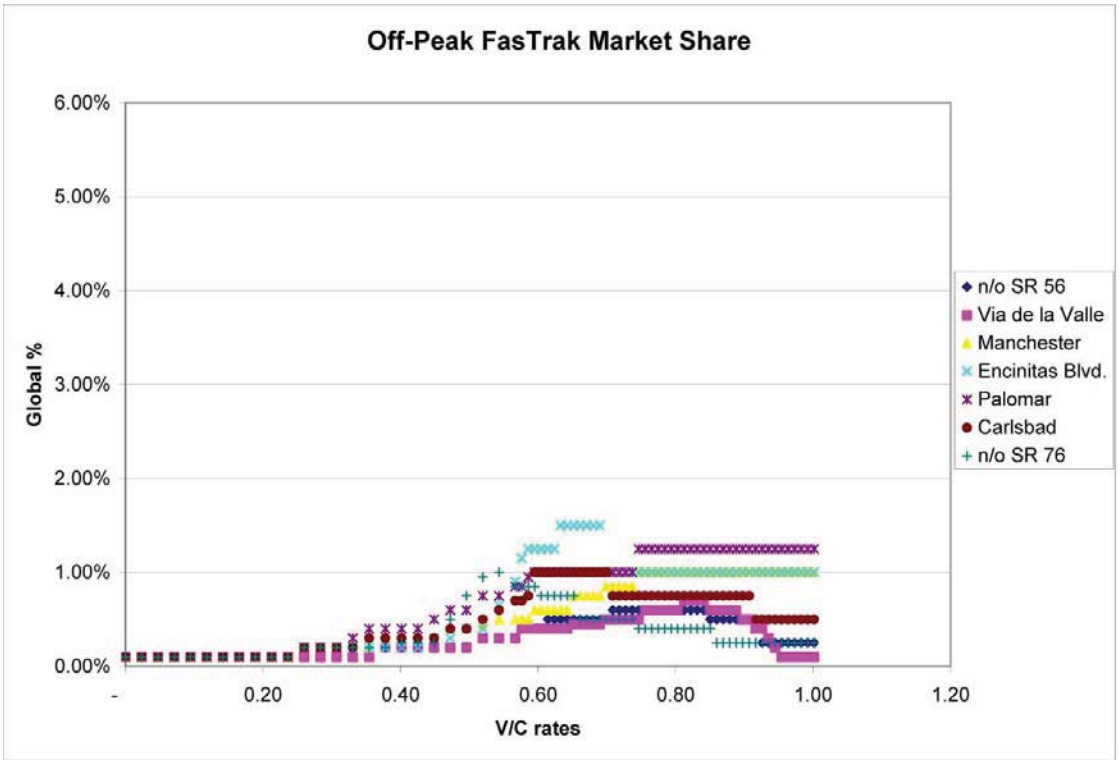
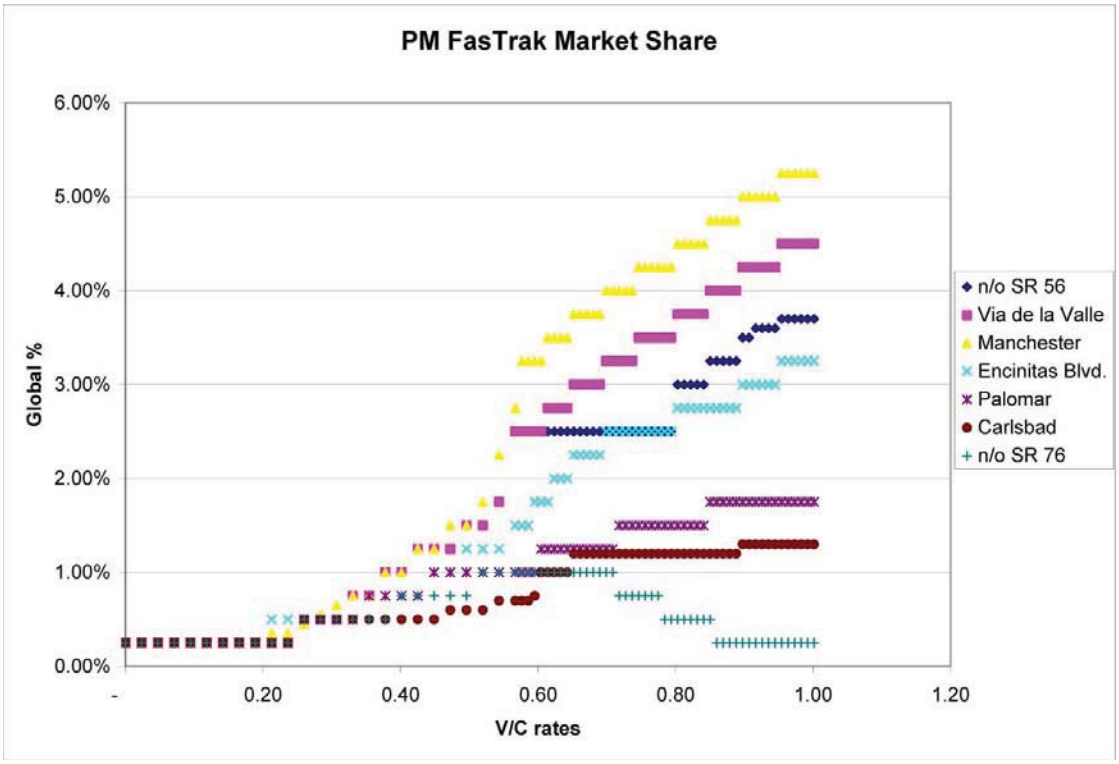
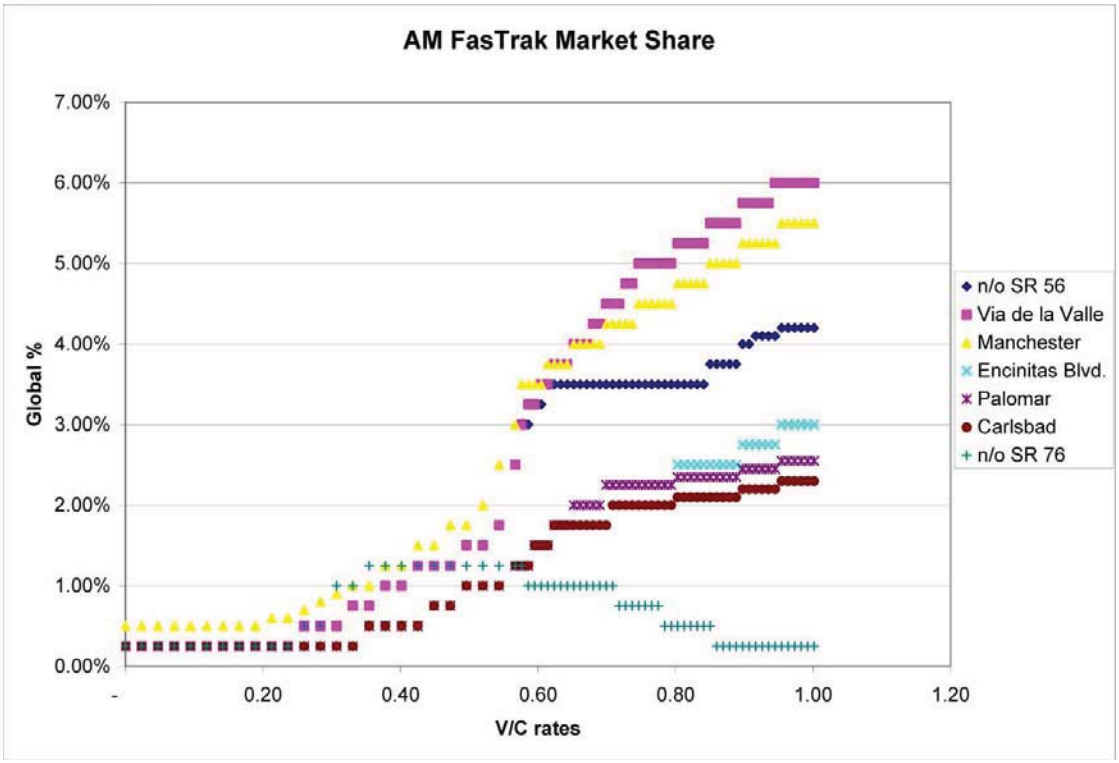
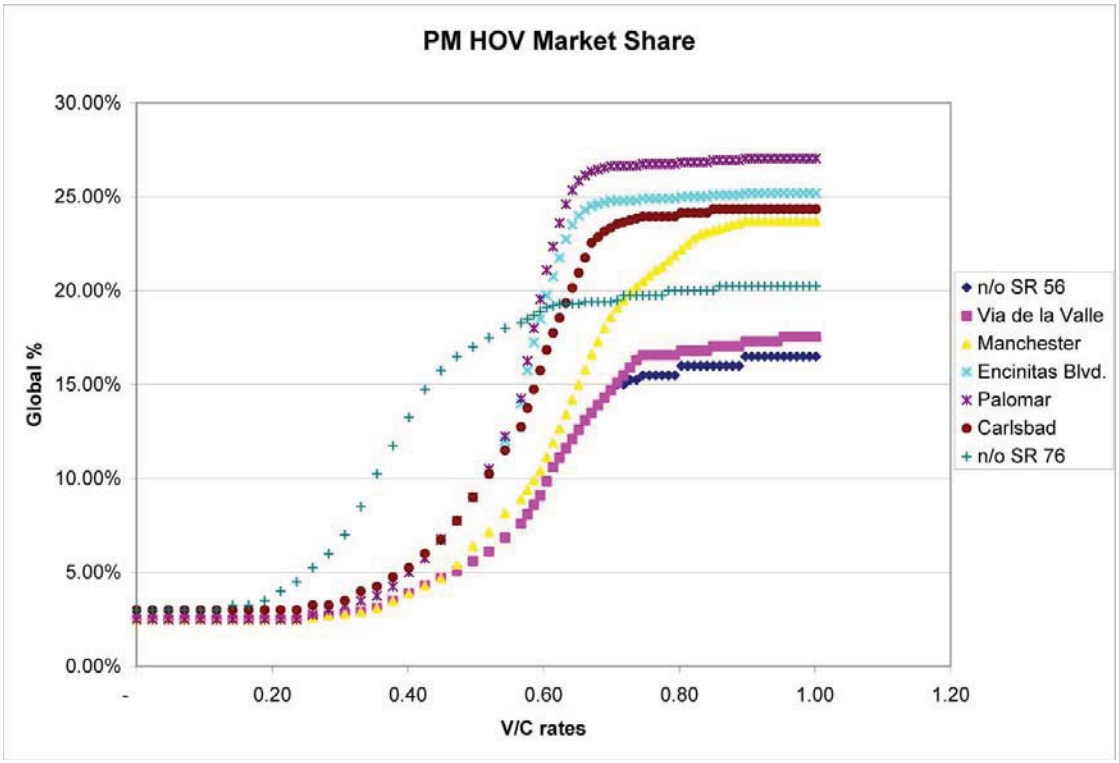

Off-Peak ML Total Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76

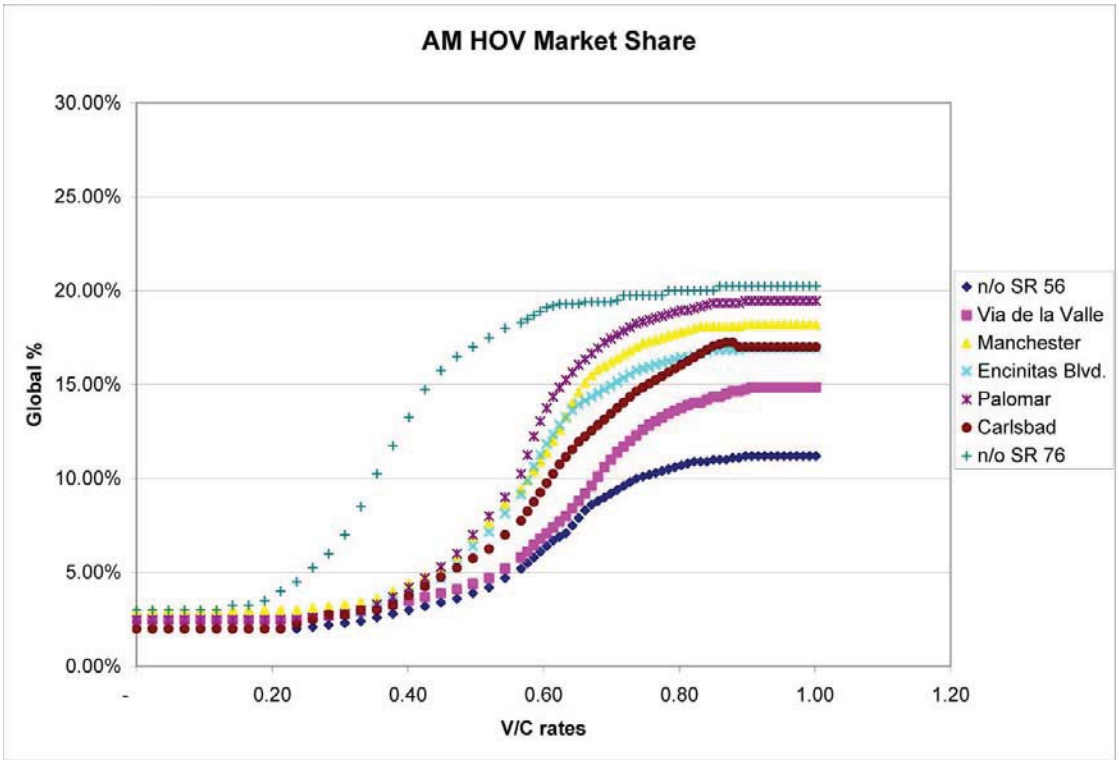
FIGURE 6-9: 2030 8+4 FASTRAK, HOV, AND TOTAL MARKET SHARE CURVES BY LOCATION

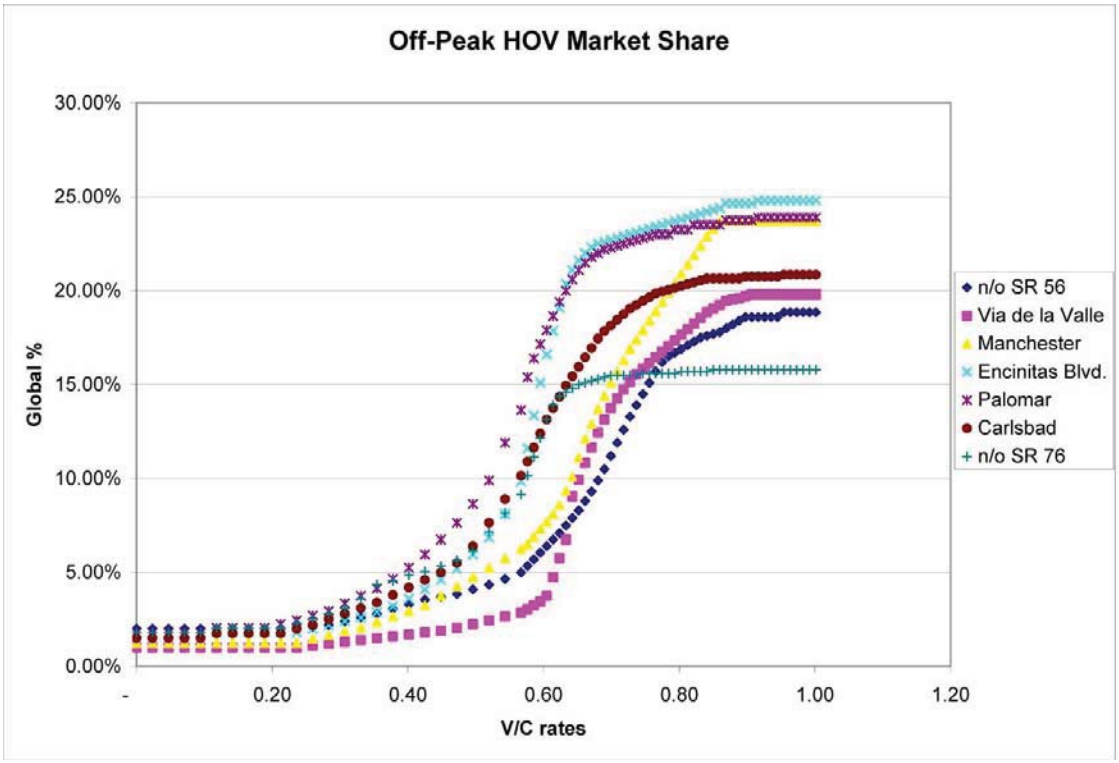


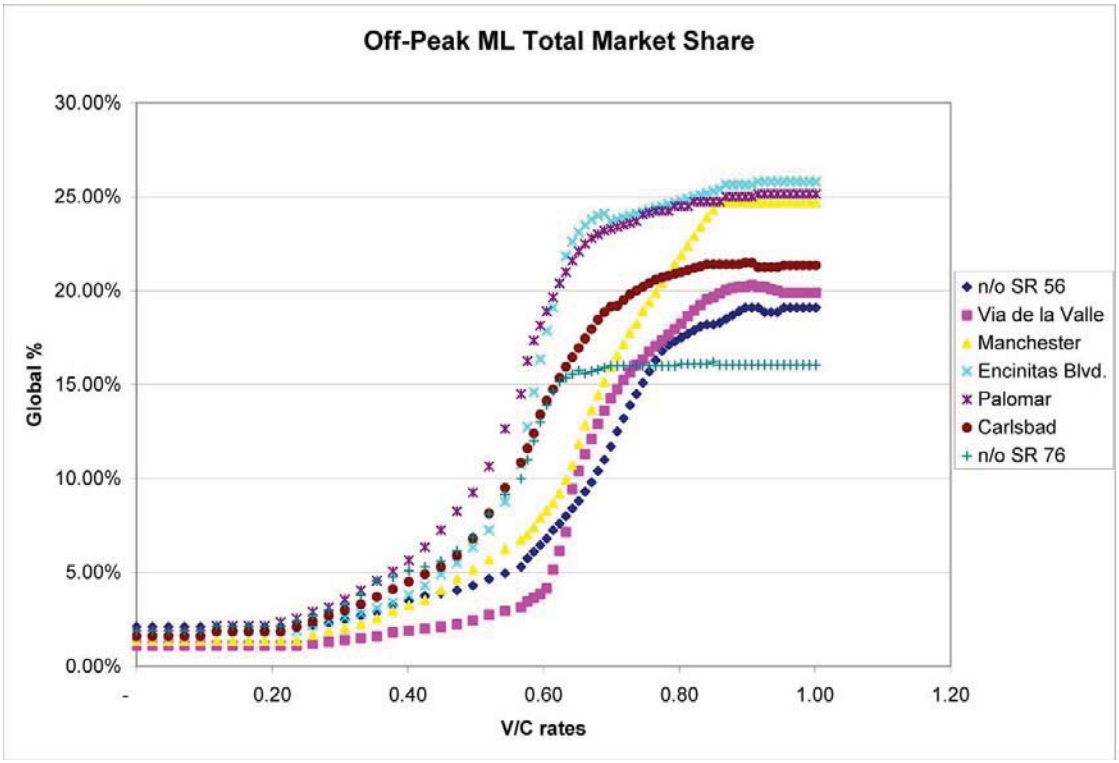


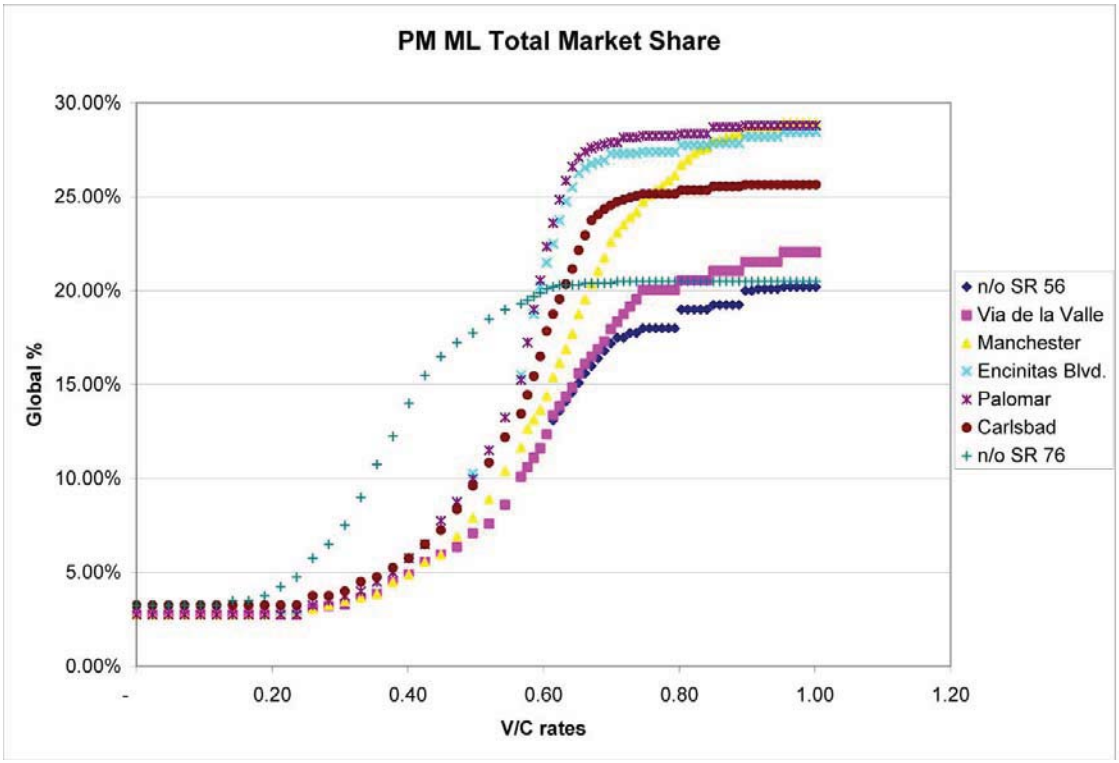

AM FasTrak Market Share
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76

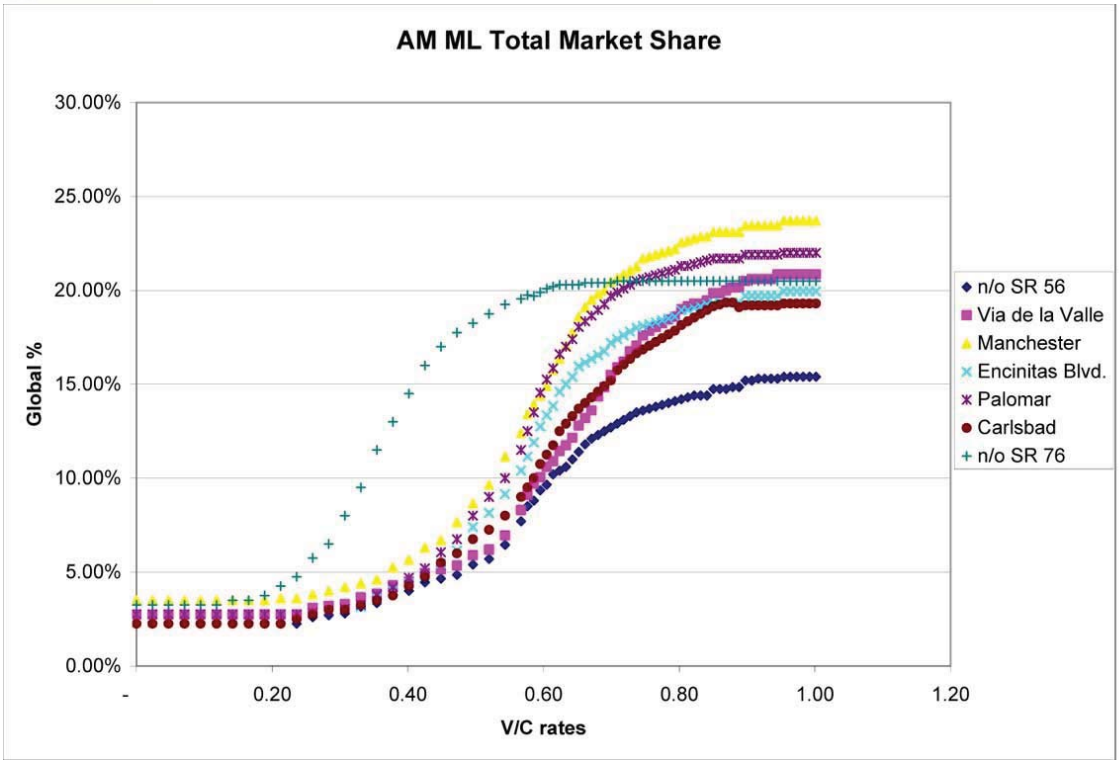

PM HOV Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


AM HOV Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


Off-Peak HOV Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


Off-Peak ML Total Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


PM ML Total Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76


AM ML Total Market Share
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Global %
-
0.20
0.40
0.60
0.80
1.00
1.20
V/C rates
n/o SR 56
Via de la Valle
Manchester
Encinitas Blvd.
Palomar
Carlsbad
n/o SR 76

6.3 ASSUMPTIONS

The regional model was assumed to effectively distribute the SOV and HOV trips between the managed lanes and the general purpose lanes. These volumes were used in the revenue analysis without adjustment. The HOV definition included vehicles with two or more people, unless discussed otherwise.

A key assumption that should be noted is that all SOVs who are required to have a transponder to pay the toll were equipped with a transponder. In a corridor such as I-5, there are many through trips that do not regularly travel the road and will not know the tolling system. There was no reduction taken for vehicles without transponders or valid accounts for payment. In addition, it was assumed that HOVs did *not* require a registered transponder to use the managed lanes facility. On facilities such as the 91 Express Lanes in Orange/Riverside County, California, all vehicles who travel on the Express Lanes are required to have a valid transponder in their vehicle to use the facility; even HOVs who use the facility for free during most times of the day.

6.4 FORECASTED TOLL REVENUE

Revenue forecasts were created for four build scenarios

- 2015 8+4
- 2015 10+4
- 2030 8+4, and
- 2030 10+4

Unadjusted model output for each of the scenarios was used to develop SOV and HOV market share curves, to simulate the hourly traffic conditions. Daily and annual revenues were then generated based on these hourly distributions. Revenues are presented in year of expenditure dollars unless stated otherwise.

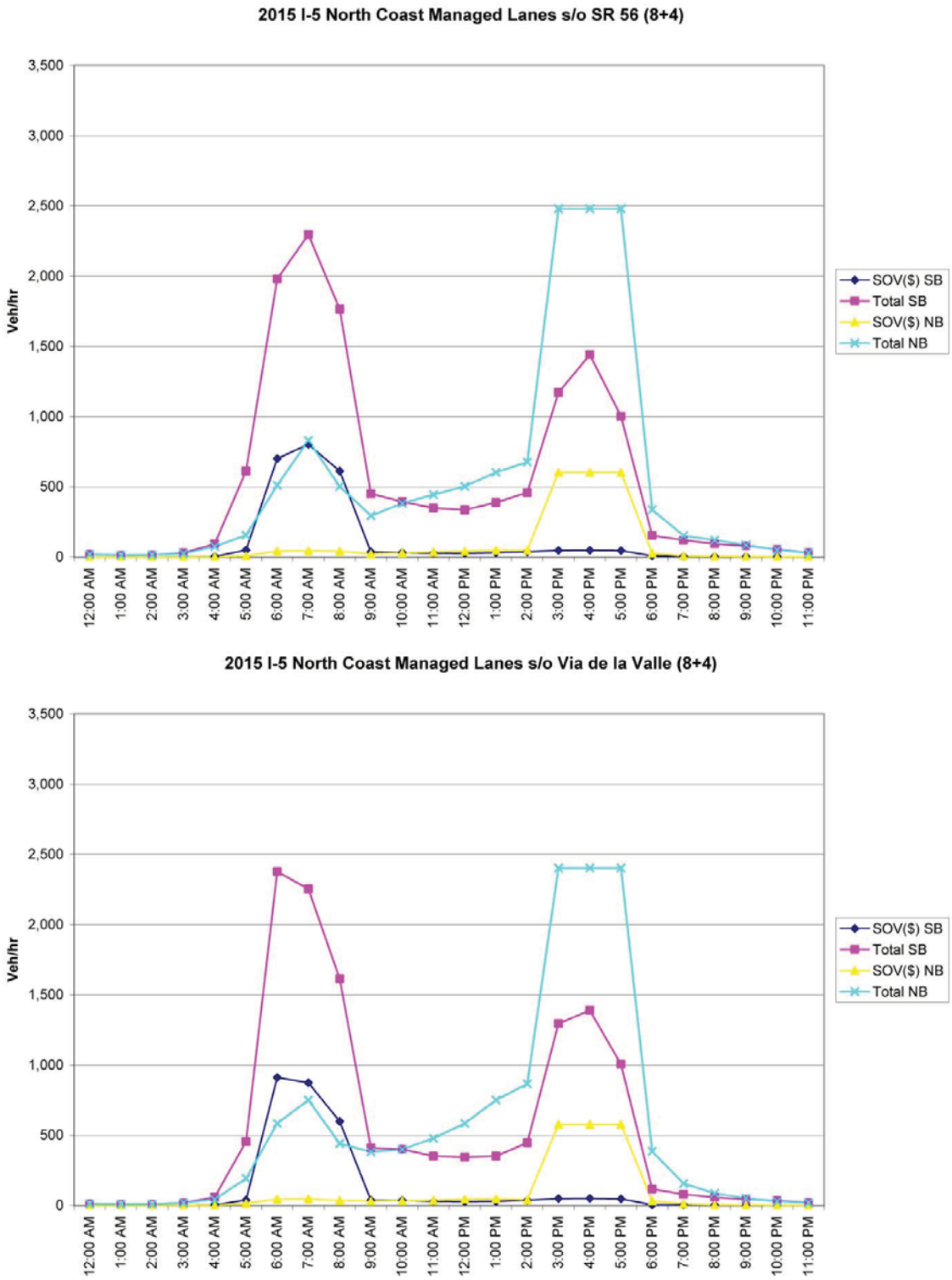
6.4.1. Intermediate Year 2015

Volume by Segment

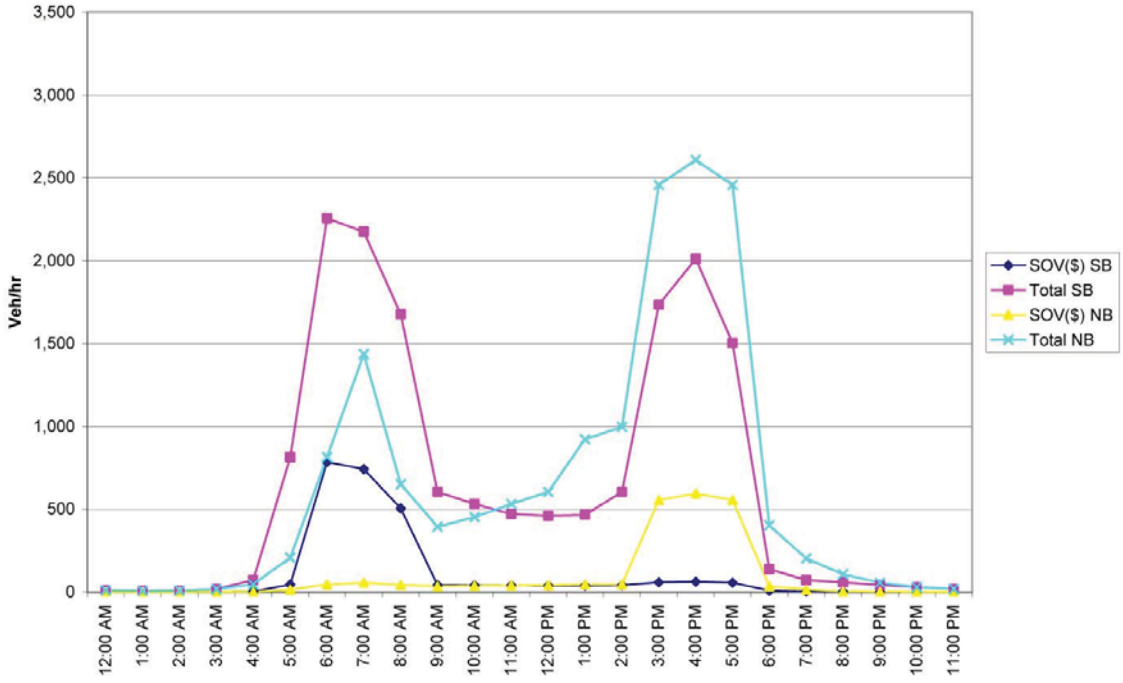
The following graphs show the hourly volumes at each of the tolling locations for 2015 for the “8+4” configuration with eight general purpose lanes and four managed lanes (Figure 6-10) (Modifications in lane configurations are discussed in the Methodology section in this chapter.); and for the “10+4” configuration with ten general purpose lanes and four managed lanes (Figure 6-11).

Volumes in the southern portion of the study area have higher corridor volumes, which are shown by the greater use of the managed lanes. As the volumes decrease further to the north, the managed lane use decreases.

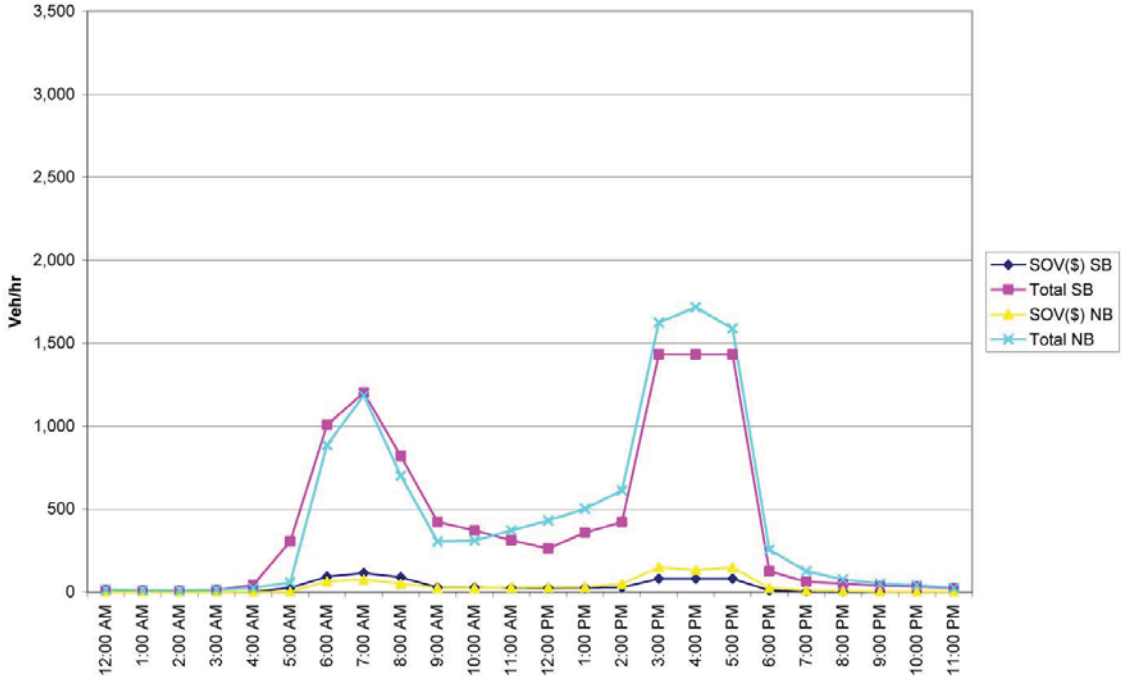
FIGURE 6-10: 2015 MANAGED LANES HOURLY TRAFFIC VOLUMES (8+4 CONFIGURATION)



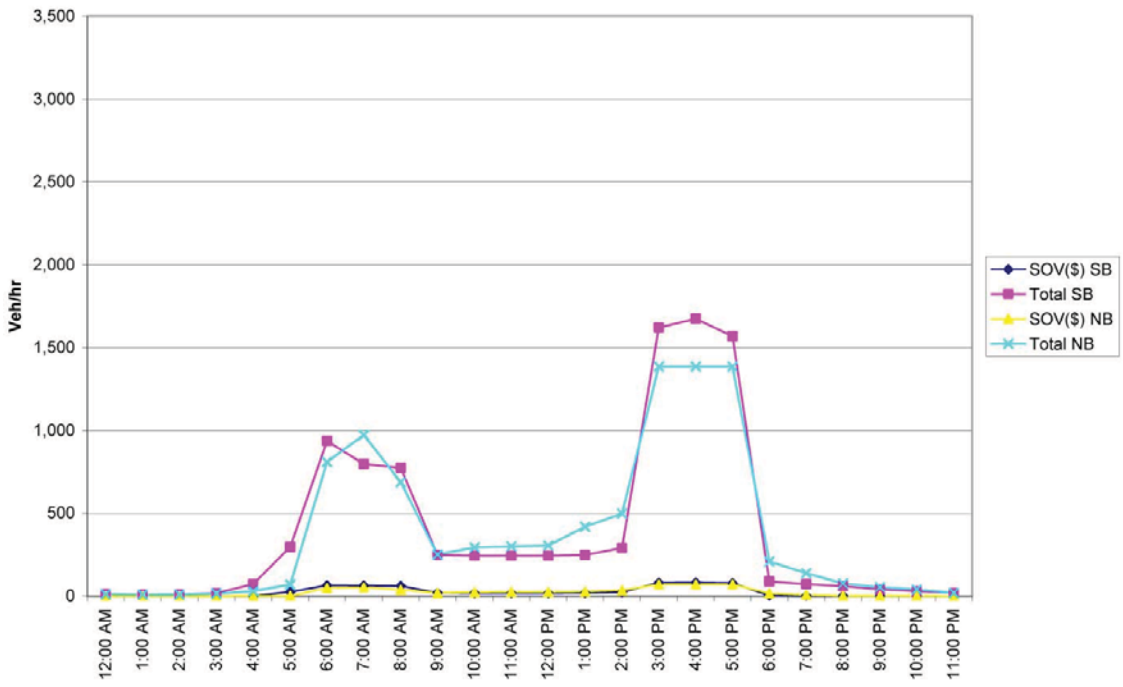
2015 I-5 North Coast Managed Lanes s/o Manchester Ave (8+4)



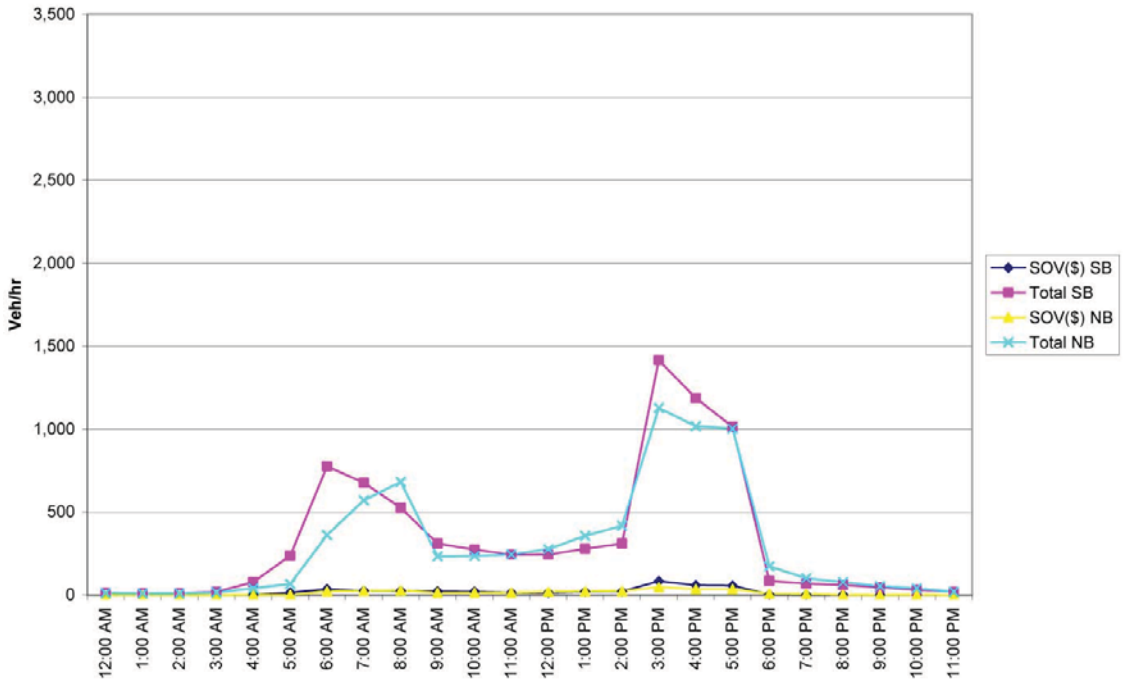
2015 I-5 North Coast Managed Lanes n/o Encinitas Blvd. (8+4)



2015 I-5 North Coast Managed Lanes s/o Palomar Airport Rd (8+4)



2015 I-5 North Coast Managed Lanes n/o Carlsbad Village Dr (8+4)



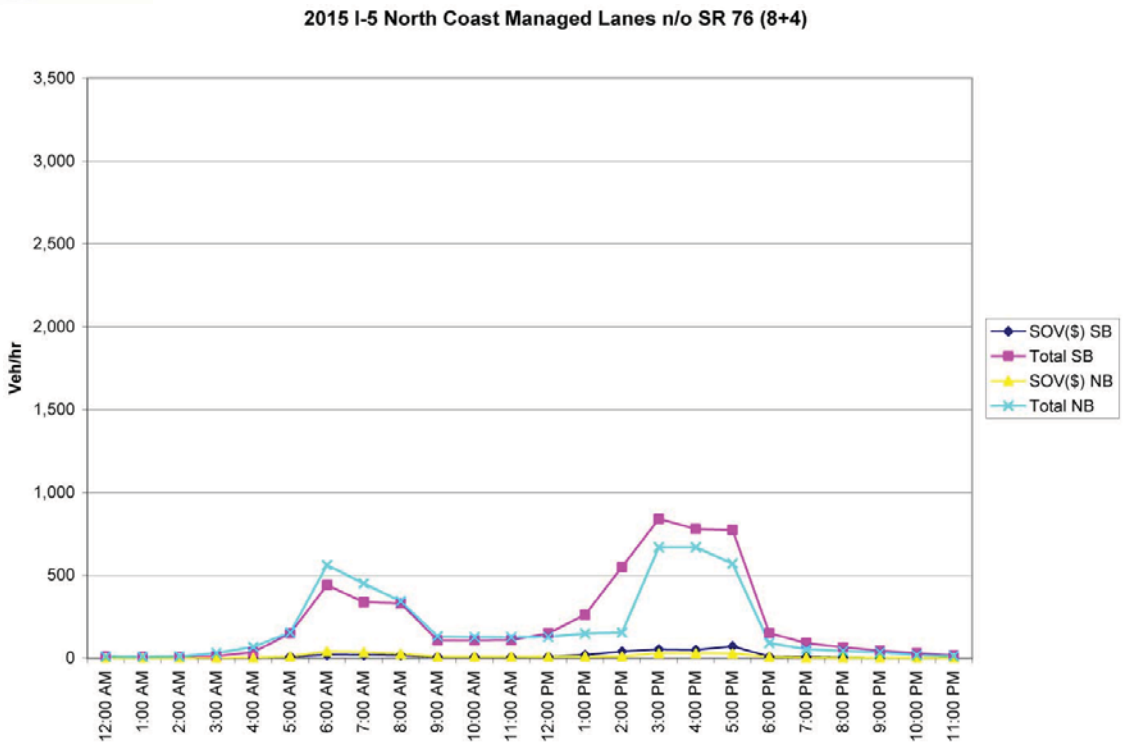
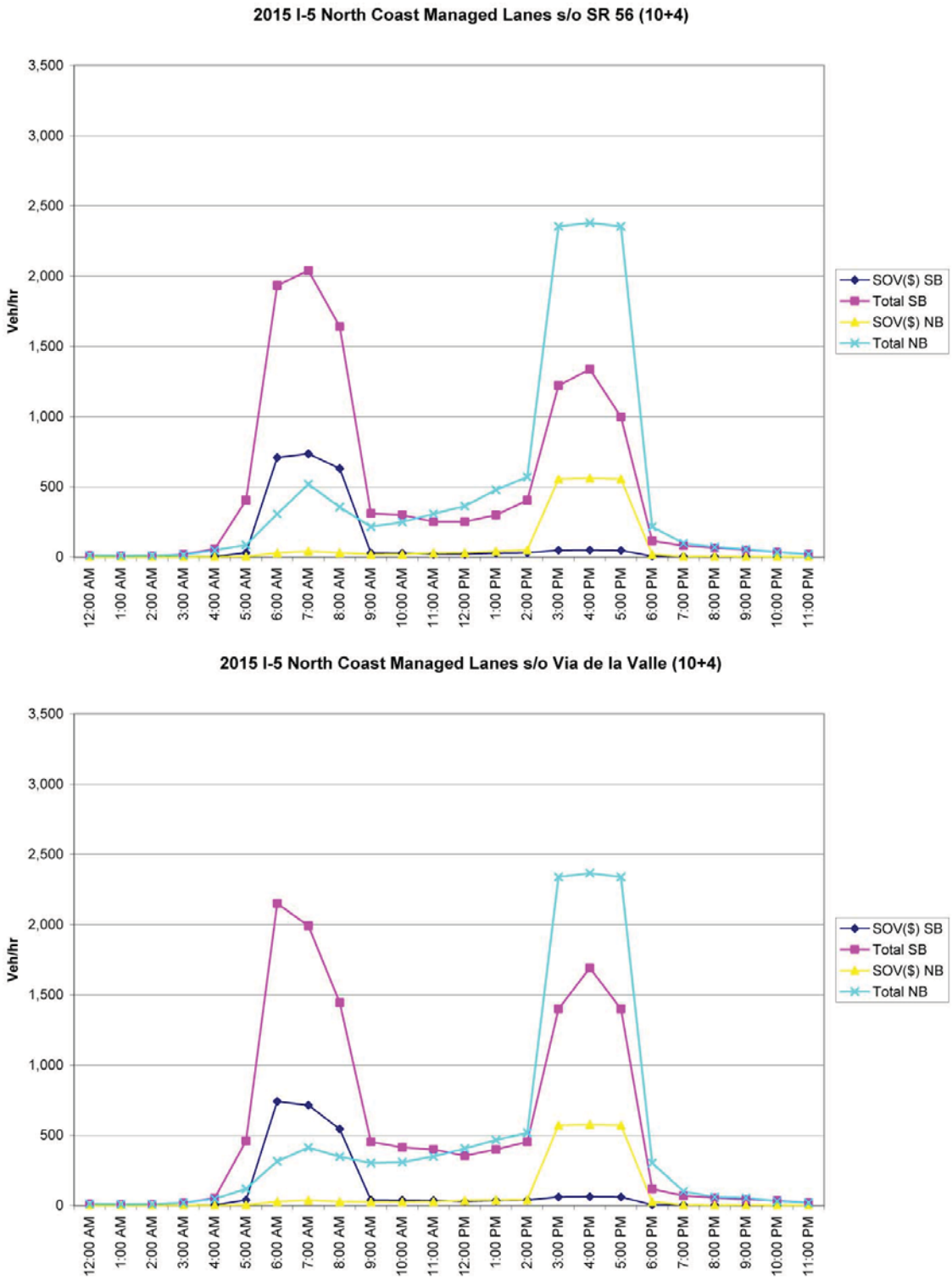
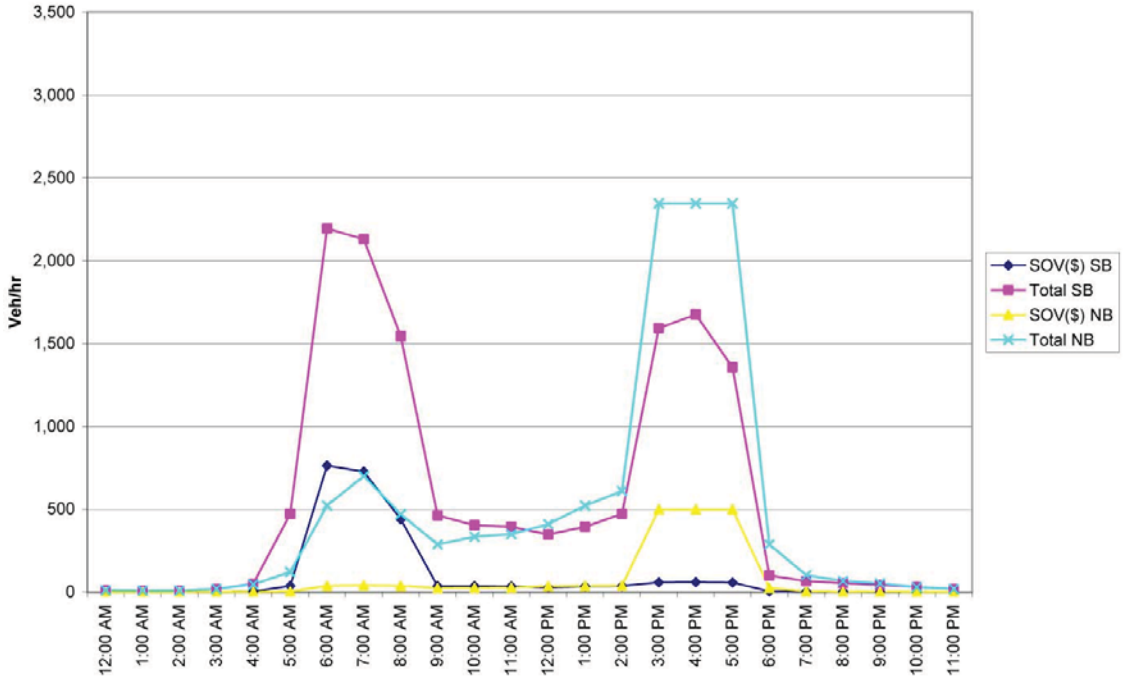

2015 I-5 North Coast Managed Lanes n/o SR 76 (8+4)
Veh/hr
3,500
3,000
2,500
2,000
1,500
1,000
500
0
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM
SOV($) SB
Total SB
SOV($) NB
Total NB

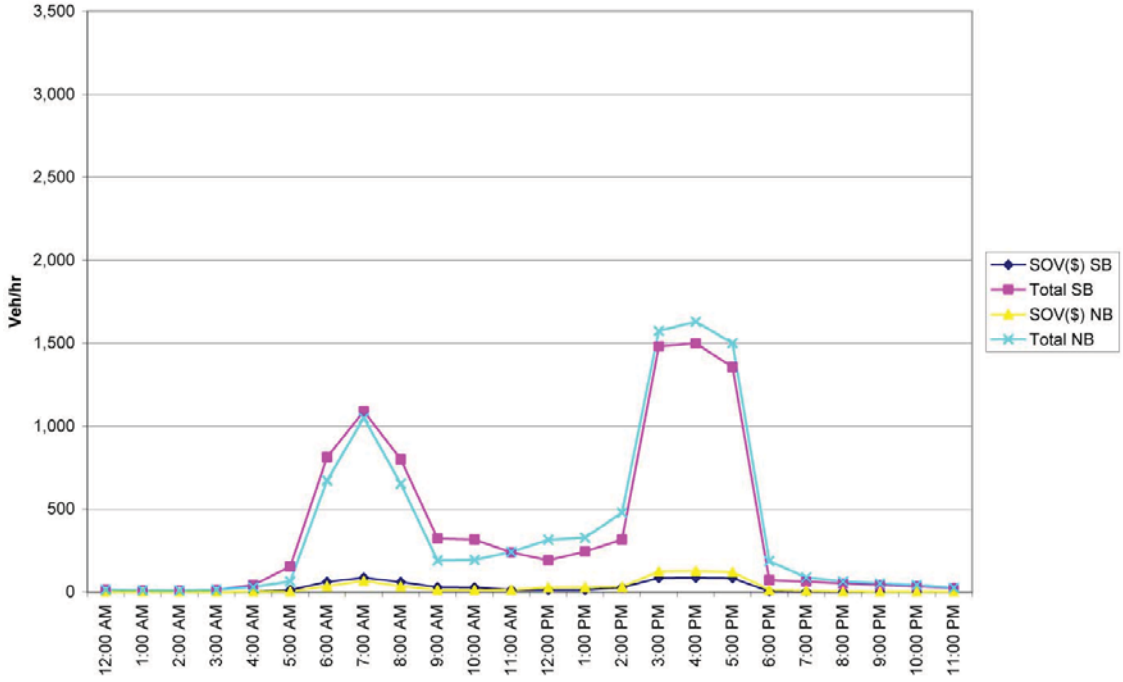
FIGURE 6-11: 2015 MANAGED LANES HOURLY TRAFFIC VOLUMES (10+4 CONFIGURATION)



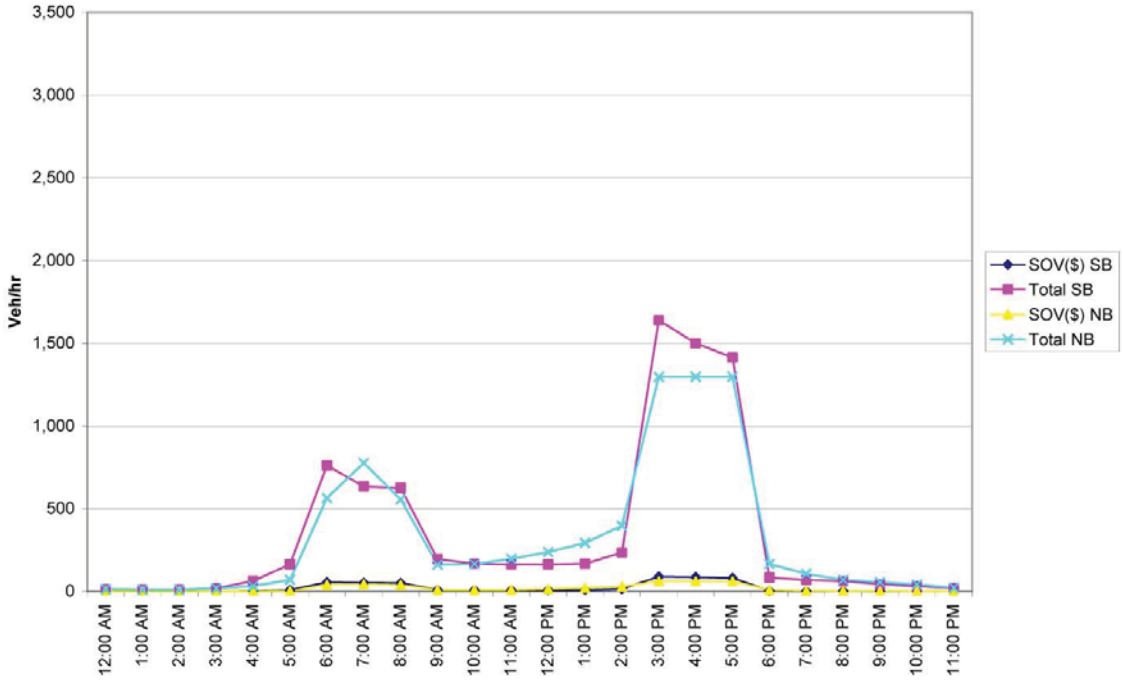
2015 I-5 North Coast Managed Lanes s/o Manchester Ave (10+4)



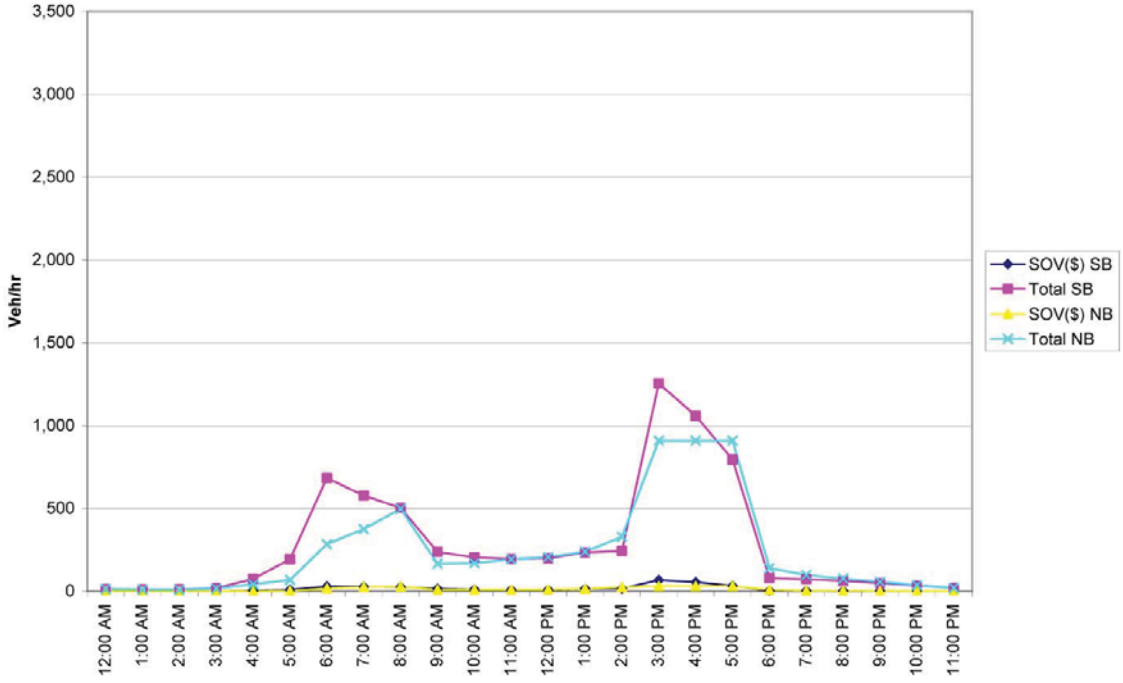
2015 I-5 North Coast Managed Lanes n/o Encinitas Blvd. (10+4)

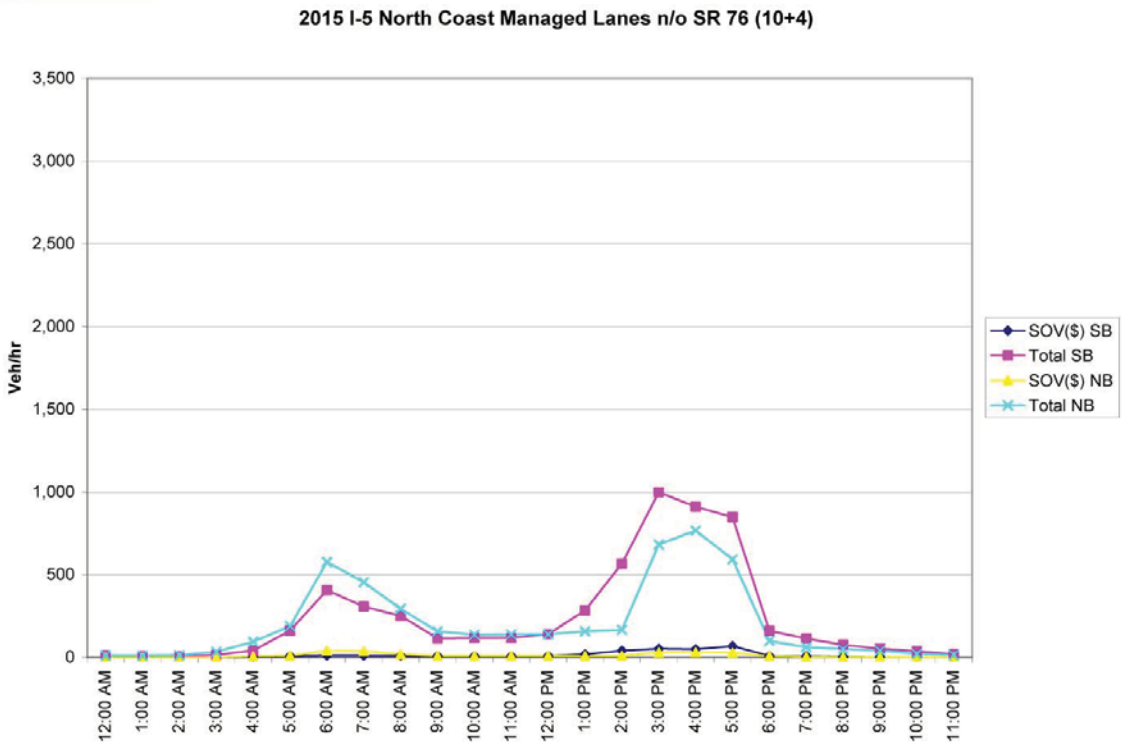


2015 I-5 North Coast Managed Lanes s/o Palomar Airport Rd (10+4)



2015 I-5 North Coast Managed Lanes n/o Carlsbad Village Dr (10+4)




2015 I-5 North Coast Managed Lanes n/o SR 76 (10+4)
Veh/hr
3,500
3,000
2,500
2,000
1,500
1,000
500
0
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM
SOV($) SB
Total SB
SOV($) NB
Total NB

Revenues by Segment

As discussed earlier, the base (uncongested) toll cost per mile in 2015 is $0.16 per mile. During peak times when the volume on the managed lanes is projected to be at its highest, these rates adjust to between approximately $4.90 (10+4) to $5.50 (8+4) during the northbound peak at the highest tolling location. Estimated annual revenues, broken down by location, are shown below in Figure 6-12.

FIGURE 6-12: 2015 MANAGED LANES ANNUAL REVENUE

Location	**2015**	
	8+4	**10+4**
s/o SR 56*	$5.555 million	$4.248 million
s/o Via de la Valle*	$3.904	$2.918
s/o Manchester Ave	$1.794	$1.376
n/o Encinitas Blvd	$0.759	$0.628
s/o Palomar Airport Rd	$0.254	$0.210
n/o Carlsbad Village Dr	$0.132	$0.108
n/o SR 76*	$0.108	$0.104
TOTAL	$12.506	$9.592

*Note: s/o SR 56 and n/o SR 76 have 10 GP lanes, and s/o Via de la Valle has 9 GP lanes in the 8+4 configuration.

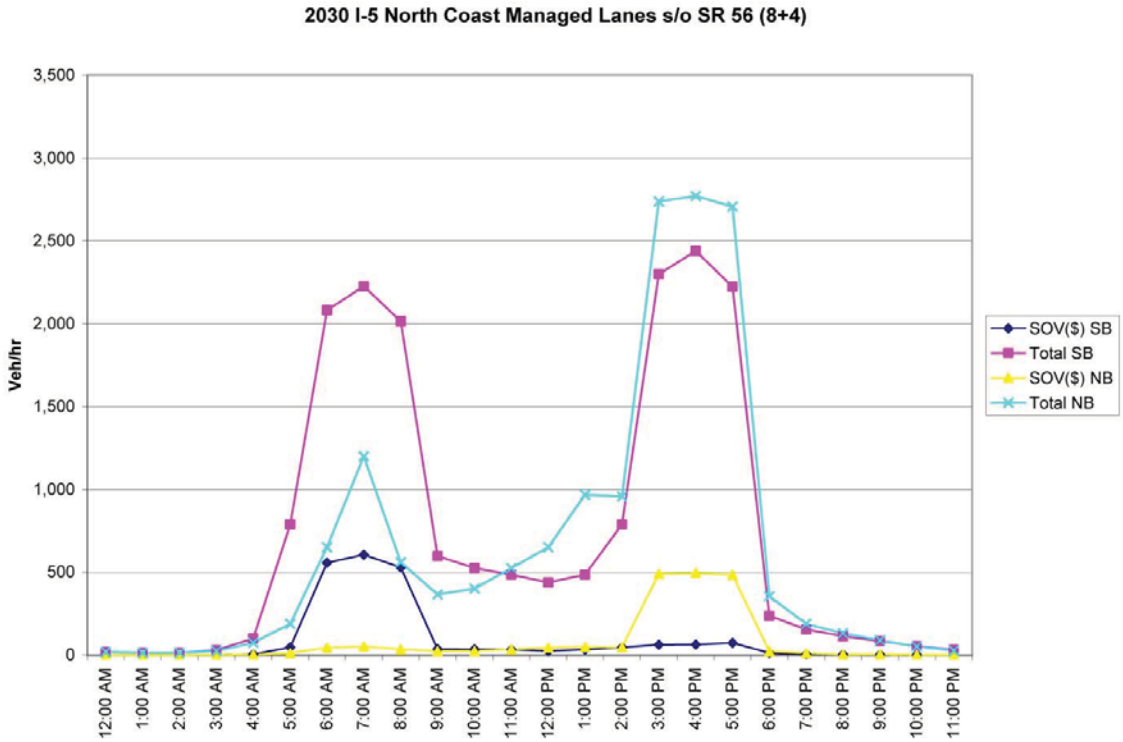
6.4.2. Design Year 2030

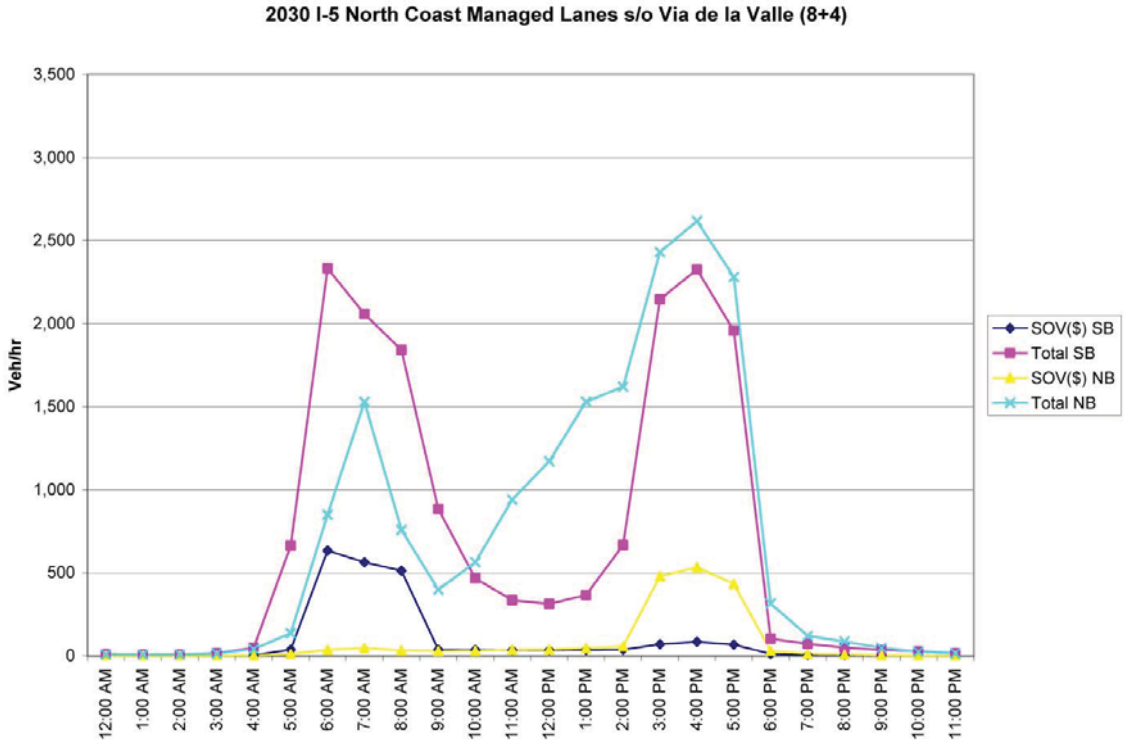
Volume by Segment

The following graphs show the hourly volumes at each of the tolling locations in 2030 with eight general purpose lanes and four managed lanes (Figure 6-13) and ten general purpose lanes and four managed lanes (Figure 6-14).

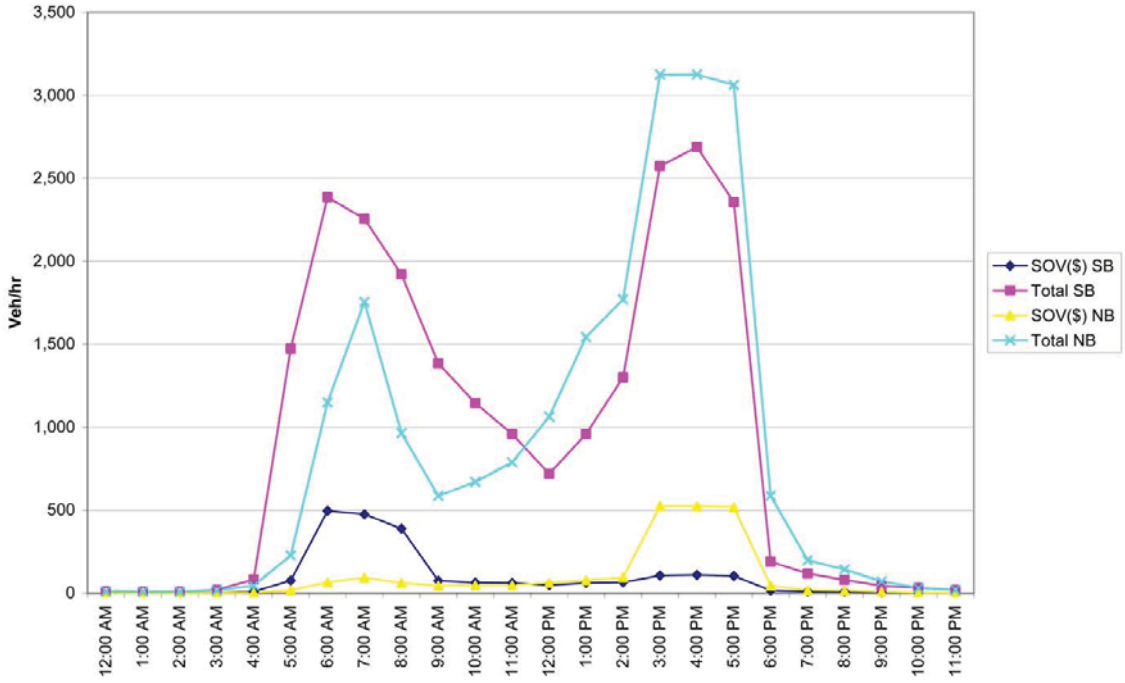
Conditions on the roadway in 2030 with the 8+4 configuration deteriorate and there is not available capacity during peak periods to allow SOVs to use the managed lanes. For this reason, the analysis for this configuration tends to break down, the data should be used carefully.

FIGURE 6-13: 2030 MANAGED LANES HOURLY TRAFFIC VOLUMES (8+4 CONFIGURATION)

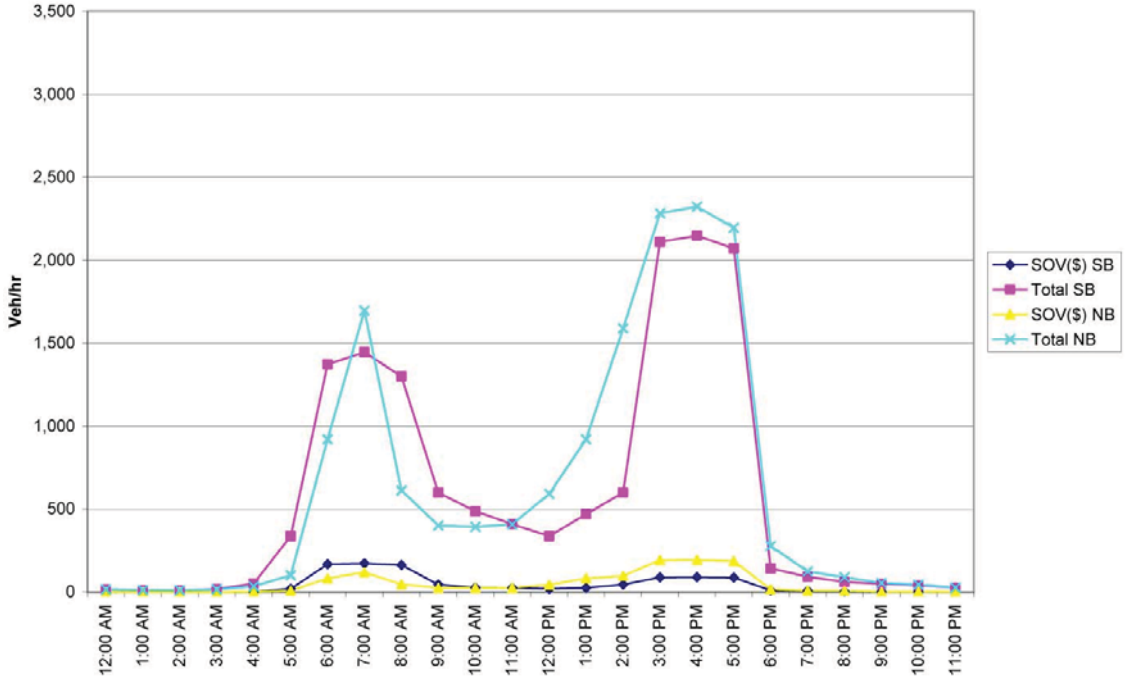




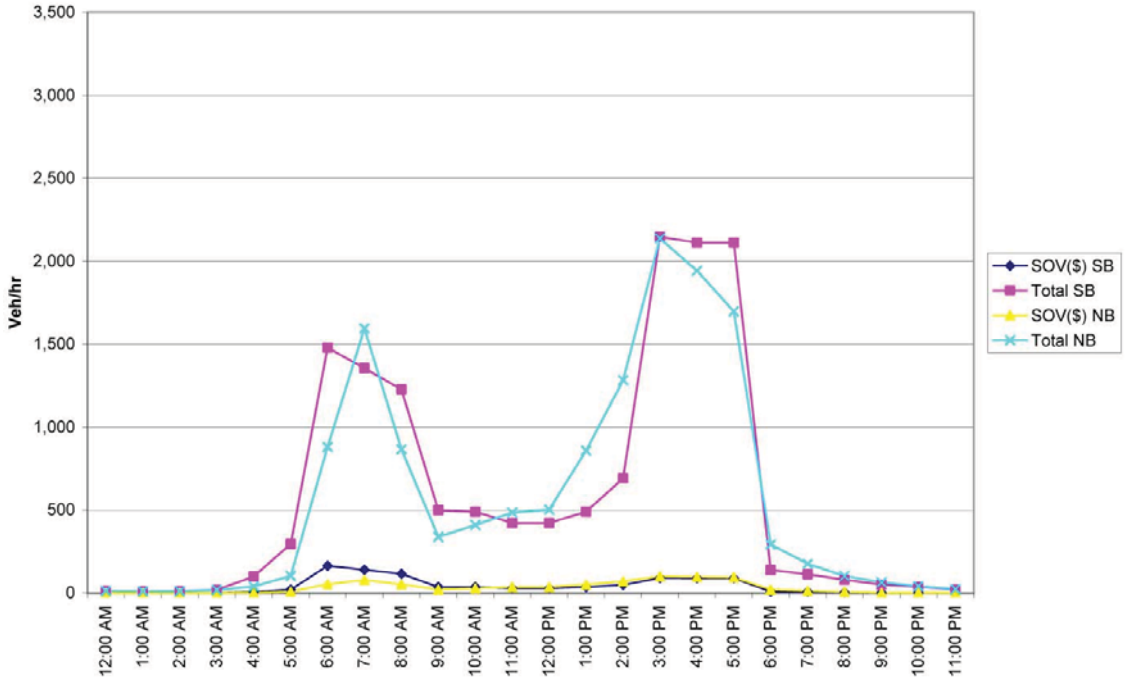
2030 I-5 North Coast Managed Lanes s/o Manchester Ave (8+4)



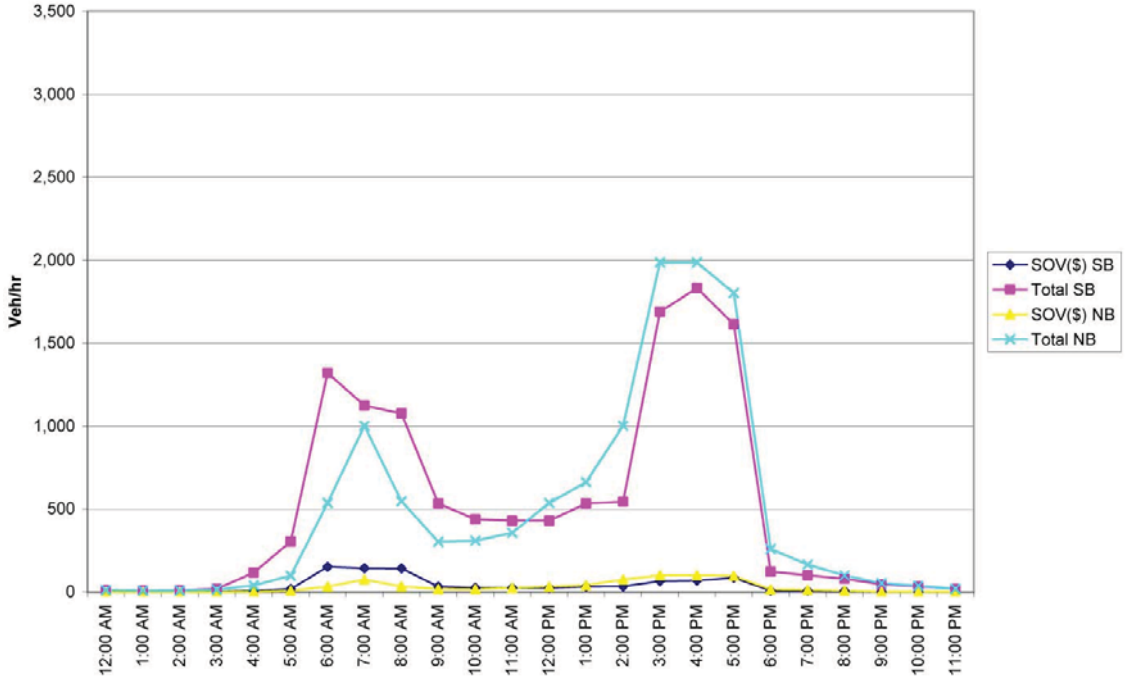
2030 I-5 North Coast Managed Lanes n/o Encinitas Blvd. (8+4)



2030 I-5 North Coast Managed Lanes s/o Palomar Airport Rd (8+4)



2030 I-5 North Coast Managed Lanes n/o Carlsbad Village Dr (8+4)



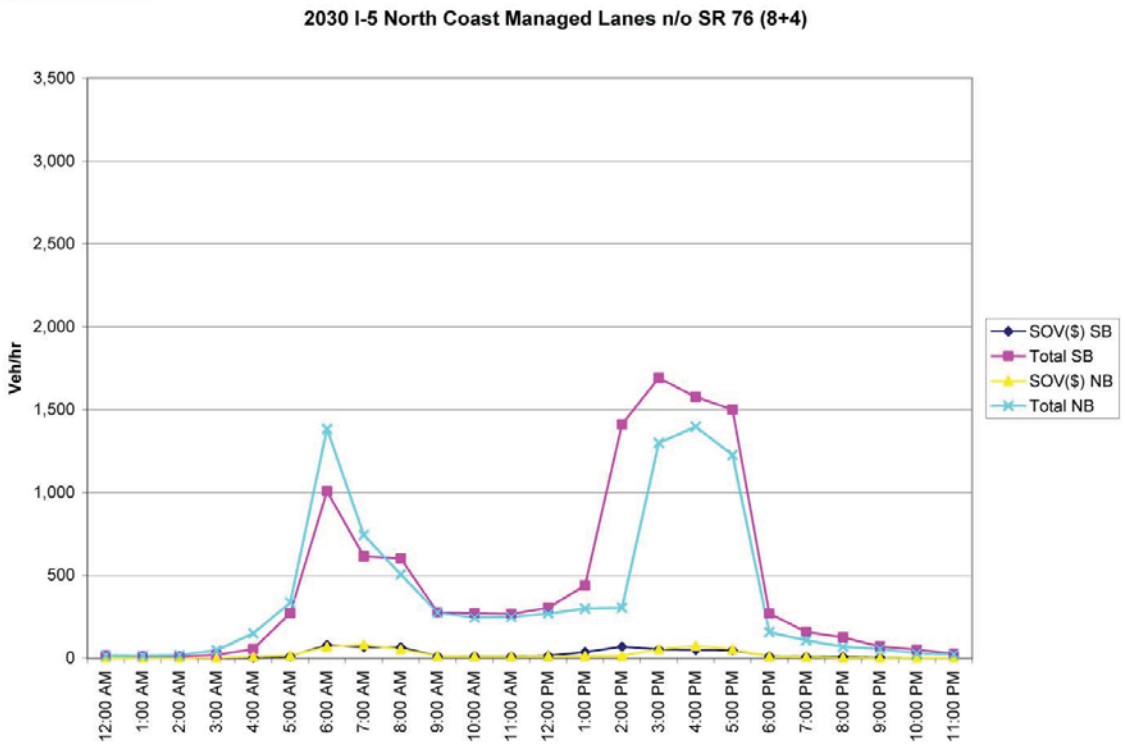
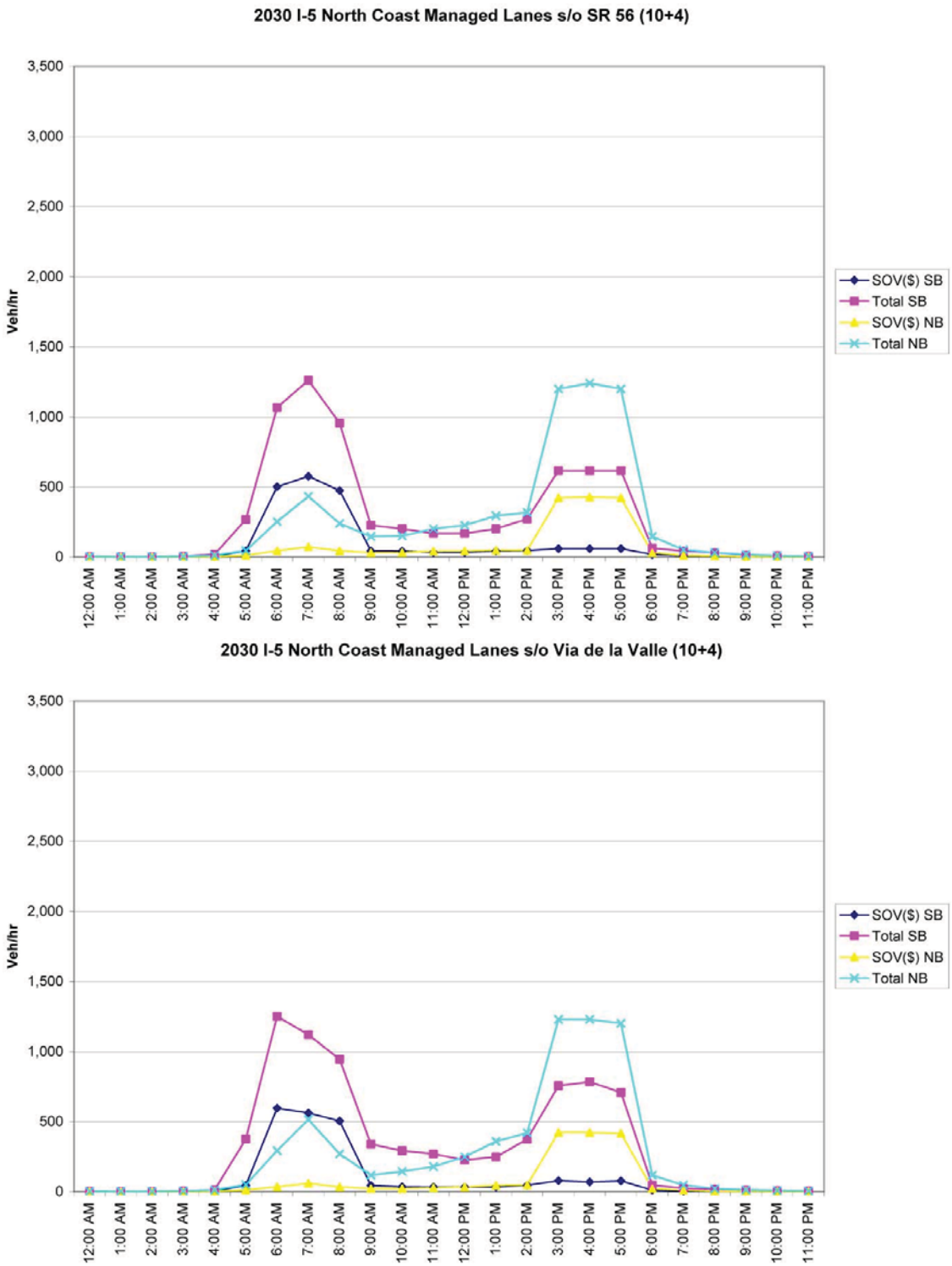
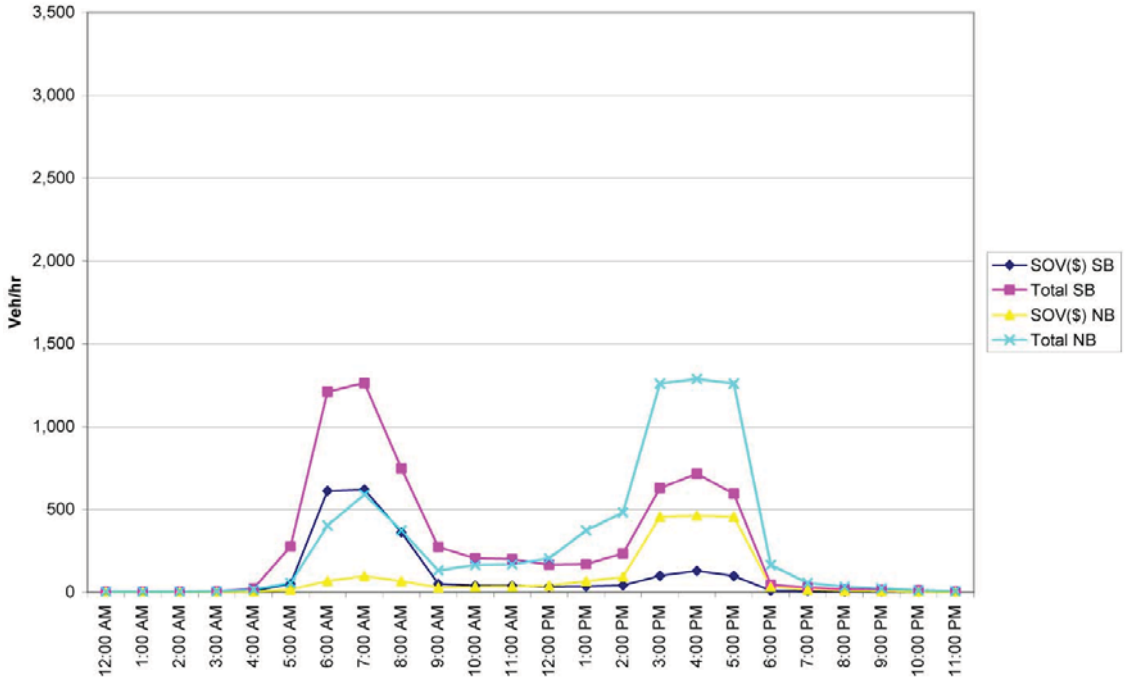

2030 I-5 North Coast Managed Lanes n/o SR 76 (8+4)
Veh/hr
3,500
3,000
2,500
2,000
1,500
1,000
500
0
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM
SOV($) SB
Total SB
SOV($) NB
Total NB

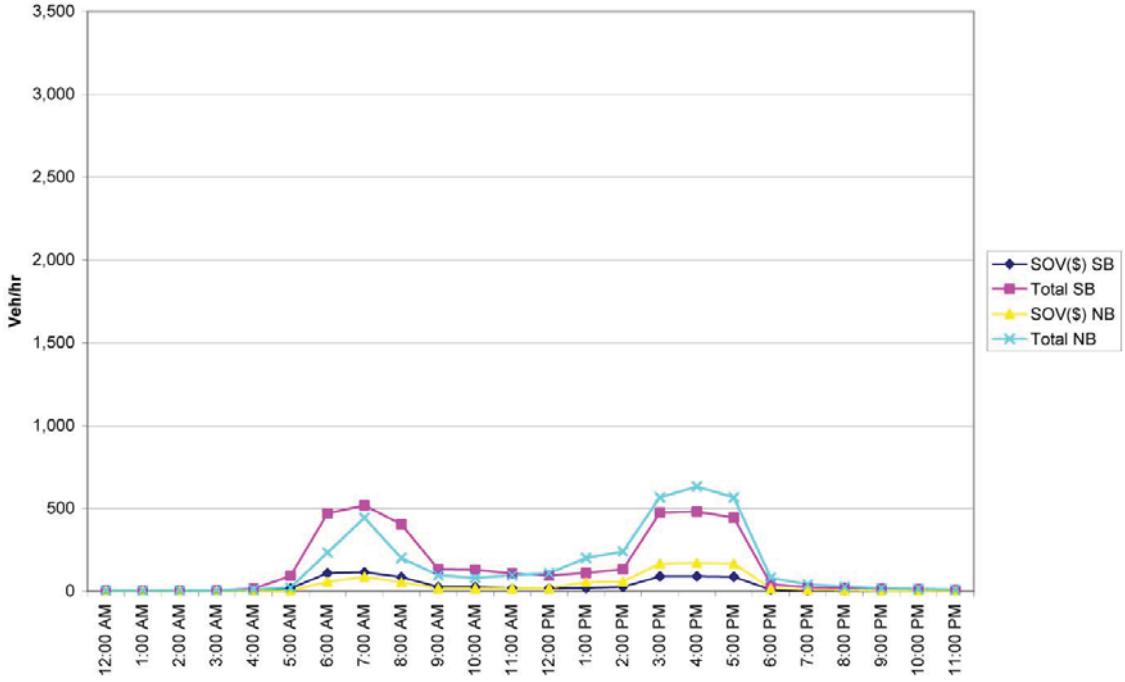
FIGURE 6-14: 2030 MANAGED LANES HOURLY TRAFFIC VOLUMES (10+4 CONFIGURATION)



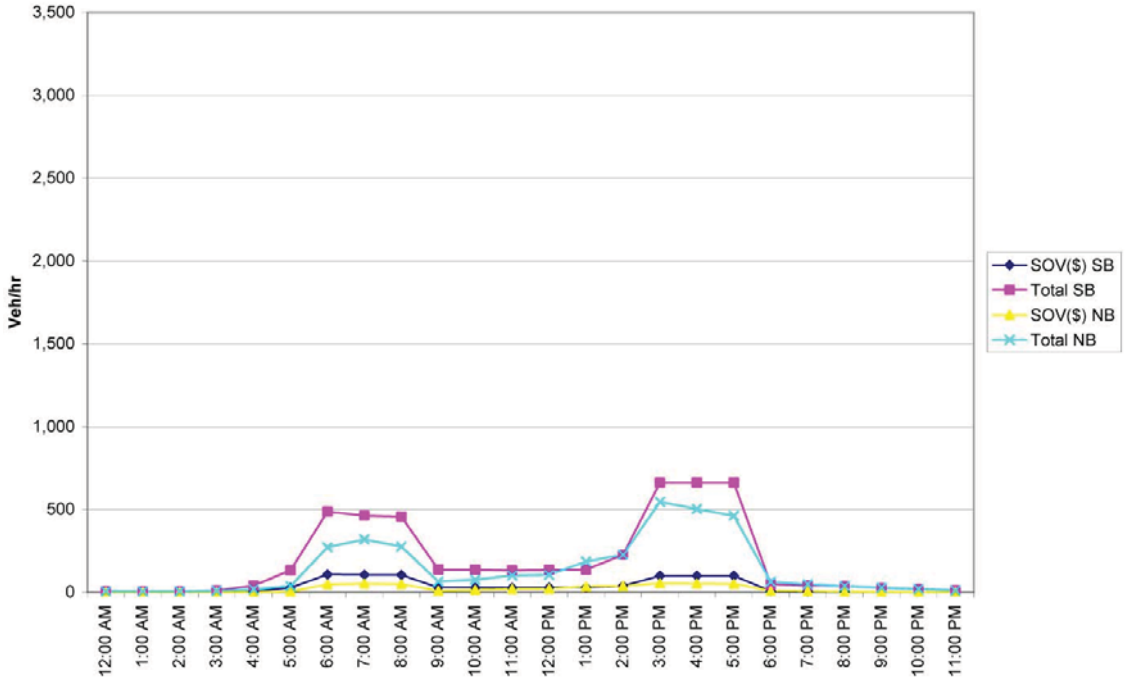
2030 I-5 North Coast Managed Lanes s/o Manchester Ave (10+4)



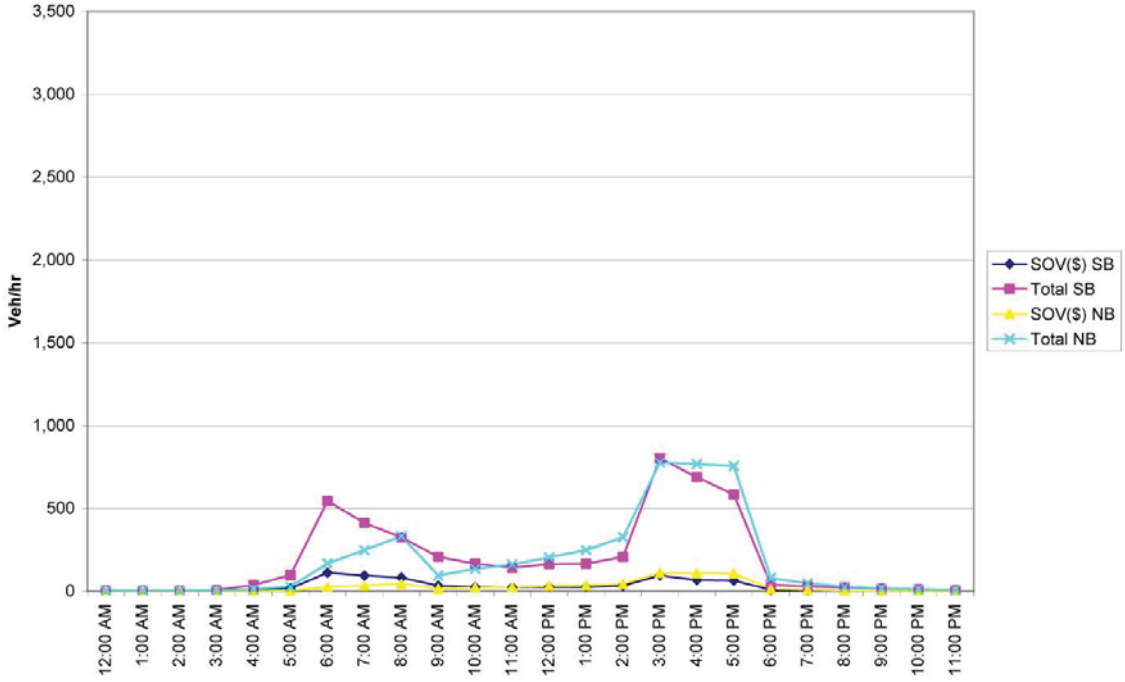
2030 I-5 North Coast Managed Lanes n/o Encinitas Blvd. (10+4)

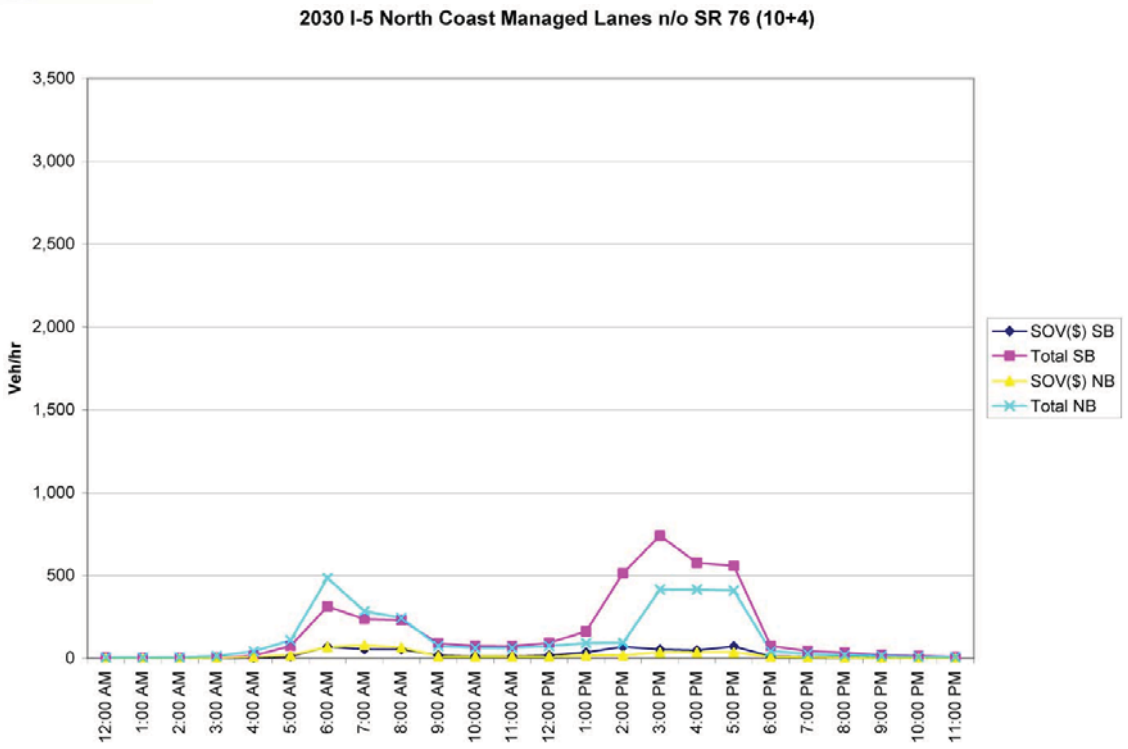


2030 I-5 North Coast Managed Lanes s/o Palomar Airport Rd (10+4)



2030 I-5 North Coast Managed Lanes n/o Carlsbad Village Dr (10+4)




2030 I-5 North Coast Managed Lanes n/o SR 76 (10+4)
Veh/hr
3,500
3,000
2,500
2,000
1,500
1,000
500
0
12:00 AM
1:00 AM
2:00 AM
3:00 AM
4:00 AM
5:00 AM
6:00 AM
7:00 AM
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
7:00 PM
8:00 PM
9:00 PM
10:00 PM
11:00 PM
SOV($) SB
Total SB
SOV($) NB
Total NB

Revenues by Segment

As discussed previously, the base (uncongested) toll cost per mile in 2030 is $0.24 per mile. During peak times when the volume on the managed lanes is projected to be at it's highest, these rates adjust to approximately $8.00 in both the 10+4 and the 8+4 configurations for the most congested segments. Estimated annual revenues, broken down by location, are shown below in Figure 6-15. As noted, the conditions in the 8+4 configuration in 2030 are very congested, and there is not available much available capacity for SOVs during the peak periods. Resulting revenues may not accurately reflect these conditions.

FIGURE 6-15: 2030 MANAGED LANES ANNUAL REVENUE

Location	**2030**	
	8+4*	**10+4**
s/o SR 56	$6.656 million	$4.329 million
s/o Via de la Valle	$6.274	$3.983
s/o Manchester Ave	$2.076	$1.154
n/o Encinitas Blvd	$2.421	$1.478
s/o Palomar Airport Rd	$1.203	$0.837
n/o Carlsbad Village Dr	$0.882	$0.629
n/o SR 76	$0.227	$0.225
TOTAL	$19.739	$12.636

*Note: Model output for peak periods provide SOVs using the managed lanes during at-or over-capacity conditions. This policy and model output should be re-evaluated.

6.5 FORECAST OF 2+ / 3+ HOV POLICY

Model output was reviewed that analyzed the option of tolling the SOVs at full price and the HOV-2 at 50percent of the SOV price due to the managed lanes being oversubscribed by 2030. This alternative tolling policy would allow the HOV-3+ to travel in the managed lanes for free. The revenue model was modified for this tolling adjustment and the market share curves were changed to match the unadjusted SANDAG model output. The SANDAG model results, a sample shown in Figure 6-16 below, show a significantly lower managed lane use when HOV-2 are tolled at 50 percent of the SOV price.

FIGURE 6-16: 2030 10+4 HOV-2+/3+ MODEL OUTPUT

Managed Lane Daily Volumes (SANDAG Model Output)					
Location		**SOV**	**HOV-2**	**HOV-3+**	**Total**
s/o SR 56	3+ Free	3,800	900	8,600	10,300
	2+ Free	3,500	21,900	7,000	32,400
s/o Palomar	3+ Free	1,400	400	6,900	8,700
	2+ Free	1,300	17,500	5,600	24,400
n/o SR 76	3+ Free	1,000	200	5,400	6,600
	2+ Free	800	13,800	4,600	19,200

The resulting managed lanes market shares are very low, and since the managed lanes toll price is directly tied to managed lanes volume, the toll rates do not rise above $1.50, which is very close to the base uncongested toll in 2030. The resulting revenue that is generated using the HOV-3+ free model output is $6.0 million in 2030, compared to $12.6 million generated when HOV-2+ is free.

It is our opinion that this model output is problematic and should not be used to evaluate the impact of charging HOV-2 vehicles in this analysis. Because of the problems with the model output, the study team has not performed a similar analysis using the 2030 8+4 model output.

6.6 SUMMARY

Pricing can be seen as a means to create adaptive management capabilities/frameworks that extend the performance of investments/expenditures in transport facilities and their ability to meet their objectives. Pricing can permit expanded flexibility and adaptiveness and thereby support expanded options and extend timelines and life cycles.

By designing to financial parameters, one can also extend the ability of a given budget to meet a region's travel needs. If one begins to take advantage, where it is compatible with one's own context, of the business decision making models that those who operate toll roads as purely business ventures use, one can build to market/demand based budgets and rebuild on schedules compatible with demand changes/shifts. The marketplace supports this very kind of adaptive decision making and that can be an advantage in some dimensions of the public sector arena.

This approach, where compatible with institutional contexts, depends less on forecasts being pressed into service as predictions, and it can enable the use of more robust decision making via risk based models

The revenue analysis for the I-5 North Coast Managed Lanes was performed using the unadjusted output from the SANDAG regional model. Two different lane configurations were studied; the 8+4 configuration which provided eight general purpose lanes and

four managed lanes throughout most of the corridor (some locations did have either nine or ten general purpose lanes), and the 10+4 configuration which provided ten general purpose lanes and four managed lanes throughout the corridor.

The revenue analysis assumed a toll rate structure that was based on the structure used on the I-15 Managed Lanes in San Diego. It was assumed that there would be variable pricing on the lanes, and the pricing would be determined based on the volume over capacity (v/c) ratio in the lanes.

The following bullet points summarize the major findings and conclusions made from the revenue analysis for this study:

- The SANDAG model output projected that there would be significantly greater use of the managed lanes in the southern portion of the facility, and as a result, the per mile toll in the managed lanes is higher in the southern segments. In addition, the AM and PM peak SOV paying customers will be higher in the southern portion of the facility.
- Conditions on the 2030 network with the 8+4 configuration deteriorate and there is no available capacity during peak periods to allow SOVs to use the managed lanes. The SANDAG model output for peak periods allows SOVs to use the managed lanes during the at-or over capacity conditions. This policy should be re-evaluated, and refinements are needed to the SANDAG model to properly evaluate these conditions.
- Base (uncongested) toll rates for using the length of the facility total $4.00 in 2015 ($0.16/mile) and $6.00 in 2030 ($0.24/mile)
- 2015 toll rates for using the length of the facility totals $4.00 in uncongested conditions and are estimated to reach up to approximately $13.90 during peak conditions, assuming the 10+4 configuration.
- In 2015, estimated managed lanes annual revenue is $12.5 million for the 8+4 configuration and $9.6 million for the 10+4 configuration
- In 2030, estimated managed lanes annual revenue is $19.7 million for the 8+4 configuration and $12.6 million for the 10+4 configuration.
- Refinements are needed to the SANDAG model to estimate the impact of changing the HOV policy from HOV-2+ free to HOV-3+ free (in which HOV-2 would pay 50percent of the SOV toll). This scenario was evaluated using the current SANDAG model, and the sensitivities to the HOV-2 toll were too great and proved to be problematic in evaluating this alternative.

CHAPTER 7

TECHNOLOGY AND SYSTEM OPERATIONS CONCEPT

7.1 INTRODUCTION

The scope of this chapter addresses electronic toll collection (ETC) technology in the context of opening managed lanes between the years 2010-2020. Technology will advance considerably between now and then, so this discussion focuses on current conditions related to value pricing within a 5 to 15-year timeframe, and within the context of technology infrastructure, violation enforcement systems (VES), automated traffic management and control systems, and freeway incident/response systems. This chapter addresses a concept of operations that covers in-lane maintenance, traffic management, customer service, violations processing, and staffing needs for front and back-end office operations of a value pricing system on the I-5 North Coast Managed Lanes. Requirements for evaluation and continuous improvements also are addressed. Finally, a preliminary cost estimate for a completely integrated electronic toll and traffic monitoring (ETTM) system, including VES that is based on current market-ready technology is provided. This estimate may need to be adjusted for inflation and changes in technology depending upon the year of investment.

7.2 FACILITY DESIGN

The following facility design assumptions and variables were considered in the technology assessment:

7.2.1. Managed Lane Configurations

The four configuration scenarios considered for the I-5 North Coast Managed Lane project include 8+4 barrier-separation, 8+4 buffer-separation, 10+4 barrier-separation, and 10+4 buffer-separation. Any are potential alternatives that may become the locally preferred alternative. More detailed definitions for each are provided below.

Barrier-separation – Use of concrete barrier separating concurrent general purpose and managed lane traffic flows, which may include emergency breakdown shoulders for each roadway.

Buffer-separation – Use of painted buffer areas between general purpose and managed lane concurrent traffic flows, which may include emergency breakdown shoulders for each roadway.

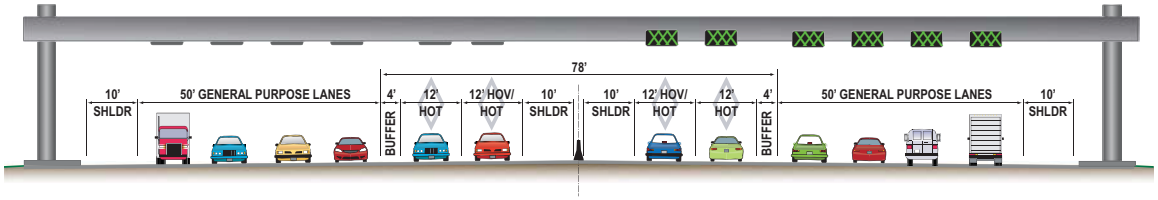
8+4 Configuration - 8 lanes for general purpose traffic (4 in each direction) and 4 lanes for managed traffic in the median (2 in each direction).

10+4 Configuration - 10 lanes for general purpose traffic (5 in each direction) and 4 lanes for managed traffic in the median (2 in each direction).

So, the possible configurations include:

- 8+4 Barrier-separated alternative;
- 10+4 Barrier-separated alternative;
- 8+4 Buffer-separated alternative (See Figure 7-1 as an example); or
- 10+4 Buffer-separated alternative.

FIGURE 7-1: 8+4 BUFFER SEPARATED ALTERNATIVE



From a technology perspective the difference between the 8+4 and 10+4 alternative will be the number of devices installed in the general purpose lanes and the size and type of the sign and gantries. The choice of barrier or buffer separation does play a role in choosing the type of ETC and VEStechnologies. With a buffer-separated facility, global positioning satellite (GPS)-based or open road tolling makes more sense as vehicles move freely between general purpose and managed lanes. Until such technology is adopted, wider use of toll readers augmented by Video Imaging Video Detection (VIVD) may be needed in support of the VES.

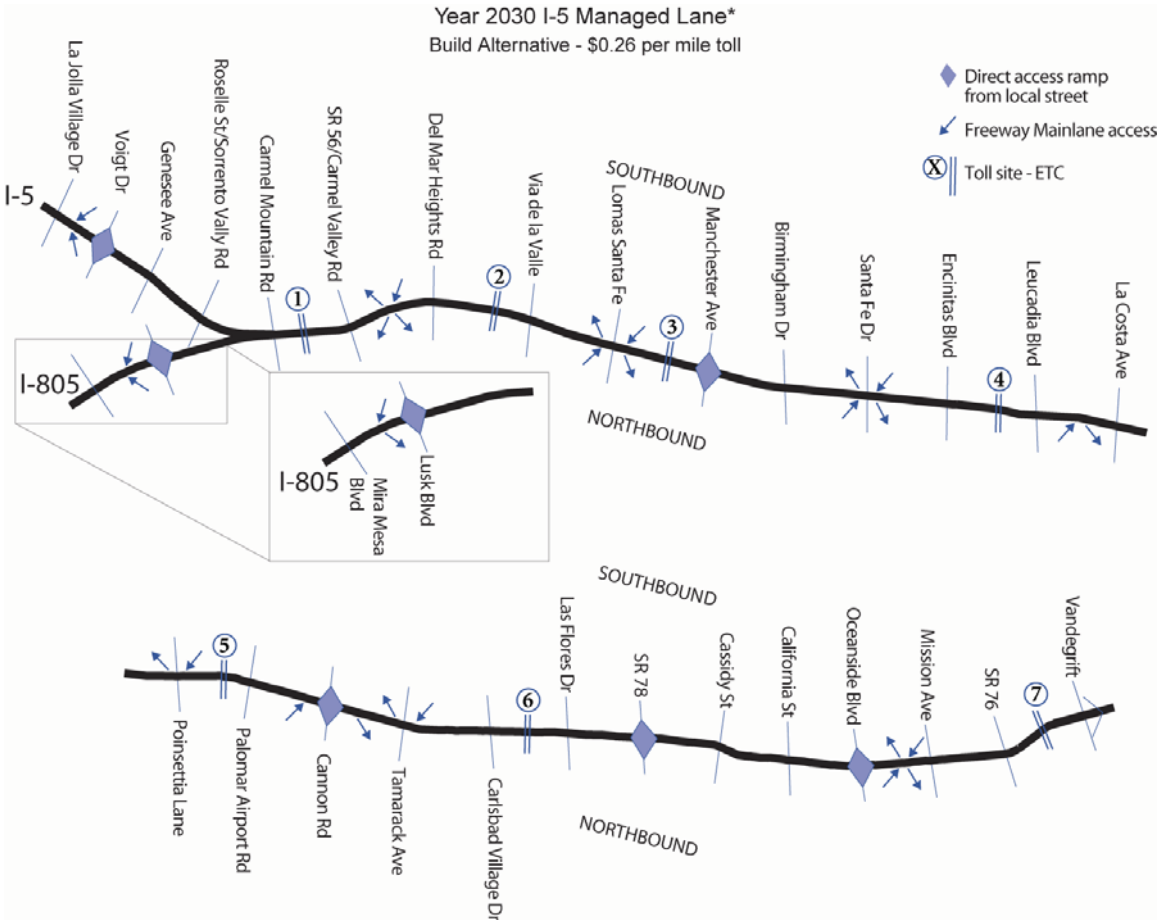
More traditional tolling methods like the transponders and toll tag readers used today can be sued in a buffer- or barrier-separated facility. The design is less complex when traditional tolling methods are paired with barrier-separated facilities.

Differences in technology, application of technology and operational concepts between a buffer-separated arrangement and a barrier-separated arrangement are noted within the specific section where differences occur. If not noted, the technology, application of the technology or operational concepts should apply to either roadway alternative.

7.2.2. Managed Lane Entry/Exit Access Points and Toll Zones

The managed lanes are assumed to have access restrictions except at designated ingress/egress treatments. Access treatments will take the form of Direct Access Ramps (DARs) with other freeways and streets and intermediate, high-speed slip ramps with the general purpose lanes. Figure 7-2 (next page) illustrates these assumptions for both of the above two lane configurations.

FIGURE 7-2: LANE CONFIGURATION



Design Vehicle Group Assumptions

For the purpose of technology assessment, the design vehicle assumptions include the following:

- Single occupancy vehicles (SOVs) have one occupant.
- High Occupancy Vehicles (HOVs) have more than one occupant. They can be classified as "2+" (two or more occupants in a vehicle); "3+" (three or more occupants in a vehicle); or as a "vanpool or transit bus".
- Motorcycles are allowed.
- Hybrid vehicles are considered eligible based on current state and federal legislation, but will probably not be eligible by the opening year due to the likely high percentage of hybrid and alternative fuel vehicles in the overall traffic stream.
- No large commercial trucks will be allowed to use the HOV lanes per Caltrans truck restriction policy on inside lanes.

- Automobiles and motorcycles will be able to use the managed lanes for a fee. SOVs will pay the full toll. HOVs with two or more occupants will not pay a toll until such time that their volumes regularly exceed the operational threshold of the lanes. At that time vehicles with two occupants may be levied a discounted toll.
- Deadheading transit vehicles and emergency vehicles will be considered eligible and will pay no toll

In order to improve travel time for HOVs and FasTrak users will have access to the managed lanes through DARs and:

- Transit signal prioritization – where priority is given to transit buses at signalized intersections or ramp meters.
- Queue jumps – facilities that can be used to bypass points on the transportation network where congestion is particularly severe and occurs in a predictable pattern.

Forecasted Volumes and Revenue Implications

The forecast traffic volumes on the Managed Lanes for 2015 and 2030 (considered the intermediate or opening year condition) are provided in the Chapter 5. Traffic demand will essentially fill the managed lanes to their operational threshold in selected segments for both 2015 and 2030. In earlier years this mix will include more SOVs than HOVs, and over time HOVs will comprise the largest number of users. Demand is not forecast to be uniform throughout the corridor. The southern two-thirds of the corridor will experience greater demand and the portion further north, and the portion between I-805 and SR 56 will experience congestion on a recurring basis for all planning horizons. These conditions suggest a dynamic operational setting in some parts of the corridor in which real-time traffic management will be needed shortly after the managed lanes open. Not all segments of the corridor will need this active management.

7.3 TECHNOLOGY INFRASTRUCTURE

7.3.1. Standards

Standards ensure interoperability and long-term affordability of technology. This means that multiple manufacturers' devices will work together to complete a system. With standards, a public agency can competitively bid its projects so that the best qualified, lowest cost solution can be employed; instead of being locked into purchasing products/devices from a single vendor or manufacturer.

Standards can also be applied to data formats, so that a uniform, known data format can be easily imported into or exported from one manufacturer's system to another.

The majority of products and devices move from their initial proprietary model to a standards-based model, as a wider base of customers demand an open, standards-based solution. California has developed and employed a standard for "traditional" ETC systems. It is expected that any improvements in ETC technology will begin with that standard or migrate to a standard.

Current Standard- California Title 21

Title 21 is an open standard developed by the California Department of Transportation (Caltrans) and adopted by California and Colorado. Therefore, transponders and readers within California must be interoperable (i.e., able to be applied and used by any agency or toll road operator) within the State. The statewide interoperable toll system is branded "FasTrak™," a registered trademark of the Transportation Corridor Agencies (TCA) of Orange County. Today, there are four active FasTrak agencies including: the Bay Area Toll Authority (BATA), who oversees electronic toll collections (ETC) operations on eight bridges (seven owned by Caltrans and one owned by the Golden Gate Bridge Highway and Transportation District); the TCA, who operates the San Joaquin Hills (SR 73), Foothills (SR 133), and Eastern (SR 241 and SR 261) Toll Roads; the Orange County Transportation Authority (OCTA), who operates the 91 Express Lanes; and SANDAG, who operates an existing 8-mile HOT lane on I-15 in San Diego County. Interstate 15 is being expanded into a 20-mile managed lane facility, and a fifth agency – the California Transportation Ventures (CTV) – is set to begin toll operations on the South Bay Expressway (SR 125) in San Diego County in 2006.

Title 21, Division 2, Chapter 16 presents the compatibility specifications for automatic vehicle identification equipment. The compatibility specifications were developed for the reader and the transponder in order to:

- Trigger or activate a transponder
- Poll the transponder for specific information
- Provide an acknowledge message to the transponder after a valid response to the polling message is received

The reader standards specify:

- Reader trigger signal length
- Reader send mode (downlink)
- Carrier frequency
- Carrier modulation
- Data bit rate
- Number of data bits
- Field strength

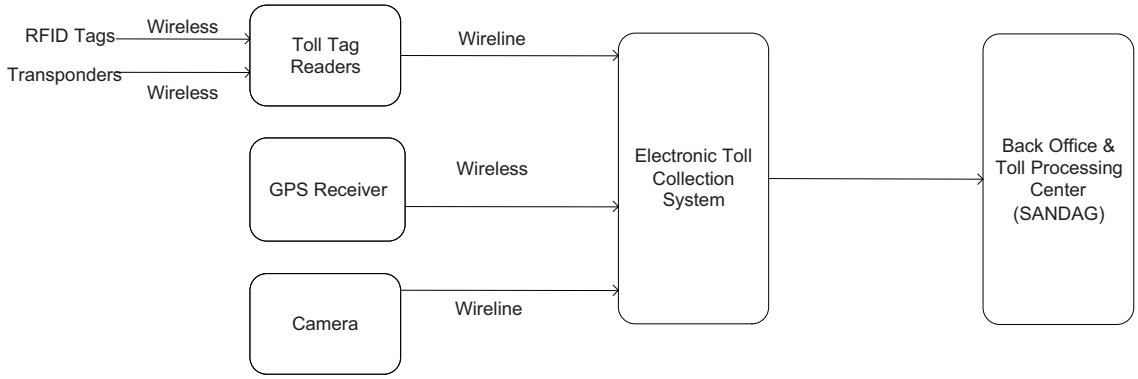
The transponder standards specify:

- Technology type
- Transponder antenna polarization
- Field of view
- Location
- Transponder send mode (uplink)
- Carrier frequency
- Carrier modulation
- Sub-carrier modulation

- Sub-carrier frequencies
- Data bit rate
- Number of data bits
- Receiver field strength
- Threshold

Further, the standard specifies communications protocol and a set of data records. The ETC functional system is illustrated in Figure 7-3.

FIGURE 7-3: ELECTRIC TOLL COLLECTION (ETC) SYSTEM



15-Year Outlook - Standardization

Interoperability will work best as the transportation agencies compel vendors to move from their proprietary solutions to an open standard, and this will happen as more projects and products surface. Standardization can be a time-consuming process. New standards, such as the dedicated short range communications (DSRC) protocol, or 5.9 GHz bandwidth, are being planned for now, but this effort involves a number of major participants to be successful, including toll industry partners and the big five automakers, and a workable solution is not anticipated until 2015 or beyond.

The I-5 toll system should be compatible with other transportation related functions, such as automated parking systems and non-transportation related functions such as purchasing goods. Systems must also include specific HOV requirements. The system must be able to incorporate the various tolling requirements of HOV's and SOV's. For example, HOV users may be allowed on the lane free of charge during certain periods of the day. However, there could be times when the HOV'er is a SOV that day and doesn't meet the HOV restrictions. In this case, the user would be charged the SOV toll rate. This transaction must occur with minimal or no effort required of the driver. Current tag technology doesn't incorporate this HOV requirement in a single tag solution.

The system design must maintain the fundamental functional characteristics, independent of a specific technology. This philosophy will enable technologies to integrate into the system. The key considerations when choosing a technology are operating function, capital and operating costs, security, product maturity, compliance with standards, maintainability and ease of use. Issues influencing the design include pricing schemes (fixed, variable, dynamic), access management (entry/exit restrictions,

lane-use eligibility requirements), enforcement (deterrent, aggressive) and technology (proprietary, open-architecture).

15-Year Outlook - Agreements between Neighboring Authorities

In addition to open protocols and standards, interoperability agreements between neighboring agencies and neighboring states will enable toll operators to share information regarding vehicles and their owners. This information will need to be in a format that each agency can use.

Regional and ultimately, national, multi-use systems have already begun to emerge, such as the EZ Pass system operated by the Interagency Group (IAG) affiliates in the northeast, and FasTrak in California and Colorado. As appropriate standards develop, SmartCards, which may replace transponders and readers, can be shared across supportive transportation programs (for multimodal fare payment), and between multiple transportation agencies. This evolution may lead to sharing transaction processing costs and ultimately driving down operational costs and increasing automation.

Developing these institutional partnerships and common data formats, while being time consuming in the short term, will lead to cost savings by reducing the transaction and violation processing time and reducing staffing requirements.

7.3.2. Electronic Toll Collection (ETC) System

ETC systems currently use devices such as radio frequency identification (RFID) transponders, readers, and communications systems. In the future, widespread adoption of RFID tolling, including open road tolling, is expected. However, alternative technologies may replace today's RFID standards, such as video camera detection with and optical character recognition (OCR), GPS tolling, and DSRC systems. Assuredly, these competing technologies will help drive the industry to accomplish ETC functions more efficiently and more cost effectively.

RFID Transponders (a.k.a. "Toll Tags")

Currently, passive and active transponders are installed in vehicles (after market) for ETC. In the future, the RFID technology that makes transponders work will probably be built into vehicles initially as options (like *On-Star*™ vehicle tracking) and ultimately will be required by statute as standard equipment on all new vehicles.

Current - Passive Transponders – RFID Toll Tags

The most common type of toll collection system operates using RFID technology. The RFID toll tag transponder is typically mounted on the inside of the vehicle's front windshield, directly beneath the rear view mirror. An overhead transceiver antenna (i.e., "RFID Reader") is mounted above the traffic lane, affixed to the underside of bridges or gantries. Today, most RFID readers transmit in the 900 MHz frequency range, and the readers are designed to cover a small footprint. When the vehicle crosses the zone of the transmitter footprint, a small portion of the radio energy from the transmitter is reflected from the toll tag back to the receiver. Within this reflected energy, the unique identification number of the tag is also transmitted back to the receiver. This type of tag is often referred to as a passive tag because it receives its energy from the incoming signal and its function is limited. A passive transponder has no battery to replace and the electronics are quite simple. Therefore, the passive toll tag is inexpensive and reliable. System management software adds date and time information to the received

information. Then, by cross-referencing the reflected ID number with the database of registered users, the toll is charged to the customer's account.

Since the system is dependent on reflective radio energy, the power is low, and limits the transmitter range to only about 30 feet. For this reason, antennae must be mounted over each lane. The low power tends to limit the amount of data that can be transmitted.

Current - Active Transponders - RFID Toll Tags

Active type toll tags are equipped with a battery, antenna, receiver, and transmitter. The battery operated tags usually result in a higher cost of ownership for the user. Battery life is dependent on basic capacity of the battery and the long-term power drain. Typical toll tag batteries last about five years. When the battery power is lost, the driver begins to be regularly recorded as a violator, and the tolling authority sends a violation notice to the user.

Active tags have a greater transmit range so it is more difficult to associate the vehicle with a specific lane. The tag is always in a low power dormant receiving mode using the same technology as found in a pager. When the driver passes under the toll authority antenna with the matching frequency, the tag goes from dormant mode to active mode and responds by transmitting the serial number of the tag. The serial number is cross-referenced with the registered users and the user's account is charged with the toll.

15-Year Outlook –Toll Tags

Once toll tags move to a universally standardized format, they will become optional and eventually standard equipment on all new vehicles. Until that time, toll tags may still be built into a vehicle and have a firmware update that will bring the toll tag in compliance with a proprietary operating system. The built in toll tags may eventually be embedded into windshields.

Additionally, toll tags will move from using the 900 MHz spectrum to the 5.9 GHz (DSRC) spectrum to transmit information between the toll tag and the reader.

RFID Readers (Antenna/Transmitter/Receiver)

Currently readers are used to receive the ETC signals from the transponder in the vehicle. They transmit the ETC information to the ETC processing center. In the future, open road tolling using RFID, video cameras with OCR back-end processing capability, or GPS-based tolling, and eventually DSRC, may augment or altogether replace today's RFID readers.

Current – RFID Readers

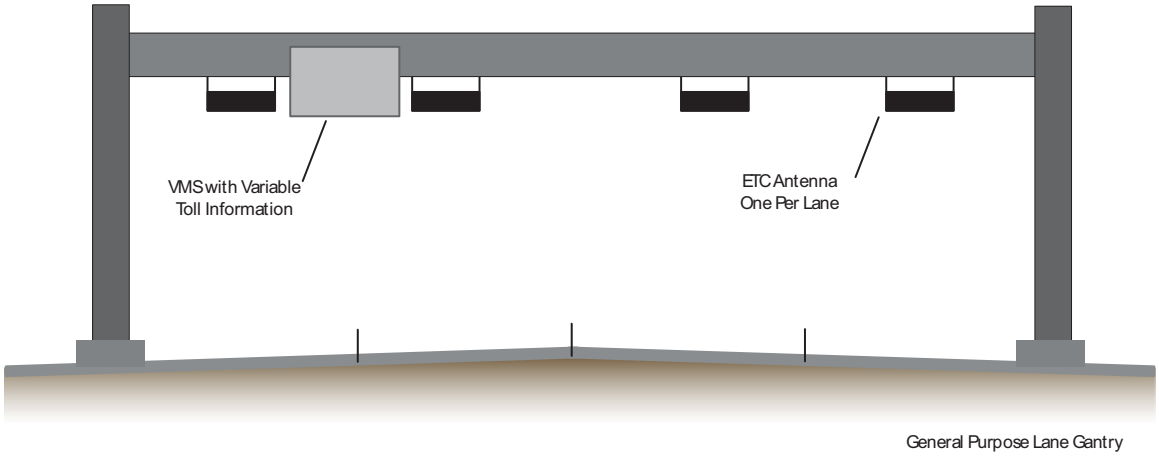
RFID readers receive the information from transponders in vehicles, add a date, time, and location stamp, and send it to the ETC processing center. The readers track a vehicle's speed, location, and travel time along a roadway. Readers play a role in deducting the appropriate toll from a user's account.

Readers consist of a computer designed to be used outdoors, a radio transceiver and an antenna. The reader is connected to the ETC processing center via a wireline or wireless connection. The majority of these connections currently use an optical fiber backbone. This communications backbone is required to provide transaction information, vehicle license plate and video images, field device status information, and lists of valid or invalid transponders. While wireless communications are being used to

connect more and more endpoints, it is not likely that RFID readers will be wirelessly connected to ETC processing centers as the distances will be too great.

Figure 7-4 depicts a general purpose lane gantry with RFID readers and a variable message sign.

FIGURE 7-4: GENERAL PURPOSE LANE GANTRY



15-Year Outlook – Open Road Tolling

Open road tolling is most often defined as a pay facility in which customers do not have to pass through a toll plaza, and customers do not have to slow down. Facilities that use toll plazas process only 400 to 700 transactions per hour per lane while open road tolling has the operational advantage of being able to process up to 1,800 vehicles per hour. Open road tolling has other cost effective benefits because there are no toll collector salaries and personnel overhead benefit costs to absorb. Also, there are no coins or cash machines to maintain.

Open road tolling looks attractive because it may reduce the installed infrastructure required to accomplish ETC. The infrastructure typically consists of lighter weight gantries that can span the roadway to support RFID reader, or similar toll systems. Open road tolling has just started being deployed. If such open road toll systems show to be reliable, they may replace the traditional toll plaza structures.

Video Capture and GPS Tolling Applications

Current – Paid-by-License Plate - Video Capture Systems and Optical Character Recognition (OCR) Image Processing

Video cameras capturing optical images of license plates, combined with highly-automated OCR systems, can be used to augment and potentially replace RFID tolling. The state issued license plate offers a unique way for each vehicle to be identified. When a vehicle comes into the tolling surveillance zone, a video image of the rear license plate is captured. Some systems are set up so that the camera captures not only a close-up image of the license plate but others catch an image of the car and driver as well.

The license plate image is transmitted to the OCR software that analyzes the image and determines the license plate characters. First, the toll agency client database is searched, and if no positive match is found, the system proceeds to search the state database of license plates until there is a match. In most cases, the patron whose account is linked to the license plate, or if a non-patron, the person that was issued the license plate by the DMV, is charged the toll fee and any applicable surcharge.

Video cameras equipped with OCR processing back-ends are most often used today for redundancy and violation enforcement, rather than as the primary toll charging system. On Toronto, Ontario's Express Toll Road (407), OCR has been used as an option available for infrequent toll road users who do not want to lease a toll transponder. The operators of the 407 chose this method of tolling because they realized that not all traffic within the province is local; therefore, those visitors may not have a transponder or an account. A small surcharge is added to the toll to cover the cost of the additional system processing.

For "paid-by-plate" video capture systems, the footprint of the camera mounting equipment is rather small. A stable platform must be provided for the camera. The camera can be mounted to a gantry or an overhead sign bridge. A camera setup is necessary for each lane of traffic.

A strobe flash unit is often used to enhance that image quality. The image quality can be further improved by adding controls for flash and camera shutter durations or adding infrared technology.

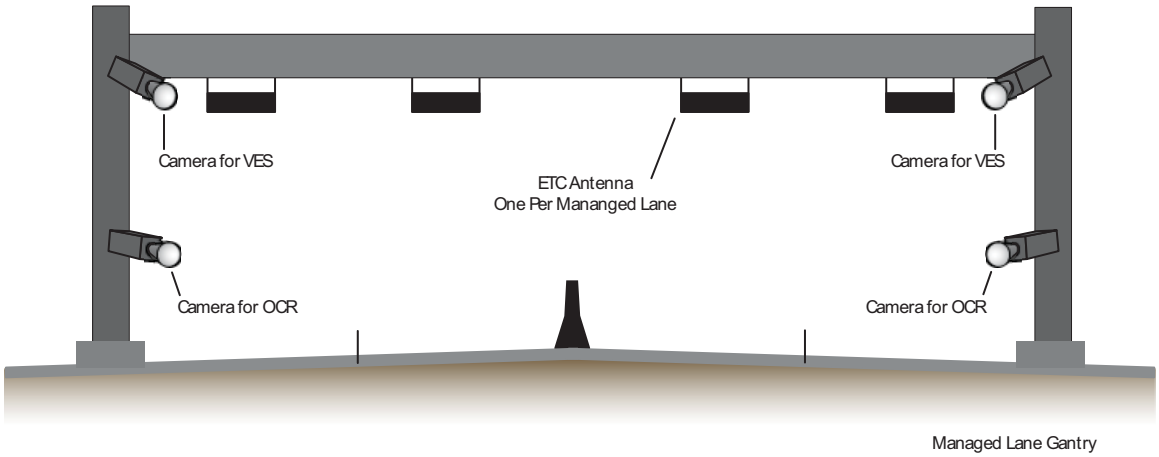
Reflective glare, heavy rain, fog, and dirt can make reading the plate more difficult. If a roadway is oriented east-west, the glare from the morning or evening sun will often cause a problem; and, when this happens it often coincides with the AM and PM peak traffic periods resulting in a loss of revenue.

The general practice has been to place cameras so they capture the rear license plate image as the vehicle leaves the toll zone. Currently, Caltrans does not allow trucks in managed lanes located within the center-median of the freeway. Should SANDAG decide to permit trucks to use the managed lanes, the viability of using video cameras to capture images of license plates may be negatively impacted. Whenever a tractor-trailer truck passes the toll zone, the rear license plate image is useless. The trailers are rented and are often transferred to another tractor after being hauled. Permitting trucks to use the managed lanes would result in a unique and difficult enforcement problem, as it is difficult to track down the truck cab or violator. One possible mitigation would be to use an additional camera to capture the front license plate if there is a significant amount of truck traffic that results in lost revenue.

Depending on license plate imaging for toll revenue introduces the opportunity for some drivers to escape the toll by using fraudulent practices. Currently, there are license plate spray coatings available for purchase that obscures the license plate when a flash is used in the photography process. The spray contains material with reflective properties that provide a glare under the bright flash conditions. The resulting photograph shows a bright white area that obscures the license plate text and the image is not readable. Some drivers could also resort to stealing license plates from other vehicles so that the owner of the plate is charged to the toll, and not the driver using the toll facility.

Figure 7-5 provides an example of where the VES and OCR cameras would be placed on a gantry.

FIGURE 7-5: MANAGED LANE GANTRY



DMV Relational Database Lookups

Using license plates as the primary toll identification technique can require a more complicated computer processing system. California's records database can contain millions of entries to be queried. The Department of Motor Vehicles (DMV) controls and updates the database of information associated with the license plates. The toll authority must rely on the accuracy of the information provided. When vehicles are sold new, transferred to new owners, or if the license plates are used fraudulently, it may take some time for the DMV to update the records. During that time, the toll charges are not assessed correctly.

15-Year Outlook - Video Capture Systems and Optical Character Recognition (OCR) Image Processing

Advancements in wireless electronic toll systems and improvements in securing those transmissions will help fuel ETC as the preferred method for collecting tolls. The video capture and OCR image processing is expected to continue its role as an enforcement technology that will be used to document violators. It is also expect that the video capture and OCR image processing systems will decrease in price and improve their accuracy to move from a secondary to primary enforcement tool.

Current – Global Positioning Satellites (GPS) Tolling

GPS tolling utilizes the technology associated with the constellation of satellites to determine the approximate location of a vehicle, expressed in terms of a set of latitude, longitude, and altitude (elevation) coordinates. This is the same satellite positioning system used by the military, airlines, and hikers. With recent advances automatic vehicle location (AVL) using GPS is typically accurate within 10 meters, and often better. An on board unit (OBU), also sometimes referred to as an integrated vehicle logic unit (IVLU) contains the required electronics and software necessary to complete the system for AVL applications. The OBU/IVLU is small enough to mount on top of the dashboard or conceal beneath/behind the seats to prevent interference with visibility.

The advantage of GPS-enabled toll systems can significantly improve cost effectiveness of the system's installation by eliminating installation of traditional ETC infrastructure. A virtual map of the toll road is digitally stored in the OBU/IVLU. The digital map highlights the roadway and the tolling limits of the roadway. The GPS system calculates when the vehicle location is within the tolled roadway limits. As the vehicle travels along, the GPS

unit continuously updates the vehicle position and a charge per mile for the affected segment is assessed to the user's account. An indication is given to the driver when a toll section is upcoming and when the vehicle is within the toll zone. The data is stored on board until the user information is downloaded to the ETC processing system. The download of toll distances and related charges can occur via a DSRC link along the roadway, or via a mobile phone link.

The on board GPS system data is linked to the back office system in order to calculate the toll and total account charge for the trip. This can be set up to occur at regularly scheduled times, not necessarily when the user is on the toll facility. This process can result in a complex operation. The tolling system must calculate vehicle locations using longitude and latitude coordinate data and compare it to a predetermined set of toll zone coordinates.

At present the GPS satellites do not send out a strong signal, and occasionally data can be lost if contact with the satellites is lost. When this happens, the system must be reset. This could result in lost toll revenues or billing errors. Enforcement of a GPS based toll system could be difficult because police would not readily be able to tell if a driver has the system turned on, turned off, or if it is disabled. Further development and testing of this technology is needed before GPS-enabled tolling is embraced as a viable solution for ETC.

Germany, Switzerland, and Austria started prototype testing of a GPS toll system for trucks in 1995. The development is continuing as improvements have been made to the antenna location. OBUs and suppression of engine electronic static have interfered with GPS operation.

Additionally, a GPS-based tolling system cannot determine the number of occupants in the vehicle. In-vehicle sensors, cameras, and police officers will provide the necessary passenger information so that the appropriate toll will be charged to that vehicle.

Further development and testing of this technology is needed before GPS-enabled tolling is embraced as a viable solution for ETC.

15-Year Outlook – Global Positioning Satellites (GPS) Tolling

As the technology improves, there may be more commercial vehicle GPS tolling used in Europe and Asia. The initial cost of the equipment is more likely offset by the higher roadway taxes that heavy commercial vehicles must pay. For passenger vehicle tolling, many industry experts believe that DSRC provides a better solution for ETC.

Communications Systems

Current Communications Systems – Fiber Optics

To support the various ETC field devices, such as readers, variable message signs, cameras, ramp meters, and detection systems, a transmission medium is needed to connect all field equipment. The most common method of connecting these ETC field devices is an optical fiber line placed alongside the roadway. During construction of the roadway, several four-inch conduits with inner- ducts are installed in a trench. Additionally, pull boxes are installed in the ductbank at anticipated field device locations. The optical fiber can be pulled into the conduits as needed.

While wireless technology is becoming more prevalent and more useful (with larger bandwidths and increased throughput), there will still be a need for large bandwidth, wireline communications, such as optical fiber. Therefore, four-inch conduits with

innerduct should be installed for any near term projects, including I-5, particularly when such installations can be included as part of more invasive widening construction where cost economies of trenching as part of an overall project and need are insignificant. Other communication and metering devices along the freeway will probably need to use optical fiber in this conduit as well.

15-Year Outlook - DSRC – Dedicated Short-Range Communications

DSRC is the name given to the 5.9 GHz spectrum. This spectrum was established by the Federal Communications Commission (FCC) to be used by intelligent transportation systems for the purpose of establishing nationwide interoperability of short range wireless communications between vehicles traveling at highway speeds and roadside devices. The wireless link is expected to enable the operation of multiple public safety and private DSRC services that will improve traveler safety, increase highway and transit efficiency, decrease traffic congestion, and reduce air pollution.

There are four classes of DSRC planned. Each class will be defined by its maximum authorized transmitter power, which will also define the typical maximum transmission range. It is expected that toll road applications would use either Class 1 with a range of 15 meters, or Class 2 with a range of 100 meters.

The data transmission rate for DSRC is expected to operate at speeds up to 25 megabits per second (Mbps). This will allow for near instant access and will be well adapted for a high-speed mobile environment.

The amount of data that a DSRC system can handle is quite large. For this reason, numerous public safety and vehicular safety applications are planned. A version of open road tolling, to reduce the expense of roadway infrastructure is expected to coincide with DSRC operation.

There is international cooperation between communications providers and the automobile industry so that the system will be able to operate in any country. The first systems may be optional or stand alone OBUs. At some point, DSRC units are expected to become a standard feature on all vehicles, probably beginning in the 2015 model production year.

7.3.3. ETC Violation Enforcement System (VES)

Enforcement goals include motorist and officer safety, reliability, and motorist adherence. There are two types of ETC violations, namely, occupancy and toll. Technology and officers are both used to catch violators. Better violation enforcement is obtained when officers and technology collaborate, and ultimately the managed lanes will experience lower violation rates.

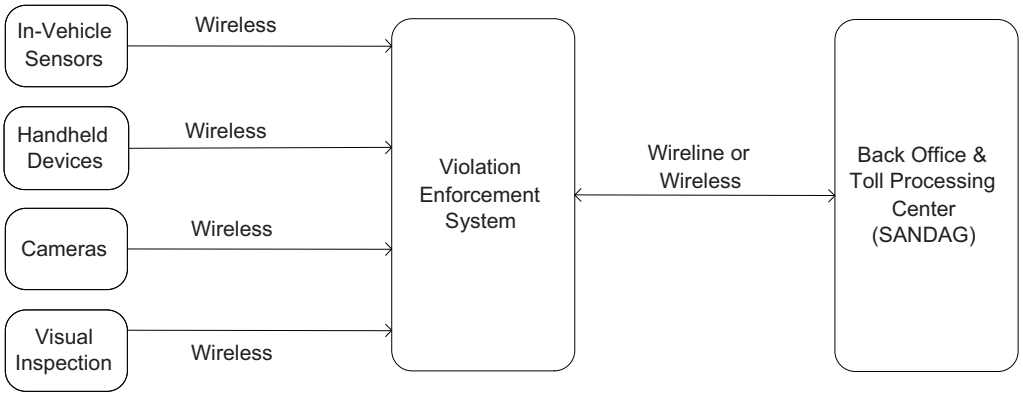
If motorists get the impression there is a lack of enforcement, they are tempted to violate the occupancy and/or toll requirement because the risk of being fined, regardless of the fine structure, is minimal. Although enforcement is essential, the level of enforcement required must be balanced with the amount of funding and police resources available. Enforcement should be conducted in a manner that does not adversely impact traffic operations, and the presence of patrol officers, while improving compliance, may also adversely affect traffic performance.

Penalties for violations must be adequate to discourage the willful violator such that reliance on dedicated enforcement officers can be minimized. The minimum fine for an HOV violation is $351 for the first offense. After the third offense, that same violation will

escalate to over $1000 inclusive of court costs. It should be noted, very little of the citation revenue feeds back into the toll system, and this policy should be changed in the future if technology and court requirements continue to rely on on-site police presence for some infractions, including meeting minimum occupancy requirements.

A violation enforcement system has already been automated for toll compliance in both San Diego and elsewhere, and statutes exist to allow for this process. Numerous projects throughout California allow for issuing a vehicle a violation notice by mail if the vehicle does not pay the requisite toll on a tolled facility. Figure 7-6 illustrates this enforcement system as is applied in a number of locations.

FIGURE 7-6: VIOLATION ENFORCEMENT SYSTEM OVERVIEW



Occupancy enforcement is more complicated and requires on-site presence, and this function has been problematic for all HOV and managed lane projects worldwide. Separating tolled versus free users creates many headaches for enforcement personnel. Originally, the I-15 Express Lanes employed a single tolling location with an observation booth and separate lane to segregate free from tolled users. Currently, both HOV and tolled users travel through the same lanes. The number of tolling zones on I-5, limited right-of-way and multiple ingress/egress locations make this approach impracticable for police enforcement alone.

Several occupancy detection advancements, including a portable verification reader carried by police, can make monitoring more efficient. But on-site presence is still a requirement by the respective traffic courts and current state statutes. A tiered pricing structure, particularly when the managed lanes overload at the HOV-2+ restricted level, will also be problematic for police. The following sections describe current and future options to address both toll evasion violations and occupancy infractions.

Current – Enforcement Area Design

Enforcement of occupancy infractions is improved by the presence of on-site law enforcement officers. Caltrans has pioneered the practice of providing designated enforcement areas where offsets in the median barrier are provided adjacent extraordinarily wide shoulders. Enforcement area design involves spacing areas periodically along facilities, particularly along roadways that do not incorporate wide median shoulders that are 14 feet or more. These areas are designed for safely monitoring traffic and apprehending violators. Provisions for enforcement areas are

included in the Caltrans HOV Guidelines. The following design features are considered for developing the enforcement area:

- If intended for monitoring and apprehension, includes a preferable length of 1300 feet
- Should be at least 14-15 feet in width
- Should have an approach taper of 115:1 and a departure taper of 80:1 or greater, or it may be controlled by general freeway criteria as required to fit in the design for proper acceleration to the design speed
- Should ideally be provided at a minimum interval of two to three miles along the managed lane facility. Some DAR sites may supplement this interval spacing, particularly if wide shoulders are provided

The managed lanes on I-5 will contain full standard width inside shoulders that can be used for continuous enforcement along the managed lanes. The location of inside shoulders may be left or right side oriented, depending on whether the lanes are buffer or barrier-separated, and whether full shoulders are provided on one or both sides of a barrier-separated configuration. In either case, the function of enforcement will allow for the ability of any officer to perform a simultaneous occupancy and toll evasion check by the use of a portable toll tag reader in the patrol vehicle while the officer is either in a roving or stationary position. This approach should alleviate the need for designated enforcement areas, other than as convenient places to perform stationary monitoring while being somewhat better protected. Unlike the current I-15 operation, this report does not recommend dedicated enforcement areas as a function of the adopted enforcement protocols or strategies. If enforcement areas are justified, the respective police may desire periodic median installations to more flexibly change directions through the median opening and observe traffic flow with some protection. The pursuit and apprehension of any motorist found without the requisite number of occupants and not having their toll tag read can be performed in the full width shoulders that will be a standard feature of the roadway's typical section.

Current Practice - Vehicle Occupancy Verification

Vehicle occupants cannot be easily verified by video images within the vehicle compartments and matched with an image of the license plate. This shortcoming, documented in numerous studies and technology demonstrations dating back more than 20 years in California, has been a major obstacle toward automating occupancy compliance. Such a technology must be "foolproof" in determining occupancy, and traffic courts must be willing to accept documentation of a violation. The prevalence of tinted windows, limited lighting conditions and children or pets riding in vehicles make the requirement of a foolproof reading difficult to distinguish between an HOV and SOV. Cameras are not yet at an advanced enough stage where they can accurately detect the number of passengers in a vehicle, and therefore, cannot be currently considered viable to address this need. Cameras can be used in concert with monitoring tools to address other forms of operational infractions, including buffer crossing and speeding. It is possible that front-facing cameras detecting occupancy in the front two seats with considerable accuracy teamed with a change in business rules that would define HOVs differently to mean two or more adult occupants driving in the front two seats could go a long way toward solving this problem in the short term. However, other concerns related

to privacy laws may prevent use of such images for the purpose of occupancy enforcement.

This matter has hampered operation of HOV lanes for more than 30 years, and throughout this period it was felt technology would eventually be adopted to address occupancy infractions. Such will happen, but there is no current evidence that the I-5 lanes can rely on a technology fix. To address this difficulty, some HOT lane operation plans are considering only allowing free use to highly visible HOVs, including vanpools and buses, and forcing all others to pay a toll at the same rate. Recommendations from this assessment must continue to focus on a VES that makes the best use of limited on-site police enforcement through the use of in-vehicle detection systems for confirming toll payment so as to separate those who have paid from those with the requisite number of vehicles. Applying a portion of the fines collected back into enforcement, can help ensure that staffing presence is always available to serve this need.

Current – Routine Law Enforcement

Routine enforcement based on accident history is a popular method to deploy personnel and focus not only on toll and occupancy violations, but other infractions and traffic management needs as well. Special enforcement assigns additional personnel and equipment during periods of need on the facility. Selective enforcement may involve the use of fixed observers, unmarked vehicles or roving spotters to enhance enforcement effectiveness. In most cases, both routine and special enforcement activities have been unscheduled, thereby not allowing motorists to predict when enforcement will occur. A more detailed discussion of the different enforcement strategies and techniques can be found in a variety of other references, including the National Cooperative Highway Research Program (NCHRP) #414, HOV Systems Manual (1998) and American Association of State Highway and Transportation Officials (AASHTO) Guide for High Occupancy Vehicle Facilities (2004).

To segregate paid from free users, most ETC reader sites in California currently employ overhead mounted indicator lights which are visible to enforcement patrols who are instructed to park downstream of the tolling installation. The overhead indicator lights alert the officer if a violation has occurred. The light is intentionally concealed from passing motorists. A combination of automatic enforcement from cameras, and observation by officers, increases the rate of violator apprehensions.

It is not possible for a police officer to issue citations or apprehend all the “free” violators in such a labor-intensive system. There also are inherent dangers associated with chasing a violator along a highway and stopping on the shoulder to issue citations.

Current Strategies– Lane Segregation

Channelizers

When managed lanes are designed and operated into the freeway cross section, a means to differentiate these lanes from the general purpose lanes is needed to maintain the integrity of tolling, promote a more reliable operation and regulate ingress and egress. The alternatives being studied in the NEPA process include buffer separation and barrier separation. Both approaches are considered in this functional plan. Barriers provide for adequate facility differentiation based on current technologies as outlined in other sections. Buffer separation poses more challenges because it relies upon pavement markings to outline or highlight the separation zone. There are typically a

series of signs that remind drivers not to cross the pavement marking stripes. If no physical separation in the buffer area is provided, the integrity of the managed lane operation may be compromised.

If some form of soft separation is applied, such as ground-mounted channelizers in the buffer area, they can help reduce access violations. Channelizers are typically posts that are made of high-impact plastic that can be anchored into the pavement or glued in place with a high strength epoxy. These posts come in a variety of shapes and sizes and have reflectorized surfaces. The base of the channelizer is often constructed with a spring-like device so that when hit, it will return to the vertical position. The plastic is of low mass so that damage to vehicles is minimized. However, channelizers have been criticized in some locales as presenting a safety hazard when they are dislodged and become projectiles, and maintenance costs to replace them can be rather high. In San Diego, Caltrans does not support the implementation of channelizers. The 15-year outlook suggests that the capital costs of toll tag reading installations, coupled with transaction costs, will become lower and allows for consideration of barrier-free alternatives to be operated. For this reason, both barrier and buffer-separated alternatives can be feasible and practical. The main issue seems to be agency preferences and likely implementation horizon for multiple toll zones along the corridor.

5-Year Outlook – Portable RFID Hand Held Devices

For occupancy and toll evasion monitoring, an enforcement officer can use a hand-held reader for two primary purposes: to determine if a toll tag is operational, and to check if the tag serial number matches the information in the database for the listed toll user. When the enforcement officer aims the reader at the toll tag, the tag reacts by transmitting the same information as when it passes through the tolling zone. The officer is able to determine if the tag is in the possession of the authorized user if the tag serial number matches the information listed in the toll road authority database, and whether or not a transaction has just occurred. The database will typically list the owner's name, license plate, and the vehicle type. The officer is then able to verify the information during a traffic stop.

The experience of some enforcement officers shows that the hand-held readers do not usually work when a vehicle is at operating speed. In general, the vehicle must be stopped, or nearly stopped, in order for the hand-held reader to operate. The reader must be at a close range to the toll tag. This often requires that the officer must lean over the hood of the vehicle before the tag responds with the transmitted user data. This shortcoming will hopefully be addressed in the not too distant future so that tags can be read more quickly and efficiently by enforcement personnel in the field.

5-Year Outlook – Smart Card/Transponder Validation

Occupancy verification could be conducted by utilizing the latest generation of SmartCards that have an RFID chip imbedded within it. The system could work in much the same way a passive transponder works to identify toll vehicles. However, in this case, a credit card sized SmartCard is carried by each occupant. Each SmartCard would transmit a signal to the receiver. If the receiver picks up the correct number of SmartCards within the vehicle it is assumed that the correct number of passengers are within the vehicle. Periodic visual enforcement would be necessary with this technology to discourage drivers from carrying extra SmartCards.

15-Year Outlook – In-vehicle Monitoring

There will likely be a shift from roadside visual monitoring to in-vehicle monitoring; thereby shifting more of the system costs from transportation agencies to individuals. Certainly it is possible that intelligent, sensing equipment will be installed directly into vehicles, and therefore, the consumer will pay the price for the devices. Examples of this sensing equipment include:

In-vehicle sensors

- Mechanical systems, such as a seatbelt. A supplementary system could monitor belt pay out, i.e. how far the seatbelt releases or retracts, or seat belt movement to determine if a person (adult or child) is in the seat. This technology has been employed in Europe for more than five years.
- Photography – inside the vehicle. Could be used in conjunction with the airbag sensors to determine occupant position sensing for a smart airbag deployment. Video for occupant counting would be far less complicated than video for smart airbag uses.
- LED imaging – inside the vehicle to produce contour images and compares that to a contour image of an empty vehicle. Difficulties arise with rear facing car seats.
- Infrared sensors could use a passive or active system. The passive system would compare body heat images to empty car images. An active system would scan the passenger compartment and develop a three dimensional model. Clothing, hot objects, or red-colored material can distort infrared images.
- Thermal imaging would be similar to infrared sensors and have the advantage of not easily identifying who the occupant is. It can verify that an occupant is present, however.
- Weight/heat sensors within the vehicle under each seat.
- Medical application sensors (heartbeat, breathing monitors). Volvo has developed a concept car that employs a heartbeat sensor. It will inform you if a person or animal has been locked in the car. It may be possible to adapt this technology to determine the number of people in a vehicle.
- Biometric recognition – makes sense for the driver, but not as much sense for passengers.
- SmartCards – again, makes sense for the driver, but not as much sense for passengers.

15-Year Outlook – Front-facing Optics

Front facing optics consist of a camera mounted so that a photographic view into the windshield of the approaching vehicle is captured. The driver and front seat passenger are usually visible, but those in the back seat can be obscured by the low light level or by the headrests. Children are usually below the level of the seatback and often do not show up in the photo. Reflection off the windshield also presents a problem. The violators often claim that the photographs are inaccurate for these reasons making reliability of enforcement difficult.

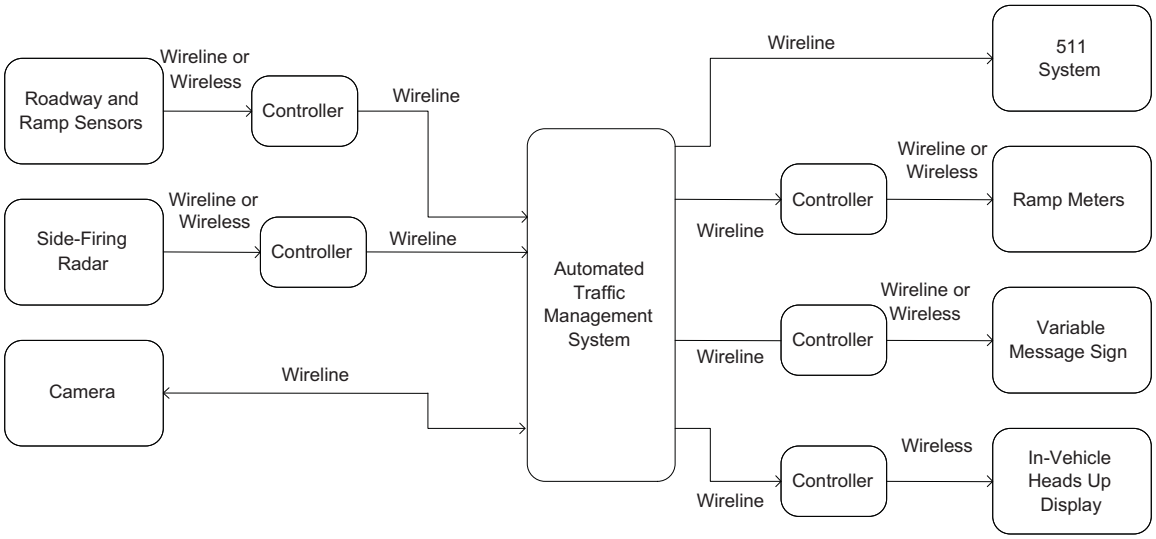
15-Year Outlook – National Identification Card

The READ ID act became law in 2005. By 2008, a national identification card will be required for an individual to use any government service, to travel on airplanes, or to open a bank account. Most likely, state-issued driver's licenses will become the national identification card. In order to get this national identification card, an individual must provide a photo identity card, document birth date and address, and show Social Security card (or valid Visa). With a few modifications, the passive ETC system could read the national identification cards of all vehicle occupants to determine the correct number of occupants and feed that information to the toll processing system to charge the correct toll based on the number of occupants in the vehicle.

7.3.4. Traffic Management and Control Systems

Traffic management systems also are an integral component to a successful managed lane system. Current traffic management systems for managed lanes also perform various functions for the adjacent lanes as well. This concept applies to the I-15 corridor and will likely be applied to the I-5 North Coast Managed Lanes corridor as well. Components include ramp metering, regulatory signing, detection systems, variable message signs (VMSs), closed circuit television (CCTV) monitors, and maintenance online management systems (MOMS). Refer to Figure 7-7 below.

FIGURE 7-7: AUTOMATED TRAFFIC MANAGEMENT SYSTEM DIAGRAM



More globally, information from the I-5 North Coast Managed Lane project should be fed into the local and regional traveler information systems and the 511 systems to inform travelers of travel times and current tolls. The information must be in a common format or re-formatted to fit the needs of the traveler information and 511 systems.

Current – Ramp Metering

Ramp metering is a freeway management tool in which a traffic signal is installed at the entry ramp with the intent of controlling the number of vehicles accessing the freeway. Loop detectors are placed upstream of the ramp to measure the speed and number of

vehicles per lane per hour on the freeway. The detector data is analyzed using freeway algorithms and when freeway conditions are too congested, the ramp meter begins operation. When the ramp meter is operating, the red traffic signal is displayed to stop vehicles from entering the freeway in queues that further degrade traffic flow. During times of high traffic congestion, the green signal is displayed for a short period of time allowing only one or two vehicles to enter the freeway at a time. When the congestion is not as severe, the ramp meter green timing is extended to allow more vehicles to enter. At times when the freeway is operating normally, the ramp meters are turned off. Ramp meters are typically operated during the AM and PM peak periods.

There are multiple algorithms to control the rate at which traffic is signaled to enter the roadway. The major categories of ramp metering include isolated, cooperative, competitive, and integral. Isolated ramp metering determines the meter rate for an individual on-ramp based on its local traffic conditions (e.g. flow, occupancy, travel speed, and queue overflow).

Cooperative ramp metering algorithms calculate an isolated meter rate and then calculate a system flow rate in order to minimize congestion at the bottleneck and spillback at critical ramps. Cooperative ramp metering reacts to critical traffic conditions and responds after the fact.

Competitive ramp metering algorithms compute a local and global traffic flow rate and choose the more restrictive rate to control the flow.

Integral ramp metering algorithms use control objectives, such as travel time or throughput, to control entrance to the facility.

Dynamic ramp metering is a subset of integral ramp metering and it takes into account the traffic congestion upstream of the meter and dynamically changes the rate at which traffic is signaled to enter the roadway. A dynamic ramp metering algorithm is the most complex and comprehensive as it combines system-wide, adaptive and predictive controls.

15-Year Outlook

Ramp metering will continue to be used in the future. The detectors may become roadway surface installed devices that transmit their information wirelessly to a reader. That detector information will be transmitted, probably via wireline, to a location for processing by an algorithm to determine the correct vehicle entry rate. The “meter” information may be transmitted to the vehicle wirelessly in a heads-up display. The processing algorithms will continue to improve and become more appropriate for a specific facility. The concepts used in ramp metering, however, will remain the same. There will be detectors, information flow, algorithms to process information, vehicle entry rate determination, and information dissemination.

Current – Pavement Markings and Signing

Pavement Markings

Pavement markings for either a buffer- or barrier-separated roadway will follow the standard MUTCD and Caltrans requirements associated with freeway applications. Buffer-separated lanes provide both white and yellow striping in accordance to the Caltrans HOV Guidelines in the buffer area, with a yellow left edge stripe. Barrier-

separated roadways carry a left solid yellow edge stripe and right solid white edge stripe. The left solid edge stripe for the general purpose lanes would be white.

Guide Signing

Guide signing is essential to direct road users along highways. The new Manual on Uniform Traffic Control Devices (MUTCD) and Caltrans HOV Guide provide guide signing examples that are appropriate for the I-5 managed lanes, and this report provides illustrative examples as recommendations for typical guide signing applications (Figures 7-8 through 7-13). New HOV signing requirements in the 2003 MUTCD include more emphasis on overhead mounted signs, particularly at lane approaches. Color and sign formatting requirements are also specified. Additional revisions to the MUTCD are likely in the next two editions, in which more emphasis will be given to the application of pricing information and sign color through ongoing research. Accordingly, guidance on signing may change before the I-5 project is finalized and constructed.

Regulatory Signing

Regulatory signs provide the critical link to the public that informs drivers of the operational and legal enforcement parameters of a managed lane. These signs must conform to state and federal specifications pertaining to shape, size, and color. Regulatory signs are typically of rectangular shape and consist of black letters against a white background.

Managed lane regulatory signs typically refer to the physical limits of the lane, the hours of operation, the occupancy requirements, and the applicable tolls. This is a relatively large amount of data that the driver must comprehend when approaching a managed lane at freeway speeds. For that reason, the information is often distributed over several signs and with adequate spacing between signs so that the driver has enough time to understand the sign and maneuver the vehicle in anticipation of the final decision points.

The design of regulatory signs requires careful consideration of the information so that the driver most readily understands it. If the signs have too much information or are confusing, it can often lead to an enforcement problem. The signs are typically mounted on overhead structures or as large ground mounts. When a managed lane is integrated into a freeway cross-section, additional consideration must be given to sign placement so that signs intended for drivers on the managed lane are not interpreted as intended for drivers traveling on the adjacent main lanes.

Locations

Overhead minimum occupancy signs shall be located at least 800m (0.5 mile) before the beginning or entry point to the managed lanes.

Ground-mounted preferential only lane signs shall be installed at the beginning, initial entry point, intermediate access ramps, and direct access ramps to all types of preferential only lanes. An overhead preferential only lane operational sign shall be installed only at the beginning or initial entry point to all types of preferential only lanes. Ground mounted preferential only lane ends signs shall be installed at least 800m (0.5 mile) in advance of the termination of the managed lane.

Examples

Figures 7-8 through 7-13 offer examples of typical sign language and placement based on access requirements associated with a buffer- or barrier-separated managed lane orientation.

FIGURE 7-8: MANAGED LANE ENTRY SIGNING

Example Managed Lane Entry Signing

Located in advance and at each entrance. Black elements are dynamic.

NOT TO SCALE

FIGURE 7-9: MANAGED LANE EXIT SIGNING

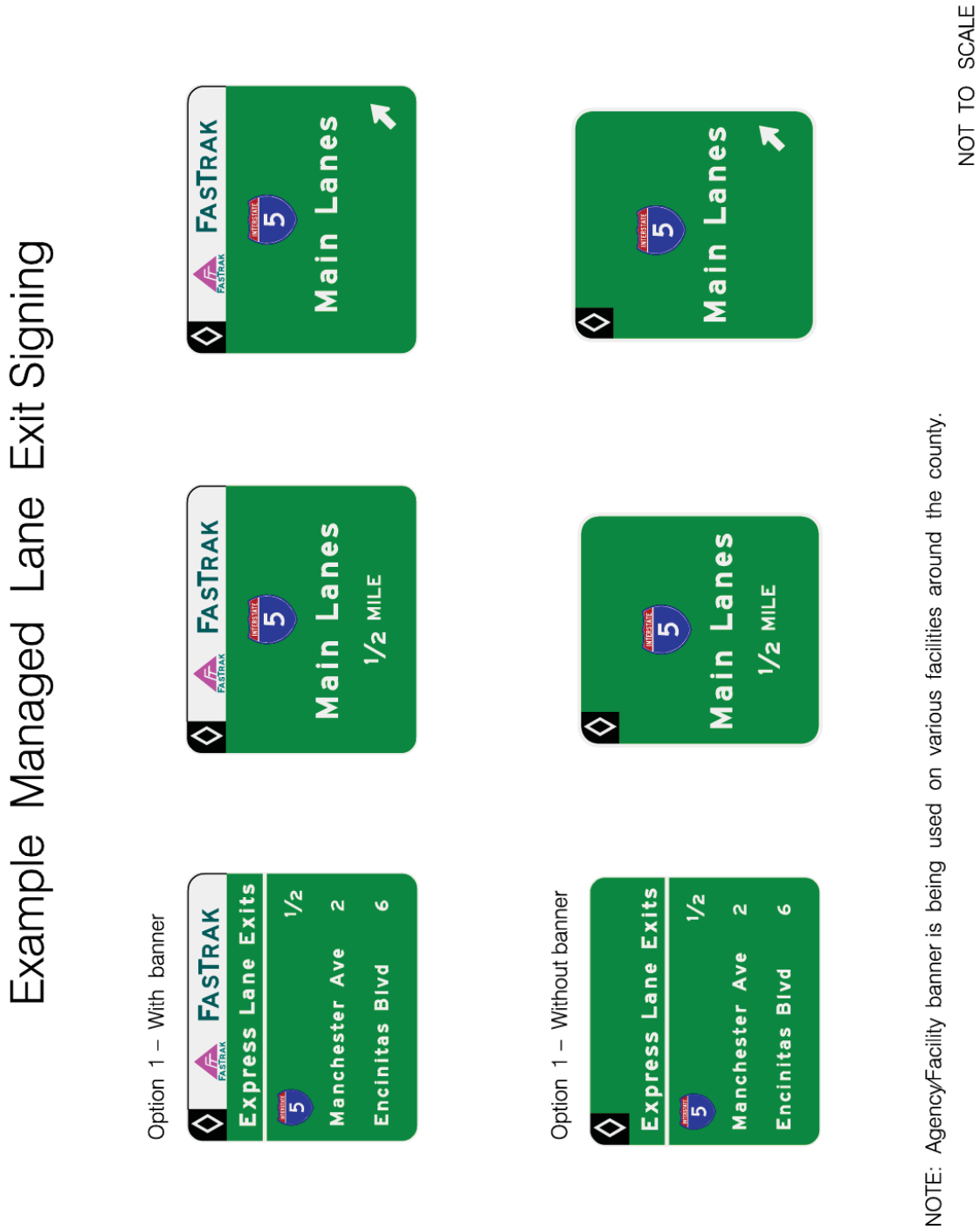


FIGURE 7-10: EXAMPLE LAYOUT ENTRANCE SIGNING

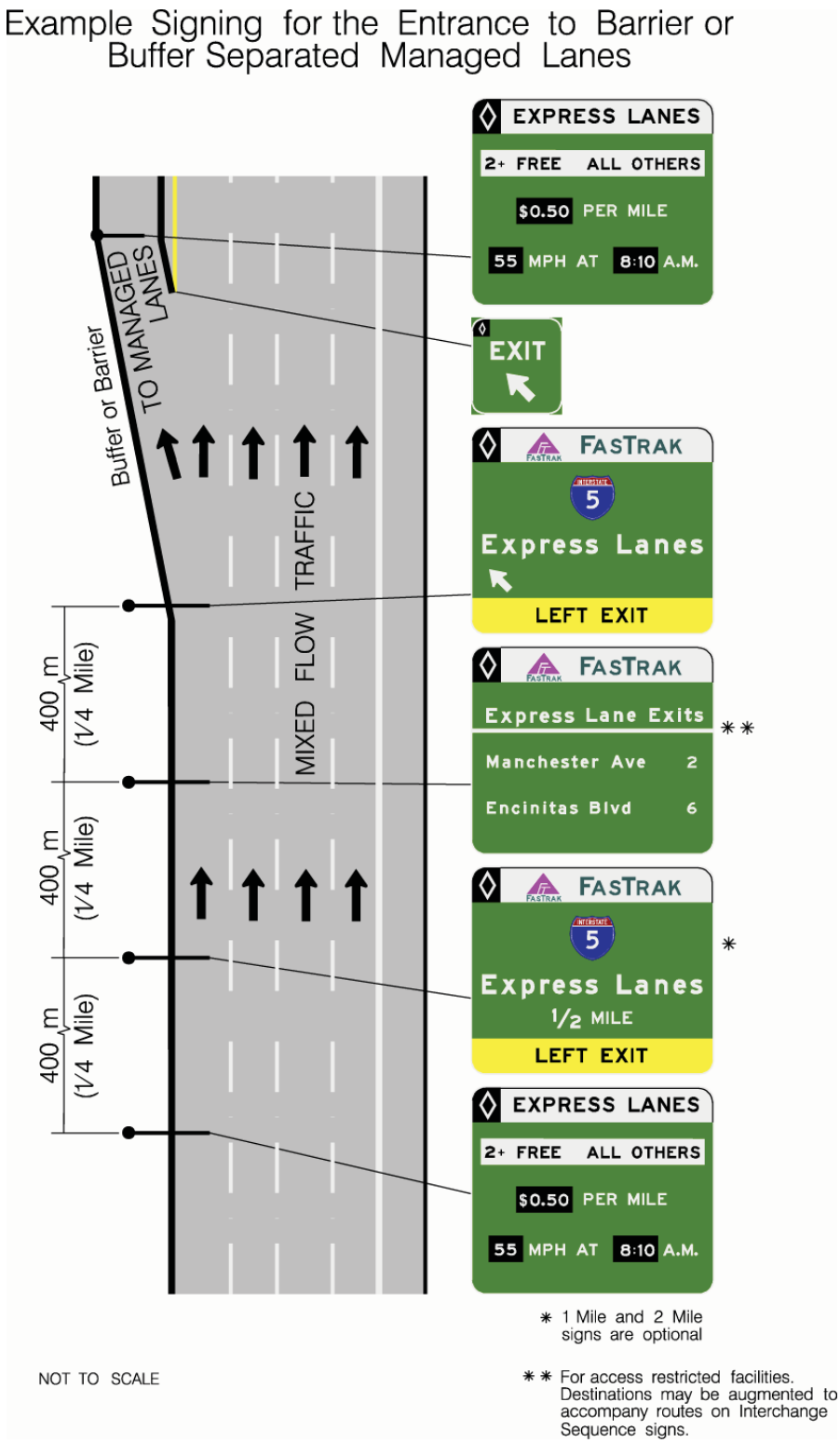


FIGURE 7-11: EXAMPLE LAYOUT EXIT SIGNING

Example Signing for the Exit from Barrier or Buffer Separated Managed Lanes

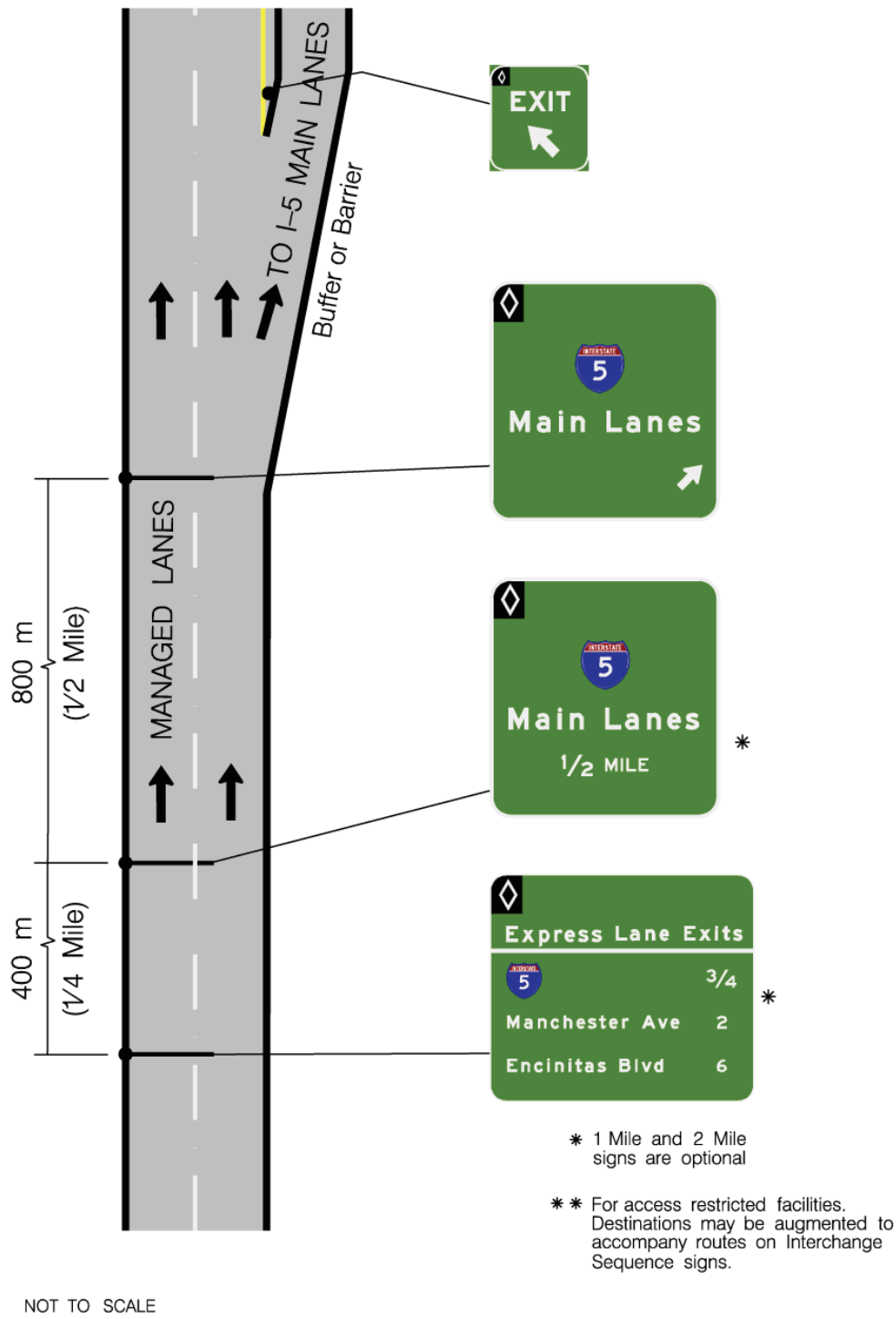


FIGURE 7-12: EXAMPLE SIGNING FOR DIRECT ACCESS FROM A PARK & RIDE FACILITY

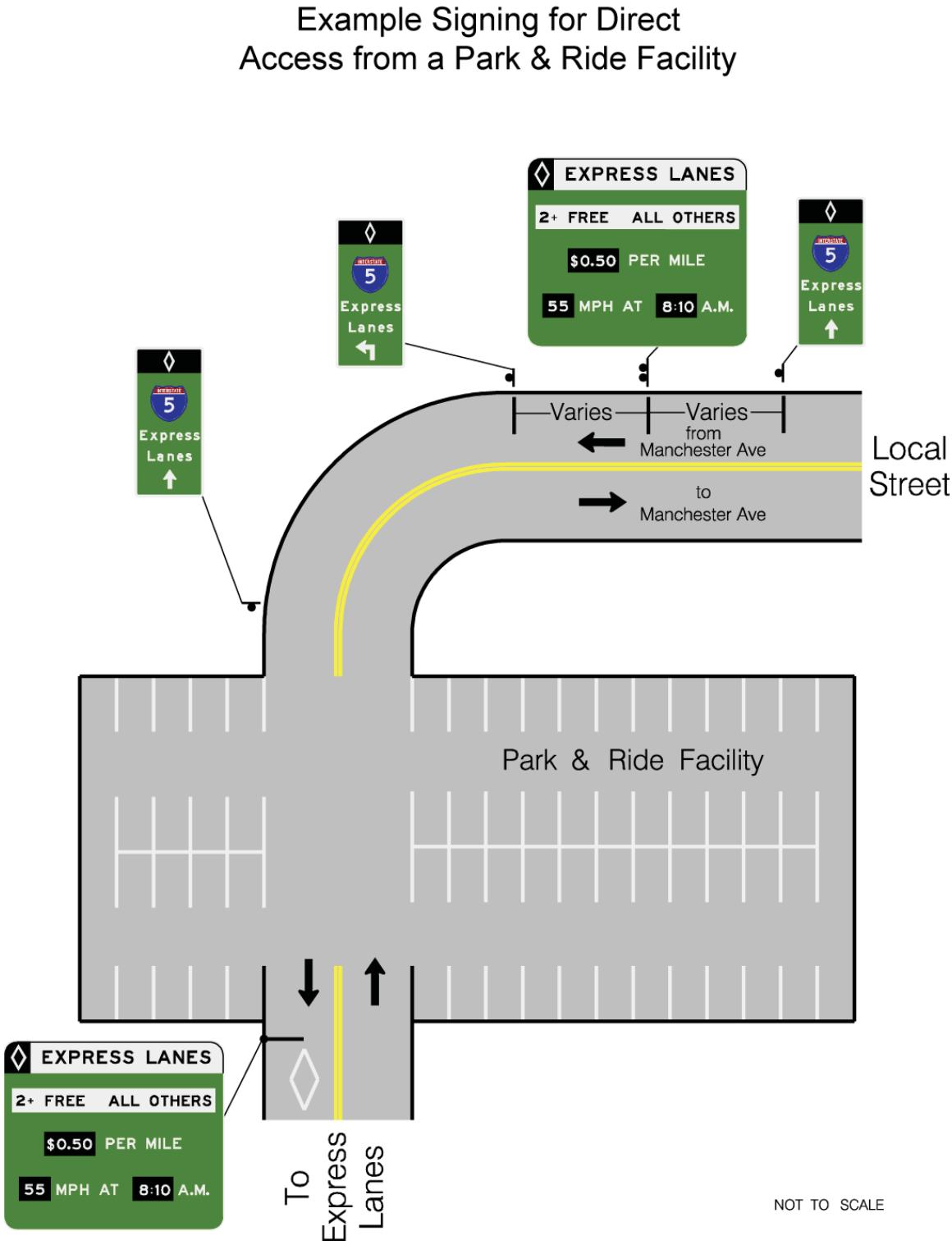
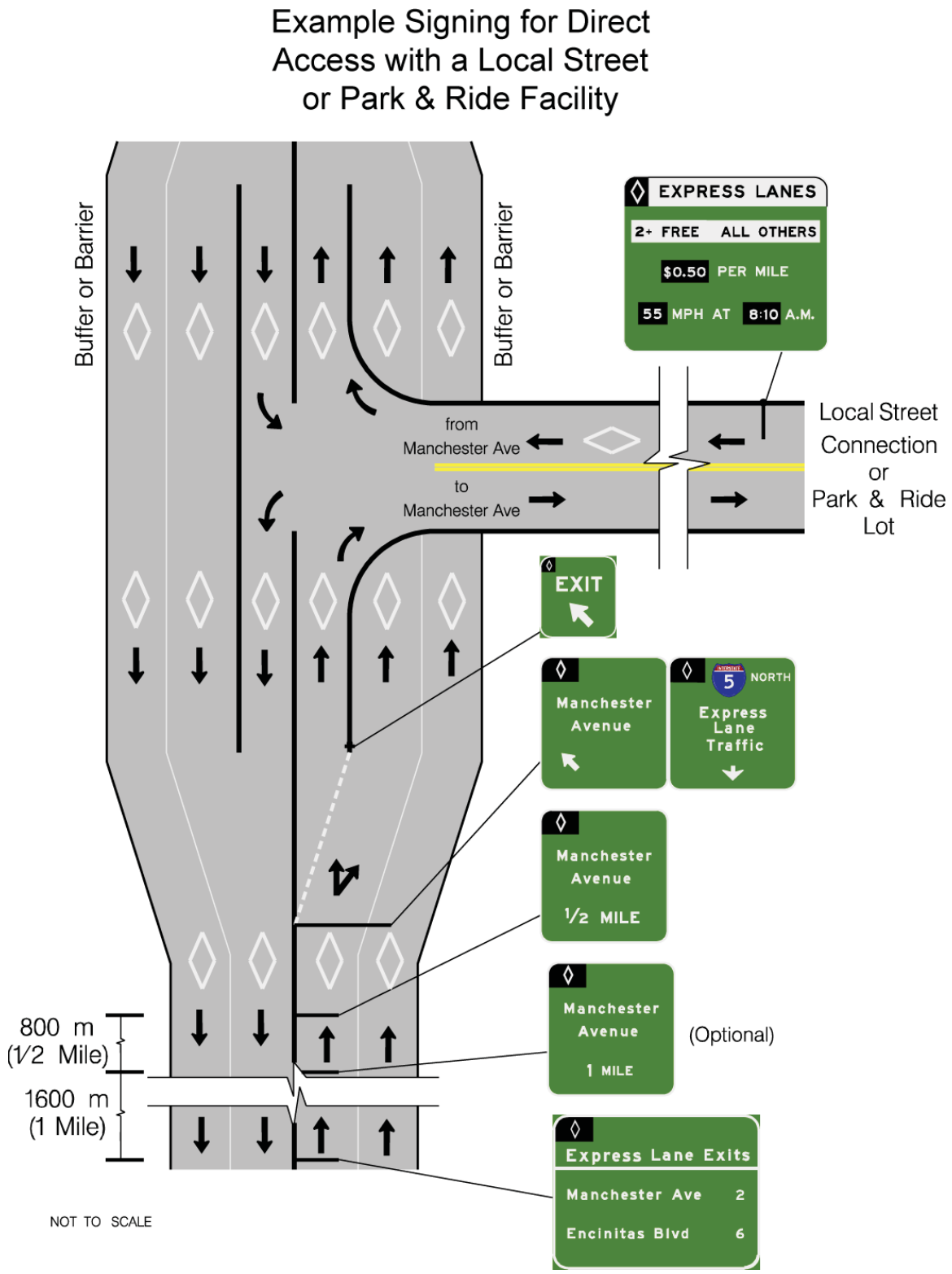


FIGURE 7-13: EXAMPLE SIGNING FOR DIRECT ACCESS WITH A LOCAL STREET OR A PARK & RIDE FACILITY



Vehicle Detection Systems: Determining Traffic Flow

Detectors and sensors will be placed in both the managed and general purpose lanes to determine the current flow in both of those lanes. The information will be used for two systems, namely, the ramp metering system and the toll rate processing systems. The detector information will be used to determine the appropriate ramp meter timing to reach the desired traffic flow. The detector information will also be used to calculate the toll charges for SOVs and HOV-2+s within the managed lanes.

The information will be collected from the detectors and sensors at the controllers and sent back to the traffic management center for ramp meter timing processing and the ETC processing center for toll calculation.

Finally, the detectors may also be used to feed the traffic management center's travel time calculation. The travel time will also be shown on the variable message signs (VMSs) to help motorists determine if they want to use the general purpose or managed lanes. The travel time for the entire I-5 North Coast Managed Lane corridor or discrete sections of the corridor may be calculated. As discrete tolls will be calculated between the seven toll zones, it will be possible to detail the travel time between those zones (and show that information on the VMSs). Therefore, travel time for the downstream toll zones will be calculated before the next VMS.

Current - In-pavement Loop Detection and Treadles

Treadles and loop detectors are currently used field devices that detect traffic flow. Additionally, software (algorithms) is required to take that count information and turn it into a useful statistic.

Treadles can be electromechanical, resistive rubber, optical or piezoelectric. They are used to determine the number of axles, number of wheels and direction a vehicle is crossing the treadle.

While mechanical treadles are well known to the industry, they have significant limitations including, mechanical problems subject to weather conditions, exacting installation, and careful maintenance. Additionally, mechanical treadles don't always register motorcycles. There is a move from mechanical to piezoelectric and fiber optic treadles.

In pavement loop detectors sense the presence of vehicles in order to measure vehicle flow, density and speed as part of the vehicle classification process. Some loops can also classify a vehicle by its speed, length, and axles. Loop detectors have a low cost and are well understood by the industry. On the downside, the need to be cut into the pavement and maintenance can be an issue when the road deteriorates. Additionally, re-bar must be protected from damage during loop detector installation to minimize future maintenance costs of the facility.

No matter which detection device is used, the vehicle presence, number of axles, number of wheels and direction data is sent via wireline to the traffic management center and the electronic toll and traffic management (ETTM) center.

Current – Video Imaging Video Detection (VIVD)

Video Imaging Video Detection (VIVD) is comprised of a camera, an image processor, and an interface capable of algorithm processing. The system is operated by placing a video camera above the freeway. The background image, with no vehicles in the field of

view is considered the natural background. When the system is operational, a new video image is loaded to the processors. The natural background is subtracted digitally from the entire video image. The remaining digital image is that of vehicles that were caught in the view of the camera. The image pattern of vehicles is fairly typical and a pattern match indicates that a vehicle is present and will be counted.

The processor uses another algorithm for pattern matching which allows the vehicle to be tracked across the field of view. The distance tracked, combined with the camera shutter speed, allows a speed for the vehicle to be calculated.

The VIVD system has been most often deployed at intersections where image zones are used to detect when a vehicle is waiting in a traffic queue. The stopped vehicles provide for a more accurate result as compared to a freeway installation.

Some systems are said to have 96 percent accuracy. However, the accuracy of detection can be reduced due to darkness, abrupt changes in lighting conditions, rain, headlights reflecting off of wet roadway surfaces, or long shadows of vehicles cast during sunrise and sunset.

5 -Year Outlook – Side-firing Radar Detection

Side-firing radar typically operates in the microwave range, allowing it to operate unaffected in such adverse weather conditions such as rain, snow, or hail. When mounted at right angles to the traffic lane, in side-firing operation, the radar footprint can detect up to eight individual lanes of traffic. The imaging and signal processing allows vehicle detection for volume, occupancy, and average speed. The ability to detect volume and average speed make side-firing radar very suitable for Advanced Traffic Management System (ATMS) operations requiring input data for traffic volumes and incident detection. The installation of the radar unit is easier than installing pavement loops. The maintenance requirements are typically less than that required for in-pavement loops.

Side-firing radar has been gaining in popularity because of the ease of installation, price, accuracy, and reliability. It is not affected by weather and even has the ability to detect vehicles that are partially hidden behind a larger passing vehicle such as a truck. The trend in popularity is expected to continue for these reasons.

5 to 10-Year Outlook – Wireless Sensors

Loop detectors often fail before they reach their 10-year design life. Sawing open the road to replace failed loop detectors is time consuming and costly. Wireless sensors are being developed to replace loop detectors. These wireless sensors can be glued onto the road surface much like reflectors. The sensors would be battery powered so wires are no longer embedded in the roadway to support a sensor. Small base stations are installed along the roadside to wirelessly collect the data. The data then could be transmitted via wireless or wireline method to the management/processing center. These devices are new and have not been tested in real world conditions for any considerable length of time. More time is needed to know if these sensors are ready for full-scale deployment.

Direct Signage Messaging: Changeable/Variable Message Signs (CMS/VMS)

CMS and VMS (used interchangeably) systems are currently the most popular technology used to convey information to drivers. The signs are quite reliable and easy to operate. When planning the location for a VMS installation, the engineer will need to

understand the impact to the visibility of the sign due to horizontal and vertical curvature, lighting conditions, and sun position.

The key to implementing dynamic pricing is installing VMSs prior to each entrance point to the managed lanes. VMSs will advise motorists of the current toll rates for SOVs and HOV-2. The toll rate displayed on the VMS must remain constant while the motorist travels the segment.

VMSs should not be used to display static information (such as occupancy requirement), but could be used to display variable information, such as:

- Current managed lane tolling prices
- Real-time traveler information
  - Segment information – "15 minutes until next interchange"
  - Corridor information – "Managed lanes travel time vs. general purpose lane travel times vs. current toll – cost/benefit ratio"

Current - VMSs to Broadcast of Current Toll Rates

The field devices such as treadles, loops, and side-firing radar will transmit their information to lane controllers and ultimately the ETC processing center in order to calculate the traffic flow and appropriate toll rate. The toll rate will be calculated to manage the traffic in the general purpose lanes and managed lanes. Once the appropriate toll rate is calculated, the toll will be displayed on the VMSs. The entire process from the detection system to the VMS message takes a few seconds.

Current – VMSs to Broadcast Travel Conditions/Incident Information

Incident notification usually consists of broadcasting the fact that there is an incident ahead, the location of the incident, and an advisory for action that could be taken by the driver. This information allows a driver to decide whether to continue on the freeway or exit to an alternate route. The VMS sign messages should use a minimal amount of text and conform to a standard format for the message layout. A standard format allows the drivers to become familiar with the layout and thereby they understand the message more quickly.

Example VMS characteristics include:

- Letter size of 18" (desirable) to 10.6" (acceptable)
- Maximum of three lines with no more than 20 characters per line
- Maximum of two displays used within any message cycle
- Readable at least twice by drivers traveling at the posted speed, the off-peak 85th percentile speed or the operating speed
- Messages centered within each line

15-Year Outlook – In-Vehicle Heads Up Display

Within the next 15 years, advances will occur in automobile technology that will bring operating agencies closer to having real time traffic, toll rates, and construction information displayed in vehicles. Instead of Caltrans or SANDAG purchasing and installing VMSs and the infrastructure to support them, a vehicle would likely have a DSRC receiver and a mechanism to display real-time information. Public agencies

(Caltrans and SANDAG) would still be responsible for installing and operating the system that detects traffic, calculates the appropriate toll rate, and transmits that information to vehicles.

Traffic Monitoring and System Alarms

Current – Closed Circuit Television Cameras and Monitors

Closed circuit television (CCTV) cameras will likely be used for both enforcement and traffic management. For the traffic management purposes, CCTV cameras should be installed along the facility at regular intervals to provide monitoring and verification capabilities of traffic conditions. Where known backups or slowdowns exist, additional cameras may be installed. A managed lane facility requires more than the usual number of cameras as managing the traffic flow requires both active and passive management and response to incidents so that the maximum operating efficiency can be gained from both parallel roadway systems.

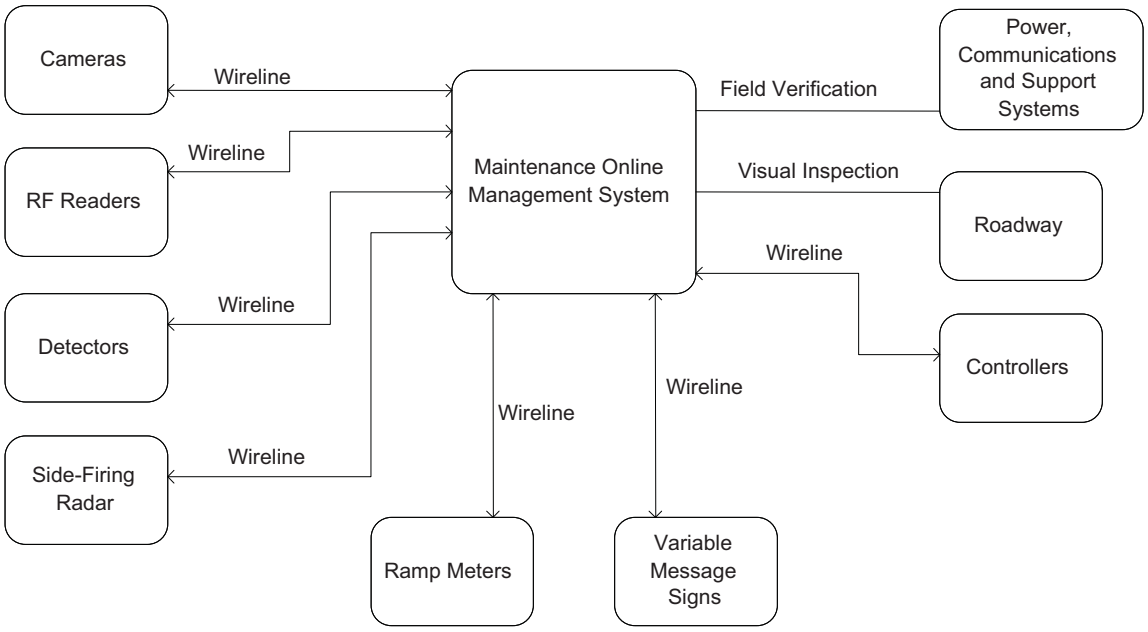
Caltrans and SANDAG may want to consider how ETC management and traffic management facilities are performed as they could share a significant amount of information, and each function impacts the other's decisions and outcomes. Therefore, the traffic management center function should be discussed with respect to how each agency will use and share potentially similar information for different end user needs.

It may make sense for SANDAG and Caltrans to consider co-locating the ETC management and/or traffic management facilities to facilitate sharing each other's information. This may reduce operating costs for each operator.

Current - Maintenance Online Management System (MOMS)

A maintenance online management system is an electronic method of supporting electronic toll collection system hardware and software elements in the field. Refer to Figure 7-14 for an overview of the MOMS components. The MOMS method is built upon a series of user-definable modules attached to the various field elements (e.g., VMS signs, loops, readers, etc.) which can provide real-time monitoring and reporting on system up-time and maintenance needs. The use of a MOMS can streamline the maintenance support required for efficient operation of the ETC system.

FIGURE 7-14: MAINTENANCE ONLINE MANAGEMENT SYSTEMS (MOMS)



Typical modules within a MOMS include:

- Lane events – which track the normal changes in the operational state of a lane.
- Diagnostic events – which verify the current operating state of the lane devices, loop detectors, cameras, etc.
- Unusual occurrences – this module requires definition and customization.
- Paging/Alarms – which notify the appropriate maintenance technician when a system failure has occurred, and ensures fast response time to repair.
- Performance history – which tracks the mean time between failure (MTBF) and mean time to repair (MTTR) for field devices and components.
- Work orders – automatically generates work orders based on diagnostic event messages.
- Part requisition – identifies and locates necessary parts and components by serial number to fulfill the work order.
- Suppliers – manages the contact information for suppliers.
- Equipment inventory – manages parts and components for the entire ETC system. Consumable items (without serial numbers), such as receipt printer paper and traffic light bulbs, can be managed through this inventor module.

15-Year Outlook – Automated Traffic Management and Control Systems

The 15-year outlook for automated traffic management and control systems includes a further deployment of technology along the roadside, in the pavement, in vehicles and in the sky. The trend will be to put the cost of ownership and maintenance on vehicle owners by using telematics, in-vehicle devices, and GPS satellites. Through this

process, SANDAG will probably not be able to completely eliminate their portion of the cost of ownership and maintenance.

7.3.5. Freeway Incident Response Provisions

Any impedance to ingress and egress locations, and blocked (managed) lanes may discourage motorists from using them. SANDAG loses toll revenue if the managed lanes are blocked and travel times do not match what was advertised on the variable message signs. Additionally, the lanes do not provide a reliable travel time for HOVs and transit. Traditional means -- road patrols and circulating tow trucks will not address the issue quickly enough. Real-time information provided by cameras and a monitored traffic management center (TMC) can more quickly identify blockages and initiate the appropriate personnel response (emergency, law enforcement, and tow trucks).

The I-5 HOT managed lane project will require more monitoring and response personnel (i.e.,freeway service patrol/customer assistance patrol) than simply a general purpose lane project. There would need to be enough staffing to meet the throughput and travel time goals of the managed lane facility and the staffing should be dedicated to serving the managed lane system. It will take SANDAG time to determine exactly how many additional staff that will be required. At a minimum, the traffic management center and freeway response systems should be fully staffed during peak demand times. The managed lane project may require this staffing for extended hours longer than peak demand periods.

Current - Incident Management Planning

Incident management is an important part of managed lane operations, just as it is important to overall freeway operations. Incidents result in delays to travelers that cost the public money. One rule of thumb is that for every minute a lane is blocked, it causes five minutes of congestion. The preparation of an incident management plan combined with training of the responders will result in a managed lane facility that is more efficient and ultimately more cost effective to operate. However, with dual roadways, the means to circumvent many incidents can be enhanced, but only if there is a means of communicating such information to motorists in a timely fashion. This means that the managed lane system will need to be able to accept large numbers of entering and exiting vehicles at the slip ramps in the event of an incident, and such information will need to be communicated to the driver. This communication medium may start with CMS displays in advance of each entrance or exit from each respective roadway, but eventually may be augmented through in-vehicle notification systems.

Current – Freeway Service Patrols

Freeway or Customer Assistance Service Patrols are extremely popular with the motoring public and are in many areas the most commonly cited service motorists could on when they need help. They are popular in the San Diego area. The provision of this service becomes more critical for managed lanes because there is no safe way for motorists who break down in these inner roadway barrels to seek help without attempting to cross busy mainlanes. Few opportunities will exist near median direct access ramps where a motorist could walk out of the managed lanes and seek assistance. Accordingly, the need for dedicated freeway service patrols, linked with rapid response telecommunications with the TMC, will be needed for both peak and off-peak operating periods. Barrier or buffer-separation for managed lanes will pose the same service assistance need. Several approaches to consider in augmenting

communications with stranded motorists will include posting emergency phone access numbers along the managed lanes for cell phone users and accessing through telecommunication links increasing use of in-vehicle emergency help requests.

7.4 CONCEPT OF OPERATIONS

The managed lanes should be operational 24 hours a day, seven days a week, and will not typically revert to free use unless in the event of a major incident. These inside lanes will be managed at an operational threshold of not more than approximately 1,650 vehicles directionally per lane per hour, depending on level of service (LOS) being experienced at key access locations based on this operational threshold.

7.4.1. System Overview

Figure 7-15 depicts the systems necessary for the I-5 North Coast Managed Lane electronic traffic and toll management (ETTM) system.

Automated traffic management and control systems will determine the traffic flow in the general purpose lanes and the managed lanes. In order to determine the pricing for the managed lanes the traffic flow must be known in the general purpose lanes and the managed lanes. Sensors will be embedded in and along the roadway of the general purpose lanes, managed lanes and ramps to determine speed of traffic and number of vehicles per hour.

In order to provide a benefit to the driver, the managed lanes must maintain a level of service (LOS) better than the general purpose lanes. To compare LOS between the ML and the GP lanes, both the GP and the ML must be instrumented with vehicle detection equipment to obtain travel time, speed and/or occupancy data. Obtaining ML and GP lane traffic data provides the most flexibility in the tolling schemes.

The ability to change the toll rate is dependent on the congestion state of the entire (GP and ML) facility. Table 7-1 provides four alternative states for the facility and the suggested toll level for that alternative.

FIGURE 7-15: I-5 NORTH COAST ETTM SYSTEM OVERVIEW

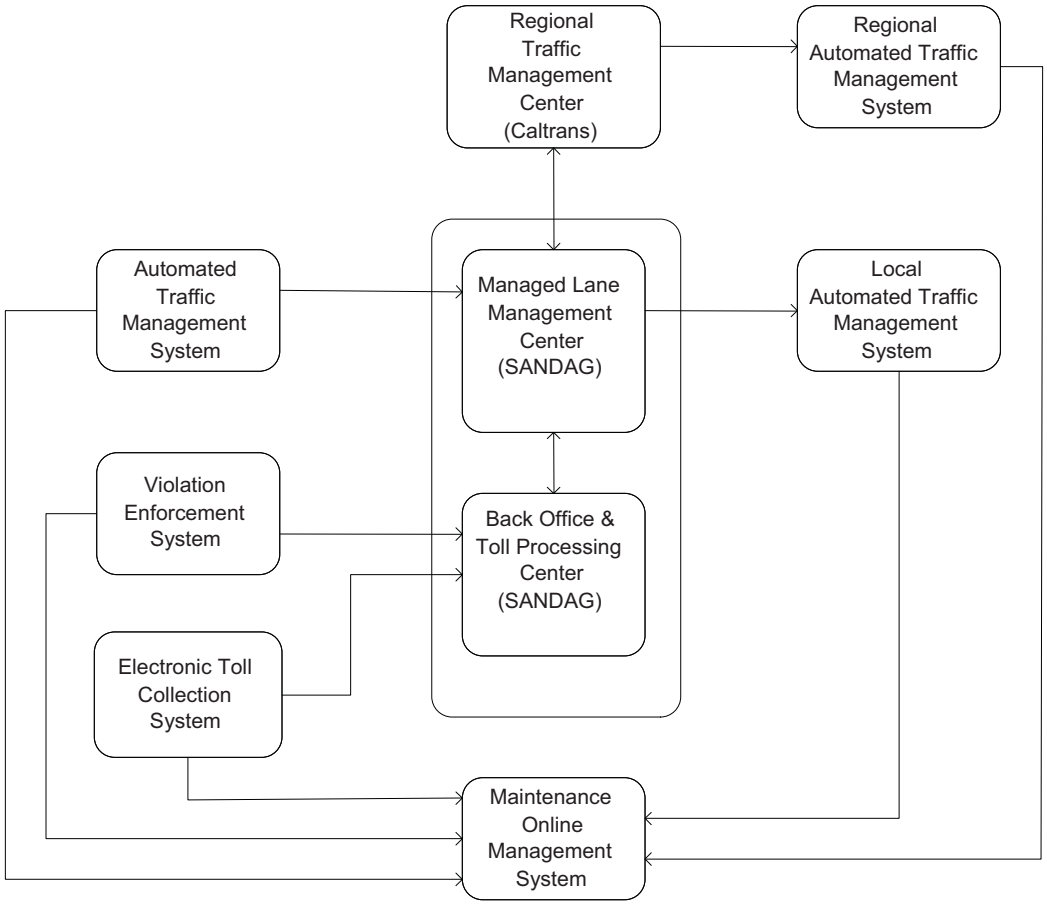


TABLE 7-1: FACILITY CONGESTION TOLL LEVELS

Managed Lanes	General Purpose Lanes	Toll Level	Reason for Toll Level
Not Congested	Not Congested	Low	No incentive to pa toll given high LOS of GP lanes.
Not Congested	Congested	High	Demand for high LOS exists on the managed lanes
Congested	Not Congested	High	Demand on ML must be reduced to regain high LOS
Congested	Congested	High	Demand on ML must be reduced to regain high LOS

The traffic flow information will be fed into the toll rate algorithm in order to determine the appropriate toll rates for SOVs and HOV-2+ (or possibly HOV-3+ at a later time). The system should be made flexible, user-defined, and table-driven to allow for periodic adjustment over time. Higher tolls will be charged during periods of peak demand. Multiple toll zones will exist in each direction; the entire corridor may not have the same

pricing basis. Each individual zone's toll rate will be calculated. Factors considered in that calculation are the number of vehicles in the general purpose and managed lanes within the zone and travel time within the zone. Toll rates for each zone will be communicated to motorists on signs in advance at access points via dynamic message signs (DMS), through the region's automated 511 traveler information system, and ultimately by way of in-dash heads up displays.

Traffic flow data is only one element to the toll rate algorithm. Levels of Service and toll rate increments are two other inputs into the algorithm. A benefit to traveling on the ML is the speed and reliability to traverse the lane within a valued time period. Therefore, the ML LOS must be better than the GP LOS and that increased LOS must be consistent from day to day. Local agencies must agree to the expected ML LOS, and the current statewide application of 1,650 vehicles/lane/hour is a realistic operational threshold.

Maintaining a high and consistent LOS comes at a price. The toll rate must be adjusted to maintain the balance between demand and access. "At what rate should the toll increase to maintain an acceptable and reliable LOS?" is another question that can only be answered at the local level. The toll increments must be consistent with other toll facilities in the area.

An entire system of electronic toll collection devices will be installed along the facility in order to collect the appropriate tolls electronically, and potentially to sample travel speeds and travel times through the managed lane segments for feedback to 511.

A combined approach to enforcement will incorporate both technology-based automated violation enforcement systems (VES) and personnel-based routine patrol enforcement provided by the CHP. The dual approach is recommended to ensure that vehicle occupancy and carpool requirements are met and that toll evasion is kept to a minimum.

A front-end (in-lane) communications server is required to communicate with the field equipment. This server may process the LOS computations and output dynamically varying toll charges, if such capability is optioned for. The front-end communications server should host the tolling algorithm and shall be fail-safe including such measures as redundant configuration and processors, uninterrupted power supply (UPS), et cetera, to lessen the possibility of system downtime.

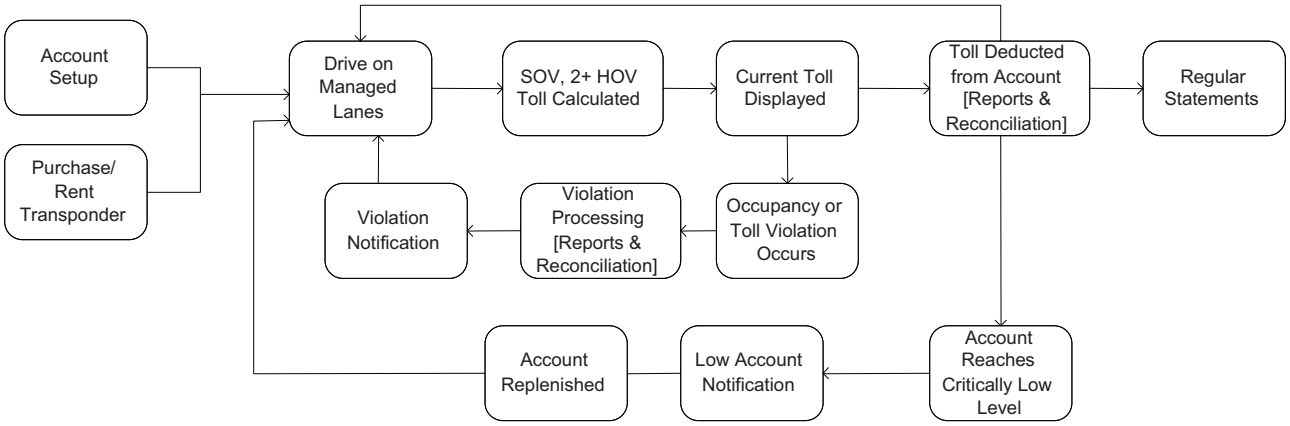
A back-end system is also required to process tolls, set up accounts, process violations, interface with neighboring agency systems, and interface with the public, and will serve as the managed lane toll system account management and revenue collection system/clearinghouse. This back office server can be independent but is more likely to be combined with the expanded I-15 back office system/server that will already be operational for the I-15 managed lane toll operation. Therefore, the back-end system/server solution should be scalable and allow for ease of interface to other back-end applications. These may include the regional transit fare collection system, electronic parking meters, or other related applications as well as the regional managed lane/tolling system(s). Each back-end system will have a process to accurately and efficiently complete its portion of electronic toll collection.

Staff augmentation will be necessary in the back office to perform a variety of I-5 managed lane functions, including management, maintenance, marketing, and traffic management specific to this corridor. Additionally, high-quality customer service for I-5

patrons should be ensured through a combination of front office customer service options, including email/web access, telephone and walk-in, The customer service front-end responsibilities will require physical space as well, to host the walk-in and account fulfillment centers. SANDAG and Caltrans may want to co-locate some of those customer service functions to save space, minimize staff requirements, share data, and reduce overhead.

Figure 7-16 depicts the process overview for account setup, toll calculation, display and deduction, violation processing, and account replenishment.

FIGURE 7-16: ACCOUNT PROCESS OVERVIEW



7.4.2. Development of Standards

Caltrans developed a Technical Specification for Automatic Vehicle Identification (AVI) and tolling in California that is codified in administrative law under Title 21 of the California Code of Regulations, Division 2, Chapter 16. With many advances in AVI and electronic payment methods since that time, there is pressure now to update the Title 21 specification to include more flexibility in technology applications, such as use of battery-less toll tags, SmartCard-enabled tags, and/or elements envisioned as part of the Federal DSRC specification. At some point, Title 21 may become totally obsolete and give way to the DSRC specification, or perhaps it will mirror the DSRC standard. Until that time, Caltrans should be concerned with modifying parameters, although not an exhaustive list, such as:

- Accuracy;
- vehicle speed;
- number of transactions per hour;
- radio frequency (RF) radiation levels;
- security measures;
- data format/content;
- power density;
- read/write capability;
- 100 mph read speed;
- compliance with existing national/International standards (like ANSI, FCC, IEEE);

- ability to use tags on vehicles with metallized windshields;
- communications protocols;
- message content;
- vehicle occupancy;
- cost of transponders; and
- interoperability with other related fare collection systems (e.g., SmartCards) deployed throughout the state.

For the I-15 and I-5 North Coast Managed Lanes toll collection and back-end processing, SANDAG should consider leveraging existing investments into automated fare collection systems and processes, such as the regional transit SmartCard, to determine what economies of scale, if any, exist; whether a consolidation of standards is possible; and what potential such consolidation has to increase ease of travel/mode crossover for regional commuters.

7.4.3. Traffic Management: Assumed Operational Parameters

Pricing is the primary management technique that will be employed to moderate demand. "The concept of value pricing within the highway sector involves the introduction of road user charges that vary with the level of congestion and/or time of day, providing incentives for motorists to shift some trips to off peak times, less congested routes, or alternate modes. Higher prices may also encourage motorists to combine lower-valued trips with other journeys or eliminate them entirely."[1] Managed lanes are designed to assess a road user fee that is in line with the value of reliable travel time to an SOV who is buying-in. Reliable travel time may be measured in how often is the calculated travel time is correct, or how effectively using the managed lanes gets commuters where they need to go more quickly.

For managed lane installations, variable pricing can also be set in real-time by the prevailing traffic conditions, an option known as dynamic variable pricing. It is recommended that the toll calculation algorithm consider several factors such as the number of vehicles in the managed and general purpose lanes, speed, number of vehicles per hour, and time of day to determine the appropriate toll for that moment in time. The toll calculation algorithm will re-calculate the toll within a set time period, or under a more complex system, whenever necessary to keep the flow at an acceptable rate.

Dynamic Variable Pricing Technique

The benefit of using the managed lanes over the general purpose lanes is reduced trip time and reliability. To maintain these benefits, traffic flow data must be collected on the entire facility, managed lanes and general purpose lanes. To maintain the trip time and reliability advantage, the level of service on the managed lanes must be controlled to maintain a LOS satisfactory to the users. This LOS is typically LOS equal to C.

[1] A Guide for HOT Lane Development, FHWA-OP-03-009, Federal Highway Administration, Washington, D.C., March 2003, page 3.

Level of service of a roadway is determined by assessing the current volume on the roadway against the capacity of the roadway. Capacity volumes vary by geometrics and operational characteristics. Typical general purpose lane capacities range between 2,000 and 2,100 vehicles per hour per lane (vphpl). Managed lane capacities range between 1,650 and 2,000 vphpl. The lower capacity is due to the lane characteristics, including whether the managed lane is separated from the general purpose lanes by a buffer or a more positive barrier.

Buffer separated managed lanes typically have lane capacities near 1,650 vphpl due to the uncontrolled interaction between managed lane traffic and general purpose lane traffic. Traffic separated only by pavement markings influence conditions of the adjacent facility. Buffers are generally less than four feet. This distance does not provide enough comfort for the driver if congestion were to occur on the adjacent lane.

In order to maintain a minimum LOS "C" (85th percentile) condition on the managed lanes, the volume-to-capacity threshold for the maximum number of vehicles per lane per hour (VPLPH) is 1,650. In most open road environments, instability occurs when the number of vehicles per lane per hour exceeds 2,000-2,100 VPLPH. The Highway Capacity Manual suggests that acceptable speeds for LOS “C” fall in the range of 35-50 mph. However, experience has demonstrated that the posted speed is the optimal rush hour speed; in the case of the I-5 North Coast Managed Lanes the posted speed is 65 mph.

7.4.4. Back-End Office Operations

Back-end office operations include toll posting; transaction auditing; recurring payment, billing and payment processing; statements and account notices; customer information/annotations; violation processing; DMV interfaces; OBU tracking and order fulfillment; interoperable interfaces; reporting; Internet hosting; marketing interfaces; communications interfaces and telephony; front end user interface, and security.

Toll Posting

An ETC system must maintain an accurate posting of all toll transactions with unique records associated with the appropriate account. Each financial record must be reconciled and closed. A transactional record should be associated with the debit/credit account system. Daily, weekly, and monthly posting reports are required for reconciliation and auditing.

While proprietary toll posting systems exist, it will be possible to find an open architecture using commercial off the shelf (COTS) hardware and Internet protocols. Since the I-5 North Coast managed lane toll system integration will follow the I-15 managed lane system design and integration, it is possible that the existing I-15 system will be expanded to handle the I-5 account and transactional data under a separate subdivision within the overall clearinghouse functionality. Therefore, it is important for SANDAG to consider scalability, expandability, ease-of-use, and maintainability.

Transaction Auditing

The tolling system integrity must be guaranteed. Therefore, independent periodic tests should be planned that test the lane and host systems to verify the accuracy of the counters, transactions, and postings.

Recurring Payment, Billing and Payment Processing

Pre-paid accounts should permit payment by credit cards, debit cards, automatic clearing house (ACH) authorizations, electronic checks, gift cards, cash and/or check deposits, and the back-end toll posting system should be configured to accept payment from third party transfers (such as a reciprocal FasTrak agency's clearing house). The back-end system will therefore require automated interfaces with credit card processors, bank processors, and check processors.

Patron Account Statements

Statements provide the account holder with a record of toll system transactions, beginning and ending balances. The system should be capable of generating statements for any interval, primarily monthly or quarterly, and should be delivered periodically to the account holder via one or more of the following means: U.S. mail, electronically (in portable document format) by email, by facsimile (FAX), or over the counter. Fees for statements could be charged if requested by U.S. mail or FAX, or if desired monthly rather than quarterly.

Customer Information/Annotations

In order to differentiate account holders, a database of customer information, such as name, address, telephone number, email address, account number, vehicle description and license plate numbers, and transponder numbers assigned to each account, should be maintained. Each account should be password-protected by a user-definable personal identification number (PIN). Furthermore, the back-end toll posting system should be designed to meet or exceed then-current payment card industry (PCI) standards for security, data encryption, and privacy protection.

Space for frequent annotations, such as statement and notice delivery dates, replenishment histories, historical changes to account information, and customer communications notes, should be provided for in the toll-posting system account database, which will greatly facilitate high-quality customer service. The system could be linked directly to the front office interactive voice response (IVR) telephone system.

Violation Processing

Through the I-15 project, SANDAG has already developed many of the internal and external processes necessary for an ETC/violation processing system. Those processes include:

- Toll amounts and occupancy requirements;
- Dispute resolution;
- Payment forms and timeline;
- Information sharing/notification between sister tolling authorities;
- DMV involvement;
- Information sharing between VES devices and violation processing; and
- Priorities and penalties.

These current procedures and processes are relevant for the I-5 North Coast Managed Lanes project as the same types of violations will be prevalent. Typical violations will involve toll evasion, occupancy infractions and if a buffer-separated project is applied without any form of soft barrier, buffer crossing could become prevalent. The VES role

will primarily reside with the operator of the managed lanes, which will include SANDAG as the tolling operator (or their contracted agent), Caltrans for operational monitoring of all roadway facilities through their traffic operation center, and the California Highway Patrol, likely under contract to provide enforcement services needed for the VES. The VES functional roles will reside with SANDAG and CHP, under contract to provide these services on a dedicated basis.

DMV Interface

SANDAG should develop interfaces to the DMV and possibly an interstate DMV consortium in order to share information related to violations processing. The interfaces would include common data standards in a format that is accessible (in order to share information between the toll posting system and the DMV, and process away-from-home transactions) and agreed-upon policies and procedures. The back-end violations processing office should be capable of transmitting and receiving the data so that registered owner/vehicle registration information, and vehicle color, make, model, year, and license plate information can be quickly queried to expedite and validate violations processing.

Transponder/OBU Tracking and Order Fulfillment

This system tracks the inventory levels of transponders or on board units (OBUs) (collectively, "tags"); including their internal ID and facility code, and assignment status. This module should be capable of documenting order placement, order fulfillment, tag assignment, tag issuance, tag return/recall, tag test/status, and warranty of tags, at any given time.

Interoperability and Reciprocity

The back-end system shall be capable of identifying, validating, accepting, and reporting transactions for both home-agency and away-agency transactions. This is accomplished by a series of interoperable interfaces between California FasTrak™ toll agencies. The guidelines for how the agencies interact is defined in a series of agency-to-agency cooperative user fee agreements, and its parameters specified in the California Toll Operator's Committee (CTOC) technical document entitled *Technical Specification for Interagency Electronic Data Interchange,* current revision G.4 (or later).

A separate example of how interoperability with the toll-posting system might be desirable is an interface with the regional SmartCard transit fare collection system.

The back-end system must be able to separately identify, validate, accept, and report tag- or image-based transactions for all interoperable applications and reciprocal accounts. The back-end system must also reconcile the tag- and image-based transactions on a routine basis, for the purpose of creating billing and settlement files. All tag- and image-based transactional and account data should be backed up regularly using redundant arrays of inexpensive disks (RAID) architecture, and the full toll-posting system and account database archived periodically on a routine basis.

Reporting

The back-end system shall be capable of generating a number of canned and customized reports. The following types of reports are necessary at minimum: financial, audit, exception, asset/inventory, warranty, local transactional, reciprocal transactional, violations, collections, MOMS (system uptime/status and system maintenance/repair

reports), and account/patron activity reports and statements. Additionally, a series of customized management, marketing, accounting, operational, and service-related reports should be easily designed, implemented, and made accessible from the main software interface.

It should be possible to generate and review those reports remotely from desktops using a secure virtual private network (VPN) connection.

Internet Hosting and Web-Enabled Account Management Tools

Prospective patrons, account holders, and others should be able to obtain general information concerning the I-5 North Coast and affiliated managed lanes toll facilities, download standard forms (e.g., new account application, account change forms), and reach a SANDAG managed lanes customer service representative via e-mail and/or web-form from a non-secure informational Website.

Just as important, patrons and violators should be able to log-in to a secure Website from the Homepage that allows them to review confidential account information, make payments, apply for additional transponders, download statements, etc. SANDAG shall provide for the development and on-going content/maintenance of both the secure and non-secure sections of the managed lanes toll facilities website. Most of the available off-the-shelf toll system software applications today include both secure and non-secure web capability.

Marketing Interfaces

To successfully operate a managed lanes facility or network as complex as the planned I-15 and I-5 North Coast Managed Lanes, an integrated and flexible marketing program is necessary. The back-end system should include a feature that is capable of tracking various marketing promotions and must enable routine measurement of these special programs and the application of the promotion/program to the account base and it should include the capability to report on the productivity of such efforts to gauge their success or failure.

Communications Interfaces and Telephony

The back-end plan must accommodate multiple remote accesses to the system, call center functions with call routing, interactive voice response (IVR), predictive dialer ability, call monitoring, and establishment of multiple call banks. This system should provide monitoring and performance reports. SANDAG's 511 IVR system will be the portal for customer telephone access to the front office.

Front End User Interface

The front end of the toll system account database should have a search engine that allows for searches based on patron information, account and transponder numbers, violation and transaction numbers, replenishment methods, et cetera.

The toll system shall be secure and must require any person logging on to provide his/her discrete user name and password, and shall track all account maintenance or database changes to the user, including the recording of a date/time stamp.

Once secure-access is granted, the front-end system should allow for authorized personnel to make updates, modifications, and/or authorize payments to be applied to an account.

Security

The back-end toll system must be secure, behind a firewall, hosted offline, and failsafe in its ability to prevent hackers from accessing account information or modifying the database in any way.

Additionally, the signal between a toll tag and reader should be encrypted, in accordance with Title 21 or more current standards; and only the account number, and not the account balance, should be stored on the tag, to prevent security breach.

7.4.5. Staffing

An electronic toll system requires more than technology to work. Administrative, customer service, marketing, accounting, violations processing, maintenance, and technical support staff are required for a successful operation. Currently SANDAG's toll business model for the existing I-15 HOT lanes is primarily outsourced operations, including customer service, maintenance, and back-end processing, with limited internal staff overseeing the effort. SANDAG should conduct an analysis of their existing and planned I-15 managed lane operation to evaluate what the potential savings or service improvements might be if they in-sourced a portion of those tasks. If proven effective, SANDAG should expand upon these findings and increase their staff involvement for the opening of the I-5 North Coast Managed Lanes to directly operate all or a portion of the critical managed lanes responsibilities, including front office (customer service), back office (clearing house and violations processing), lane level (technical and maintenance), and support (accounting, marketing, et cetera) roles. Any in-sourcing will require SANDAG to hire and train new staff and should be planned for accordingly.

Customer Service

Account Representatives

SANDAG will operate a front office customer service center (CSC) staffed with customer service representatives (CSRs). The CSC will handle frontline communication with the account base and ensure a responsive account management and order fulfillment process. All CSRs shall be capable of accepting and recording account and violation payments.

Like the current practice on I-15, it is recommended that SANDAG continue a pre-paid balance accounting policy. A pre-paid balance accounting policy offers the highest assurance of timely toll transaction payments, requiring the patron(s) to deposit the funds or pre-authorize payments through a credit card, debit card, or ACH in advance of their use of the lanes. Accounts are set-up like debit accounts, and paper or electronic statements are periodically forwarded to the account base in order that they may monitor their transaction activity and balance.

The CSC will also be the channel through which transponders/OBUs are distributed to account holders. Therefore, all CSRs must be trained in the fulfillment of transponder distribution and collection, and a select number of CSRs should specifically be assigned to handle inventory, warranty processing, and procurement/receiving of transponder shipments.

SANDAG's current operational policies (or "Business Rules") for handling low balances, expired credit cards, failed AVI transactions, deactivation of accounts, and collection of

negative balances should be reviewed for currency and applicability to this facility. If necessary, those policies may be updated.

Point of Sale

For the near term, it is envisioned that SANDAG will continue to purchase and in turn lease the use of toll tags (transponders or OBUs) to patron accounts through its CSC. The CSC policies should ensure a simple transaction for prospective patrons to obtain those items. The more automated the system, the less expensive it will be for SANDAG to administer, so there is a motivation to shift a large portion of these transactions to the e-commerce (Internet) site. Additionally, SANDAG should consider making available a limited number of its transponder inventory from nearby convenience stores, government outlets, or even possibly custom-fabricated transponder vending machines.

Marketing

Marketing involves two components, namely, public education and sales. Many of the current and future lessons being learned from the I-15 managed lanes project will be known and able to be applied to the I-5 corridor before it opens. So many of the fundamentals presented here are assumed to be baseline needs that will already have practices and policies in place prior to initiating operations.

Public Education

The public wants to know:

- What are the travel benefits and travel impacts
- What is the public funding benefit
- What are the users fees
- How will the project address social and geopolitical equity issues
- Where will the toll money go
- Address technology concerns, such as privacy
- Address environmental issues

A clear, concise message must be developed in order to address the list of concerns. Once the message is developed, public meetings, focus groups, newsletters, websites and formal hearings will help educate the public.

Sales

Before sales can begin, a marketing campaign should be launched using media events, press/news releases using media (websites, television, radio, print) advertisements, telephone and paper surveys, and direct mailings. It is crucial that the information provided be balanced, timely, and accurate. SANDAG must be careful to craft an information-based (not opinion-based) message.

Violations

Regardless of site conditions, a combination of routine (manual) and automated violation enforcement is recommended to ensure success in operation of the I-5 North Coast Managed Lanes.

Routine Enforcement with California Highway Patrol (CHP) Officers

The strategy for the initial six (6) months of operation should be to implement a routine enforcement campaign based on a high degree of law enforcement presence. This will help ensure operational integrity during this critical introductory period as well as set the tone for future operations. The precise level of medium- and long-term CHP enforcement presence needed will be determined based on experimentation, continuous monitoring, and from first-hand Officer/operational experience. The enforcement hours and mix of motorcycle versus patrol car units assigned should be adjusted through these periodic evaluations.

Automated Violation Enforcement System (VES)

Automated VES will include components such as cameras, video capture, optical character recognition image processing, hand held readers, and in-vehicle sensors. These devices would send their signals to a system for processing to determine if an occupancy or toll violation has occurred. A warning letter and ultimately a ticket would be generated from the evidence collected.

With the dynamic pricing and occupancy requirements for this managed lane facility, automated VES is not ready to replace routine enforcement. For now, enforcement will be improved when routine and automated procedures are used together. As technology improves, there may come a time when routine enforcement can be minimized or eliminated.

Back-end Violations Processing and Dispute Resolution

While much of the violation process will occur electronically, all of the commercial VES applications require a degree of manual review and an on-going quality assurance program. Additionally, the generation of paper violation statements and resolution of violations through payment or dispute require a staff presence. Significant mail handling costs can be attributed to the processing of violations and a dispute process should be available to patrons who receive a violation notice but whose accounts are otherwise in good standing. The underlying motivation of the violation policy should be to convert violators to good customers.

Maintenance and Support

In-Lane Maintenance

A comprehensive maintenance program, including preventive maintenance, diagnostic maintenance, and repair, is required for all toll system field elements/infrastructure. This includes, but is not limited to:

- RFID (or other ETC device) system elements (readers, antenna, transceivers)
- Changeable/variable message signs (CMSs/VMSs)
- Closed-circuit television (CCTV) surveillance cameras
- Video-camera detection systems for VES (cameras, arms, etc.)
- Communications infrastructure (wireless modems, antenna, and fiber/hardwired communications cabling)

- Electrical infrastructure (wires, cables, connectors, pull/junction boxes, etc.)
- Vehicle sensor equipment (loops, side-firing radar detectors, treadles, etc.)

The toll system application shall incorporate a maintenance online management system (MOMS) which shall help identify and track preventative maintenance plans and actual maintenance conducted; shall allow for notes to be recorded about various field elements; shall permit equipment to be accurately managed, including a spare parts inventory; and shall automatically monitor and generate timely notification alarms to maintenance staff who are responsible for testing, maintaining, and responding to ad-hoc system interruptions or device failures. The MOMS shall be capable of automatically paging a maintenance technician remotely, and it is the technician's responsibility to assess, troubleshoot, and repair system failures identified by the MOMS.

Routine maintenance reporting will be an important aspect of the toll system reporting feature, and the system should be capable of producing a total system uptime report that calculates a percentage failure rate for all parts, and for the system at large.

Software Maintenance

Software maintenance is important to the long-term success of the managed lanes project. SANDAG's Information Technology (IT) staff and system operators will be trained how to use and update the integrated ETC software system. However, the trend in software is to outsource the software's maintenance to a vendor (the company that provided the software or a third-party vendor). It is unlikely that SANDAG's staff currently has an individual who will understand all of the areas required making the system work well. Additionally, the software should not require a full time employee for maintenance.

Software Management

Skilled personnel will be required to update and operate the software. SANDAG will have to expand their technology staff (in number and/or job responsibilities) to manage the databases and Internet aspects associated with the integrated software system. SANDAG will also require database entry personnel to enter new and update existing accounts.

While not recommended, it is also possible to outsource all of the software management functions. SANDAG should carefully weigh the short and long-term benefits and risks of outsourcing software management.

Network Maintenance

While the end devices are different than a typical local area network (LAN) or wide area network (WAN), the concept of LAN/WAN applies to the managed lanes ETTM system. Just as a LAN or WAN needs network support, so will the I-5 North Coast Managed Lane ETTM network. Both the network and end devices will need to be monitored for proper operation and replacement when they are not functioning properly.

Appropriate systems support for data archival, redundant power and communications, proper hardware and software for data storage and processing, proper environmental conditions for server placement and appropriate security for safeguarding of the central computers are all important considerations to the managed lanes information technology network. Adequate assurances of the stability of the managed lanes network are thus an

important area of emphasis. The administration of the network will require some level of dedicated staffing.

System Auditors

A plan of regular, independent periodic tests of the hardware, software, and network systems should be planned that test the lane and host systems continuity, accuracy, adherence to procedure, and to vouch for the integrity of the transaction postings. The system audit should be easily reconciled to the financial system transactional audits. If travelers feel that their ETC account is being mismanaged, they are unlikely to consider using the managed lanes.

Traffic Management

Incident Management

In incident response team and procedures must be established to coordinate multiple agencies and various types of events including accidents, breakdowns, rain/mudslide control, routine maintenance, and ad-hoc occurrences, such as an evacuation or special event. The I-5 North Coast Managed Lanes incident management plan should be specific enough to deal with nuances of the corridor, but integrated into a larger regional approach to freeway and managed lanes emergency response.

FSP or Customer Assistance Patrol

The regional freeway service patrol (FSP) fleet that SANDAG operates already provides service to the I-5 North Coast corridor; however, there may be a need to augment existing or planned FSP levels with a more frequent or dedicated fleet of early responders, including tow trucks. Other managed/HOT lanes such as the 91 Express Lanes in Orange County augment their FSP with a “customer assistance patrol” (CAP) that raises the bar in rapid incident detection and clearance on the managed lanes. Physical space to park and stage FSP/CAP vehicles should be considered during final design of the managed lanes facility.

Traffic Operations Center and Traffic Management Center (TMC) Coordination

SANDAG does not operate a traffic operations center (TOC) today. SANDAG coordinates with Caltrans through its jurisdiction and operation of a Regional Traffic Management Center (TMC). Because so many of the traffic management and toll processing functions of the I-5 North Coast Managed Lanes will require timely response and rapid dissemination of information, it may make sense for SANDAG to physically occupy one or more corridor-specific TOCs or a consolidated TOC hub for all of its managed lanes operations. Otherwise, SANDAG should continue to work closely with Caltrans to exchange information and respond to operational events. If SANDAG does develop its own TOC(s), it may consider also to co-locate those TOC(s) within or nearby Caltrans’ existing TMC; and/or to establish dedicated communications interfaces to transmit data and voice communications in real- or near-real-time.

7.5 EVALUATION AND CONTINUOUS IMPROVEMENT PROCESS

7.5.1. Performance measures

Managed Lanes capacity

"There is a trade off between maximum capacity and managed capacity. As volume increases, speed generally decreases until reaching a point of instability typically between 2,000 and 2,100 vehicles per lane per hour. When throughput degrades beyond maximum capacity, speeds decline to levels around 15 miles per hour and flows drop as low as 1,300 vehicles per lane per hour.

When lanes are managed to promote "free flow" conditions, throughput must be contained to a level below maximum capacity. This regulated threshold, or managed capacity, is simply a management benchmark that ensures premium traffic service for HOT lane users."[2]

The operational threshold of 1,650 vehicles per lane per hour is the guideline from which a variety of operational management strategies and future policy decisions are based in order to adjust these as demand changes. Once the facility is built and operational, it is clear that SANDAG will need to monitor the traffic flow and choose the correct balance between maximum capacity and managed capacity.

User accounts

Performance measures for user accounts include accuracy of user and accounting information. There will be a correlation between user account/accounting accuracy and customer service calls.

Violations/enforcement

Performance measures for violations/enforcement include:

- Percentage of correct/incorrect violation events. (Can faulty violation events be traced back to faulty equipment or insufficient training?)
- Percentage of violation events becoming violation notices (and payments)

Customer service/call handling

Performance measures for customer service/call handling include:

- Percentage of complaints versus number of calls
- Response time to handle a customer inquiry/complaint
- Retention rate of customer service agents. If agents are not given proper training or do not have the skills to deal with stress, there will be an unusually high turnover rate.

System performance

Performance measures for system performance include uptime for field devices, system infrastructure (such as power and communications), and ETC sub-systems. Mean time between failure (MTFB) should be compared to expected value. The time of day the

[2] FHWA, "A Guide for HOT Lane Development", Publication Number: FHWA-OP-03-009, pg. 64.

failure occurs should be watched for trends. For example, failure at 4:00 a.m.has less of an impact than failure at 4:00 p.m..

7.5.2. Monitoring program

Monitoring will occur in several areas and the combination of this monitoring will quantify the successfulness of the program. A regular program of data collection, analysis, device inspection/testing, and review must be established as part of the ETTM operational plan to ensure proper operation of the managed lanes.

ETTM field devices

- Are all of the devices functional?
- Are the loops, treadles, beam sensors and side-firing radar detecting the appropriate number of vehicles and speed of vehicles?
- Are the toll tag readers reading the correct number of transponders?
- Are the VMSs displaying the correct message?
- Are the devices living up to (or beyond) their life expectancies?

Should SANDAG choose to employ any aspect of GPS-based tolling, additional considerations might include:

- Is the system calculating correctly the number of miles traveled?

[Note: It will be difficult to test the accuracy of in-vehicle sensors without the approval of individual vehicle owners.]

Communications systems

Serving as the backbone of the information network for the managed lanes, communications systems must also be checked for proper operation.

- Does the information from the automated traffic control system reach the traffic management system in the correct amount of time?
- What is the error rate?
- Does the VMS message (with the current toll information) display in the proper amount of time?
- Is the optical fiber performing as specified?

The central processing system

- Are transponder reads being associated with the correct account?
- Are the correct toll rates being computed?
- Is the appropriate amount of money being debited from the correct account?
- Is the MOMS system correctly determining, scheduling, and replacing broken items of the system?

The customer service system

- How long is it taking to process a new order and send out a transponder?
- Is the transponder arriving at the account holder's residence in a reasonable amount of time?

- How long does it take to resolve billing or violation issues?

The enforcement system

The following enforcement monitoring data would be of great benefit for future planning and identification of resource requirements for ongoing enforcement activities:

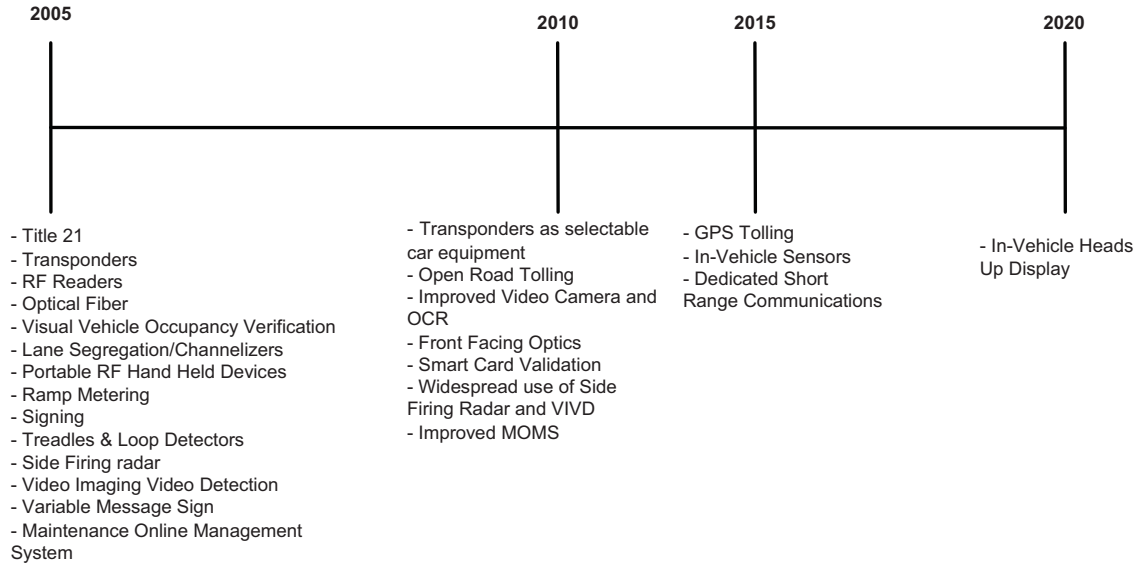
- The method of enforcement (officer, officer with video, etc.)
- The time the enforcement began and ended
- The location where enforcement took place (direction and location)
- The number of police personnel on duty (officers supplied, person hours used)
- A summary of violations issued (warnings, violation tickets)
- General notes regarding typical response of motoring public and challenges faced in carrying out this type of enforcement
- The results from any court actions regarding disputes of HOT/HOV violations.

7.6 POTENTIAL TIMELINE FOR TECHNOLOGY ADOPTION

This report has focused on current and future technology options for implementing an I-5 North Coast Managed Lanes Value Pricing project.

Figure 7-17 lays out the timeline for projected project development and implementation between now and 2015-2020. It should be noted that the future technology options are not cast in stone and represent the best informed estimate for the availability of those technologies at the present time. They do not correspond in any way to the adopted project schedule associated with construction I-5.

FIGURE 7-17: TIMELINE FOR TECHNOLOGY ADOPTION



7.7 PRELIMINARY COST ESTIMATE OF CURRENT TECHNOLOGY

7.7.1. Assumptions for Estimate

ITS installations for the corridor are provided in Table 7-2. ETC and related equipment estimates are provided in Table 7-3. Both estimates are based on current year dollars (2005). Estimate assumptions include the following:

- 8+4 lane configuration assumed to be the same for 10+4 for purposes of this analysis.
- Four-inch mainline conduit with 48 strands of single mode optical fiber installation for 26 miles.
- Lateral conduit as (2) two-inch conduits with six strands of single mode optical fiber and (3) #8 THW (copper stranded, insulated wire) for power.
- Optical fiber splicing to be done in manholes only.
- VMS (arterial) signs to be installed prior to entrance to all on-ramps on the managed lanes.
- VMS (managed lanes) signs to be installed on the managed lanes in advance of the toll collection site.
- VMS (general purpose lanes) signs are to be installed on the main freeway at one-mile advance and at the entrance to the managed lanes.
- This estimate does not include fixed message signs required for static messages.

7.7.2. Annual Operating Expenditures

Operating costs likely to be incurred by SANDAG and affiliated agencies for the I-5 North Coast Managed Lanes are divided into three categories: operations, maintenance and violation processing. Each category includes functional areas for the provision of services associated with the tolling operation.

Operation costs involve administration, finance and accounting, customer service, and support staff at the tolling center. Operating expenses can include facility costs, office equipment costs, supplies and other direct costs associated with account management and revenue handling. In an established operation, the operating costs/expenses can be estimated to increase somewhere between $0.20-$0.50/transaction processed.

Maintenance costs involve preventative and corrective maintenance activities of the roadside tolling equipment and collection locations and central computer systems and application software. Maintenance expenses include facility and vehicle costs, technical support type contracts, and consumables. Maintenance services will generally approximate $100,000 to $500,000 annually.

Violation processing costs for toll evasion involve violations image review, finance and accounting, customer service, and appeals and hearing support. Additionally the cost of on-site enforcement activities and judicial or other adjudication proceedings must be included. Violation processing expenses include facility costs, office equipment, lookup fees, supplies and other direct costs associated with revenues handling. Excluding fixed

costs for facilities and computer assets, the operating expenses can be estimated to be between $1and $5 per violation processed.

Additionally, enforcement presence likely to be needed on site for occupancy enforcement may vary from as low as $120,000 annually to $300,000 annually depending on the level of presence that may be needed for different parts of the corridor and level of enforcement visibility that may be required. There is no viable alternative in the near, and perhaps long-term future that will replace this function through technology due to court and institutional concerns over this issue, and the cost to advance this technology in each affected vehicle may be considerably more than the added enforcement presence.

Buffer-separation in this analysis assumes soft barriers (pylons), thus negating the need for more instrumented roadway treatment to monitor and remotely catch access violations. The cost for this approach is not considered feasible given the length of the corridor, but the cost of pylon maintenance is a factor to consider for buffer-separation.

Operating costs can be significantly reduced if the operations activities are supported by web-based applications. On-line account management and payment, including for violation fines and fees, on-line account statements, and other e-services dramatically reduce the cost of service center operations. Depending on how many processes are automated and web-based, an agency could reduce its annual operating expenses by 10 to 25 percent.

Estimated capital and operation costs for managed lanes under the two configuration scenarios are summarized below:

Barrier-separated Configuration

ETC installations	$1.7 million
Enforcement (CHP)	$120,000-$200,000/year
Maintenance of ETC system:	$300,000/year

Buffer-separated Configuration

ETC installations	$1.7 million
Enforcement (CHP)	$200,000 - $300,000/year
Maintenance of ETC system:	$300,000/year
Pylon Maintenance:	$500,000 - $800,000/year

TABLE 7-2: PRELIMINARY COST ESTIMATE FOR GENERAL PURPOSE LANES

Description	Unit	Quant.	Unit Cost	Mtl. Cost	Hr/Unit	Labor Cost	Total Cost
Antenna	EA	140	$2,500	$350,000	6	$42,400	$78,400
ETC reader	EA	28	$1,300	$36,400	4	$5,600	$21,000
ETC reader/controller	EA	28	$7,300	$204,400	4	$5,600	$105,000
CCTV Controller+Cabinet	EA.	30	$6,000	$180,000	16	$24,000	$204,000
Loop Detection Controller+CCTV Controller + Cabinet	EA.	12	$10,000	$120,000	16	$9,600	$129,600
VMS Controller+Cabinet	EA	39	$6,000	$234,000	16	$31,200	$265,200
Controller Cabinet Foundation	EA	81	$2,672	$216,432	16	$64,800	$281,232
TMS Manhole	EA	60	$3,500	$210,000	8	$24,000	$234,000
Splices	EA.	240	$20	$4,800	0.5	$6,000	$10,800
SM splice case	EA.	60	$600	$36,000	4	$12,000	$48,000
NEMA 4x Box	EA.	60	$65	$3,900	1	$3,000	$6,900
4"conduit (PVC) with quad innerduct*	LF	132000	$12.00	$1,584,000	0.32	$2,112,000	$3,696,000
6 SM Fiber	LF	12500	$2.00	$25,000	0.01	$6,250	$31,250
48 SM Fiber	LF	132500	$4.50	$596,250	0.02	$132,500	$728,750
Optic Transceiver	EA	60	$7,000	$420,000	1	$3,000	$423,000
Video Optic Transceiver	EA.	40	$3,000	$120,000	1	$2,000	$122,000
Test Fiber Optic Cable*	LS	1	$10,000	$10,000	0	$0	$10,000
#8 THW or USE Power	LF	37500	$0.28	$10,388	0.005	$9,375	$19,763
2"conduit (PVC)	LF	25000	$4.55	$113,750	0.16	$200,000	$313,750
Electrical Connection & Transformer	EA.	60	$3,000	$180,000	2	$6,000	$186,000
VMS (Arterial)*	EA	12	$10,000	$120,000	12	$7,200	$127,200
VMS Foundation (Arterial)	EA.	12	$1,500	$18,000	8	$4,800	$22,800
VMS (Managed Lane)*	EA	15	$30,000	$450,000	12	$9,000	$459,000
VMS Foundation (Managed Lane))	EA.	15	$3,500	$52,500	8	$6,000	$58,500
VMS (Freeway)*	EA	12	$100,000	$1,200,000	24	$14,400	$1,214,400
VMS Foundation (Freeway)	EA	12	$7,000	$84,000	8	$4,800	$88,800
CCTV Camera	EA.	30	$5,200	$156,000	4	$6,000	$162,000
CCTV Pole Foundation	EA.	30	$1,500	$45,000	12	$18,000	$63,000
Detection Loops	EA.	160	$75	$12,000	2	$16,000	$28,000
Sub Total							$9,373,945
30% Contingencies							$2,812,183
Total							**$12,186,128**

TABLE 7-3: PRELIMINARY COST ESTIMATE FOR MANAGED LANES

					LABOR COST =	$50.00	Per HR
Description	**Unit**	**Quant.**	**Unit Cost**	**Mtl. Cost**	**Hr/Unit**	**Labor Cost**	**Total Cost**
Antenna	EA	28	$2,500	$70,000	6	$8,400	$78,400
ETC reader	EA	14	$1,300	$18,200	4	$2,800	$21,000
ETC reader/controller	EA	14	$7,300	$102,200	4	$2,800	$105,000
CCTV violation cameras	EA	28	$5,200	$145,600	8	$11,200	$156,800
Power	LS	7					$2,500
Lane controller	EA	14	$11,400	$159,600	16	$11,200	$170,800
Support Structure	EA.	14	$45,000	$630,000	24	$16,800	$646,800
Support Foundation	EA.	14	$7,000	$98,000	24	$16,800	$114,800
Communications interface	LS	1					$5,000
Local Field processing Equipment+Software	LS	1					$100,000
Integration & Toll Tag Tracking	LS	1					$300,000
Detection Loops	EA.	64	$75	$4,800	2	$6,400	$11,200
Sub Total							$1,307,300
30% Contingencies							$392,190
Total							**$1,699,490**

CHAPTER 8

MONITORING AND EVALUATION PLAN

8.1 PURPOSE OF THE MONITORING AND EVALUATION PLAN

This Monitoring and Evaluation Plan (MEP) is intended to provide SANDAG and Caltrans with the fundamental information necessary to prepare a detailed work scope for the future monitoring and evaluation of the I-5 North Coast Managed Lanes. The cooperative relationship between Caltrans and SANDAG for the ownership and operation of the proposed managed lanes similarly requires a cooperative approach to monitoring and evaluation of the lanes.

Traditionally throughout California, Caltrans has lead efforts to monitor and evaluate the performance of freeway facilities and in particular high occupancy vehicle lanes. In areas with extensive HOV systems exist (such as Los Angeles County, Orange County, the Inland Empire, and the San Francisco Bay Area), Caltrans conducts comprehensive monitoring of HOV lanes and publishes annual reports documenting evaluation results. Where HOV lane operations are actively managed using value pricing by local transportation agencies (i.e. OCTA on SR 91 Express Lanes and SANDAG on I-15 Managed Lanes), Caltrans monitoring efforts are typically enhanced and expanded by the local transportation agency consistent with the operation of the managed lanes to provide more robust evaluation results. It is anticipated that a similar cooperative approach between Caltrans and SANDAG will be necessary for monitoring and evaluating the performance of the I-5 North Coast Managed Lanes (and the adjacent general purpose lanes).

This plan provides guidance for the data collection, performance measures and evaluation necessary to assess the overall performance of the I-5 North Coast Managed Lanes and related Value Pricing project. As such, the MEP includes the following elements:

- Evaluation Objectives
- Overview of Evaluation Approach
- Key Performance Measures
- Recommended ‘Before’ Data Set
- Recommended ‘After’ Data Set
- Ongoing Monitoring Activities
- Schedule and Budget
- Continuing Improvement Process

The inclusion of a recommended ‘before’ data set is a critical part of the MEP establishing the baseline to evaluate the effectiveness of the I-5 North Coast Managed Lanes. The existing traffic operating characteristics within the I-5 North Coast study corridor were generally identified in terms of traffic volumes, vehicle classifications,

vehicle occupancy profiles, truck volumes, and operating speeds as part of Chapter 2. A more comprehensive before data set is recommended as part of the MEP in order to allow SANDAG and Caltrans to have adequate time to plan, coordinate and execute the collection of baseline data for future detailed evaluation and monitoring of performance on I-5 within the study corridor.

This MEP follows closely the I-15 Managed Lanes Value Pricing Project Planning Study Monitoring and Evaluation Plan that was prepared by Wilbur Smith Associates in 2002 to ensure compatibility with previous SANDAG evaluation efforts for other similar managed lanes performance monitoring and evaluation efforts. Similar data sets will be assembled, performance measures identified and compatible analyses applied to enable comparisons between earlier study efforts and related corridors (e.g., I-15 ML). However, the desire to be consistent with previous or similar study efforts did not preclude the consideration of monitoring and evaluation needs that are unique to the I-5 North Coast Managed Lanes. Consideration of differing demographics and inter-regional travel needs within the study corridor, the presence of land uses with unique trip generation characteristics within the study corridor (such as the University of California at San Diego, the Del Mar Racetrack and Fairgrounds, and Legoland), the use of multiple access locations (including the use of both general purpose lane ingress/egress and direct access ramps), the requirement to manage demand on a fixed number of managed lanes in each direction, and the impact on parallel fixed rail transit services all contrast with the I-15 ML thereby requiring customized monitoring data, performance measures and evaluation methods described herein.

8.2 EVALUATION OBJECTIVES

This chapter identifies objectives relating to the I-5 North Coast Managed Lanes project and in particular to the application of eligibility limitations and value pricing as a mechanism to manage demand on the proposed managed lanes facility. Modeled after the existing I-15 Express Lanes, the I-5 North Coast Managed Lanes project represents a key component of the SANDAG 2030 Regional Transportation Plan strategy to “deploy a network of connected and free flowing managed lanes throughout the San Diego region.” This chapter outlines the project need and objectives identified through the project development process by the various I-5 North Coast stakeholders, including federal, state and regional implementing partner agencies.

8.2.1. Project Need

Caltrans has stated the following purpose for the I-5 North Coast Managed Lanes project:

> “The purpose of the project is to reduce current and future congestion and improve safety and operations on Interstate 5.”

Building upon the Caltrans purpose statement, SANDAG has stated the following need for the I-5 North Coast Managed Lanes project:

> “The I-5 North Coast corridor experiences recurrent traffic congestion during weekday rush hours and also is heavily traveled on weekends. Interstate 5 is a major corridor connecting San Diego, Los Angeles, Orange County, and Baja California, Mexico regions.

- Average daily traffic on I-5 is at 261,000 vehicles (near SR 56) and is projected to increase to 430,000 daily vehicles by the year 2030. Over 10,000 daily truck trips are made on I-5.
- Interstate 5 is important for commuter, commercial, and recreational travel. Without capacity improvements, the increases in traffic in the corridor will result in congestion throughout the entire day.
- The arterial roadways parallel to I-5 are segmented and do not provide a continuous north-south alternative route to the freeway. No new parallel arterial roadways are planned. The Coaster commuter rail service is being expanded; however, I-5 will carry the burden of trips in the corridor."

8.2.2. Project Objectives

To meet the purpose of the I-5 North Coast Managed Lanes project, Caltrans has identified the following five project objectives:

- Adding capacity to the highway system to aid in the movement of goods
- Provide free-flow carpool lanes
- Improving the efficiency of the existing facility by managing the congestion
- Provide efficient public transportation
- Add double tracking the rail corridor

Similarly, SANDAG has identified a number of specific objectives relating to the proposed I-5 North Coast Managed Lanes. Reiterating capacity limitations and congestion within the corridor as the principle project need, the project objectives emphasize mobility options, traffic flow and minimizing impacts. The project objectives as defined by SANDAG are as follows:

- Maximize mobility for all modal choices, including passenger rail, bus, vanpool, carpool, FasTrak, bicycle and pedestrian, single occupant vehicles, and trucks.
- Maintain free flow conditions in the Managed Lanes.
- Employ the use of value pricing techniques and other technology to improve operation of the HOV/Managed Lanes.
- Minimize impacts to aesthetic, historic and environmental resources.
- Minimize private property takes.

The I-5 North Coast project is intended to improve mobility in the region for both daily commuters and commercial traffic. The addition of managed lanes is intended to provide high occupancy vehicles, transit and value pricing customers with an option that ensures improved traffic flow, trip reliability and travel time savings as an incentive to carpool, vanpool, ride transit or pay a toll. The I-5 North Coast corridor objectives relating to mobility choices, traffic flow and utilization of value pricing and technology to manage demand are most applicable for consideration in the context of performance monitoring and evaluation.

8.3 EVALUATION APPROACH

To assess the effectiveness of the I-5 North Coast Managed Lanes project to fulfill the previously stated objectives, a four-tiered evaluation approach is recommended. This approach is consistent with the evaluation approach proposed for the I-15 Managed Lanes Value Pricing project. Each of the following four-tiers of the recommended evaluation approach is described below:

- Measurement of Project Impact
- Measurement of Project Utilization
- Measurement of Project Acceptance
- Assessment of Project Operations

8.3.1. Measurement of Project Impact

The measurement of project impact will be based primarily on the comparison of before and after conditions within the I-5 North Coast corridor to assess apparent changes. In particular, changes in average vehicle occupancy (AVO) or mode split are indicative of the effectiveness of managed lanes to encourage carpooling or transit usage. Similarly, the assessment of lane volumes and average travel speeds/times reflect the effectiveness of improvements within the corridor to provide additional capacity and relief from congestion. A comparison of public opinions will indicate changes in the level of public acceptance and overall satisfaction with the investment in the corridor and subsequent refinements to operating design and policy.

To facilitate the measurement of project impacts, a 'before' data set is recommended to establish the baseline of traffic conditions and public opinions for subsequent comparison. An 'after' data set is recommended to be collected at regular intervals on an ongoing basis. The collection of time series data will allow for the analysis of before and after conditions, and the analysis of continuing changes over time during project implementation.

8.3.2. Measurement of Project Utilization

Utilization of the managed lanes facility can be determined by the combination of lane volumes and AVO to determine the total number of person trips. Person trips in the managed lanes can subsequently be compared to those in the adjacent general purpose lanes to determine the effectiveness of the I-5 North Coast project to encourage carpooling and transit utilization. In the I-5 North Coast corridor, it also is appropriate to monitor patronage on the Coaster (which runs parallel to the freeway) to determine any change in rail patronage resulting from diversion to carpools or bus transit.

Utilization of the value pricing system can be assessed by reviewing the level and frequency of toll use. Information on toll usage can be collected from a combination of account information and lane volumes to determine the effectiveness of various tolling levels to manage demand. Supplemental information on toll user characteristics can also be collected through surveys of toll users and can be compared to results to the I-15 corridor to assess public acceptance of then current and proposed future toll levels.

8.3.3. Measurement of Project Acceptance

This I-5 North Coast Managed Lanes Value Pricing Study includes market research elements to complete an initial assessment of public and stakeholder attitudes regarding managed lanes on I-5 and the concept of value pricing. A continued understanding of

attitudes toward the managed lanes, toll levels and toll systems will be important to understand the impact of changes in operational policy. The attitudes of Managed lanes users, I-5 users that do not us the managed lanes, residents of the I-5 corridor and project stakeholders (technical staff, elected officials, etc.) will be assessed at regular intervals to evaluate issues related to value pricing acceptance, equity and perceptions of project success. The results of the measurement of project acceptance for I-5 will be compared over time to track changes in attitudes and will be compared to results obtained for I-15 and other similar facilities to help understand any unique attitudes or perceptions regarding I-5.

8.3.4. Assessment of Project Operations

This tier of the evaluation approach encompasses the traditional elements of performance monitoring and evaluation. For the assessment of project operations, the performance of the managed lanes and the adjacent freeway lanes will be evaluated in terms of lane utilization (including traffic volume and person trips), travel speeds and trip reliability, user perceptions, costs (including capital infrastructure costs, operations and maintenance, enforcement, marketing, monitoring, etc.) and revenues. The assessment of project operations will draw largely from the data gathered to support the preceding three tiers and represents the consolidation of the individual analyses into an overall assessment for the project performance. Key pieces of the information used to support the assessment of project operations will also provide the basis for determining demand management needs as they relate to value pricing of the managed lanes. This highlights the close relationship between performance monitoring/evaluation and tolling systems/value pricing operations.

8.3.5. Summary of Evaluation Approach

The recommended evaluation approach can be summarized in two parts:

- A before and after analysis to measure the impact of adding managed lanes to the I-5 North Coast corridor and to measure the effectiveness of using value pricing to manage demand.
- Ongoing evaluation of system performance to measure the impact of changing travel behavior and changes in operational policy for the I-5 North Coast Managed lanes.

The evaluation will focus on addressing the specific objectives of the I-5 North Coast project. In particular, the evaluation effort will assess the effectiveness of the I-5 North Coast Managed Lanes and value pricing at providing (and encouraging) alternative mobility choices, improving traffic flow, improving travel reliability and managing demand.

8.4 KEY PERFORMANCE MEASURES

To accomplish the evaluation of performance and to address the specific measurements of performance described in the evaluation approach, it is necessary to define appropriate measures of effectiveness (MOEs) or performance indicators. The following MOEs are recommended to support the evaluation of the I-5 North Coast project. Generally the MOEs are consistent with those previously recommended for the I-15 Managed Lanes Value Pricing Project.

- Level of service
- Changes in travel speed, travel time and delay
- Changes in vehicle occupancy
- Changes in mode split
- Change in vehicle classification
- Changes in travel behavior
- Toll utilization
- Park and ride utilization
- Rate of toll evasion violations

The following sections provide a more detailed description of each MOE.

8.4.1. Level of Service

It is anticipated that a maximum level of service (LOS) threshold will be established as a policy standard to preserve mobility within the Managed lanes. LOS, defined as the ratio of volume to capacity, will be monitored to determine the effectiveness of eligibility and value pricing policy at managing demand in the Managed lanes. Volume data (as the basis for determining LOS) can be collected automatically using inductive loops, side-firing radar, video/optics, or other similar fixed traffic count devices. Eligibility limitations (i.e. high occupancy vehicle [HOV] minimum occupancy thresholds) and toll pricing will be used to maximize the number of people and vehicles using the lanes while still maintaining desirable traffic flow.

In the original I-15 Congestion Pricing demonstration project, the LOS threshold was established at LOS C. Maintaining LOS C met the primary purpose of the I-15 managed lanes by providing free flow conditions to transit, HOV, and toll paying SOV users. By striving to ensure LOS C is maintained, travel time savings afforded to I-15 managed lane users provides an incentive for commuters to use transit or to carpool.

Caltrans utilizes an alternative approach for evaluating LOS in HOV lanes. The Caltrans approach establishes a maximum optimal operating capacity of 1,650 vehicles per hour per lane (vphpl) for HOV facilities. Caltrans considers an HOV lane to have exceeded its optimal operating capacity when the 1,650 vphpl threshold is exceeded in 80 percent of the peak hours. A similar threshold may be appropriate for the purposes of monitoring and evaluating the I-5 North Coast Managed Lanes to ensure free flow traffic conditions are maintained.

LOS will need to be measured by time of day, day of week and month of the year to assess the ability of eligibility limitations and value pricing to maintain the LOS threshold. Furthermore, LOS will need to be monitored in each operating segment of the freeway to

reflect changes in freeway operations between major interchange locations. The preliminary pricing plan designates multiple tolling zones, each of which will require independent monitoring to maintain LOS. In addition to time of day, day of week and monthly LOS monitoring as described previously to track LOS over time, real-time monitoring of LOS in both the managed lanes and the adjacent general purpose lanes will be desirable to determine appropriate toll levels for true real-time value pricing and demand management.

8.4.2. Changes in Travel Speed, Travel Time and Delay

Related to LOS in the managed lanes is change in travel speed, travel time and delay. As indicated previously, travel time savings is the primary motivation for people to use managed lanes for transit, carpool or for a toll. Observing travel speed and/or travel time in the managed lanes and adjacent general purpose lanes will provide an indication of the relative time savings in the managed lanes. The relative time savings is a critical piece of information to potential managed lanes users, particularly those paying a toll. Findings from the market research activities associated with this study highlight the importance of developing and disseminating this information for each toll segment on a real-time basis. Monitoring changes in travel speed, travel time and delay over time will provide an important indication of the performance of the managed lanes and any impact of the managed lanes on the adjacent general purpose lanes. Evaluating changes in travel speed, travel time and delay over time also will provide important information to allow project stakeholders to establish and modify operating policy to better meet project objectives.

Travel speeds can be estimated automatically using induction loops, video or other similar traffic counting technologies. These methods are used extensively for traffic congestion monitoring in the San Diego area. Manual observations using radar or laser devices can validate travel speeds at a given location while floating car travel time runs can validate travel times between given points. Travel times can also be monitored automatically using in-vehicle toll transponders by tracking the progress of a vehicle from observation point to observation point. A combination of methods may be most appropriate to monitor travel speed, travel time and delay in both the managed lanes and general purpose lanes on I-5 North Coast.

8.4.3. Changes in Vehicle Occupancy

Evaluating changes in vehicle occupancy provides a measure of effectiveness related to mode split. Monitoring changes in vehicle occupancy generally reflects the effectiveness of managed lanes at encouraging new carpool users or transit riders. AVO is generally measured using manual observation of the number of passengers in vehicles passing a given point, although new technologies offer the prospect of automated AVO counting with certain limitations.

8.4.4. Changes in Mode Split

Building on the observation of changes in vehicle occupancy, changes in mode split can also highlight the effectiveness of managed lanes to attract new bus or rail transit riders, and lead to the formation of new vanpools or carpools. Evaluating changes in mode split in addition to vehicle occupancy can provide important insight into the choice of commuters to switch from driving alone to other higher occupancy travel modes utilizing the managed lanes.

Changes in mode split are typically measured using a combination of transit passenger boardings for routes operating in the corridor, visual observations of carpools and/or by obtaining data related to the formation of vanpools (associated with the previous MOE) from the local rideshare organization (in this case, SANDAG also oversees the region's RideLink ridesharing program), and from direct surveys of transit and HOV users. The key evaluation of changes in mode split involves a before and after comparison for the corridor although the ongoing monitoring of mode share in the corridor can highlight the impact of changes in operating policy (e.g., changing HOV occupancy thresholds or toll levels) or changes in commuter behavior (e.g., shift to alternate modes to avoid congestion or higher gas prices). In the case of the I-5 North Coast corridor, it will also be important to monitor ridership on the Coaster service to determine any impact of the managed lanes on commuter rail share.

8.4.5. Change in Vehicle Classification

The influence of truck traffic in the I-5 North Coast corridor has been highlighted in the project need and is reflected in regional policy goals. While the I-5 North Coast Managed Lanes do not directly address goods movement in the current proposed form, the impact of the project on goods movement can be evaluated by monitoring changes in the number of vehicles of different vehicle classifications over time. At present, trucks with three or more axles are prohibited from traveling in the inside lanes, which includes existing I-15 Express Lanes (California Vehicle Code (CVC) 21655(b)) and would conceivably restrict truck traffic on the I-5 North Coast Managed Lanes. Automatic vehicle classification data can be collected automatically using loop detection or video traffic count equipment on the adjacent I-5 general purpose lanes to assess total truck traffic demand. Due to the nature of goods movement in the corridor, a limited number of observation points tracked over time would be sufficient to highlight any noticeable changes in truck traffic patterns over time.

Additionally, it will be necessary to monitor the use of alternative fuel vehicles over time to determine any impact on managed lanes performance. In addition to inherently low emission vehicles (ILEVs) authorized previously, recently enacted federal legislation (SAFETEA-LU) also provides states the discretion to permit certain high mileage gas/electric hybrid vehicles to operate in HOV lanes with only one occupant. In anticipation of SAFETEA-LU, California passed legislation to permit high mileage gas/electric hybrid automobiles to utilize HOV lanes with a single occupant (CVC 5205.5 and 21655.9). The California legislation (currently authorized only through January 1, 2008) specifically requires Caltrans to monitor and evaluate HOV lane performance to determine if permitting single occupant hybrid vehicles to use HOV lanes leads to significant congestion or breakdown of the lanes (CVC 5205.5 (d) and (g)). Consistent with the state statute, it will be necessary to monitor the level of utilization of the lanes by the alternate vehicle types to determine the relative impact on project performance.

8.4.6. Changes in Travel Behavior

In addition to the changes in travel behavior described previously under changes in mode shift, likely changes in travel behavior may also include changes in the time of day of travel, frequency of travel, length of trips and route of travel. Monitoring changes in travel behavior will help to understand the impact of traffic congestion within the corridor and any benefit of the proposed project.

Changes in travel behavior should be monitored for managed lane users (including bus and rail transit users, HOV users and toll users) and freeway users that do not use the

managed lanes. The primary instruments for collecting this information include telephone or direct mail surveys and/or administration of travel diaries with a focus on before and after project changes in addition to ongoing changes as drivers in the corridor respond to continued traffic growth.

8.4.7. Toll Utilization

The volume of toll usage will be monitored to assess the effectiveness of value pricing to maximize the efficiency of the managed lanes. Monitoring toll utilization over time will validate toll operating policy and toll calculation assumptions by determining the elasticity of toll pricing and the ability to vary toll levels to best regulate demand. This approach is fundamental to the success of the value pricing initiative by ensuring the maximum number of toll users can utilize the managed lanes without compromising the maximum LOS threshold described previously.

Toll utilization is collected routinely as part of the automatic toll collection and account process. Comparing toll utilization to LOS, in addition to comparing toll utilization to differing toll rates charged, will provide an assessment of the effectiveness of various toll levels at managing demand under differing traffic flow conditions.

8.4.8. Park and Ride Utilization

The provision of park and ride facilities is integral to the effectiveness of a managed lanes facility to attract and service transit and HOV users. Monitoring the utilization of park and ride facilities can provide an additional measure of the ability of the managed lanes project to encourage carpooling or transit usage. Park and ride lot utilization can be tracked automatically by monitoring ingress and egress to the park and ride lot using automated traffic counting equipment. It can also be collected manually through visual observation.

8.4.9. Rate of Toll Evasion Violations

The number of toll evasion violations and/or citations issued will be monitored to assess public acceptance of value pricing rates and lane demand management, and the effectiveness of toll collection systems and lane segregation. Like toll utilization, monitoring toll violations over time will validate toll operating policy by determining public acceptance of toll pricing and the ability best regulate demand. The review of toll evasion violators will also be critical for assessing the effectiveness of lane delineation and segregation from general purpose lanes, particularly if buffer separation is selected over barrier separation. In the case of buffer separation, high levels of toll evasion by crossing the buffer may necessitate a review of toll collection systems and enforcement to help minimize violations and loss of revenue.

8.5 RECOMMENDED 'BEFORE' DATA SET

A critical element of the monitoring and evaluation plan is to establish a comprehensive and robust 'before' project data set as the basis for all subsequent evaluation of the performance of the managed lanes. Consistent with the Evaluation Approach described previously, the before data set can be categorized in the context of the four-tier system with a principal focus on the Measurement of Project Impact.

The traffic data collected as part of the initial review of operating characteristics provides an overview of historic data for before analysis purposes. However, a more comprehensive and robust data set must be developed at least one year prior to the commencement of significant project construction and monitored, as possible, through construction to serve as the basis for subsequent detailed 'after' project comparison.

The before data set should be designed and collected to be consistent with the ultimate plan for monitoring the project. It should be based on the design of the facility to ensure appropriate comparative data is developed. Specifically, data should be developed for each functional operational segment of the toll facility and adjacent freeway to reflect the selected toll collection system and operating plan. Furthermore, baseline public attitude data should be developed prior to the disruption of project construction as a point of reference for future comparisons to after project conditions.

8.5.1. Project Impact Data

As described previously, the measurement of project impact is based primarily on the comparison of before and after conditions and as such will rely heavily on the development of a robust before data set. The evaluation of system impact will involve an assessment of changes in volumes, travel speeds, vehicle occupancy and mode split as indications of the effectiveness of the managed lanes.

System impact data includes four primary data items:

- Traffic counts (volumes, speeds and classification)
- Vehicle occupancy
- Mode split
- Transit ridership and route on-time performance

Traffic Counts

Traffic volumes, speeds, classification and LOS can all be derived from automated traffic count equipment. Automated traffic count stations are typically established at a permanent fixed location and most commonly use inductive loops. For the purposes of the I-5 North Coast corridor, permanent count stations capable of detecting lane volume and speed should be established in both the general purpose lanes and future managed lanes for each of the proposed toll operating segments. It would be desirable to locate these stations nearest the future point of ingress to the managed lanes toll segment in order for these stations to ultimately be used to monitor changing demand for the managed lanes in conjunction with calculating the real-time toll (should real-time value pricing be utilized). In addition, it is recommended that count stations be located nearest the future points of egress for each managed lanes toll segment to effectively monitor potential queuing impacts downstream. Traffic count data should be summarized by location, direction, lane (if applicable), time of day, day of week, and month of year.

HOV lane volume data for the existing northbound HOV lane in the vicinity of the I-805 interchange will also provide important insight into HOV lane utilization in this segment of the study corridor. The comparison of before HOV lane volumes to HOV volumes after managed lanes will help in understanding the number of new carpools being created as a result of the managed lanes.

Automatically collected traffic speeds should be compared with sample floating travel time runs in the corridor to validate the use of automatically collected, fixed location speeds as the basis for calculating corridor travel times. In the before case, investment in fixed count locations capable of detecting speeds may not be possible due to the imminent nature of construction and the associated 'throw-away' cost of installing the counters. In this circumstance, the use of floating car travel time runs may serve as a suitable alternative as the basis for future analysis using fixed locations.

Vehicle classification data can also be obtained from fixed traffic count stations and can be utilized to determine the impact of managed lanes on the overall mix of traffic. Due to the nature of heavy truck traffic movements within the I-5 North Coast corridor, it would be appropriate to collect vehicle classification data at a minimum of two (2) locations to provide a sample of the traffic mix. It is recommended that the classification data stations be located near each end of the corridor to assess the mix and volume of differing vehicle types at these locations.

Like volume and speed data, establishing permanent vehicle classification count stations in the before case may not be practical due to the potential for equipment to be removed during construction. Alternatively, manual classification counts at the proposed count stations would be appropriate to establish the baseline classification data. Similarly, manual classification counts should be conducted periodically in conjunction with automated count stations to ensure data validity.

Vehicle Occupancy

At present, direct observation is recommended as the most effective way of obtaining vehicle occupancy data. Conducting manual occupancy counts at appropriate overhead vantage points will allow visual observation of the number of persons within each vehicle as the basis for estimating vehicle occupancy. Although it is not essential to have occupancy counts completed for each volume count location in order to assess person movement within the corridor, this level of data collection would be desirable.

AVO collected from visual observation can then be combined with vehicle volume information to determine total person movement within the corridor. Vehicle occupancy data can also be utilized to help determine changes in mode split by reviewing changes in the number of vehicles carrying more than one person.

Mode Split

In addition to the review of vehicle occupancy data described previously, user surveys should be conducted as the basis for evaluating mode split and mode choice. Surveys should be designed to gather sufficient data to measure baseline mode split on I-5 for comparison to the mode split after the opening of the managed lanes. Sufficient sample size should be obtained within the survey to include SOV, HOV, and transit users (and additionally toll users and non managed lane users for after project evaluation).

Transit Ridership and Route On-Time Performance

Provisions for improved transit service and operations are a critical element of the I-5 North Coast project and therefore the evaluation of the impact of the project on transit

ridership and service performance will be important. For this reason, collection of before project transit ridership and route on-time performance data is recommended. Counts of passenger boardings for transit routes operating within the I-5 corridor should be assembled from operator collected data or gathered using visual observation. Similarly, route on-time performance and travel time data should also be collected as a basis for after project comparison.

Monitoring ridership on the Coaster commuter rail (which operates parallel to I-5) as well as express bus service which operates in the I-5 North Coast corridor will be an important determinant of impacts from the managed lanes on commute transit patronage. Both bus transit passenger boardings and alightings, and Coaster rail passenger boardings and alightings data should be gathered from the service operators or from visual observation for subsequent after project comparison. A variety of manual observation and automated techniques are available for this purpose.

8.5.2. Project Utilization Data

Project utilization data focuses on counts of various user groups to support ongoing long term monitoring and evaluation of project performance. As such, most of the data items required for monitoring and evaluating project utilization are duplicative of components of the impact data in the before data set. Utilization data tends to place a stronger focus on the delineation of specific user groups, particularly once the project is operational.

For the purposes of the I-5 North Coast corridor, before utilization data will encompass the following three data types:

- Carpools and vanpools
- Transit ridership
- Park and Ride lot utilization

Carpools and Vanpools

Building on the vehicle occupancy and mode split data collected as part of the project impact before data set, information on the frequency of HOV use, origin and destination (O/D), HOV participation (how long they have participated in a carpool or vanpool), and mode to access the HOV arrangement can provide an understanding of changes in travel behavior as a result of providing the managed lanes. The previously described I-5 user survey will provide the opportunity to collect data as it specifically relates to those that participate in carpools or vanpools.

Transit Ridership

Again building on the passenger boarding and alighting data collected as part of the project impact before data set, information on socio-economic characteristics, O/D and mode to/from transit (trip ends) for transit riders will provide fundamental information to evaluate changes in transit rider behavior and characteristics as a result of completing the project. Information derived from the user survey will serve as the basis for developing this before data set.

Park and Ride Lot Utilization

Counts of vehicles within existing park and ride lots within the I-5 North Coast corridor should be conducted prior to the start of construction of the managed lanes to allow for the assessment of park and ride lot utilization. Additional park and ride lots associated with the managed lanes represent an integral part of the overall project. Understanding

current park and ride lot utilization will allow evaluation of the effectiveness of the managed lanes (and additional park and ride lots) at attracting new park and ride participants in carpools, vanpools or transit service.

8.5.3. Project Acceptance Data

The use of surveys to gather information as the basis for monitoring and evaluating project performance has been described previously as it relates to a number of specific performance measures and data needs. The evaluation of project acceptance will rely exclusively on data collected through surveys taken directly of I-5 users and affected stakeholders. Surveys that specifically target and distinguish between managed lane users and non-users should be administered during the after data collection effort and subsequently compared to the before data. In a previous task of the current study (I-5 North Coast Managed Lanes Value Pricing Study), the study team conducted preliminary market research to develop an initial understanding of attitudes and opinions regarding the proposed project. It is recommended that subsequent surveys be conducted to further develop the understanding of perceptions relating to the I-5 North Coast Managed Lanes project.

Project acceptance data for the before data set encompasses two data types:

- User perceptions
- Stakeholder perceptions

User Perceptions

For the purposes of before data gathering, surveys of I-5 users should be undertaken to determine their attitudes and opinions toward the proposed project. Specific questions to be addressed may include perceived advantages/disadvantages of the managed lanes system, acceptance of the value pricing concept, likelihood of utilizing the managed lanes, awareness of the project, and perceived inequity of pricing the managed lanes. Surveys should include sufficient samples of HOV and transit users to address specific data needs described previously.

Many of these questions are addressed in surveys conducted as part of the I-15 managed lanes project development and therefore provides a basis for comparison to this project. Unlike I-15, the I-5 corridor does not presently contain managed lanes incorporating value pricing. For this reason, after surveys of user perceptions will require delineation between users of the managed lanes (including HOV, transit, and toll users) and users of I-5 that do not use the managed lanes.

Stakeholder Perceptions

The perceptions of technical staff, decision-makers, elected officials and community leaders can be useful in assessing attitudes towards managed lanes and value pricing. These results also can provide an interesting contrast between the opinions of those who are responsible for developing the managed lanes and value pricing project and the ‘customers’ that will ultimately use the facility.

Stakeholder interviews were conducted during a previous phase of this study in order to assess stakeholder opinions. Additional stakeholder interviews would be appropriate as part of establishing the before data set, particularly as it relates to stakeholder perceptions of likely outcomes of the project and resultant benefits and impacts to I-5 users.

8.5.4. Project Operational Data

Further building on data developed to evaluate project impacts, project utilization, and project acceptance, project operational analysis encompasses the traditional elements of performance monitoring and evaluation. The assessment of project operations will consolidate data developed for the preceding data sets to support the overall assessment for the project performance.

To support the assessment of project operations, lane utilization data (including traffic volumes and person trips), travel speed data and user perception data will be combined with the following additional data elements:

- Reliability
- Costs and revenues
- Safety and violations

Reliability

As indicated for other data types, before and after trip reliability data should be comparable. The use of previously described level of service and travel speed data to estimate trip reliability should enable this compatibility. In particular, travel speed in terms of average delay and LOS in terms of percentage of time exceeding a given LOS threshold provide trip reliability estimates.

Costs and Revenues

Costs to be considered for evaluating the managed lanes project could include capital infrastructure, operations, maintenance, enforcement, marketing and monitoring costs. Potential revenues for the project could include revenues from toll generation or violation fines.

In the context of the before data set, cost and revenue data gathered will be limited by the nature of the facility. Typically, operations, maintenance, enforcement, and monitoring costs would be incurred as would fine revenues. However, this data may not be available specifically for the study corridor. To the extent possible, cost and revenue data should be assembled for the I-5 North Coast corridor to support subsequent after project evaluation.

Safety and Violations

Safety data including accident rates, frequency of occurrence by location, contributing factors, as well as number of injuries and fatalities should be assembled for the study corridor. Accident data is typically available through accident reporting conducted by the California Highway Patrol and assembled by Caltrans. Assembling this information for the before data set will allow the project to be evaluated in terms of changes in accident rates and locations.

Violations of HOV eligibility requirements can provide an indication of the effectiveness of lane operations. In particular, high violation rates can indicate poor performance of a managed lanes facility with capacity being ‘stolen’ by ineligible users. Data relating to violations on the existing northbound HOV lane will provide a limited basis for before-after comparison. Comparison to data collected on the existing I-15 Express Lanes may provide a more useful comparison.

Violation data can generally be collected by one of two means. The first involves the review of vehicle occupancy data to determine the proportion of HOV lane users that do

not meet minimum eligibility requirements. Where value pricing is utilized for managed lanes, vehicle occupancy observation also would require confirmation of a valid toll collection to determine a violation. The second method would involve the review of actual citations issued by law enforcement officials or through the automated monitoring of lane compliance (typically video or photographic monitoring and enforcement of toll collections).

8.5.5. Summary of Before Data Set

Table 8.1 below summarizes the data elements comprising the before data set.

TABLE 8-1: SUMMARY OF BEFORE DATA SET

DATA ELEMENT	PRIMARY METHOD (S)	VALIDATION METHOD (S)
Project Impact Data		
Volumes	Automated, fixed location count stations	None
Speeds	Automated, fixed location count stations	Floating travel time runs (also an alternate primary method)
Vehicle Classification Counts	Automated, fixed location count stations	Manual classification counts (also an alternate primary method)
Vehicle Occupancy	Manual occupancy counts at overhead vantage points	None
Mode Split	1. Manual occupancy counts 2. User surveys	None
Transit Ridership	Boarding counts as available from operator or manual	None
Transit Performance	On-time performance data from operator or manual	None
Project Utilization Data		
Carpool and Vanpool Data	1. Manual occupancy counts 2. User surveys	None
Transit Ridership	1. Boarding counts 2. User surveys	None
Park and Ride Lot Utilization	Counts of vehicles in lots	None
Project Acceptance Data		
User Perceptions	User surveys	None
Stakeholder Perceptions	Surveys of stakeholders	None
Project Operational Data		
Volumes, person trips, speeds, user perceptions	As indicated above	As indicated above
Reliability (based on speed and LOS)	See speed and volumes above.	See speed and volumes above.
Costs and Revenues	As available	None
Safety and Violations	1. CHP/Caltrans accident and citation records 2. Manual occupancy counts	None

8.6 RECOMMENDED 'AFTER' DATA SET

Much of the 'after' data set replicates the before data set to allow direct comparison of the various key performance measures. After data should be collected to be consistent with the before data in terms of collection times (time of day, day of week, month), physical locations and data collection methodology. In addition, several specific analyses based on the evaluation of before and after data have been identified. These analyses include cost of delay, institutional assessment and technical assessment.

The after data set can be categorized using the same four-tiered system described in the Evaluation Approach. For each of the four project data categories, before and after data will be evaluated by comparing specific performance measures. Appropriate statistical evaluation should then be conducted to determine whether any observed changes in behavior between before project and after project, and between different user groups are statistically significant. This statistical evaluation may include difference of means (averages) and data variance around the means.

8.6.1. Project Impact Data

As described in the before data section, project impact data includes the following four data elements:

- Traffic counts (volumes, speeds and classification)
- Vehicle occupancy
- Mode split
- Transit ridership and route on-time performance

The following additional data element is recommended to be added to the after data set to better understand the performance of the managed lanes:

- Cost of delay

Traffic Counts

Traffic volumes, speeds, classification and LOS data were recommended to be assembled as part of the before data set covering various time periods and locations within the existing I-5 freeway. Under the after condition, similar data should be collected during corresponding times and at corresponding locations in both the general purpose lanes and the newly added managed lanes. Traffic count data should be collected automatically and regularly from the appropriate stations and summarized by location, direction, lane (if applicable), time of day, day of week and month to be consistent with the before data set.

As part of the construction of the managed lanes and the reconstruction of the existing freeway, automated traffic count equipment should be installed at permanent fixed locations along the corridor to support performance monitoring efforts. This equipment also will be necessary to support value pricing and in particular, the monitoring of LOS to determine appropriate tolling levels. As part of the before data set, it was recommended that at least one count location (for volume and speed data) be established within each of the tolling zones. With the completion of the facility, additional traffic count stations should be implemented at regular intervals to supplement the primary toll segment locations and to provide redundancy in the event of a primary counter failure.

Automatically collected traffic speeds should again be compared with sample floating travel time runs in the corridor to validate fixed location speeds as the basis for calculating corridor travel times. However, in the after case, the primary source of speed and travel time data should be fixed count locations capable of detecting speeds to help reduce the long term labor cost of generating this information.

The introduction of electronic tolling in the corridor will provide the opportunity to monitor speed and travel time data automatically, and on a continuous basis, by tracking vehicle progress through the corridor using in-vehicle toll collection technology. Toll transponders, global positioning systems, license plate matching, and other similar technologies each have the potential to enable real-time tracking of vehicle progress from observation point to observation point through the corridor to determine average travel speeds and times.

Vehicle classification data should also now be obtained from fixed traffic count stations at the northern and southern ends of the corridor. Manual classification counts at the permanent counts stations would be appropriate to validate automatically collected data, but again, to the extent feasible, data should be derived from automated sources to reduce labor costs.

Vehicle Occupancy

In the absence of a reliable automated vehicle occupancy detection method, direct observation is again recommended as the most effective way of obtaining vehicle occupancy data for the after data set. Visual observation of the number of persons within each vehicle should be conducted again from the same vantage points utilized in the before data collection to ensure consistency. Separate observations and estimations of AVO should be developed for the managed lanes and the general purpose lanes for comparison to the before data set and for after project comparison between lane types.

Mode Split

Consistent with the before data collection methodology, mode split data should again be developed in the after case by reviewing the vehicle occupancy data described previously (to determine the overall percentage of carpools) and through user surveys. Surveys of the users of the managed lanes and the adjacent general purpose lanes will yield the most detailed information regarding mode split and mode choice. Surveys should be designed to mimic the before data survey, and should gather sufficient sample size to include SOV, HOV users, transit users, and toll users for both managed lanes users and those that do not utilize the managed lanes. .

Transit Ridership and Performance

The completion of the managed lanes and associated support facilities will provide the opportunity for improved transit service and operations. Counts of passenger boardings for transit routes operating within the I-5 North Coast corridor (both in the managed lanes and outside of the managed lanes) should be assembled from operator collected data or gathered using visual observation. Similarly, route on-time performance and travel time data should also be collected as a basis for comparison to the before project data set.

As indicated previously, monitoring the ridership on the Coaster also will be important to understand any impact the completion of the managed lanes and the provision of improved bus service may have on commuter rail patronage. Like bus transit passenger

boardings, Coaster passenger boardings data should be gathered from the service operator or from visual observation for comparison to the before project data.

Cost of Delay

The impact of changes in delay within the overall corridor can be quantified and evaluated in terms of the dollar cost to freeway users for lost time, productivity and resources. An assessment of the overall cost of delay will reflect the value of any time savings realized by the managed lanes. These cost savings can be calculated by determining the time loss caused by system delay and applying standard factors to reflect the monetary value of the time lost.

8.6.2. Project Utilization Data

With the completion of the managed lanes, project utilization data will encompass the three data types described in the before data set, but will also now include toll user data reflecting a new user group of the I-5 North Coast corridor. Therefore, after project utilization data will encompass the following four data types:

- Toll users
- Carpools and vanpools
- Transit ridership
- Park and Ride lot utilization

Toll Users

Toll user data can be developed primarily through a review of toll user accounts and activity on those accounts. Toll utilization data can include monitoring of the number of active user accounts, the number of transponders distributed to accounts, frequency of use on the accounts/transponders, average distance of toll use, and value of tolls paid. Additionally, socio-economic data relating to toll users could be developed through surveys of registered toll account holders.

Carpools and Vanpools

Consistent with the data developed for the before data set, information on the frequency of HOV use, O/D, HOV participation, and mode to access the HOV arrangement should again be collected through user surveys to assess the impact of the project. With the inclusion of the new managed lanes, sufficient survey samples should be obtained to also allow comparison between the managed lane users and users of the freeway that do not use the managed lanes in order to identify any notable differences between these user groups.

Transit Ridership

Surveys of transit patrons will allow further comparison of socio-economic characteristics, O/D and mode of access to/from transit (trip ends) for after project transit riders. Building on the transit ridership data described previously, the after project transit rider survey data will allow comparison to before data to determine changes in rider behavior as a result of completing the project. Like previously described data types, sufficient survey sample sizes should be obtained to differentiate between those using transit service operating within the managed lanes and those using service on the freeway that operates outside the managed lanes (if applicable).

Park and Ride Lot Utilization

Utilization of park and ride lots along the I-5 North Coast corridor should be collected to assess changes in total park and ride usage and, in particular, increased usage at existing and new lots following implementation of the managed lanes. Counts of vehicles within previously existing and new park and ride lots in the corridor should be compared to before data to determine the impact of the managed lanes and the related improvement in HOV and transit service. Park and ride lot utilization should also be compared to mode share data and tracked over time to evaluate the effectiveness of the managed lanes and new park and ride lots to attract new participants in carpools, vanpools or transit service.

8.6.3. Project Acceptance Data

Survey data will again provide the basis for the evaluation of project acceptance. Comparison of I-5 users and stakeholders after project survey results with before project data will enable an evaluation of changing attitudes and perceptions after the opening of the managed lanes and as the project matures. Project acceptance data for the after data set will again encompass the two data types detailed in the before data set:

- User perceptions
- Stakeholder perceptions

The after data evaluation of project acceptance also is recommended to incorporate an additional data type:

- Institutional assessment

User Perceptions

Specific questions to determine after project user perceptions of the I-5 North Coast project should reflect those questions originally asked before project implementation. Like the before project scenario, surveys should include sufficient samples of HOV and transit users in addition to toll users to address specific data needs between these groups. Similarly, with the completion of the managed lanes, it will be important to gauge the attitudes and perceptions between the following two distinct sub-groups of I-5 users:

- Managed lanes users
- Freeway users that do not use the managed lanes

Although the data collected for these two sub-groups will address the same fundamental questions, the comparison of the two sub-groups will be important to understanding the overall perception of the managed lanes investment. In particular, this comparison will provide useful information regarding perceptions of inequity and fairness of the managed lanes for the different user sub-groups.

Stakeholder Perceptions

Additional stakeholder interviews should be conducted after project implementation to assess any changes in the perceptions of technical staff, decision-makers, elected officials and community leaders towards the managed lanes and value pricing. In particular, the after project stakeholder interviews can address the perceived benefits and impacts of the project, key implementation and operational issues, and the fulfillment of project objectives.

Institutional Assessment

Similar in approach to the stakeholder interviews, an institutional assessment of the I-5 North Coast project should be conducted after project completion to assess issues and outcomes relating to the project, and the overall project development process and experience. Debrief interviews or 'focus group' panels with key project staff should be conducted to discuss lessons learned relating to project implementation and initial operations, why certain project outcomes were realized and why certain project objectives were fulfilled or remain unfulfilled. This information could be utilized to further enhance the I-5 North Coast project or could be applied to improve the potential for success on other similar projects.

8.6.4. Project Operational Data

The evaluation of project operations becomes more critical following the completion of the I-5 North Coast project. The assessment of project operations will again consolidate data developed for the preceding data sets to support the overall assessment of the project performance. Lane utilization data (including traffic volumes and person trips), travel speed and travel time data, and user perception data will be combined with the following data elements described in the before data set to evaluate project operations:

- Reliability
- Costs and revenues
- Safety and violations

Additionally, with the completion of the project and the utilization of technological elements for tolling and project monitoring, a technical assessment will be applicable as part of the assessment of after project operations.

Reliability

In accordance with project objectives, the operation of the managed lanes places increasing importance on trip reliability. The analysis of LOS and travel speed data for both the managed lanes and the general purpose lanes will enable a comparison of trip reliability between the two options. Similarly, a comparison to before data will reflect changes in trip reliability in the corridor overall as a result of the completion of the project.

Costs and Revenues

Following the implementation of the I-5 North Coast project, it will be possible to more accurately evaluate project costs including capital infrastructure costs, operations and maintenance costs (including the costs of operating and maintaining the tolling systems), enforcement costs, marketing costs and monitoring costs. This information can be compared to actual revenues derived from the project, including revenues from toll generation or violation fines to complete an assessment of the ratio of costs to revenues.

Safety and Violations

Safety data including accident rates, frequency of occurrence by location, contributing factors and number of injuries and fatalities were recommended to be assembled for the before condition on the I-5 North Coast corridor. Comparison of this data with corresponding after project data will provide an understanding of the impact of the project on safety in the corridor.

Violations of HOV eligibility requirements and levels of toll evasion can provide an indication of the effectiveness and acceptance of the managed lane operations. Data relating to violations for the managed lanes should be compared to both before data collected for the existing northbound I-5 HOV lane, and similar data for other managed lane facilities.

Technical Assessment

The implementation of automated data collection, tolling and enforcement systems makes it appropriate to review and evaluate the performance and reliability of these systems in the context of overall project success. Assessment of technical systems should be conducted to evaluate failures of technical systems and any associated monetary cost (including losses in toll revenues). Understanding the failures of technical systems will allow these systems to be further refined or superceded to improve overall reliability and cost effectiveness. This information will also be useful for understanding the limitations of other data that may be affected by technical systems failure.

8.6.5. Summary of After Data Set

Table 8-2 summarizes the data elements comprising the after data set. They are largely similar to the before data set, although some additional data elements are included and data collection methods have changed in some cases. The additional data elements are as follows:

- Cost of delay
- Toll user data
- Institutional Assessment
- Technical Assessment

TABLE 8-2: SUMMARY OF AFTER DATA SET

DATA ELEMENT	PRIMARY METHOD (S)	VALIDATION METHOD (S)
Project Impact Data		
Volumes	Automated, fixed location count stations	None
Speeds	1. Automated, fixed location count stations 2. Tracking vehicle progress using tolling devices	Floating travel time runs
Vehicle Classification Counts	Automated, fixed location count stations	Manual classification counts
Vehicle Occupancy	Manual occupancy counts at overhead vantage points	None
Mode Split	1. Manual occupancy counts 2. User surveys	None
Transit Ridership	Boarding counts as available from operator or manual	None
Transit Performance	On-time performance data from operator or manual	None
Cost of Delay	Automated count stations and available value-of-time estimates	None
Project Utilization Data		
Toll User Data	1. Toll user account data 2. Surveys of toll account holders	None
Carpool and Vanpool Data	1. Manual occupancy counts 2. User surveys	None
Transit Ridership	1. Boarding counts 2. User surveys	None
Park and Ride Lot Utilization	Counts of vehicles in lots	None
Project Acceptance Data		
User Perceptions	User surveys	None
Stakeholder Perceptions	Surveys of stakeholders	None
Institutional Assessment	Interviews of individuals or focus group panels	None
Project Operational Data		
Volumes, person trips, speeds, user perceptions	As indicated above	As indicated above
Reliability (based on speed and LOS)	See speed and volumes above.	See speed and volumes above.
Costs and Revenues	As available	None
Safety and Violations	1. CHP/Caltrans accident and citation records 2. Manual occupancy counts and toll records	None
Technical Assessment	Evaluate performance, reliability, and failures of technical systems and associated monetary costs	None

8.7 ONGOING MONITORING ACTIVITIES

The data elements described in the before and after data sets provide the basis for establishing an ongoing monitoring and evaluation framework for the I-5 North Coast corridor following the implementation of the managed lanes project and associated value pricing element. While the comparison of before and after conditions can provide a comprehensive and immediate understanding of the impacts of the project, continuous project monitoring and benchmarking over time can provide an equally important insight into changing trends in travel behavior and operational needs.

As development continues in the I-5 North Coast corridor, traffic conditions will likely change causing users of the corridor to respond by modifying their travel behavior. Ongoing monitoring of traffic conditions and travel behavior in the corridor will provide useful information to allow responsible agencies to better address these changes and to refine the operation of the managed lanes to better meet the needs of I-5 users.

Table 8-3 summarizes the various data elements previously described in the before and after data set descriptions, and recommends desirable frequencies for ongoing data collection and performance monitoring and evaluation. The frequency of evaluation is intended to achieve a balance between the need to monitor meaningful changes in travel behavior and the relative cost of collecting and analyzing the required data.

TABLE 8-3: SUMMARY OF ONGOING MONITORING ACTIVITIES

DATA ELEMENT	METHOD (S)	MINIMUM FREQUENCY
Project Impact Data		
Volumes	Automated, fixed location count stations	Quarterly by season [3]
Speeds	1. Automated, fixed location count stations 2. Track vehicle progress using transponder data 3. Floating travel time runs for validation [1]	Quarterly by season [3]; validation as needed [1]
Vehicle Classification Counts	1. Automated, fixed location count stations 2. Manual classification counts for validation [2]	Quarterly by season [3]; validation as needed [2]
Vehicle Occupancy	Manual occupancy counts at overhead vantage points	Annual (quarterly by season if available)
Mode Split	1. Manual occupancy counts 2. User surveys [4]	Annual counts (quarterly by season if available); Biennial surveys
Transit Ridership	Boarding counts as available from operator or manual	Annual (bi-annual if available)
Transit Performance	On-time performance data from operator or manual	Annual (bi-annual if available)
Project Utilization Data		
Toll User Data	Transponder and toll user account data	Quarterly by season
Carpool and Vanpool Data	1. Manual occupancy counts 2. User surveys [4]	Annual counts (quarterly by season if available); Biennial surveys
Transit Ridership	1. Boarding counts 2. User surveys	Annual counts (bi-annual if available); Biennial surveys
Park and Ride Lot Utilization	Counts of vehicles in lots	Annual (bi-annual if available)
Project Acceptance Data		
User Perceptions	User surveys [4]	Biennial
Stakeholder Perceptions	Surveys of stakeholders	Biennial
Volumes, person trips, speeds, user perceptions	As indicated above	As indicated above

TABLE 8-3: SUMMARY OF ONGOING MONITORING ACTIVITIES (Continued)

DATA ELEMENT	METHOD (S)	MINIMUM FREQUENCY
Project Operational Data		
Reliability (based on speed and LOS)	See speed and volumes above.	See speeds & volumes above
Costs and Revenues	As available	Annual
Safety and Violations	1. CHP/Caltrans accident and citation records 2. Manual occupancy counts and toll records	Annual CHP/ Caltrans records; Annual counts (quarterly if available)

Notes:

[1] Floating travel time runs to be used to validate automated speed and travel time data on an as needed basis.

[2] Manual classification counts to be used to validate automated counts on an as needed basis.

[3] Real time monitoring of volumes, speeds and travel times may be necessary for toll operations.

[4] Three types of user surveys to be conducted biennially: license plate, transit rider, and phone.

8.8 SCHEDULE AND BUDGET

This section discusses the proposed schedule and estimated budget for conducting the MEP described herein and summarized by Tables 8-1, 8-2, and 8-3. These tables list the data elements comprising the before, after, and ongoing data sets, respectively.

It is recommended that a "third party" that is neither the implementing agency (e.g., SANDAG or Caltrans), nor the funding agency [Federal Highway Administration (FHWA)], be involved in reviewing the evaluation. Periodic "third party" reviews could help ensure the evaluation is objective and addresses the breadth of issues relevant at any given time.

8.8.1. Schedule

Since the projected implementation date for the I-5 North Coast Managed Lanes and Value Pricing project has not been determined, specific evaluation dates cannot be recommended. However, when the implementation date is determined, the evaluation activities should be scheduled with the following considerations.

Before Data Set Schedule:

- It is suggested that evaluation activities be initiated no less than one year prior to project implementation to allow for data to be collected at a time that reflects baseline conditions and accepted travel patterns.
- The evaluation contractor should be retained at about the same time as the consultant for the value pricing planning and pre-implementation services. This would enable the evaluation to be integrated into planning and pre-implementation activities.
- Depending on the project implementation date, data collected as part of this study will likely be too historic to be used in the before data set.

After Data Set Schedule:

- It is suggested that evaluation activities be initiated following project opening. Data should be collected at a time when travel behavior has reasonably adjusted and stabilized in response to the project opening.
- Data collection for the after evaluation should duplicate, to the extent feasible, the times of the year (e.g., spring and fall) and other parameters defining the before data collection effort.

Ongoing Data Set Schedule:

- Table 8-3 indicates the suggested minimum frequency per data element in the ongoing data set. Frequencies range from quarterly to biennial.
- Data elements collected more that once a year (e.g., quarterly) should be collected at approximately the same time each year to facilitate comparisons between years.

A general rule of thumb which applies to scheduling all three data collection efforts (before, after, and ongoing) is that it is desirable to collect data for "typical" travel conditions. Some common circumstances that often lead to atypical travel conditions include:

- Heavy rain that could affect speeds and travel patterns

- Commonly observed holidays that could affect travel patterns
- Severe accidents or incidents that could cause abnormally long delay or result in full re-routing of traffic to alternate facilities.

In order to avoid such atypical conditions, it may not always be desirable to collect data on precisely the same days from year to year, but rather to collect data at approximately the same times of the year.

8.8.2. Budget

The budget necessary for implementing the MEP was estimated based on the cost of HOV monitoring programs around the country, the San Diego region's I-15 Managed Lanes Value Pricing Project MEP, the San Diego region's I-15 FasTrak Program, the length of the project corridor, and the data elements included in the program. It is estimated that implementation of the MEP would cost approximately $300,000 annually in the first several years of implementation. It is further estimated that the cost could decrease to approximately $200,000 annually in subsequent years due to increased automation, tailoring of the data set, and possible economy of scale effects from the expansion of the managed lane network in the San Diego region.

While the MEP has been substantially defined herein, the finalization of several data parameters and other program characteristics will affect the cost of implementing the MEP. These parameters and characteristics are as follows:

- Frequency of Data Collection: The estimated budget does not include data collection, but rather assumes data collected by local agencies or the toll operator for other needs could also be utilized for the MEP.
- Frequency of Data Analysis: Minimum frequencies for ongoing data analysis have been identified, however greater frequencies for several data elements would be useful if budget should permit.
- Number of Analysis Locations: A minimum number of data collection locations have been recommended, however a higher density of analysis locations along the corridor would be beneficial for several data elements if budget permits.
- Frequency of Validation Activities: Validation activities have been identified for several data elements, to be conducted on an as needed basis.
- Which Costs are Included: The estimated budget does not include data collection. It assumes that the MEP will be able to make use of data collected by Caltrans, SANDAG, Metropolitan Transit System (MTS), the North County Transit District (NCTD), or other local agencies. The budget does, however, include a portion of data processing, user and stakeholder surveys, all data analysis, and all report development activities. These various budget components and their inclusion in the budget estimate are further explained below:
    - Automated Data Collection: Equipment, installation, and maintenance costs (not included)
    - Manual Data Collection: Administrative and logistical planning, staffing, and equipment such as vehicles for travel time runs (not included)

- Data Processing: Selection of suitable analysis dates based on weather, accidents, holidays, and the availability of data resources. Requesting and obtaining data from Caltrans, SANDAG, MTS, NCTD, or the toll operator. Inputting data only available in hard-copy format into the computer. Reformatting electronic data in preparation for analysis (partially included)
- User and Stakeholder Surveys (included)
- Data Analysis: Calculation of performance measures. Analysis of current period performance and year-to-year performance trends (included)
- Monitoring Reports: Development of charts, graphs and summary text (included).

8.9 CONTINUING IMPROVEMENT PROCESS

It is expected that the MEP defined herein will continually improve and adapt as opportunities or necessities to do so materialize. For example, changing regional goals or changes in corridor-specific goals might lead to changes in the measures of effectiveness or data elements comprising the MEP.

Technological advances may provide improved data collection possibilities worth incorporating into the MEP. They may enable more meaningful measures of effectiveness to be calculated, higher quality data, lower costs due to automation of manual data collection items, or more frequent analysis due to data collection automation. For example, a Global Positioning System (GPS) rather than transponder based toll collection method might offer improved speed and travel time data. Similarly, more widespread use of GPS and automated fare collection in bus and rail systems would improve the range and frequency of transit data available.

It is foreseen that the MEP will rely heavily on data collected by local agencies and toll operators for other purposes. As local agencies and toll operators adopt new technologies, such investments should be utilized to improve the quality of the MEP in order to maximize their cost-effectiveness. For instance, investments in equipment supporting toll collection and value pricing for operations of the managed lanes could also be useful to the MEP. Similarly, investments in improved bus and rail technology for operation of the integrated bus and rail transit system may also offer new data opportunities for the MEP.

8.10 SUMMARY OF RECOMMENDED PLAN

In conclusion, the recommended Monitoring and Evaluation Plan consists of three components:

- Before: Monitoring and evaluation of conditions before project implementation,
- After: Monitoring and evaluation of conditions after project opening, and
- Ongoing: Annual monitoring and evaluation of conditions thereafter.

The before, after, and ongoing components each adopt a four-tiered approach to assess the effectiveness of the I-5 North Coast Managed lanes project to fulfill the previously stated objectives. This approach is consistent with the evaluation approach proposed for the I-15 Managed Lanes Value Pricing project.

- Measurement of Project Impact
- Measurement of Project Utilization
- Measurement of Project Acceptance
- Assessment of Project Operations

Specific data elements included in the before, after, and ongoing components are summarized in Tables 8-1, 8-2, and 8-3, respectively.