Bay Area High Occupancy Toll (HOT) Network Study

December 2008 Update

Appendices

Section I Appendices: Initial Feasibility Study (Phase 1 and Phase 2, complete September 2007)

Attachments

Section II Appendices: Updated Assessment (Phase 2B, complete June 2008)

Attachments

Section I Appendices: Initial Feasibility Study
(Phase 1 and Phase 2, complete September 2007)

Consultant assistance by PB Americas, Inc. and ECONorthwest

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Appendix 1: Regulatory Setting

New federal and state legislation would be required for implementation of the Bay Area HOT lanes network. The following outlines existing federal and state laws that pertain to HOT lanes.

Federal Law

ISTEA specifically authorized the creation of up to five congestion pricing pilot programs, no more than three of which could implement tolls on the interstate system. The program, renamed the Value Pricing Program in TEA-21, has been continued through successive reauthorizations including SAFETEA-LU and has provided funding for the planning and development of several HOT lanes projects. The objective of this program is to encourage implementation and evaluation of value pricing pilot projects in order to promote economic efficiency in the use of highways and support congestion reduction, air quality, energy conservation, and transit productivity goals. SAFETEA-LU maintains a limit of 15 pilot pricing programs.[1]

In contrast to prior legislation, SAFETEA-LU grants states broad authority to implement HOT lanes on interstate and non-interstate facilities. Section 1121 of SAFETEA-LU replaces Section 102(a) of Title 23 of the United States Code (23 U.S.C.) with a new Section 166. The new legislation allows states to charge tolls to vehicles that do not meet the established occupancy requirements to use an HOV lane, provided the agency meets certain criteria to enroll participants, collect fees electronically, manage demand by varying tolls, and enforce against violations. SAFETEA-LU establishes minimum operating standards for HOT lanes. There is no limit on the number of projects or the number of states that can participate.[2]

California Law

State law remains more restrictive than federal law. State law, amended by 2004 legislation (AB 2032, Dutra), permits implementation of new HOT lanes as demonstration projects in a few specific cases: two new HOT lane projects in Santa Clara County, two in San Diego County, and the I-680 Sunol Grade HOT lane and one additional project in Alameda County. AB 2032 sets forth specific requirements for each of the demonstration projects including:

- The demonstration period is four years after implementation;[3]
- A minimum level of service C must be maintained in the HOT lane (this may be relaxed to level of service D through consultation with Caltrans);
- Revenues from each HOT lane must be spent on investments within that corridor;
- An evaluation must be conducted for each project and submitted to the legislature.

In May 2006, the governor approved AB 1467 (Nunez), which increases the number of HOT lanes projects by four (two in northern California and two in southern California).[4] These projects

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[1] See http://ops.fhwa.dot.gov/tolling_pricing/value_pricing/index.htmfor additional information.

[2] See http://www.ops.fhwa.dot.gov/tolling_pricing/programs/hov_facilities.htm for additional information.

3 AB 574 (Torrico), currently under consideration by the California Legislature, would remove the four-year limit and allow the authorized agencies to operate the HOT lanes indefinitely.

[4] See http://www.dot.ca.gov/hq/innovfinance/Public_Private%20Partnerships/ab_1467_bill_20060519_chaptered.pdf#search=%22california%20AB%201467%22

must be reviewed by the California Transportation Commission (CTC) and then approved by the legislature prior to implementation. The requirements established by AB 2032 also apply to the projects authorized under AB 1467.

Appendix 2: When HOV Lanes Get Full

Review of the regional HOV network suggests HOV lanes will become increasingly crowded over time. HOV lane crowding will need to be addressed whether or not the region pursues HOT lanes because, as they fill, HOV lanes will cease to offer travel timesavings and reliable trip times for carpools and express buses. At the same time, the expected level of carpooling is an important consideration in assessing the opportunities for and likely success of HOT lanes. If HOV lane volumes are low, converting to HOT lanes makes good use of excess capacity and improves the overall efficiency of the freeway system while putting in place a management tool. Where carpools fill the lanes, HOT lanes will generate little revenue and may fail to cover their operating costs.

An important threshold in evaluating crowding is the volume at which 85% of the useful capacity of a lane is reached over a significant distance within a travel corridor. The intent in flagging corridors when they reach this threshold is to allow actions to preserve capacity and keep an HOV lane from reaching stop-and-go conditions. For purposes of this analysis, useful capacity is defined to be 1,600 vehicles per hour (vph). This volume corresponds roughly with level of service C and is characterized by relatively free flowing traffic. The threshold for identifying HOV lanes as crowded is 1,360 vehicles per hour per lane (85 percent of 1,600 vehicles per hour) over 20% of the corridor distance. (See map, next page.)

For purposes of this analysis, corridors are considered candidates for increasing vehicle occupancy when they become crowded according to this definition. While there may be some opportunities to address crowding through other means (spot improvements, adding a second HOV lane), increasing vehicle occupancy is likely to be the most cost-effective response in most corridors. The figure below indicates the approximate date at which HOV lanes are projected to become crowded based on this threshold.

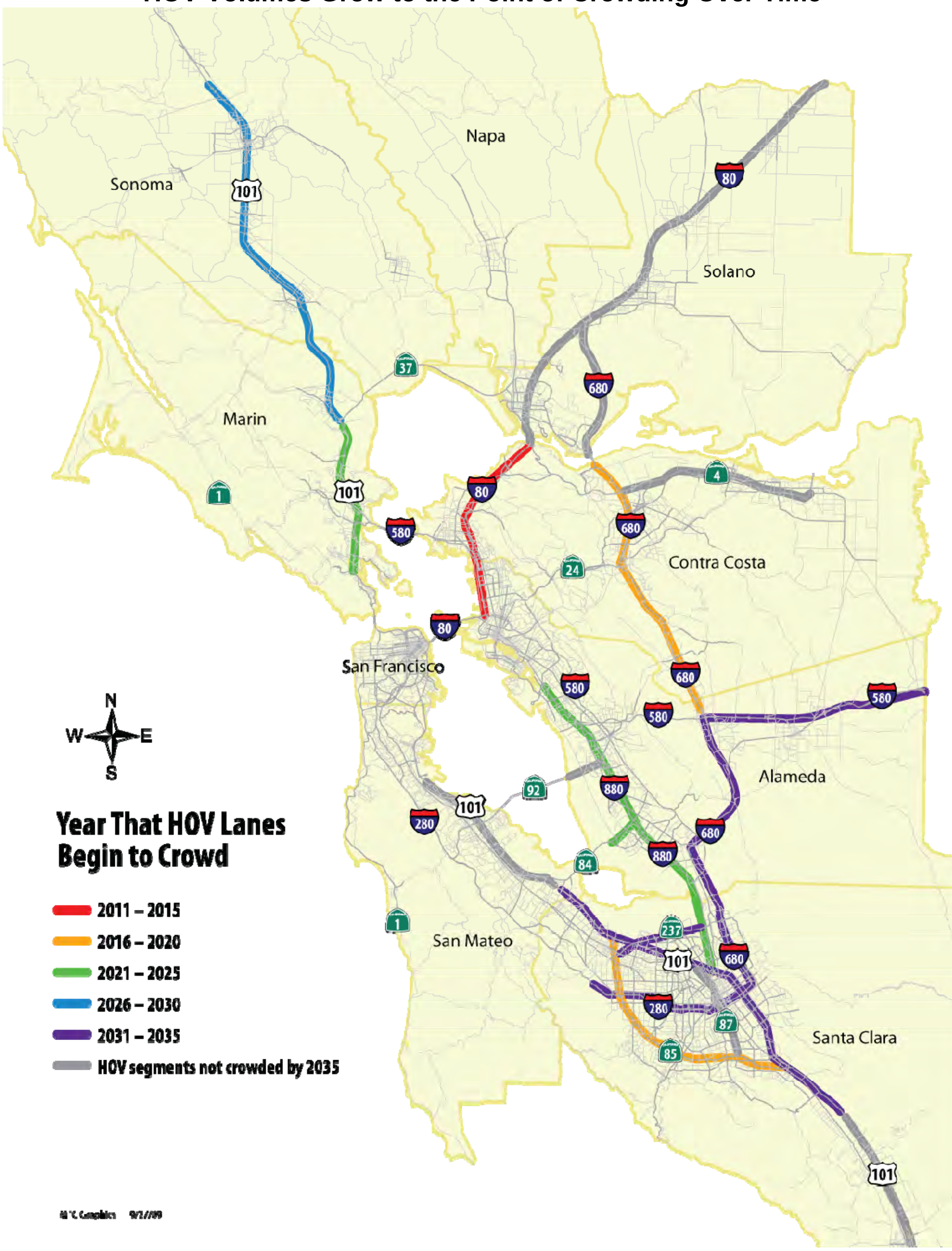
There are several approaches to handling implantation of HOT lanes relative to growth in HOV volumes:

1. Convert an HOV lane to a HOT lane before the HOV lane becomes congested
2. Convert an HOV lane to a HOT lane just at the point it is becoming congested and when the HOV occupancy requirement needs to be increased to maintain acceptable travel conditions (perhaps 1,360 to 1,600 vehicles in the peak hour). Open the HOT lane with a tolling policy that allows HOVs to travel free of charge only if they meet the increased occupancy requirement.
3. When the HOV lane begins to get crowded, add a second lane for a total of one HOV and one HOT lane or two HOT lanes.

The phased plan for this study assumes the first approach where lanes could be opened and in operation for at least five years before HOV volumes reached the point of crowding. In other cases, the second approach is assumed. This study does not explicitly account for the third approach because it is unlikely to be a cost-effective solution for extensive crowding in most Bay Area corridors where right-of-way is tightly constrained. However, the third approach has clear operational benefits, and is under study by the Valley Transportation Authority.

A principle of this review should be underscored. It is important to preserve the functionality of HOV lanes for their intended purpose of encouraging higher vehicle occupancy travel. By applying a threshold above which tolled vehicles cannot enter the HOT lane, it is possible to maintain priority for high occupancy vehicles. This assures that tolled vehicles will not displace HOVs as carpool volumes grow. However, even without consideration of tolling, growth in HOV volumes will reach a point where HOV lanes become crowded. If crowding is not addressed, the HOV lane will not serve their intended purpose of providing faster, more reliable trips for carpools and express buses.

HOV Volumes Grow to the Point of Crowding Over Time



Appendix 3: Cost Analysis

Because it is a first-order analysis, this study takes a conservative approach to estimating costs and revenues. The following steps are taken to ensure conservative cost estimates:

- Low, medium, and high unit costs were applied to estimate HOT lane capital costs. The low cost was applied in very few locations
- Capital cost estimates include a large contingency ranging from 40% where low unit costs were applied to 60% high unit costs were applied.
- Capital cost factors were checked against the cost for the 95% design of the I-680 Sunol HOT lane.

Because of the large contingencies, the analysis did not make the additional, explicit assumption that construction costs would grow faster than inflation, as has been the case in the past few years.

Cost Estimating Assumptions

HOT lane costs are estimated based on previous work conducted by Caltrans, ACCMA, and VTA as well as commonly accepted unit costs. All cost figures are in 2006 dollars. Design assumptions influencing the capital cost estimates are listed below. (See the Task 4 paper for this study for a more detailed discussion of HOT lane design features and tolling equipment.)

- HOT lanes would be separated from the adjacent general-purpose lanes by painted double yellow lines and four-foot buffer.
- Where right-of-way permits, HOT lanes would be a standard 12-foot lane width and existing lanes would not be narrowed to accommodate the HOT lane. A 14-foot median shoulder would be provided, though this width could be used to accommodate enforcement zones and weave lanes at spot locations if needed.
- Widening may be needed in spot locations to accommodate electronic toll pricing gantries, CHP enforcement areas and weaving lanes at ingress and egress locations; these costs are captured in the contingency for this initial assessment.
- The average distance between ingress locations, and, thus, toll tag readers and variable message signs would be four miles. Readers would be located immediately downstream of each entrance on same sign pedestal as a variable message sign posting the price and travel time in the opposite direction, thus there are two such installations in each direction for access openings in each direction. At each ingress location there are one variable message sign installation advertising the price and travel time and two redundant readers and enforcement cameras.
- Communication along the freeway is not assumed to be shared with any existing fiber telecommunications ITS infrastructure that may already exist. This assumption will be revisited when more corridor detail is developed.

Capital Costs

The regional HOT network has two major capital cost components: (1) The cost to convert HOV lanes to HOT lanes or is funded; (2) The cost to add new HOT lanes where no HOV lane exists.

Cost to Convert HOV Lanes to HOT Lanes

The extent of facility modifications required to convert an HOV lane to a HOT lane differs from corridor to corridor and within a given corridor depending on the age of the freeway, number of structures and paved right-of-way. Thus, high, medium and low unit costs were developed to reflect the range of modifications likely to be required[5]:

- Low Range – No widening needed; no structures to be replaced; 40% contingency; $1.6 million per lane-mile
- Mid Range – Some widening needed; 1.5 bridges per lane mile to be modified; 50% contingency; $2.7 million per lane-mile
- High Range – More widening needed; 2.5 bridges per lane mile to be modified; 60% contingency; $4.4 million per lane-mile

Where a Caltrans project study report (PSR) documented corridor-specific engineering features or constraints, this information was used to evaluate whether the cost to convert that corridor would fall in the low-, mid- or high-range unit cost. Where no PSR was available, the unit cost ranges were selected based on an engineer's inspection of Google™ Earth photos and, in some cases, review with local agencies. Where no project study report was available, the unit costs above were considered for the HOT lane corridors and applied based on engineers' inspection of Google™ Earth photos and, in some cases, review with local agencies. Segments with sufficient right-of-way and very few structures were costed at the low level. Depending on right-of-way availability, extent of structures, and other factors, higher unit costs were applied in other segments.

Cost to Add New HOT Lanes

Where the cost of HOV widening has already been estimated in PSR, that cost estimate is reflected in the HOT network cost. Where no cost estimate exists, the cost to add a new travel lane is estimated to be $8 million per lane mile. This cost for the additional travel lane is added to the unit costs for HOT lane elements described above. It is likely that developing the HOV and HOT elements simultaneously will lead to cost savings. At this early stage, accounting for both costs with no assumption of economies or savings results in a conservative capital cost assumption.

The total capital cost of the Bay Area HOT network is estimated to be $4.8 billion. This includes $1.4 billion to convert HOV lanes to HOT lanes and $3.4 billion to add new HOT-equipped travel lanes, where HOV lanes do not currently exist or are not otherwise funded. Attachment A includes a more detailed breakdown of the unit costs. Attachments B through D present the capital cost estimate for each corridor: those that can be developed by converting HOV lanes and those that require widening.

Operating and Maintenance Cost

Operations and maintenance (O&M) costs are estimated at $70,000 per lane-mile per year. This estimate is based on planning by ACCMA for the I-680 HOT lane. It includes the following costs

[5] These unit cost are higher than those used in Phase 1 and documented in the Task 3 report. Unit costs were increased by 20% following further review of the 95% design capital cost for the I-680 Sunol HOT lane to allow for greater contingency.

proportional to corridor distance: a) maintenance of toll equipment; b) supplies; c) utilities; d) lease of communications system; and, e) enforcement. Enforcement unit costs for the system, however, may differ from those for a single corridor. Administrative costs and a 25% contingency are added to these items resulting in the $70,000 operations and maintenance cost per lane-mile. This estimate cost does not include the cost of roadway maintenance.

The annual operations and maintenance cost for the entire Bay Area HOT network is about $55 million per year (in 2006 dollars).

Centralized Costs

Centralized system costs are a factor of HOT lane usage and are not proportional to corridor length. These include: the cost to BATA for processing a tolling transaction, estimated to be $0.16 per transaction; 2.2% of transaction costs for bank or financial institution processing fees; and $18 each for purchase and replacement of a transponder. In addition, the centralized system costs include a one time start up cost of $1 million to expand BATA operations from the current scale, designed to handle traffic on the seven state-owned toll bridges, to one capable of handling traffic on a regional HOT lane network.

Over 20 years (2015 – 2035), the total operating and maintenance cost and centralized system cost for the phased plan described in the final report (and shown in Attachment E) is $1.6 billion.

Roadway Maintenance Costs

At Caltrans' request, this study enumerates the cost of roadway maintenance for the Bay Area HOT network. Under current policy, the state of California covers roadway maintenance costs for all portions of state-owned roadways, including all HOV lanes, the existing HOT lanes in San Diego (30 miles) and the Orange County toll roads (51 miles). The SR 91 HOT lane does pay for pavement maintenance under the terms by which the state acquired the HOT lane from the private owner.

Caltrans provided a statewide average unit cost for roadway maintenance of $93,700 per lane mile per year. This cost includes maintenance of pavement, signs, barriers, guardrails and other design features. At this rate, the annual cost to maintain the region's existing HOV system (350 lane miles) is approximately $33 million per year. The roadway maintenance cost for the full Bay Area HOT network (approximately 800 lane miles) would be approximately $74 million per year.

The estimated 20-year cost (2015 – 2035) to maintain the HOT network roadway, based on the phased plan described in the final report is $1.2 billion. Because the phased plan calls for converting existing HOV lanes to HOT lanes before closing gaps and extending the system, the bulk of this ($800 million) is the cost of roadway maintenance for HOT lanes associated with existing HOV lanes that Caltrans currently maintains. This estimate does not include the cost to bring current pavement up to standards, which would likely be desirable before converting an existing HOV lane to a HOT lane.

A refined estimate of roadway maintenance cost would reflect the average cost in the Bay Area, which might differ from the statewide average. It also would useful to understand whether the unit cost for HOV/HOT lanes would be lower than the average unit cost due to less vehicle usage and exclusion of heavy trucks. And further whether full-time HOT lanes might have a less robust cross section, resulting in lower capital costs.

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Appendix 4: Revenue Analysis and Revenue Compared to Cost

Revenue estimates can be considered conservative for the following reasons:

- The analysis is based on a range of revenue. The high end of the range is directly forecast range based on travel demand forecasts. The low end of the range represents a 30% reduction in gross revenue.
- The assumed tolling policy is to maximize travel timesavings rather than maximizing revenue. Analysis shows that a revenue maximizing policy will tend to generate revenues at least 20 percent higher.
- Daily and annual corridor revenue forecasts are developed using explicit weekday AM peak period travel demand forecasts, which typically show strong peaking in one direction, and observed data of daily traffic distribution on the corridor. This will tend to generate lower daily revenue estimates for the reverse travel direction than if the PM peak period were also modeled explicitly. A less conservative approach would have compensated for this by assuming PM peak period revenue mirrored the AM peak period revenue in the reverse direction of travel in each corridor.

Because this is a first-order assessment, the technical analysis makes some simplifications in estimating revenue. These are described further below.

Assumptions

The MTC travel forecasting model is used to forecast future travel and a separate toll optimization model is used to estimate HOT lane utilization, toll levels and revenue.
The revenue and other performance statistics presented in this report depend upon numerous policy and modeling assumptions. Most important among these are the following:

- It is assumed the tolling policy has the primary objective of maximizing the value of travel time savings across all of the users of a facility, subject to the overarching constraint that a minimum LOS be maintained. The objective maximizes travel timesavings for HOVs, toll paying vehicles, and vehicles in the general-purpose lanes. The assumed LOS constraint is that vehicle per hour (VPH) in the HOT lane will not exceed 1,600, which is roughly equivalent to LOS C. See discussion below on HOT lane volume criteria.

- It is assumed that the facility will be operated and priced seven days a week, twenty-four hours per day. This assumption is particularly influential on revenues in future years when peaks are broader and midday volumes higher.

- Hybrid vehicles are not assumed to receive special toll treatment. Under current law, the total number of hybrid HOV lane permits is capped. In the absence of a clear basis for assuming extension of this policy, no preference is assumed.

- The toll treatment of HOVs has a major influence on the performance of HOT lanes. The modeling assumes qualifying carpools would be able to use the HOT lanes free of charge. Current HOV occupancy requirements are two persons in most corridors today and three persons in the I-80 corridor in Alameda and Contra Costa County and on selected toll bridges. Current policies are assumed to continue unless carpool volumes would begin to approach the level of service C threshold. For corridors in which two persons currently qualifies as a carpool, the occupancy requirement for qualifying carpools is increased to three persons at that time. In corridors where three persons presently qualify as carpools, no increase is assumed and this issue was flagged for further study.

- Operational constraints on HOT lane access have not been modeled explicitly. Management of merge-weave turbulence, toll compliance and system cost and other considerations likely will require limited access and/or egress as part of the engineering design. The unlimited access assumption made in the modeling for this initial assessment simplifies these issues. Depending upon the natural pattern of access and egress in specific corridors, abstracting from these considerations may have little import or may overstate somewhat the revenue potential of a corridor.
- The modeling for this initial assessment does not reflect feedback from the tolling model to the regional travel demand model. This simplification reduces the analytical effort required by several orders of magnitude. It likely does not affect the relative performance observed across corridors or road segments. In order to obtain better measures of absolute performance, however, feedback of tolling to the regional travel demand model is required and will be conducted in future phases of work.

HOT Lane Volume Criteria

Current law requires HOT lanes to maintain level of service C conditions. Operational and performance experience from concurrent HOV lanes (one lane in each direction with little or no median shoulders or buffer areas) suggests that speeds and operational reliability start to fail in various conditions when volumes exceed 1,550 to 1,650 vehicles per hour (vph) per lane.

Previous HOT lane studies in the San Francisco Bay Area (in Alameda and Santa Clara counties) have assumed maximum allowable volumes in the range of 1,450 to 1,650 vehicles[6] per lane per hour. Values in the range of 1,500 and 1,650 vph have also been applied to value pricing studies on I-15 and I-5 in the San Diego area where multiple-lane HOT facilities are presently in operation or are planned for implementation.

For this study, which assumes a network of single-lane HOT lane facilities, a 1,600 vph threshold was selected as the basis for the initial analysis as the optimum representation of current operating conditions on the region's most successful HOV lanes.

For forecasting future travel, no limit is set on the number of carpools that can use an HOV lane. The forecasts of HOT lane usage set a limit of 1,600 vph of combined HOV and tolled vehicles. After that threshold, no more tolled vehicles are allowed in the HOT lane.

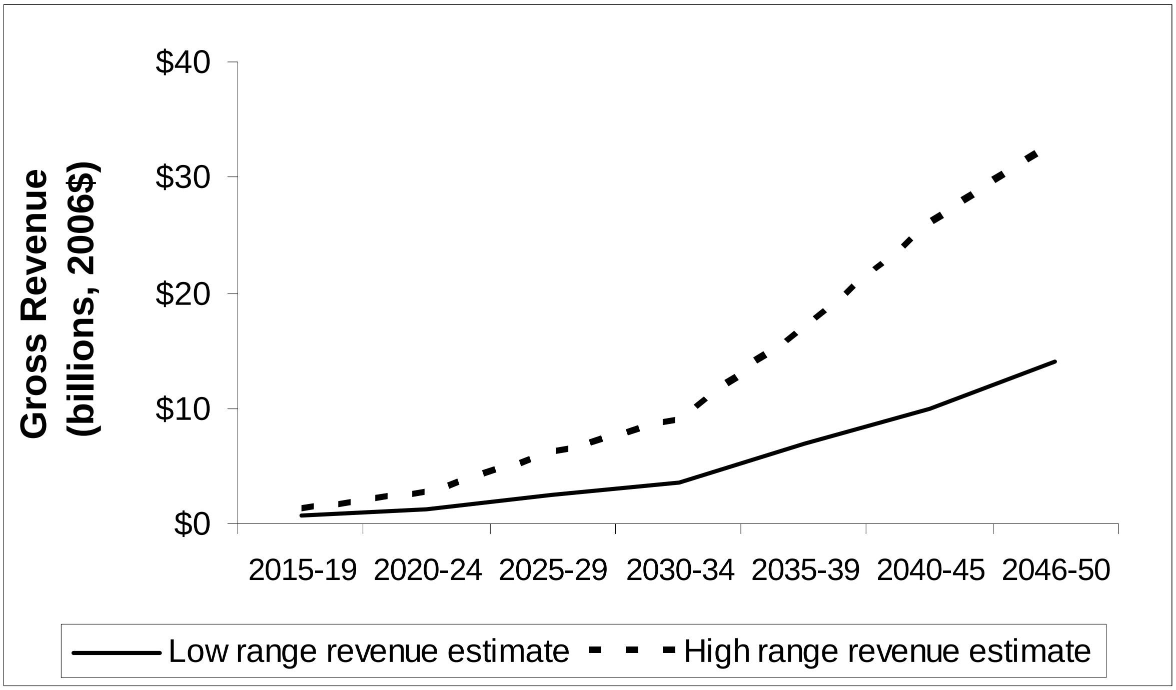
Revenue Estimates

The total gross revenue for the phased implementation plan assumed in this study (and shown in Attachment E), is estimated to range from $8.0 billion to $11.4 billion over the period from 2015 to 2035.[7] Under this plan, the initial four demonstration projects would on-line prior to 2015 and all remaining corridors in the regional HOT network would phase in between 2015 and 2025. As shown in the graph below, revenue growth is robust over time as congestion grows. It is especially robust after 2030 or 2035, by which point the peak period HOV volume in nearly every corridor has reached the point of crowding. This study assumes the longer-term approach

[6] Vehicles are classified as passenger car equivalents, which are intended to classify all vehicles using a facility into fractions or multiples of passenger cars depending on size, speed, and other factors.

[7] As described above, the low end of the range is 30 percent less than the revenue forecast by the tolling model. This range reflects an appropriate level of uncertainty given the level of analysis to date.

to preserve HOV lane function will be to increase carpool occupancy requirements, and the HOT lane revenue grows accordingly reflecting a big increase in the number of tolled vehicles that may use the lanes.



Attachment F includes revenue forecasts by corridor for years 2015 and 2030 for two distinct Bay Area HOT network configurations considered in the development of the HOT network phased implementation plan: (1) a partial network developed by converting only existing HOV lanes and those fully funded through year 2015; this is called the “Existing and Funded Network” and (2) the complete network or “Connected Network” proposed in this report. Further explanation of revenue forecasting and corridor by corridor revenues is included in the Task 3 technical report.

The following observations are of note:

- In general, corridors that have high levels of congestion in the general-purpose lanes and relatively low numbers of carpools in the HOT lanes will generate higher annual toll revenue per mile.
- For corridors in the “Existing and Funded Network”, most corridors show increasing revenue from 2015 to 2030, reflecting increases in congestion as traffic grows over time. Exceptions to the rule include: I-680 southbound in Contra Costa at a 2+ HOV requirement, I-880 in Alameda and Santa Clara southbound at a 2+ HOV occupancy and SR 84 in Alameda westbound to the toll plaza at a 2+ HOV occupancy. The decrease in revenue for these three is likely due to the HOV lanes becoming more congested over time, leaving very little room for tolled vehicles. When those same corridors are considered at a 3+ occupancy level, revenues grow from 2015 to 2030.
- All corridors would generate higher revenues under a 3+ vehicle occupancy requirement than under a 2+ requirement because there is more room for toll-paying vehicles. In

addition, 2-person carpools would pay tolls to use HOT lanes under a 3+ vehicle occupancy policy, and they are typically willing to pay higher toll rates since the cost is shared between the two occupants.

- Some corridors have estimated average annual revenues in 2030 at greater than $1 million per mile, including:
    - I-680 southbound in Alameda-Santa Clara
    - I-680 southbound in Contra Costa (at 3+ only)
    - I-880 in Alameda-Santa Clara in both directions
    - SR 237 eastbound in Santa Clara
    - SR 87 in both directions in Santa Clara County
    - US 101 southbound in San Mateo and Santa Clara in most conditions and northbound at a 3+ occupancy requirement
- In several corridors for which the Connected Network includes HOT lane extensions, the average annual toll revenue per mile in 2030 is lower in the Connected Network than it was in the Existing and Funded Network. These include: SR 4, SR 237, I-280, and I-680. This may reflect the fact that the additional segments are less productive in terms of revenue than those in the Existing and Funded Network. However, it may also reflect some redistribution of trips as the HOV/HOT lane network becomes more connected.
- 21 of the 35 directional corridors in the Connected Network have average annual revenue of over $1 million per mile at a 3+ occupancy requirement but only one does at the 2+ level.

Impact of Limited Hours of Operation

The table below provides a rough estimate of the percent share of all-day revenues obtained when HOT lane pricing is limited to the most heavily congested weekday and weekend hours. For instance, if HOT lane pricing is limited to the 8 most heavily congested weekday hours/day and 4 most heavily congested weekend hours/day, we would expect on average that 71 percent of the revenues obtained under all-day pricing would be realized. The figures below are based on an in-depth analysis for the I-680 Sunol Corridor and represent generalized information about congestion patterns over the course of a day or week. The actual sensitivity of limited hours may in the end vary by corridor.

Average Share of All-Day Revenues Obtained Under Limited Hours of Operation

Hours Operated per Day on Weekdays	***And Hours Operated per Day on Weekends***				
	4	**8**	**12**	**16**	**24**
4	48%	56%	61%	62%	62%
8	71%	80%	84%	85%	85%
12	82%	91%	95%	96%	96%
16	86%	94%	99%	100%	100%
24	86%	94%	99%	100%	100%

Appendix 5: Financing Assumptions

With the intent of advancing development of HOV lanes and HOT lane upgrades, MTC and its partners will find it necessary to either use public funding sources or to borrow funds to pay for project costs not now funded in the 2007 Transportation Improvement Program (Federal TIP) or State Transportation Improvement Program (STIP) or other established and committed program. In discussions with MTC, it was agreed that this financial review would not assume use of any public funds other than those presently committed through MTC's 2007 TIP.

This means that HOT lane toll revenues would need to fund conversion of about 490 existing and funded HOV lanes to HOT and addition of 300 lane miles of travel lane and HOT associated costs where HOV lanes presently do not exist and are not funded through committed sources. The combined capital cost of these investments is estimated to be approximately $4.8 billion.

Financing Assumptions

The borrowing analysis used the following factors:

- Annual coupon rate of 5.0%
- Annual yield of 5%
- Bond price of $100
- Interest rate earned on cash balances of 4.5%
- All figures are stated in 2006 dollars.

Bond issuance costs have not been estimated in this review.

Borrowing Requirements

The estimated amount that must be borrowed to complete the network by 2025 is $4.725 billion.[8] This figure is based on two factors: 1) the amount of borrowing needed to have the entire HOT lane network constructed by 2025; and, 2) seeking to keep the borrowing within a 3:1 coverage ratio. While these two factors could counteract each other, this particular cash flow table is reasonably workable at a borrowing level of $4.725 billion.

With the assumptions above, the financing review provides the following results:

- Debt service over 20 years totals $6.67 billion (with ten more years of payments due)
- Debt service over 30 years totals $9.39 billion.
- Interest paid over 30 years totals $3.85 billion.

The table below shows HOT network revenue and costs for the period between 2015 and 2035, after accounting for debt service. If revenues lie at the low end of current estimates, HOT network revenues are approximately equal to costs over the 20-year period.[9] Modest

[8] Assumes the phasing plan described in the final report and shown in Attachment E.

[9] Given the level of detail in this analysis a net revenue figure of plus or minus $300,000 million over 20 years can be considered breaking even.

adjustments to the phased plan can be expected to improve the outlook at the low end of the revenue estimate range while refined approaches to costs and revenues will eventually narrow the range over all. Further, strong projected revenue growth starting in 2030 suggests the HOT network will make up lost ground quickly.

HOT Lane Revenue, O&M Costs, Debt Service (billions of 2006$)

	2015-35 (20 year period)	
	Low revenue level	**High revenue level**
Gross revenues	$ 8.0	$ 11.4
Less O&M + centralized services costs	$ (1.6)	$ (1.6)
Balance available for capital and/or debt service[1]	$ 7.4	$ 9.8
Estimated debt service (with borrowing of $4.725 billion)	$ (6.7)	$ (6.7)
Net revenue after debt service	$ (0.3)	$ 3.1

[1] Based on borrowing $4.7 billion over 30-years. Debt service repayment continues through 2045 for a 30-year total of $9.4 billion.

Conditions Affecting Bonding for HOT Lanes

While the HOT lane program financing issues have not been reviewed with financial institutions, several conditions are readily apparent and will guide future financial reviews. These include the following:

- MTC will need to develop an investment grade revenue forecast – The travel and revenue forecasts conducted to date provide a reasonable basis for assessing the feasibility of a HOT lane network. However, with the need to validate the HOV volumes, detail the HOT lane configurations (ingress and egress locations, weave locations, etc.), and run the travel and revenue models to equilibrium and in an interactive manner, the revenue estimates must be considered to be preliminary. Bond financing organizations will require an investment grade revenue forecast before they will be in a position to identify appropriate coverage ratios, bond costs, and interest rates.

- Uncertainties will affect bonding – A financing institution will need to understand and assess the likelihood of a variety of risks associated with a HOT lane network. Among the factors that are critical to the revenue forecasts provided through Phase 2 are:

- Tolling principles – Whether dynamic tolling, flat rate rolling, 24/7 or part time tolling, or other approaches will be used has a significant impact on likely revenues. This review has assumed 24/7 and dynamic tolling. If another approach is used or if there is a likelihood of the method changing during the bonding period, the financial institutions will reflect that probability in the amount that may be borrowed, the interest rate, or other features.

- HOV occupancy requirements – The revenue forecasts have assumed that Caltrans, MTC, and the partner organizations will increase HOV occupancy requirements for the various lanes when HOV volumes rise to the point of crowding. The review assumes that the HOV lanes must function for HOV purposes and that tolled vehicles will be allowed to use the lanes to the extent there is available space. If the region does not (or is not committed to) increase the occupancy requirement when the lanes fill with HOVs, there will be less lane space to offer to tolled vehicles. That would keep revenues far lower than estimated to date.

- Use of HOT lane net revenues across a variety of corridors – Some corridors can produce sufficient revenues not only to fund their own costs but also costs for other less financially self-sufficient corridors. Over time, two facets of revenue usage will be critical: 1) higher revenue producing corridors helping to pay development costs for other corridors; and, 2) higher revenue producing corridors' revenues being available to repay bonds used for other corridors. If revenues from one corridor are limited to use only in that corridor, those HOT lanes that are unlikely to cover their own costs for a long time (e.g., 30 years or more into the future) may not be financeable through bonding.

- <u>A form of repayment guarantee will be needed</u> – Financial institutions will look to either a guaranteed revenue source as assurance that the bonds can be paid or will need to discount the anticipated HOT lane revenues sufficiently to assure repayment. The only source considered to date that could provide a significant repayment guarantee is the Bay Area toll bridge revenue pool. That pool or cash flow stream is presently the basis for seismic retrofit bonding and, therefore, is not considered to be a likely basis for HOT lane bond repayment. That leaves the HOT lane revenues themselves as the repayment guarantee source. As noted above, some discounting of the forecast HOT lane revenue stream will be applied.

- <u>Financial institutions will require a coverage ratio</u> – At this very early stage of regional HOT lane planning, there are significant uncertainties about revenues. To be conservative, this study assumes that over a 30-year period, MTC and its partners would need to have at least three times the revenues needed to repay the bonds.[10] With a net revenue estimate (defined in this case as gross revenue less operations and maintenance and centralized services costs) over 30 years of $25 to $36 billion, the 3:1 coverage ratio suggests consideration of repaying a total amount of $8 to $12 billion. The analysis assumes borrowing of about $4.725 billion, which is workable within the 30-year period, although the low range revenue estimate would have a coverage ratio below the target of three. The concept of a coverage ratio would probably take the form of an annual ratio of available revenues (after deducting

[10] For this initial study, the coverage ratio was assumed to apply over the total 30-year period, rather than on an annual basis, as might well be the case when it eventually comes time to finance and the phasing plan has been refined.

operating costs) to debt service. The Bay Area Toll Authority (BATA) presently operates with a bonding ratio for available revenue to debt service of 1.5.

Summary

Important decisions that will affect cash flow, borrowings, bond interest payments, and other elements include the following:

1. What source or means of repayment guarantee will be used?
2. What range of HOV and HOT lane investments are to be included in the projects to be paid for through the bonds?
3. Will MTC and its partners build cash balance over time or will some portion of that be used for financing projects in addition to HOT lanes?

Appendix 6: List of Technical Memos (MTC website and library)

The following technical memos are available on the MTC website (www.mtc.ca.gov) or through the MTC/ABAG library (library@mtc.ca.gov or 510.817.5836).

Phase 1: Initial Assessment

Task 3: Initial Assessment Report (February 2007). Reviews costs, revenues and traffic impacts of two potential HOT networks in 2015 and 2030. The first network is composed only of those HOV lanes that exist or are presently funded through committed source. The second network is the complete regional HOT network featured in the study final report. This report documents the assumptions used in the cost and revenue analysis; however, the capital cost assumptions were subsequently updated in Phase 2.

Task 4: Policy and Operational Considerations for a Regionwide Bay Area HOT Lane Network (December 2006). Outlines technical and policy considerations in the following ten categories: (1) HOT lane design principles; (2) interface with HOV lanes; (3) Pricing policy and tolling technology; (4) linkages to the ITS regional architecture; (5) HOT equipment maintenance practices; (6) enforcement options; (7) public acceptance variables; (8) equity considerations; (9) HOV and HOT planning an adjoining regions; and (10) governance considerations.

Phase 2: Additional Network and Corridor Review

Task 9: Operations Impact and Performance (September 2007). Identifies four operational issues that may be encountered in developing the regional HOT network and provides schematic drawings of approached to addressing these concerns. The four issues are: (1) Speed differential between HOT lanes and adjacent general-purpose lanes; (2) weaving-related concerns; (3) accommodations for enforcement; (4) concerns related to HOT lane termini.

Task 10: Comparison of Capital and Operating & Maintenance Cost Estimates for I-680 (September 2007). Reviews costs developed by the Alameda County Congestion Management Agency for the I-680 Sunol HOT lane with those used in Phase 1 of the Regional HOT Network study.

Task 11: Preliminary Financial Assessment of the HOT System (September 2007). Reviews financing needs and cash flow for a phased implementation plan that delivers a self-funded HOT network by 2025, as described in the study final report.

Task 12: Phased HOT Lane Development Process (September 2007). Describes phasing principles and presents the phased implementation plan that delivers a self-funded HOT network by 2025, as described in the study final report. Includes a discussion of the project development process and timeline.

Task 13: MTC HOT Lane Governance Review (September 2007). Outlines the state, regional and local interests in HOT corridors and the regional network. Lists a number of topics related to governance structures and decision-making authority. Identifies a few local governance models based on Bay Area experience in the transportation sector.

ATTACHMENT A: UNIT COST COMPARISON FOR HOT LANE NETWORK - Low, Medium, and High Range Costs Per Lane Mile

	Low Range		Medium Range		High Range	
Item	Lane Mile Cost	Comments/Assumptions	Lane Mile Cost	Comments/Assumptions	Lane Mile Cost	Comments/Assumptions
Pavement Demolition	$ 50,000		$ 50,000		$ 50,000	
Haul Debris	$ 25,000		$ 25,000		$ 25,000	
Aggregate Base	$ 20,000		$ 20,000		$ 20,000	
Subgrade	$ 4,000		$ 4,000		$ 4,000	
Asphalt Concrete	$ 41,000		$ 41,000		$ 41,000	
Drainage Modifications	$ 65,000	Inlet modifications etc. along shoulder	$ 65,000	Inlet modifications etc. along shoulder	$ 65,000	Inlet modifications etc. along shoulder
Metal Beam Guardrailing	$ 42,000	Replace 25% per lane mile	$ 42,000	Replace 25% per lane mile	$ 42,000	Replace 25% per lane mile
Concrete Barrier	$ 50,000	Replace 20% per lane mile	$ 50,000	Replace 20% per lane mile	$ 50,000	Replace 20% per lane mile
Shoulder reconstruction	$ 78,000		$ 78,000		$ 78,000	
Asphalt Concrete- Shoulder	$ 20,000		$ 20,000		$ 20,000	
Temporary K-rail	$ 22,500	0.25 mile of placement per mile	$ 45,000	0.5 mile of placement per mile	$ 45,000	0.5 mile of placement per mile
Temporary Striping	$ 3,000		$ 3,000		$ 3,000	
Permanent Striping	$ 7,000		$ 7,000		$ 7,000	
Traffic Markings for HOT lanes	$ 3,000		$ 3,000		$ 3,000	
HOT Lane Striping	$ 15,000		$ 15,000		$ 15,000	
Enforcement Area	$ -	None Assumed	$ 40,000	Use of median shoulder every 4 miles	$ 86,250	Standard enforcement & Weaving Lanes
Misc.Sign Allowance	$ 10,000	Small signs posted on median barrier	$ 10,000	Small signs posted on median barrier	$ 10,000	Small signs posted on median barrier
Guide Sign Allowance	$ 22,500	3 prior to start of each HOT every 10 miles	$ 22,500	3 prior to start of each HOT every 10 Miles	$ 22,500	3 prior to start of each HOT every 10 miles
CMS/VMS	$ 37,500	1 per 4 lane mile @ 150,000 ea.	$ 75,000	2 per 4 lane miles @ 150,000 ea.	$ 75,000	2 per 4 lane miles @ 150,000 ea.
Utility Relocation Allowance	$ 25,000		$ 50,000		$ 50,000	
Structure Modification	$ -	None Assumed	$ 300,000	1.5 bridge per lane mile, $500/sq.ft due to addition of substructure, assume 100 foot long bridge	$ 500,000	2.5 bridges per lane mile, $500/sq.ft due to addition of substructure, assume 100 foot long bridge
Sound wall Modification	$ -	None Assumed	$ -	None Assumed	$ 396,000	10% replacement per lane mile
ITS Elements	$ 300,000		$ 300,000.00		$ 300,000	
Sub-total	**$ 840,500**		**$ 1,265,500**		**$ 1,907,750**	
Mobilization 10%	84,050		126,550		190,775	
Contingency	$ 184,910	Assume 20%	$ 417,615.00	Assume 30%	$ 839,410	40% Contingency; greater uncertainty with ROW acquisition and structure replacement
Total	**$ 1,109,460**		**$ 1,809,665.00**		**$ 2,937,935**	
Traffic Management	33,284	Assume 3% of total	72,387	Assume 4% of total	146,897	Assume 5% of total
Design and Construction Management	221,892	Assume 20% of total	361,933	Assume 20% of total	587,587	Assume 20% of total
	272,927	Added 20% for overall contingency	448,797	Added 20% for overall contingency	734,484	Added 20% for overall contingency
Grand Total	**$ 1,637,563**		**$ 2,692,782**		**$ 4,406,903**	

Note: Shaded rows indicate cost items where assumptions differ for the low, medium and high range cost estimates.

Note: All Costs are in 2006 Dollars (2006 $)

ATTACHMENT B - 2015 EXISTING AND FUNDED NETWORK -- CONSTRUCTION COSTS

County	Route	From	To	Distance (Lane Miles) WB	Distance (Lane Miles) EB	Distance (Lane Miles) SB	Distance (Lane Miles) NB	HOT Cost (millions) Estimated Upgrade Costs	Comments
CC	SR4	SR 160	Port Chicago Highway	15.3	15.4			$ 108.98	**50% Medium and 50% High Cost Option:** Soundwall to outside makes widening difficult.
Total Corridor SR4				**15.3**	**15.4**			**$ 108.98**	
CC		Carquinez Bridge	Central Ave (Alameda County Line)	16.0	14.6			$ 134.85	**High Cost Option:** Total median width about 6' throughout the corridor (2' either side pluss 2' median barrier). Approx. 10 bridge
ALA	I-80	Central Ave (Alameda County Line)	Bay Bridge Toll Plaza	5.9	6.0			$ 52.44	structures.
SOL	I-80	Air Base Pkwy IC	SR 12	6.6	6.7			$ 35.81	**Medium Cost Option**
Total Corridor I-80				**28.5**	**27.3**			**$ 223.11**	
ALA	SR 84	Newark Blvd	Paseo Padre/Thornton incl. Toll Plaza Dumbarton Bridge	3.5				$ 15.42	**High Cost Option:** PSR describes only 1 mile of HOV widening with possible ROW take. No specific plan details.
Total Corridor SR 84				**3.5**				**$ 15.42**	
SC	SR 85	US 101 (South San Jose)	US 101 (Mountain View)			26.5	26.3	$ 119.89	**Medium Cost Option:** North of I-280 (approx 5 miles). **50% Low Cot Option and 50% Medium Cost Option** south of I-280. Standard outside and inside shoulders
Total Corridor SR 85						**26.5**	**26.3**	**$ 119.89**	
SC	SR 87	US 101	SR 85			9.1	9.2	$ 29.97	**Low Cost Option:** Construction cost for the VTA HOV segment on this route (7 miles) was $68 Million. Input from VTA suggests using a low range cost to convert to HOT lane.
Total Corridor SR 87						**9.1**	**9.2**	**$ 29.97**	
ALA	SR 92	Hesperian	Toll Plaza - San Mateo Bridge	1.6				$ 7.05	**High Cost Option**
Total Corridor SR 92				**1.6**				**$ 7.05**	
SM	US 101	Whipple Ave	San Mateo/Santa Clara County Line			7.0	7.0	$ 61.70	**High Cost Option**
SC	US 101	San Mateo/Santa Clara County Line	Cochrane			35.0	34.0	$ 145.98	**75% segment is Low Cost Option** (South of San Jose to Cochrane) and **25% of segment is equally split between High and Medium Cost Option:** From San Jose to north
MAR	US 101	SB 101/Seminary Ave & NB 101/SR1	SR 37			13.8	14.9	$ 82.01	**25% Low and 50 % Medium Cost Option:** Novato, **25% High Cost Option**: Southern Marin
SON	US 101	Old Redwood Highway (Petaluma)	Windsor River Rd			21.7	21.2	$ 115.52	**Medium Cost Option:** Santa Rosa.
Total Corridor US 101						**77.5**	**77.1**	**$ 405.21**	
SC	SR 237	I-880	Mathilda I/C	7.0	7.0			$ 61.70	**High Cost Option:** Outside shoulders 12'. Median shoulders vary from areas with 6' median shoulder to 10' -12' . Highway segment includes 11 bridge structures
Total Corridor SR 237				**7.0**	**7.0**			**$ 61.70**	
SC	I-280	Magdelena Ave	Leland Ave			11.5	11.1	$ 60.86	**Medium Cost Option**
Total Corridor SR I-280						**11.5**	**11.1**	**$ 60.86**	
ALA	I-580	Hacienda	Greenville		10.8			$ 29.08	**Medium Cost Option:** Widen to outside
Total Corridor I-580					**10.8**			**$ 29.08**	
SC	I-680	Caleveras	Alameda/Santa Clara County Line			2.5	2.5	$ 12.98	**Medium Cost Option:** NB direction. Cost of SB HOT lane from I-680 Smart Carpool Project (2.5 mill/lane mile)
ALA	I-680	Alameda/Santa Clara County Line	SR 84			11.5	10.8	$ 57.83	**Medium Cost Option:** NB direction. Cost of SB HOT lane from I-680 Smart Carpool Project (2.5 mill/lane mile)
CC	I-680	Marina Vista	Alcosta Blvd.			26.0	22.3	$ 130.06	**Medium Cost Option**
Total Corridor I-680						**40.0**	**35.6**	**$ 200.88**	
ALA	I-880	Marina	SR 237			25.0	22.9	$ 128.98	**Medium Cost Option**
ALA	I-880	16 th Street	Merge with I-80 W				1.8	$ 6.39	**50 % Medium to 50 % High Cost Option;** Appears that median shoulder widen for future lane and shld.
Total Corridor I-880						**25.0**	**24.7**	**$ 135.37**	
Sub-Total Lane Miles and Total Cost				**55.9**	**60.5**	**189.6**	**184.0**	**$ 1,397.51**	
Total Lane Miles all Directions					**490.0**			*$2.9 M/mile*	

Note 1: **HOT upgrade cost may be a combination of the different costing options (low, medium, high) or one option is chosen due to specific information available.**

Note: All Costs are in 2006 Dollars (2006 $)

ATTACHMENT C - HOT NETWORK SEGMENTS ADDED 2015 and 2030 CONSTRUCTION COSTS

County	Route	From	To	Distance (Lane Miles) Added		Distance (Lane Miles) Added		Total Lane Miles HOT Lane Network (2015+2030)				HOV Lanes Added in 2030 Network Cost /Lane Mile (1) $ 8.00	HOT Cost (millions) Estimated Upgrade Costs	Total HOT Cost and HOV Cost (in Millions)	Comments
				WB	EB	SB	NB	WB	EB	SB	NB				
CC	SR4	Port Chicago Highway	I-680	4.1	3.7			19.4	19.1			$ 77.22	$ 27.69	$ 104.91	**50% Medium and 50% High Cost Option: Soundwall to outside makes widening difficult. Used $ 9.9 million per lane mile for HOV estimate based on PSRs available for the corridor.**
CC	SR 4/I-680	HOV Connector Facility										$ 75.00	$ -	$ 75.00	No cost to convert HOV connector to HOT lane due to no additional ITS elements or striping requirements
Total Corridor SR4				**4.1**	**3.7**			**19.4**	**19.1**			**$ 152.22**	**$ 27.69**	**$ 179.91**	
ALA/CC	I-80	Pomona/San Pablo thru IC and to Cummings (Carquinez Bridge)	Bay Bridge Toll Plaza					21.9	20.6						
SOL	I-80	Yolo County Line	SR 37	32.7	32.5			32.7	32.5			$ 521.60	$ 141.17	$ 662.77	50% Low and 50% Medium Cost Option: Outside shoulder widths vary (10'-13') and the median shoulder width varies from 20' (south of SR 37) to 30' (north of Vallejo). 7 bridge structures (No PSR)
SOL	I-80	SR 37	Carquinez Bridge	4.6	4.6			4.6	4.6			$ 73.60	$ 24.77	$ 98.37	**Medium Cost Option: PSR shows $48 mill. Need to be confirmed HOV widening assumed to be funded in Transportation 2030 Plan**
SOL	I-80	Air Base Pkwy IC	Suisun Valley Rd/I-680					6.6	6.7						
Total Corridor I-80				**37.3**	**37.1**			**65.8**	**64.4**			**$ 595**	**$ 166**	**$ 761**	
ALA	SR 84	I-880/Newark Blvd	Paseo Padre/Thornton incl. Toll Plaza Dumbarton Bridge					3.5							
Total Corridor SR 84								**3.5**							
SC	SR 85	SR 87 Almaden	Moffett US 101							26.4	26.1				
Total Corridor SR 85										**26.4**	**26.1**				
SC	SR 87	US 101 Skyport	Capitol Expwy SR 85							9.1	9.2				
Total Corridor SR 87										**9.1**	**9.2**				
ALA	SR 92	Clawiter	Toll Plaza - San Mateo Bridge					1.6							
Total Corridor SR 92								**1.6**							
SM	US 101	Millbrae Ave	Whipple Ave			11.4	11.7			11.4	11.7	$ 184.80	$ 101.80	$ 286.60	**High Cost Option, No PSR**
SC	US 101	Cochrane	SR 25			14.9	14.6			56.9	55.6	$ 182.90	$ 48.31	$ 231.21	**Low Cost Option, HOV Costs based on VTP 2030, Approx. 6.2 million/lane mile**
MAR	US 101	SR37	San Antonio Rd			9.7	9.4					$ 285.19	$ 51.43	$ 336.62	**Medium Cost Option for HOT conversion. HOV cost is 17.32 mill/lane mile based on estimate from the Marin/Sonoma Narrows project provided to MTC. HOV widening assumed funded in Transportation 2030 Plan**
SON	US 101	San Antonio Rd	Old Redwood Highway (Petaluma)			7.8	7.6			53.0	53.1	$ 229.95	$ 41.47	$ 271.42	**Medium Option for HOT conversion. HOV cost is 17.32 mill/lane mile based on estimate from the Marin/Sonoma Narrows project provided to MTC. HOV widening assumed funded in Transportation 2030 Plan**
Total Corridor US 101						**43.8**	**43.3**			**121.3**	**120.4**	**$ 882.84**	**$ 243.01**	**$ 1,125.85**	
SC	SR 237	Mathilda	SR 85	2.7	2.9			9.7	9.9			$ 44.80	$ 24.68	$ 69.48	**High Cost Option: Outside shoulders 12'. Median shoulders vary from areas with 6' median shoulder to 10' -12' . Highway segment includes 11 bridge structures HOV widening from Mathilda to SR 85 assumed funded in Transportation 2030 Plan**
Total Corridor SR 237				**2.7**	**2.9**			**9.7**	**9.9**			**$44.80**	**$ 24.68**	**$ 69.48**	
SC	I-280	Leland Ave	US 101			3.5	4.2			15.0	15.3	$ -	$ 20.73	$ 20.73	**Medium Cost Option, No PSR**
Total Corridor I-280						**3.5**	**4.2**			**15.0**	**15.3**	**$ -**	**$ 20.73**	**$ 20.73**	
ALA	I-580	Greenville	San Joaquin County Line		10.2							$ 102.00	$ 27.47	$ 129.47	**Medium Cost Option;PSR for part of segment shows $10 mil/HOV lane mi WB HOV from Greenville to Tassajara assumed funded in Transportation 2030 Plan**
ALA	I-580	San Joaquin County Line	I-680	20.9				20.9	21.0			$ 107.30	$ 56.28	$ 163.58	**Medium Cost Option;PSR for part of segment shows $10 mil/HOV lane mi WB HOV from Greenville to Tassajara assumed funded in Transportation 2030 Plan**
ALA	I-580/I-680	Connector Facility										$ 325.00	$ -	$ 325.00	**No cost to convert HOV connector to HOT lane due to no additional ITS elements or striping requirements. Note that the connector cost comes from a preliminary cost estimate and is subject to change.**
Total Corridor I-580				**20.9**	**10.2**			**20.9**	**21.0**			**$ 534.30**	**$ 83.75**	**$ 618.05**	
ALA	I-680	SR 84	Calveras/SR 237							14.0	13.3				
SC	I-680	Caleveras	US 101			9.0	9.0			9.0	9.0	$ -	$ 48.47	$ 48.47	**Medium Cost Option**
ALA	I-680	Alcosta Blvd	SR 84			10.6	10.5			10.6	10.5	$ 137.15	$ 56.82	$ 193.97	**Medium Cost Option, HOV estimate for portion of NB 680 equal to 6.5 million/lane mile $2006**
CC	I-680/80	HOV Connector										***No cost available at this time***			**No cost to convert HOV connector to HOT lane due to no additional ITS elements or striping requirements**
CC	I-680	N/O Waterfront (Benicia Bridge)	Alcosta Blvd.			1.2	3.6			27.2	25.9	$ 38.40	$ 12.93	$ 51.33	**Medium Cost Option, No PSR**
SOL	I-680	I-80	I-780			12.4	12.3			12.4	12.3	$ 197.60	$ 66.51	$ 264.11	**Medium Cost Option**
Total Corridor I-680						**33.2**	**35.4**			**73.2**	**71.0**	**$ 373.15**	**$ 184.72**	**$ 557.87**	
ALA	I-880	98th Ave	Marina (SB) and Lewellling (NB)			3.3	4.3					$ 26.00	$ 20.33	$ 46.33	**Medium Cost Option, No PSR**
SC	I-880	SR 237	US 101			3.3	4.3			31.5	31.5	$ -	$ 20.33	$ 20.33	**Medium Cost Option, No PSR**
ALA	I-880	I-880 SFOBB approach prior to off ramp to I-80 E	I-880 SFOBB approach prior to merge with I-80 W								1.8				
Total Corridor I-880						**6.5**	**8.6**			**31.5**	**33.3**	**$ 26.00**	**$ 40.66**	**$ 66.66**	
Sub-Total Lane Miles and Cost				**65.0**	**53.9**	**87.0**	**91.5**	**120.9**	**114.4**	**276.5**	**275.3**	**$ 2,609**	**$ 791**	**$ 3,400**	
Total Lane Miles all Directions/Total Upgrade Cost				**297.4**				**787.1**				*$ 11.43*	**$ 3,400**		

Note 1: Use $ 8 million per lane mile if no PSR is available

Note 2: HOT upgrade cost may be a combination of the different costing options (low, medium, high) or one option is chosen due to specific information available.

Note: All Costs are in 2006 Dollars (2006 $)

ATTACHMENT D: 2030 CONNECTED NETWORK (2015 Network Plus Segments Added Through 2030) CONSTRUCTION

County	Route	From	To	Total Lane Miles HOT Lane Network (2015+2030) WB	EB	SB	NB	HOT Upgrade Cost (millions) Estimated Upgrade Costs (2)	Total HOT Cost and HOV Cost (in Millions)	Comments
CC	SR4	SR 160	I-680	19.4	19.1			$ 136.67	$ 213.89	**Medium to High Cost Option:** Soundwall to outside makes widening difficult.
CC	SR 4/I-68(	HOV Connector Facility						$ -	$ 75.00	No cost to convert HOV connector to HOT lane due to no additional ITS elements or striping requirements
Total Corridor SR4				**19.4**	**19.1**			**$ 136.67**	**$ 288.89**	
CC	I-80	Carquinez Bridge	Central Ave (Alameda County Line)	16.0	14.6			$ 134.85	$ 134.85	**High Cost Option:** Total median width about 6' throughout the corridor (2' either side pluss 2' median barrier). Approx. 10 bridge structures.
ALA	I-80	Central Ave (Alameda County Line)	Bay Bridge Toll Plaza	5.9	6.0			$ 52.44	$ 52.44	**High Cost Option:** Total median width about 6' throughout the corridor (2' either side pluss 2' median barrier). Approx. 10 bridge structures.
SOL	I-80	Yolo County Line	SR 37	32.7	32.5			$ 141.17	$ 662.77	Low and Medium Cost Option: Outside shoulder widths vary (10'-13') and the median shoulder width varies from 20' (south of SR 37) to 30' (north of Vallejo). 7 bridge structures
SOL	I-80	SR 37	Carquinez Bridge	4.6	4.6			$ 24.77	$ 98.37	**Medium Cost Option** HOV widening assumed to be funded in Transportation 2030 Plan
SOL	I-80	Air Base Pkwy IC	Suisun Valley Rd/I-680	6.6	6.7			$ 35.81	$ 35.81	**Medium Cost Option**
Total Corridor I-80				**65.8**	**64.4**			**$ 389.05**	**$ 984.25**	
ALA	SR 84	Newark Blvd	Paseo Padre/Thornton incl. Toll Plaza Dumbarton Bridge	3.5				$ 15.42	$ 15.42	**High Cost Option:** PSR describes only 1 mile of HOV widening with possible ROW take. No specific plan details.
Total Corridor SR 84				**3.5**				**$ 15.42**	**$ 15.42**	
SC	SR 85	US 101 (South San Jose)	US 101 (Mountain View)			26.5	26.3	$ 119.89	$ 119.89	**Medium Cost Option:** North of I-280 (approx 7 miles). **Low Cost Option and Medium Cost Option** south of I-280. Standard outside and inside shoulders
Total Corridor SR 85						**26.5**	**26.3**	**$ 119.89**	**$ 119.89**	
SC	SR 87	US 101	SR 85			9.1	9.2	$ 29.97	$ 29.97	**Low Cost Option:** Construction cost for the VTA HOV segment on this route (7 miles) was $68 Million. Input from VTA suggests using a low range cost to convert to HOT lane.
Total Corridor SR 87						**9.1**	**9.2**	**$ 29.97**	**$ 29.97**	
ALA	SR 92	Hesperian	Toll Plaza - San Mateo Bridge	1.6				$ 7.05	$ 7.05	**High Cost Option**
Total Corridor SR 92				**1.6**				**$ 7.05**	**$ 7.05**	
SM	US 101	Millbrae Ave	Whipple Ave			11.4	11.7	$ 101.80	$ 286.60	**High Cost Option:** Soundwalls to outside and minimal median shoulder.
SM	US 101	Whipple Ave	San Mateo/Santa Clara County Line			7.0	7.0	$ 61.70	$ 61.70	**High Cost Option:** Soundwalls to outside and minimal median shoulder.
SC	US 101	San Mateo/Santa Clara County Line	SR 25			49.9	48.6	$ 194.29	$ 377.19	**Low Cost Option:** South of San Jose to Cochrane, **High & Medium Cost Option:** From San Jose to north
MAR	US 101	SB 101/Seminary Ave & NB 101/SR1	San Antonio Rd			24.0	24.0	$ 133.44	$ 418.63	**Low and Medium Cost Option:** Novato, **High Cost Option**: Southern Marin. HOV widening from Petaluma to Novato assumed funded in Transporation 2030 Plan
SON	US 101	San Antonio Rd	Windsor River Rd			29.0	29.1	$ 156.99	$ 386.94	**Medium Cost Option**
Total Corridor US 101						**121.3**	**120.4**	**$ 648.21**	**$ 1,531.05**	
SC	SR 237	I-880	SR 85	9.7	9.9			$ 86.38	$ 131.18	**High Cost Option:** Outside shoulders 12'. Median shoulders vary from areas with 6' median shoulder to 10' -12' . Highway segment includes 11 bridge structures HOV widening from Mathilda to SR 85 assumed funded in Transportation 2030 Plan
Total Corridor SR 237				**9.7**	**9.9**			**$ 86.38**	**$ 131.18**	
SC	I-280	Magdalena Ave	US 101			15.0	15.3	$ 81.59	$ 81.59	**Medium Cost Option**
Total Corridor I-280						**15.0**	**15.3**	**$ 81.59**	**$ 81.59**	
ALA	I-580/680	HOV Connector						$ -	$ 325.00	No cost to convert HOV connector to HOT lane due to no additional ITS elements or striping requirements
ALA	I-580	San Joaquin County Line	I-680	20.9	21.0			$ 112.83	$ 322.13	**Medium Cost Option:** Roadway median already widen for future lane and shoulder. WB HOV from Greenville to Tassajara assumed funded in Transportation 2030 Plan
Total Corridor I-580				**20.9**	**21.0**			**$ 112.83**	**$ 647.13**	
SC	I-680	Caleveras	US 101			9.0	9.0	$ 48.47	$ 48.47	**Medium Cost Option**
SC	I-680	Alameda/Santa Clara County Line	Caleveras			2.5	2.5	$ 12.98	$ 12.98	**Medium Cost Option**
ALA	I-680	SR 84	Alameda/Santa Clara County Line			11.5	10.8	$ 57.83	$ 57.83	
ALA	I-680	Alcosta	SR 84			10.6	10.5	$ 56.82	$ 193.97	**Medium Cost Option**
CC	I-680/80	HOV Connector								No cost to convert HOV connector to HOT lane due to no additional ITS elements or striping requirements
CC	I-680	Marina Vista	Alcosta Blvd.			27.2	25.9	$ 142.99	$ 181.39	**Medium Cost Option**
SOL	I-680	I-80	I-780			12.4	12.3	$ 66.51	$ 264.11	**Medium Cost Option:** Standard outside shoulders with median shoulders varying from 10'-20'.
Total Corridor I-680						**73.2**	**71.0**	**$ 385.60**	**$ 758.75**	
ALA	I-880	98th Ave	Marina (SB) and Lewellling (NB)			28.3	27.2	$ 149.31	$ 175.31	**Medium Cost Option**
SC	I-880	SR 237	US 101			3.3	4.3	$ 20.33	$ 20.33	**Medium Cost Option**
ALA	I-880	16th Street	Merge with I-80 W				1.8	$ 6.39	$ 6.39	**Medium and High Cost Option;** Appears that median shoulder will be widened for future lane and shld.
Total Corridor I-880						**31.5**	**33.3**	**$ 176.03**	**$ 202.03**	
Sub-Total Lane Miles and Total Cost				**120.9**	**114.4**	**276.6**	**275.5**	**$ 2,189**	**$ 4,797**	
Total Lane Miles all Directions/Total Upgrade Costs including 2030HOV						**787.4**		**$ 4,797**		

Note 1: Use $ 8 million per lane mile if no PSR is available

Note 2: HOT upgrade cost may be a combination of the different costing options (low, medium, high) or one option is chosen due to specific information available.

Note: All Costs are in 2006 Dollars ($2006)

Attachment E: Bay Are HOT Network Phasing Plan - Corridor Opening Sequence

Opening Year	I-680 Group		SC/SM Group		I-80 Group		Marin-Sonoma		I-880	
	Corridor	Comment		Comment	Corridor	Comment	Corridor	Comment	Corridor	Comment
	Calveras Note this includes: (a) ALA-680 SB SR 84 to ALA/SCL County line and (b) SCL-680 SB ALA/SCL County line to Calaveras.	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2035	**SR 85 SC**	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2020						
By 2015 for demo projects	**I-580 ALA EB from Hacienda to Greenville**	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2035	**SR 101 SC from San Mateo/Santa Clara Co line to Cochrane**	Begins HOT lane operation with HOV requirement at 2+; HOV occupancy increases to 3+ in 2035						
					I-80 ALA Central Ave (ALA Co line) to Bay Bridge Toll Plaza	Begins HOT lane operation at 3+ and stays at 3+ (test in 2nd scenario even though lane appears full)			**SR 84 (bridge approach)**	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2025
			SR 87 from US 101 to SR 85	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2040	**I-80 CC Carquinez Bridge to Central Ave (ALA Co line)**	Begins HOT lane operation at 3+ and stays at 3+ (test in 2nd scenario even though lane appears full)			**SR 92 (bridge approach)**	Begins HOT lane operation at HOV requirement of 2+; HOV lane requirement stays at 2+
			SR 237 I-880 to Mathilda	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2035					**I-880 ALA 16th St to merge with I-80 W**	Begins HOT lane operation at 3+ and stays at 3+
2015	**Calaveras.** Note this includes: (a) ALA-680 NB SR 84 to ALA/SCL County line and (b) SCL-680 NB ALA/SCL county line to Calaveras.	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2035	**I-880 SC from SR 237 to US 101**	Begins HOT lane operation with HOV requirement at 2+; HOV occupancy increases to 3+ in 2030	**I-80 SOL from Airbase Parkway IC to SR 12**	Begins HOT lane function at HOV occupancy of 2+ and HOV occupancy increases to 3+ in 2040			**I-880 ALA/SC Marina to SR 237**	Begins HOT lane function at HOV occupancy of 2+ and HOV occupancy increases to 3+ in 2025
	SR 4 CC from SR 160 to Port Chicago Highway	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2040	**SR 237 SC Mathilda to SR 85**	Begins HOT lane at HOV requirement of 2+ and HOV requirement goes to 3+ in 2035	**I-80 SOL thru Vallejo (Carquinez Bridge through SR37)**	HOV occupancy of 2+ with HOV occupancy increase at Carquinez bridge; HOV occupancy requirement increases to 3+ in 2040			**I-880 ALA 98th to Marina/Lewelling**	Begins HOT lane function at HOV occupancy of 2+ and HOV occupancy increases to 3+ in 2025
	I-680 CC from Benicia Bridge to Alcosta. Includes segments described as: Marina Vista to Alcosta (in E&F), N/O Waterfront (Benicia Bridge) to Alcosta (Connected Network); and NB segment between Rudyear and North Main (Connected Network)	Begins HOT lane operation when HOV lane requirement increases to 3+ in 2020	**US 101 SM Whipple to County Line**	Begins HOT lane function with HOV lane at 2+ and HOV goes to 3+ at 2035 due to SC 101 segment						
	I-580 ALA WB SJ Co to I-680	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2035	**I-280 SC from Magdalena to Leland Ave**	Begins operation with HOV lane at 2+ and HOV goes to 3+ at 2035						
	I-580 ALA EB Greenville to SJ Co	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2035								
	SR 4 CC from Port Chicago Hwy to I-680	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2040								
	SR4/I-680 CC HOV Connector Facility									
	I-680 ALA from Alcosta to SR 84	HOV requirement at 3+ due to adjoining segment of I-680 being at 3+								
2020	**I-580/I-680 ALA Connector**									
	I-680 SOL from I-80 to I-780	Begins HOT Lane operation with HOV lane requirement at 2+	**US 101 SC Cochrane to SR 25**	Begins operation with HOV lane at 2+ and HOV stays at 2+	**I-80 SOL from SR 37 to SR 12 and from Airbase Parkway to Yolo Co line**	Begins HOT lane operation with HOV requirement at 2+; HOV requirement increases to 3+ in 2040	**US 101 Marin SB 101/Seminary and NB 101/SR 1 to SR 37**	Begins HOT lane operation with HOV requirement at 3+		
	I-680/I-80 SOL Connector		**US 101 SM Whipple to Millbrae**	Begins HOT lane at HOV requirement of 2+ and HOV requirement goes to 3+ in 2040			**US 101 Marin SR 37 to San Antonio Road**	Begins HOT lane operation with HOV requirement at 3+ (5 years earlier than the HOV volumes would suggest going to 3+)		
			I-680 Calaveras to US 101	Begins HOT lane at HOV requirement of 2+ and HOV requirement goes to 3+ in 2035			**US 101 Sonoma San Antonio Road to Old Redwood Highway**	Begins HOT lane operation with HOV requirement at 3+ (5 years earlier than the HOV volumes would suggest going to 3+)		
2025			**I-280 SC from Leland to US 101**	Begins operation with HOV lane at 2+ and HOV goes to 3+ at 2035			**US 101 Sonoma Old Redwood Hwy to Windsor River Rd**	Begins HOT lane operation with HOV requirement at 3+		

Attachment F
HOT Network Revenues by Corridor

Table 1: Existing and Funded Network[11] – Average Annual Revenue/Mile in 2015 and 2030 (Thousands of 2005 Dollars)

		2015		2030	
Corridor	**Direction**	**HOV 2+**	**HOV 3+**	**HOV 2+**	**HOV 3+**
SR 4 CC	EB	$2	$11	$74	$138
SR 4 CC	WB	$105	$278	$207	$743
I-80 ALA-CC	EB	NA	$514	NA	$3,055
I-80 ALA-CC	WB	NA	$653	NA	$1,101
I-80 SOL	EB	$51	$104	$327	$609
I-80 SOL	WB	$77	$266	$291	$1,097
SR 84 ALA (Dumbarton Bridge approach)	WB	$249	$873	$146	$1,591
SR 85 SC	NB	$42	$217	$77	$703
SR 85 SC	SB	$211	$326	$315	$564
SR 87 SC	NB	$959	$1,957	$2,987	$8,162
SR 87 SC	SB	$271	$485	$1,177	$2,418
SR 92 ALA (San Mateo Bridge approach)	WB	$349	$903	$460	$1,890
US 101 SM-SC	NB	$700	$1,751	$842	$5,642
US 101 SM-SC	SB	$434	$1,012	$1,166	$4,517
US 101 MAR-SON	NB	$20	$35	$51	$92
US 101 MAR-SON	SB	$45	$134	$103	$608
SR 237 SC	EB	$134	$209	$1,038	$1,813
SR 237 SC	WB	$313	$645	$601	$3,564
I-280 SC	NB	$133	$265	$256	$569
I-280 SC	SB	$109	$179	$241	$405
I-580 ALA	EB	$36	$80	$680	$1,380
I-680 ALA-SC	NB	$86	$462	$599	$2,235
I-680 ALA-SC	SB	$1,725	$3,130	$4,667	$17,521
I-680 CC	NB	$340	$793	$593	$1,285
I-680 CC	SB	$165	$1,009	$90	$2,112

[11] This is a network of HOV lanes that exist or are fully funded through 2015. Because it was developed in Phase 1 of the study, it excludes HOV lanes segments that were fully funded with the California Infrastructure Bond Corridor Mobility Improvement Account in early 2007.

Table 1, cont.: Existing and Funded Network[12] – Average Annual Revenue/Mile in 2015 and 2030 (Thousands of 2005 Dollars)

		2015		2030	
Corridor	**Direction**	**HOV 2+**	**HOV 3+**	**HOV 2+**	**HOV 3+**
I-880 ALA-SC	NB	$683	$2,289	$1,283	$4,090
I-880 ALA-SC	SB	$1,213	$3,549	$1,065	$8,942
I-880 ALA Bay Bridge approach	NB	NA	$19	NA	$63

[12] This is a network of HOV lanes that exist or are fully funded through 2015. Because it was developed in Phase 1 of the study, it excludes HOV lanes segments that were fully funded with the California Infrastructure Bond Corridor Mobility Improvement Account in early 2007.

Table 2: Connected Network[13] – Average Annual Revenue/Mile in 2030 (Thousands of 2005 Dollars)

		2030	
Corridor	**Direction**	**HOV 2+**	**HOV 3+**
SR 4 CC	EB	$29	$53
SR 4 CC	WB	$115	$414
I-80 ALA-CC	EB	NA	$621
I-80 ALA-CC	WB	NA	$634
I-80 SOL east of Vallejo	EB	$927	$1,499
I-80 SOL east of Vallejo	WB	$683	$2,066
I-80 SOL through Vallejo	EB	$132	$225
I-80 SOL through Vallejo	WB	$215	$307
SR 84 ALA (Dumbarton Bridge approach)	WB	$163	$1,718
SR 85 SC	NB	$76	$436
SR 85 SC	SB	$401	$717
SR 87 SC	NB	$780	$1,345
SR 87 SC	SB	$200	$416
SR 92 ALA (San Mateo Bridge approach)	WB	$492	$2,143
US 101 SM-SC	NB	$662	$4,473
US 101 SM-SC	SB	$725	$3,450
US 101 SM	NB	$803	$2,611
US 101 SM	SB	$656	$1,951
US 101 MAR-SON	NB	$80	$144
US 101 MAR-SON	SB	$126	$714
SR 237 SC	EB	$748	$1,345
SR 237 SC	WB	$514	$2,676
I-280 SC	NB	$194	$1,763
I-280 SC	SB	$432	$1,066
I-580 ALA	EB	$480	$1,351
I-580 ALA	WB	$168	$2,192
I-680 ALA-SC	NB	$303	$1,394
I-680 ALA-SC	SB	$1,147	$7,669

[13] This is the complete regional HOT network as described in the study final report.

Table 2, cont.: Connected Network – Average Annual Revenue/Mile in 2030 (Thousands of 2005 Dollars)

		2030	
Corridor	**Direction**	**HOV 2+**	**HOV 3+**
I-680 CC	NB	$635	$1,394
I-680 CC	SB	$61	$2,666
I-680 SOL	NB	$63	$91
I-680 SOL	SB	$81	$199
I-880 ALA-SC	NB	$805	$2,513
I-880 ALA-SC	SB	$953	$4,370
I-880 ALA Bay Bridge Approach	NB	NA	$22

Section II Appendices: Updated Assessment (Phase 2B, complete June 2008)

Consultant assistance by PB Americas, Inc. and ECONorthwest

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Appendix 7: Rapid Delivery Design Principles (Task 16 Technical Report)

Regional HOT Lanes Network Feasibility Study

Phase 2b, Task 16
RAPID DELIVERY DESIGN PRINCIPLES

Prepared for:
Metropolitan Transportation Commission

Prepared by:
PB
with
ECONorthwest

December 2007
(v4)

Introduction

This memorandum develops a project development approach and set of corresponding design principles to be applied in subsequent Phase 2b tasks that attempt to minimize the need for widening and implementing higher cost elements for a HOT lane network in the Bay Area in order to implement the system faster. The design approach for this new paradigm primarily builds on over 20 years of HOV lane implementation practice applied in California and nationally for concurrent-flow lane treatments in highly constrained urban settings. The identified principles take into account the lessons learned by other projects and studies that have attempted to fit HOV and a limited number of HOT lanes into existing freeway settings. This approach will ultimately be compared with general design guidance applied in Phases 1 and 2a, principally contrasting the new design paradigm with the State's and CHP's preference for recommended design features to support a Bay Area HOT lane network. This alternate design approach (not stated as a "design standard") is being developed for application to the Regional HOT Network.

Project Development Approach

This project development approach strives to provide the most effective safe, design for completing a HOT lane system in the shortest timeframe, assuming the rapid roll-out of HOT lanes can be financed. This approach also assumes that additional design exceptions generated from an early roll-out could be corrected through subsequent improvement projects that could be implemented over time. This approach is similar to the methods in which some HOV lanes have been implemented by Caltrans and partnering county transportation authorities, based on further discussion of examples from design and implementation experiences in the next section. In these widely practiced applications in which HOV lanes were often created by converting the inside emergency breakdown shoulder to a HOV lane and narrowing adjacent lanes, a common goal was to provide the greatest system level mileage of HOV benefits early, and fill in the harder to implement gaps as funding became available. This practice was reflected in the rapid roll-out of HOV lanes in both northern and southern California. This approach promoted the implementation of HOV lanes where environmental clearance and funding allowed for the projects to happen more rapidly than in segments where no options existed for early roll-out. This early implementation required numerous design exceptions. Findings a decade or more later show these HOV lanes have been widely used, benefiting more than a million users daily in the Los Angeles area alone. The results would have been even better if the HOV lanes had been continuous. Since they were not, the current Los Angeles County HOV system lacks continuity, and up to 60 percent of the potential travel time benefits is being lost at the HOV temporary project termini, based on southern California experience. If this system had been able to be financed implemented sooner, perhaps with more design exceptions, these shortcomings could have been overcome.

This design approach strives to provide a comprehensive system illustrated in the Regional Network, filling in existing gaps and extending lanes into planned corridors within a short 5-10 year total project development timeframe. The resulting benefits will address current travel savings deficiencies; however, the approach also creates a number of additional design exceptions. Net revenues generated in this earlier timeframe may both help fund the early roll-out of HOT lanes and in the longer term help address design improvements to the initial facility.

Implementing HOT lanes under this development approach will result in a more modest footprint on the affected corridors and surrounding stakeholders that will make it easier to achieve approval through environmental assessments. The approach will limit corridor widening to isolated settings where minimum lane widths and pavement edge offsets cannot be accommodated within the existing ROW. Because a minimum design may eliminate some inside shoulders, it may be appropriate to incorporate ramped up enforcement and incident management strategies as part of the approach. This development approach will mirror past Caltrans practice in rapidly implementing HOV lanes in highly constrained corridor settings. Key project development assumptions:

- Concurrent development of Project Study Reports (PSR) and preliminary environmental assessments.
- Approval of design exceptions, perhaps on an interim basis.
- Accelerated review and approval of project development documents, including PSRs, Project Reports/Environmental Documents (PR/ED) and designs.
- Simultaneous construction of multiple corridors.

Design and Implementation Experience

HOV lane design principles and related guidance have been in existence for many years, and the design of HOT lanes has typically followed this guidance since most all projects to date have augmented pricing onto existing HOV lanes. The design of HOT facilities have mostly involved minor modifications to existing HOV roadway settings, typically including installation of new signing and overhead transponder readers and related support infrastructure as evidenced on I-25 in Denver, I-15 in San Diego, I-394 in Minneapolis and I-10 and US 290 HOV lanes in Houston. HOT lanes to date often have exhibited some form of physical separation (i.e., concrete barriers or plastic channelizers), access control for getting in and out, and some form of separation between free and paid users at electronic toll stations. These practices are changing as newer projects add more tolling zones, intermediate access locations and less emphasis on positive (concrete barrier) separation between the HOT and adjacent lanes. While no definitive design criteria currently exist within Caltrans or other professional organizations like AASHTO for HOT lanes, some guidance is available from FHWA's HOT lane guide. General roadway design guidance being applied follows the AASHTO "Green Book" and evolving practice from various locales implementing HOT lanes. Various ongoing safety studies are contributing to this evolving body of knowledge.

Since more than 90 percent of HOV lanes implemented in California since 1985 have been added to existing freeways that generally date from the 1950s through 1970s, design exceptions are prevalent. For example, fewer than five percent of the HOV lane-miles in California incorporate continuous 14-foot enforcement shoulders. Inside (median) shoulder widths on more than 40 percent of this mileage is less than eight feet, typically reflecting the minimum separation with median barriers and even less at bridge columns and other median impediments. Lane widths on perhaps as much as 40 percent of the statewide HOV lanes system are less than the standard 12 feet.

Some corridors, including SR 91 and SR 55 in Los Angeles and Orange counties, opened with designs that reflected the minimum conditions noted and have been widened and reconstructed to regain full design attributes over a 20-year period. However, the vast majority of HOV lanes in the Los Angeles area may never regain full design standards due to the severe right-of-way constraints and cost-prohibitive nature of acquiring additional space. In the Bay Area, I-680 offers an example of a project that began as an interim HOV lane with a capital cost of $26 million. Current plans call for a $4 million auxiliary lane and additional investment of $86 million to upgrade the interim facility to HOT lanes and include other improvements to make the facility more consistent with Caltrans design standards. Figure 1 illustrates some of the typical designs of existing HOV sections that do not meet full design standards found in southern California.

Figure 1: Examples of Current HOV Designs in Southern and Northern California

I-10 El Monte Busway, 1980
4-foot left shoulder, wide right buffer

I-405, Orange County, 1995
4-foot left shoulder, 11-foot lanes

I-210 Pasadena, 1994
2-foot left shoulder, 11-foot lane, 1.5-foot buffer

US 101, Marin County, 1990
4-foot left shoulder, 11-foot lane

Of particular note in these examples is that the striping and pavement edges often were controlled by external features, including bridges, signs and drainage inlets, so the resulting section varies considerably to best fit the HOV lane within the existing roadway.

The fact that many existing Bay Area HOV lanes were incorporated with design exceptions on older freeways (and have not been updated) is significant when considering development of a regional HOT network here. On the one hand, it provides a potential model for approaching accelerated implementation of HOT lanes. On the other hand, it means we are already operating in unusually constrained environments in many corridors. In this way, the Bay Area context for a minimal design differs from some of the recent HOT lane projects, such as I-394 in Minneapolis and I-15 in Salt Lake City, that have pursued low-cost, less capital-intensive designs that require a minimum of modifications and no new or added pavement. Both the I-394 and I-15 projects were incorporated into new freeway facilities reconstructed since the late 1980s to incorporate features such as full inside and outside shoulders, greater sight distances for ramps, improved drainage, full vertical clearances and superior design speeds. These design attributes have made it easier to incorporate pricing onto HOV lanes and convert some pavement to a buffer area.

Phasing Development to Regain Design Standards

Limited documentation exists on HOV examples where lanes were implemented rapidly and design standards regained in subsequent stages of construction. Two illustrative examples are provided in this section.

SR 55 Phased Development: To demonstrate HOV potential in Orange County, Caltrans and the Orange County Transportation Commission (OCTC, predecessor to OCTA), opened concurrent flow HOV lanes on a 11-mile portion of SR 55 in 1985. The lanes were created by repaving and restriping the inside breakdown shoulder, narrowing other lanes and in some cases narrowing the outside shoulder at some bridges. The overall cost of this project was less than $50,000 per route mile in 1985 dollars.

The resulting design exceptions included narrow lanes and left side shoulders. An enforcement area was created along the length of the project. Ultimate plans called for rebuilding SR 55 to include one new general-purpose lane and auxiliary lanes between ramps, plus sound walls and related improvements. Funding availability slowed the phased roll-out of reconstruction for about a decade after the initial HOV lane operation opened. As noted in the photos, HOV lane operation was maintained through all phases of reconstruction. The final roadway layout included 8-foot left shoulders, 12-

foot HOV lanes, and 4-foot buffers, plus standard lane widths for the balance of the freeway. Reconstruction of all sections of SR 55 was not completed until about 2003. Some of the design deviations from the original project in 1985 lasted about 18 years.

Figure 2: SR 55 Phased HOV Lane Development

Initial operation by restriping shoulders


Initial operation with all lanes narrowed


HOV operation during reconstruction


HOV operation after reconstruction

The overall cost for reconstruction of SR 55 is difficult to ascertain since work was sequenced along the corridor for more than a decade and involved substantially more improvements than regaining HOV design standards. Order-of-magnitude costs ranged from $20-40 million per route mile, of which perhaps only 10 percent was related to upgrading the HOV lanes.

SR 91 Phased Development in Los Angeles County. At about the same time as the inauguration of HOV lanes on SR 55, part-time, peak direction-only HOV lanes were created from the left shoulders of SR 91 along an 8-mile section in Los Angeles County in 1985.[1] The integrity of the shoulder pavement allowed this project to primarily be a

[1] This is not related to the SR-91 Express Lanes project (HOT lane corridor) in Orange County.

signing and striping project, with less than $20,000 (1985 dollars) invested per route-mile. Subsequent safety problems incurred from motorists who became confused and used the shoulders during operating periods caused Caltrans to shift the operations to all-day in both directions. One spot enforcement area was created by narrowing all lanes and consuming some of the outside shoulder area for a short segment (Figure 3). Note the HOV lane shift from the shoulder to prior general-purpose lane in the photo.

Figure 3: SR 91 Early Development

Enforcement area created from left shoulder, 1985

SR 91 was subsequently upgraded between 2000 and 2004 to replace the median barrier, add more long-lasting pavement under the prior median shoulders, add noise walls and make other minor improvements to general-purpose lanes. Lane and shoulder widths were upgraded in some segments and not in others. These improvements represented construction costs ranging from $5 to $8 million per mile, of which perhaps 25 percent was related to upgrading the HOV lane.

Bay Area Design Exceptions

I-680's HOV lane conversion to HOT lanes reflects a similar reconsideration of early design treatments that are being revisited as part of the implementation of pricing.

The Bay Area exhibits a wide variety of HOV lane designs, but very few projects include all of the design attributes desired from the Caltrans guide. Current programs in the 2007 Transportation Improvement Program (TIP) are primarily geared to adding more HOV lanes to the existing system, not going back and addressing design exceptions. More recent HOV lane experience suggests that obtaining design exceptions may require that a set timeframe be established in multi-party agreements between Caltrans, FHWA and the local partnering agencies to ensure some of the more critical design exceptions are addressed.

Available Design References

A host of HOV design references are available, including the Caltrans HOV Guide, 2003 edition, and the latest AASHTO HOV Guide (see reference list). Both guides provide recommended design practice and tools to apply when constrained corridors limit the ability to achieve all desired design attributes. Often referred to as "reduced" designs, many Bay Area freeways found in the Regional HOT Network reflect reduced design attributes in lane, shoulder widths. Following is brief summary of this guidance and its relevance to HOT lane implementation under the new paradigm.

California HOV Guide

The latest version of the Caltrans HOV Guide recommends full 10-foot inside (left-side) shoulders and 12-foot lanes for contiguous HOV lanes (those operating part-time) and an additional 4-foot shoulder for full-time buffer separated lanes. A series of trade-offs are provided when not all of these attributes can be accommodated, and all trade-offs involve a study of impacts before requisite design exceptions are approved. As a minimum, trade-offs include the following for a full-time buffer-separated treatment. Similar trade-offs are provided in the Caltrans Guide for contiguous part-time lane treatments.

- Reduce the median shoulders from a 14-foot (4.2m) enforcement shoulder to 10 feet (3m).
- Reduce median shoulder to 8 feet (2.4m)
- Reduce HOV lane width to 11 feet (3.3m)
- Reduce adjacent mixed-flow lane widths to 11 feet (3.3m) working from the median to the outside leaving the right-most lane at 12 feet unless truck volumes are less than 3 percent.
- Reduce median shoulder to 4 feet (1.6m), by taking any residual space between 4 and 8 feet and regaining full general-purpose lane widths working from the outside to inside (in order to reduce potential drivers misconstruing the remaining space as wide enough to park in).

Source: Caltrans HOV Guidelines, Chapter 3, pp. 14-15 , August 2003

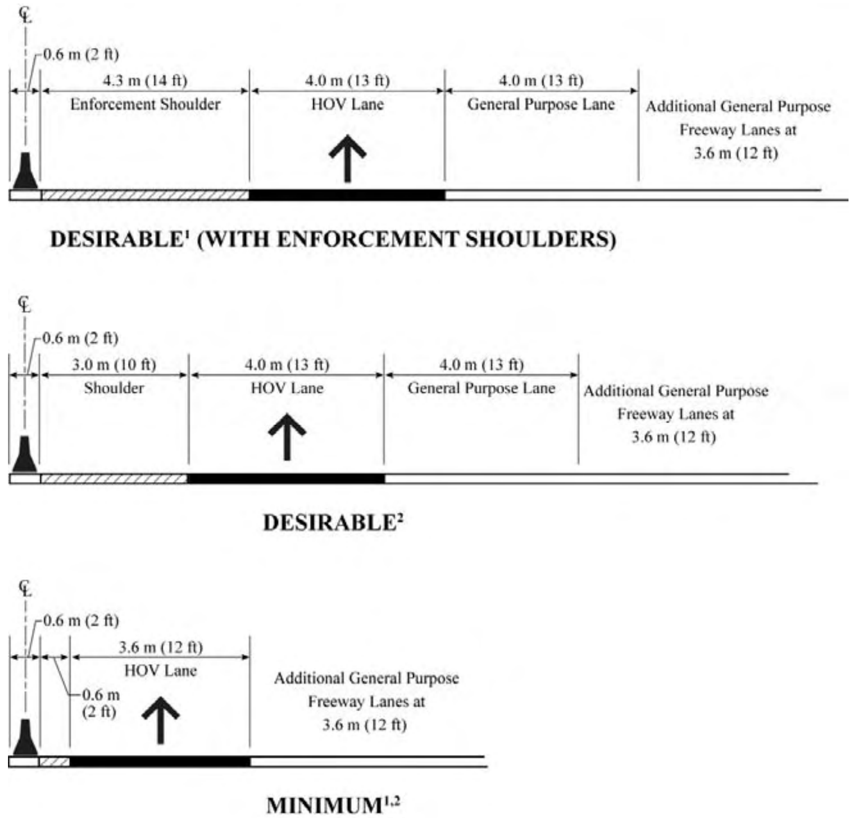
No guidance in the Caltrans reference is provided for HOT designs that include transition lanes at access openings or added space at tolling stations for segregating different types of users.

AASHTO HOV Guide

The 2003 AASHTO Guide provides both desired and reduced HOV lane design recommendations. Desired designs closely parallel the Caltrans guide for concurrent flow lanes. For constrained settings, AASHTO also provides guidance for minimum or reduced settings. These are show in Figures 4 and 5 for contiguous (part-time) and full-time (buffer) lane designs.

The minimum section in AASHTO guidance is not considered a typical condition. Limitations imposed on its use include the length of the segment affected which should be around specific constraints such as an overcrossing or undercrossing bridge. AASHTO guidance also includes the same trade-off options for narrowed lanes and buffer widths found in the Caltrans guide.

Figure 4: Contiguous HOV Design Sections from AASHTO Guide

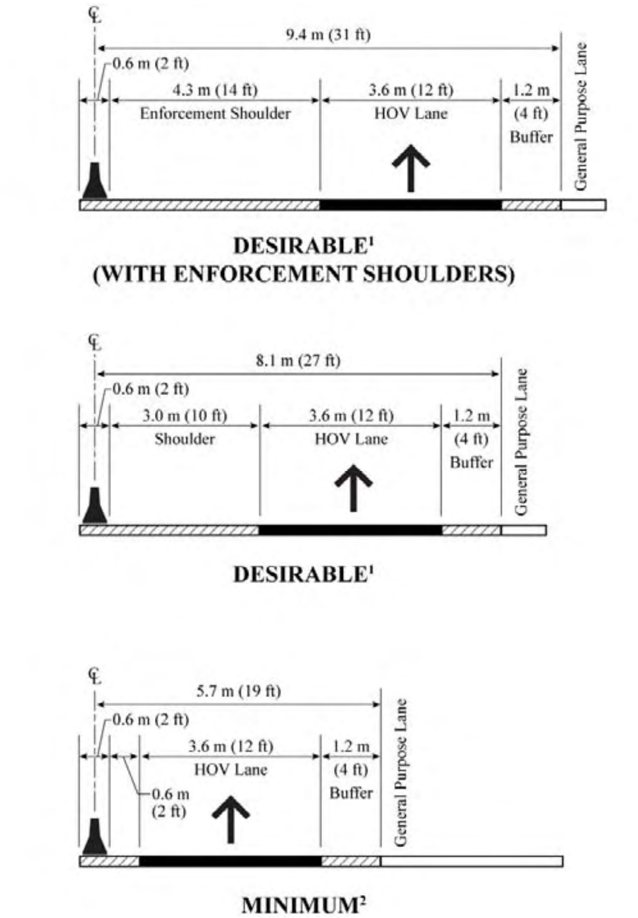


[1]This cross section is applied when the HOV lane will convert to a general-purpose lane during the off-peak periods.

[2]Operational treatments should be incorporated if the minimum design cross section is applied. The minimum section should only be used as an interim project or over short distances. Increased enforcement and incident management should be implemented to successfully operate the facility.

Source: AASHTO HOV Guide, Figure 3-14, p. 101, August 2003.

Figure 5: Buffer-Separated HOV Design Sections from AASHTO Guide



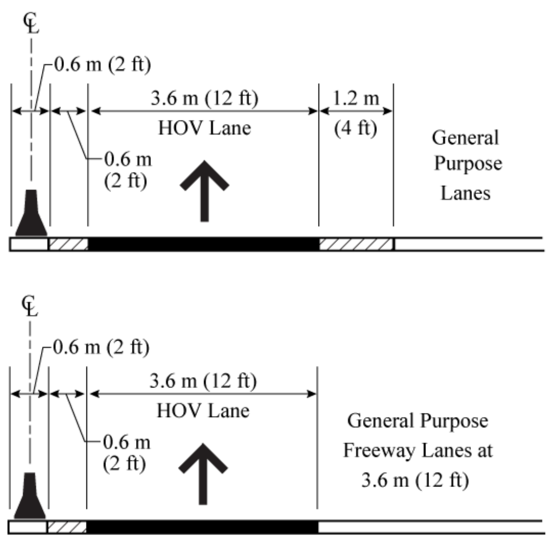
[1]Enforcement personnel should be consulted about how and where enforcement provisions may be made, or whether the shoulder is satisfactory to perform enforcement activities. In recent discussions, the California Highway Patrol has expressed a preference for providing enforcement from the outside (right) side rather than the inside (left) shoulder.
[2]Operational treatments should be incorporated if the minimum design is applied. The minimum cross section should be used as an interim project or over short distances. Increased enforcement and incident management should be implemented to successfully operate the facility

Source: AASHTO HOV Guide, Figure 3-13, p. 100, August 2003.

Recommended Design Principles

In examining the new paradigm, the recommended design principles for implementing HOT lanes are drawn primarily from AASHTO guidance for minimum contiguous and buffer-separated lane HOV lane treatments (Figure 6). Variations and trade-offs in this application will vary based on site conditions and whether the lanes are added to existing routes without HOV lanes or converted from current HOV lane operations. The next sections provide this guidance.

Figure 6: Designs Recommended for Interim Rapid HOT Implementation



Note: Four feet would be typically applied next to the median barrier. In very constrained settings, all lane widths except the right-most lane would be reduced to 11 feet, and the buffer would be reduced to two feet.

Note: HOV designation in figure is a direct reference from the AASHTO guide, but assumed to apply for HOT lanes in this study. Four feet would be typically applied next to the median barrier. In very constrained settings, all HOT and general-purpose lane widths except the rightmost lane would be reduced to 11 feet, and the buffer would be reduced to 2 feet (not shown in figure).

Source: Excerpted from AASHTO HOV Guide, August 2003.

Converted HOV to HOT Lanes

The following principles will be followed for existing HOV lanes and those already programmed for implementation and environmentally cleared in the Bay Area as part of the Regional HOT Network:

- Utilization of existing pavement by re-striping of existing lanes to achieve a 4-foot buffer by narrowing of existing lanes (except outside mixed use lane) to no less than 11 feet. In isolated locations (preferably less than 0.25 mile), the buffer may be 2-feet in width around structural impediments. This width is similar to the I-394 HOT lanes.
- If encroachment into left shoulder is required and the shoulder is at least 8 feet in width, the resulting shoulder will be reduced to 4 feet to gain buffer area, and the residual will be spread among the remaining lanes to regain full widths of 12 feet. This is done to prevent motorists from parking in a shoulder that is less than 8 feet wide.
- If the existing HOV lane is already reduced to 11 feet along with narrow general-purpose lanes and inside shoulder width of 4 feet or less, then the minimum contiguous section shown in Figure 4 will be applied without a buffer, separated only by a solid pavement marking.
- Ingress/egress areas will be designated using broken striping only. No weave lanes or continuous enforcement shoulders will be provided unless already existing or planned for the HOV lanes.
- Signing will be minimized to one dynamic sign on cantilever mount at each ingress/egress area with periodic static signing mounted to the median barrier.
- No allowance for additional mitigation improvements such as noise walls are considered since all HOT lane modifications are contained on the existing lanes with no pavement widening.
- No provision for drainage improvements are included since no addition in permeable surface will occur, but left shoulder may need to be retained at 4 feet to avoid traffic driving on inlets and pavement swales.

Additionally, the following cost estimating principles will be applied as assumptions to this design setting:

- No additional enforcement areas beyond those already existing or planned for the HOV lanes.
- Toll detection equipment will be provided downstream of every access point (no separate ingress/egress)

New HOT Lanes

The prior scenarios following Caltrans guidance, the study team applied full lane widths, inside shoulder of 10 feet, a four-foot buffer and retained a full 10-foot outside shoulder, which often resulted in outside widening. The following principles will be followed for this scenario where added HOT lanes are required to be added to the existing section:

- Widen into the median where such space exists to fit the minimum buffer separated section shown in Figure 6, plus allowance for eight foot median shoulders if sufficient width is available (essentially filling in the available median area with pavement). Total space needed for this design principle is 18 to 24 feet in each direction of travel (minimum 2- to 8-foot median shoulder plus 12-foot HOT lane plus 4-foot buffer). The “median” is defined as the area between inside travel lanes, inclusive of any existing left side shoulders which would have to be rebuilt.
- If a minimum 18-foot median area does not exist sufficient to meet the above condition for each direction of travel, narrow the HOT and mixed use lanes to 11 feet to gain as much as a 4-foot left shoulder where possible (i.e, around drainage inlets, sign pedestals, etc). (If full widths cannot be provided, AASHTO and Caltrans prefer to not have any residual median shoulder width between 4 and 8 feet which could be construed as wide enough to park in for refuge, but would leave a vehicle exposed to high speed traffic. Any residual would be returned to improved lane widths.)
- If narrowing of lanes still does not provide the minimum section shown in Figure 6, outside widening would be needed in the affected section. Right shoulders are assumed to be narrowed only at bridges to avoid structural widening and/or replacement.
- If existing mixed use lanes and shoulders are already reduced, the proposed section would not regain these reductions to full standards; widening would only accommodate the added width for HOT lanes.

- Ingress/egress areas will be designated using broken striping only. No weave lanes or continuous enforcement shoulders will be provided unless already existing or planned for the HOV lanes.
- Signing would be minimized to one dynamic sign on cantilever mount at each ingress/egress area and periodic static signing mounted to the median barrier.
- No allowance is made for additional mitigation improvements such as noise walls are included in widened sections, but a linear measurement of such widening for the system will be tabulated.

Additionally, the following cost estimating principles will be applied as assumptions to this design setting:

- No modifications will be made to the existing median barrier.
- Enforcement areas will be provided only where physically feasible or an allowance will be established to provide one area for every 5-6 miles or per segment between intersecting freeways, whichever is less.
- Toll detection equipment will be provided downstream of every access point.
- Drainage allowance will be provided only for segments where outside widening is required to meet the minimum section.

<u>References</u>

1. *A Policy on Geometric Design of Highways and Streets.* American Association of State Highway and Transportation Officials, Washington, D.C., 2004
2. A Guide for HOT Lane Development, Parsons Brinckerhoff and Federal Highway Administration, FHWA-OP-03-009 or EDL #13668, 2003. www.ops.fhwa.dot.gov
3. Freeway and Geometric Design Handbook - HOV/Managed Lanes Chapter 12, Institute of Transportation Engineers, Washington, D.C., 2004
4. Fuhs, C. *High Occupancy Vehicle Facilities, Current Planning, Operations and Design Practice.* Parsons, Brinckerhoff, Quade and Douglas, New York, New York, October, 1990.
5. Guide for High-Occupancy Vehicle Facilities, American Association of State Highway and Transportation Officials, Washington D.C., November 2004.
6. High Occupancy Vehicle (HOV) Guidelines, California Department of Transportation, Division of Traffic Operations, August 2003.
7. HOV Systems Manual, #414, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., 1998.
8. Manual on Uniform Traffic Control Devices for Streets and Highways-2003 Edition (or subsequent updates), (restricted lane guide and regulatory signing sections), Federal Highway Administration, U.S. Department of Transportation, 2003.

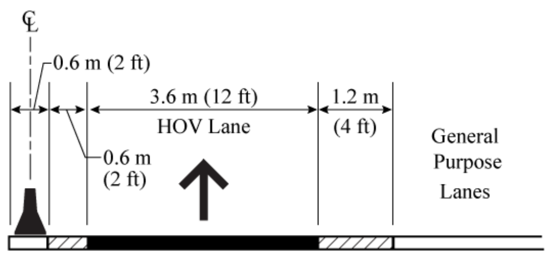
Appendix 8: Methodology for Estimating Capital Cost for the "Rapid Delivery" Approach[1]

The "rapid delivery" approach can be described as a list, in descending order of preference, of trade-offs involving design features in the event that the design standard cannot be met. In places where there are no HOV lanes exist or are currently funded and where HOT lanes would need to be added to the existing section the following principles would be followed:

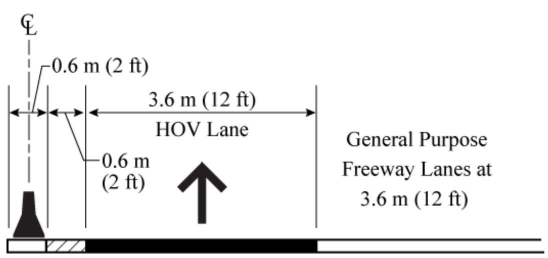
- Widen into the median where such space exists to fit the minimum buffer separated section shown in Figure 1A, plus allowance for eight foot median shoulders if sufficient width is available (essentially filling in the available median area with pavement). Total space needed for this design principle is 18 to 24 feet in each direction of travel (minimum 2- to 8-foot median shoulder plus 12-foot HOT lane plus 4-foot buffer). The "median" is defined as the area between inside travel lanes, inclusive of any existing left side shoulders which would have to be rebuilt.

Figure 1: Designs Recommended for Interim Rapid HOT Implementation

1A)



1B)



Note: Four feet would be typically applied next to the median barrier. In very constrained settings, all lane widths except the right-most lane would be reduced to 11 feet, and the buffer would be reduced to two feet.

Source: Adapted from AASHTO HOV Guide, August 2003.

[1] This appendix describes application and cost for the "rapid delivery" approach to HOT Network design. Based on discussions subsequent to this analysis, it seems likely that the ultimate HOT Network design would incorporate features of both the "full feature" (as described in Section I) and "rapid delivery" approaches. In particular, the "full feature" design would likely be pursued where it can be readily accommodated and the "rapid delivery" design approach would be used in more constrained settings.

- If a minimum 18-foot median area does not exist sufficient to meet the above condition for each direction of travel, narrow the HOT and mixed use lanes to 11 feet to gain as much as a 4-foot left shoulder where possible (i.e., around drainage inlets, sign pedestals, etc). In some places there may be no buffer (Figure 1B).
- If narrowing of lanes still does not provide the minimum section shown in Figure 6, outside widening would be needed in the affected section. Right shoulders are assumed to be narrowed only at bridges to avoid structural widening and/or replacement.
- If existing mixed use lanes and shoulders are already reduced, the proposed section would not regain these reductions to full standards; widening would only accommodate the added width for HOT lanes.
- Ingress/egress areas will be designated using broken striping only. No weave lanes or continuous enforcement shoulders will be provided unless already existing or planned for the HOV lanes.
- Signing would be minimized to one dynamic sign on cantilever mount at each ingress/egress area and periodic static signing mounted to the median barrier.
- No allowance is made for additional mitigation improvements such as noise walls are included in widened sections, but a linear measurement of such widening for the system will be tabulated.

Characterization of Network Segments

The study team examined aerial photographs of different segments[2] of the potential regional HOT lane network in order to characterize each segment by how easily the "rapid delivery" approach could be implemented. The width of the left shoulder, right shoulder, and any unpaved areas within the freeway right-of-way (ROW) were noted in a GIS network file for each direction of travel for each segment. Segments were then grouped into four categories for which unit costs were developed (see Attachment G):

Low Development Cost – Sufficient ROW exists in the median to allow for a new HOT lane with the 18-to-24-foot cross-section shown in Figure 1A.

Medium (Left) Development Cost - Sufficient ROW is available to allow for a new HOT lane with the 14-foot cross-section shown in Figure 1B. The ROW would come through a combination of space available in the median and possibly some narrowing of existing lanes.

Medium (Right) Development Cost - Sufficient ROW is available to allow for a new HOT lane with the 14-foot cross-section shown in Figure 1B. The ROW would come through a combination of space available in the right shoulder and some narrowing of existing lanes. New sound walls were assumed to be needed for 70% of the section[3].

High Development Cost – There is not sufficient space within the existing ROW to allow for a new HOT lane with the 14-foot cross-section shown in Figure 1B. New ROW would have to be acquired before a lane could be added. New sound walls were assumed to be needed for 70% of the section.

[2] Segments were defined as the length of freeway between on- or off-ramps. Segments were examined separately in each direction of travel.

[3] It is assumed that sound walls either already exist or will not be needed over the remaining 30% of project length.

The categories describe the characteristics of the majority of the segment. In some cases the segment included short sections of structure, such as railroad overcrossings, that were narrower than the rest of the segment. These locations were noted, and an adjustment was made to the cost estimation to take them into account, but they were not studied individually as part of this concept-level study.

A further category was provided for segments where HOV lanes already exist or are already funded. These segments were not included in the aerial photograph survey because it was assumed that HOT lanes could be implemented through relatively minor changes in the HOV design.

Figure 2 (below) shows an overview of the potential Regional HOT Network disaggregated into the categories described above. Figures 3 through 10 (below) show sections of the network in greater detail (the figure number of each sub-area is shown in Figure 2). Table 1 (below, following Figure 10) summarizes this information in terms of lane-miles in each category.

<u>Project Delivery Schedule</u>

Because the “rapid delivery” approach stays within existing pavement and right-of-way as much as possible, it minimizes environmental impacts and time required for environmental review. Construction time is also reduced by minimizing the need to widen the roadway. The tables below compare the estimated project development and construction time lines for the “rapid delivery” and “full feature” approaches. The abbreviated project delivery schedule also impacts capital outlays by reducing inflation-related costs.

Conversion of Existing Carpool Lanes

	Rapid Delivery **No ROW** **No Merge Lanes**	**Full Feature** **New ROW** **New Merge Lanes**
Environmental/Design	1 year	4-6 years
Construction	1 year	2-3 years
Total Time	2 years	6-9 years

Widen for New HOT Lanes

	Rapid Delivery **No ROW** **No Merge Lanes**	**Full Feature** **New ROW** **New Merge Lanes**
Environmental/Design	2-5 years	6-8 years
Construction	1-2 years	3-4 years
Total Time	3-7 years	9-12 years

To deliver projects on the schedule above, the “rapid delivery” approach would require an accelerated approach to design and review. This would include concurrent project-level studies, as well as accelerated review and approval of project development and construction documents. Such an effort would require dedicating personnel and resources beyond those currently available at the county congestion management agencies, Caltrans and MTC. HOT network revenues might be used to fund the expanded effort.

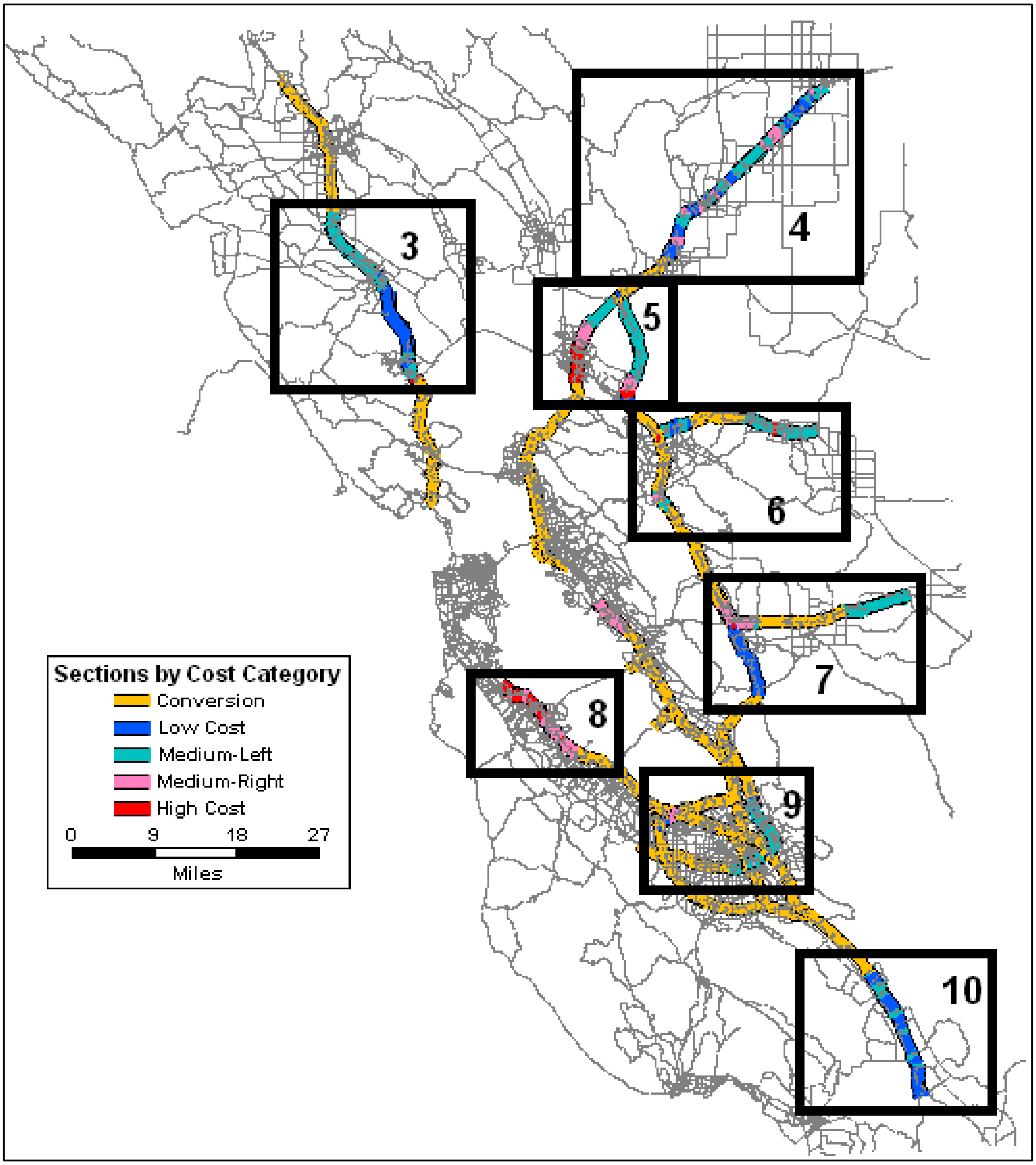


Figure 2: Regional HOT Network by "Rapid Delivery" Category[4]

[4] Some additional segments, including I-580 and I-238 west of I-680 in Alameda County and I-880 and Route 17 south of US 101 in Santa Clara County, are under study as part of continuing technical analysis. These may ultimately be incorporated into the regional network.

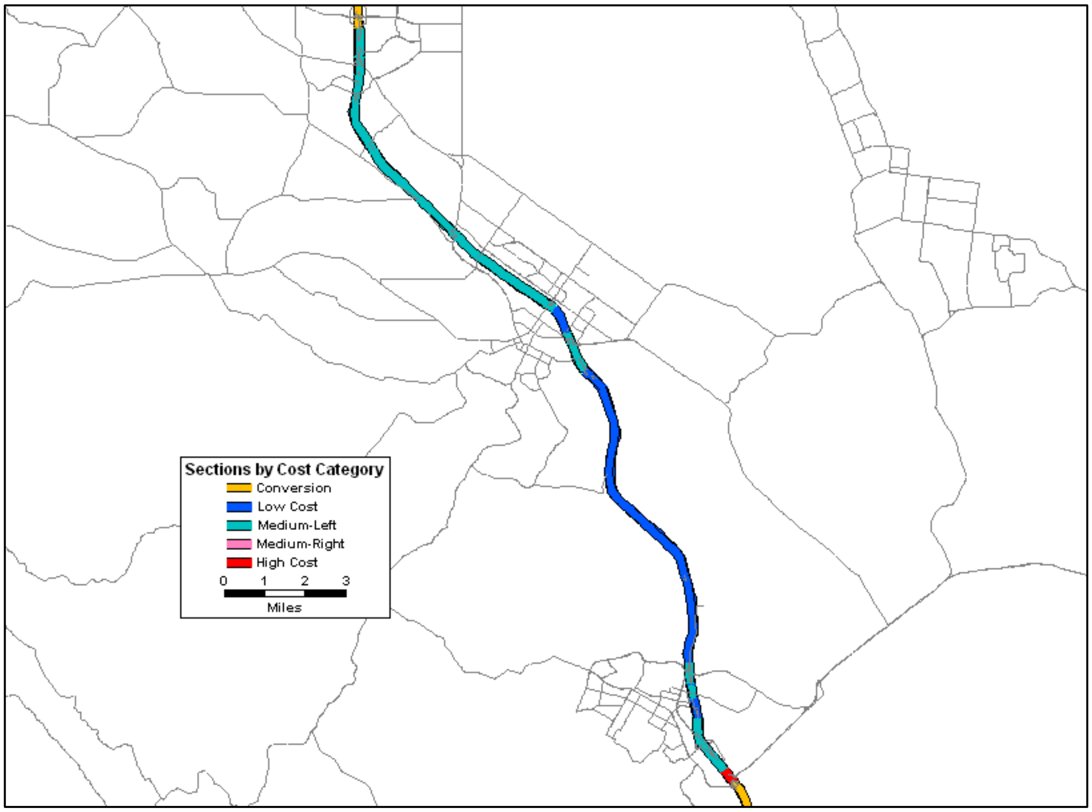


Figure 3: U.S. 101 Sonoma County HOT Lanes by "Rapid Delivery" Category

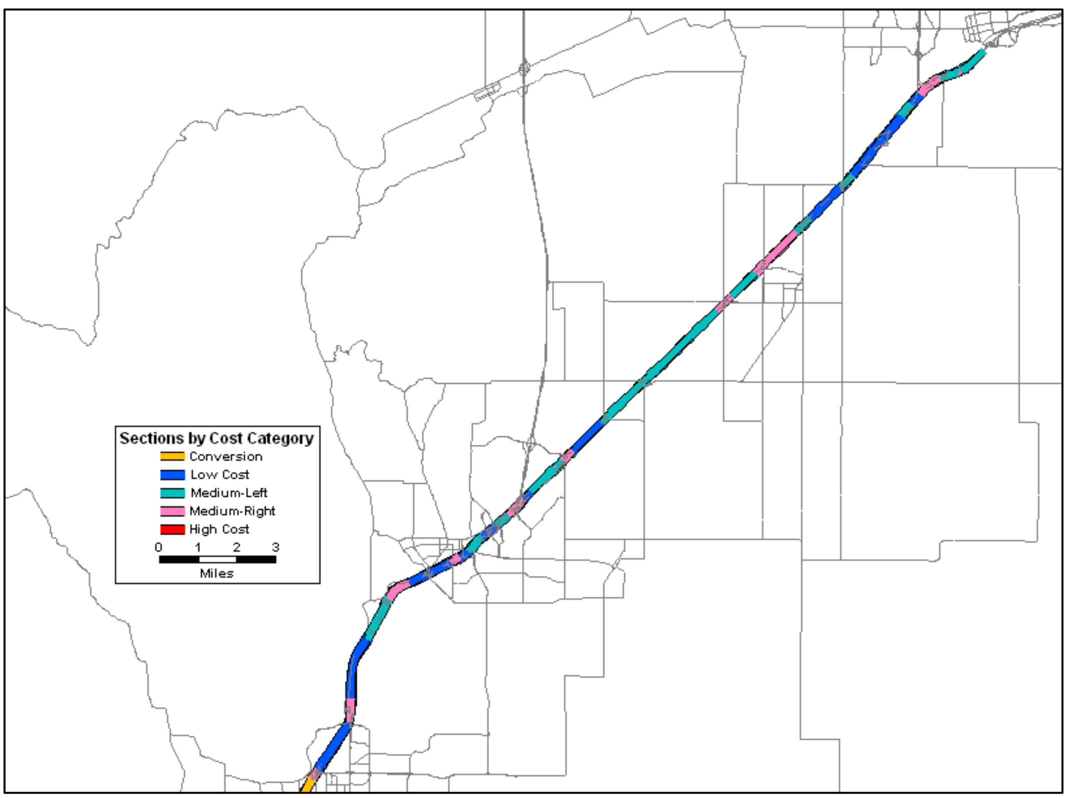


Figure 4: I-80 NE Solano County HOT Lanes by "Rapid Delivery" Category

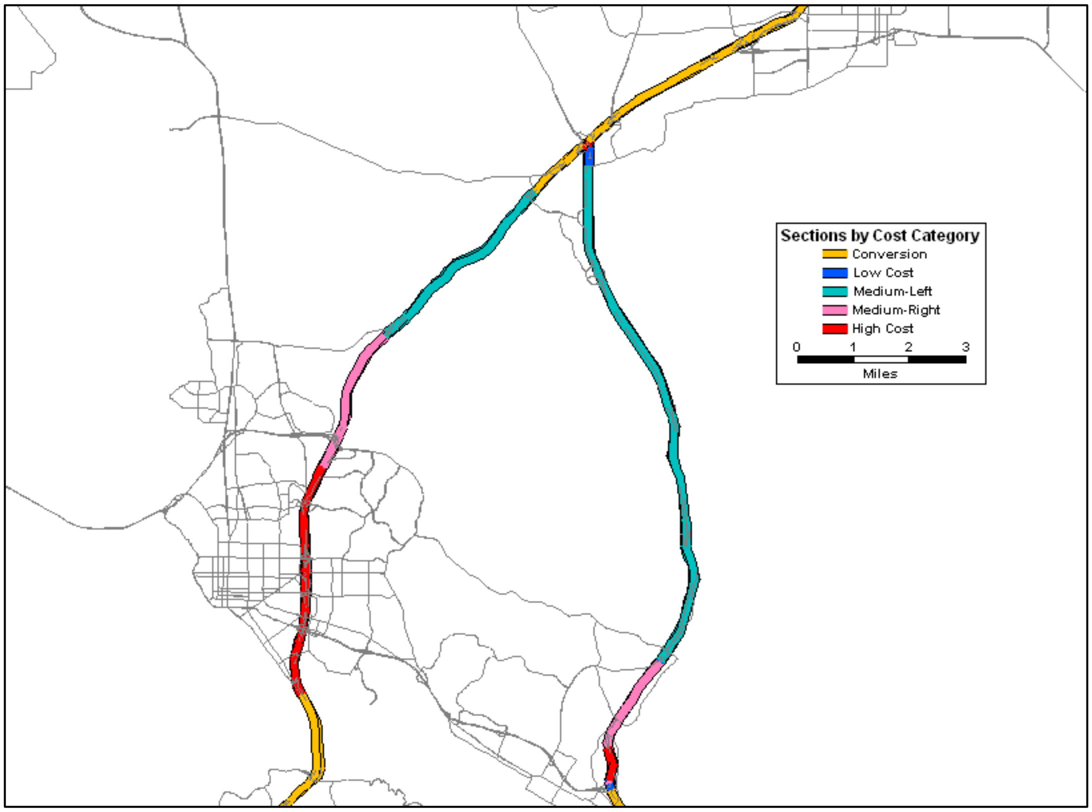


Figure 5: SW Solano County HOT Lanes by "Rapid Delivery" Category

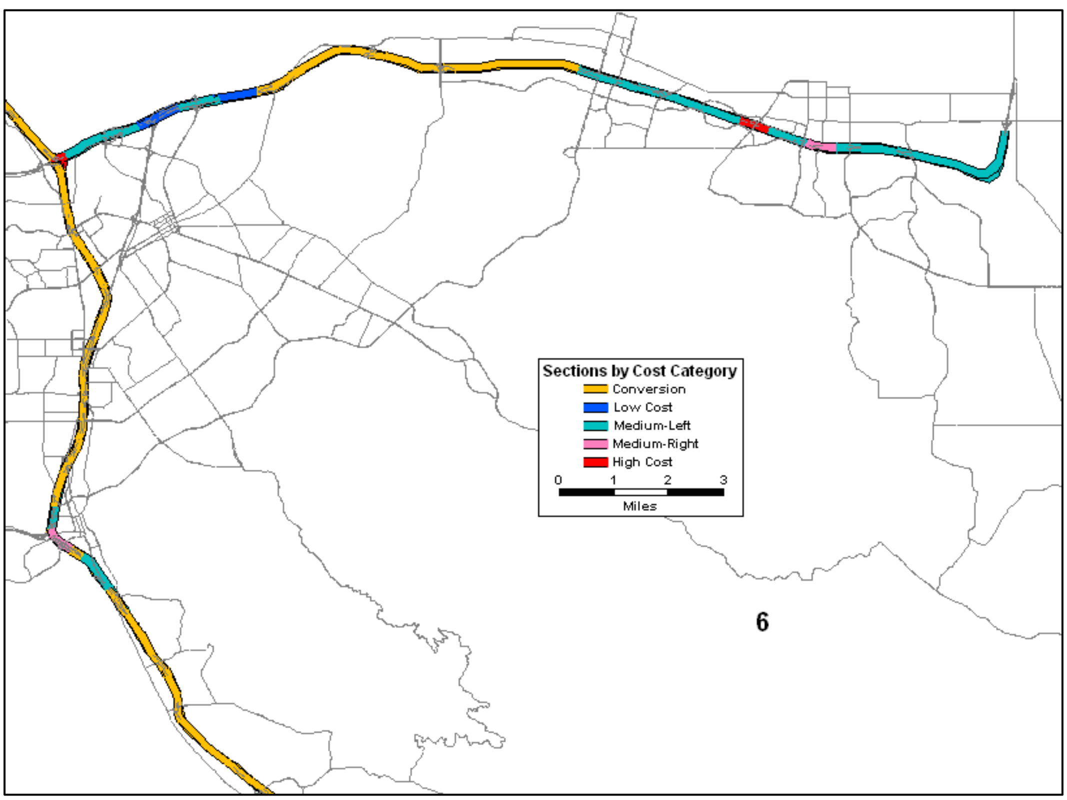


Figure 6: E Contra Costa County HOT Lanes by "Rapid Delivery" Category

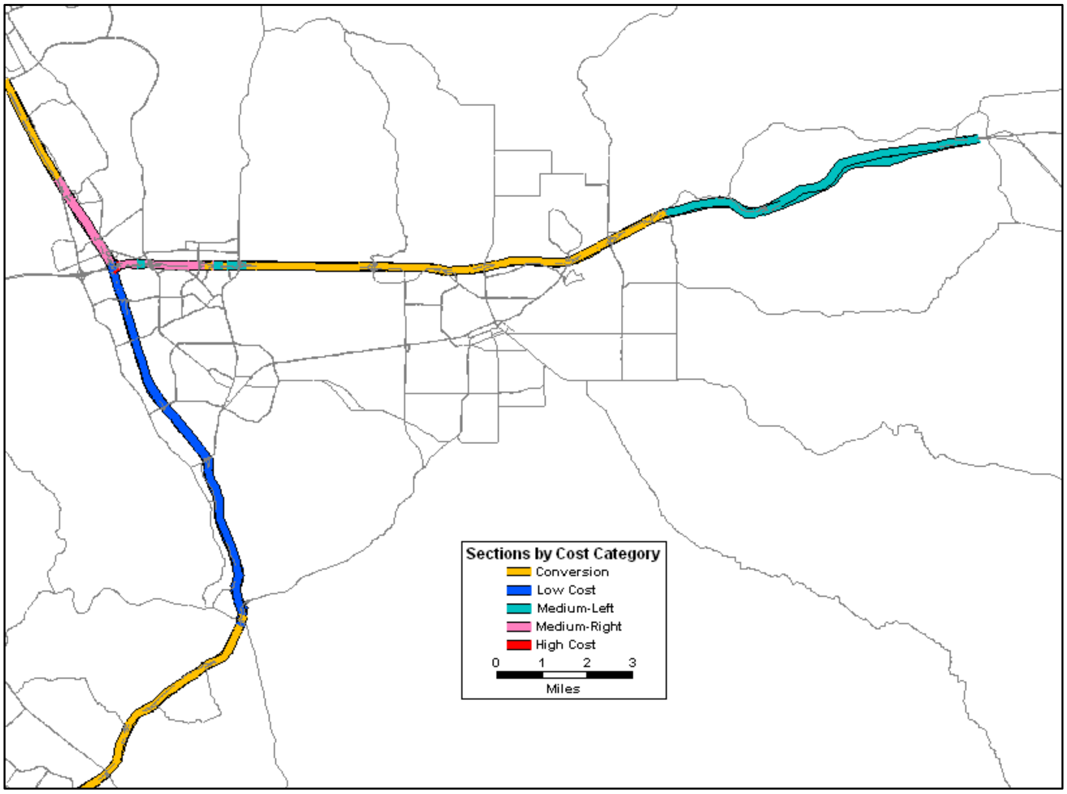


Figure 7: E Alameda County HOT Lanes by "Rapid Delivery" Category

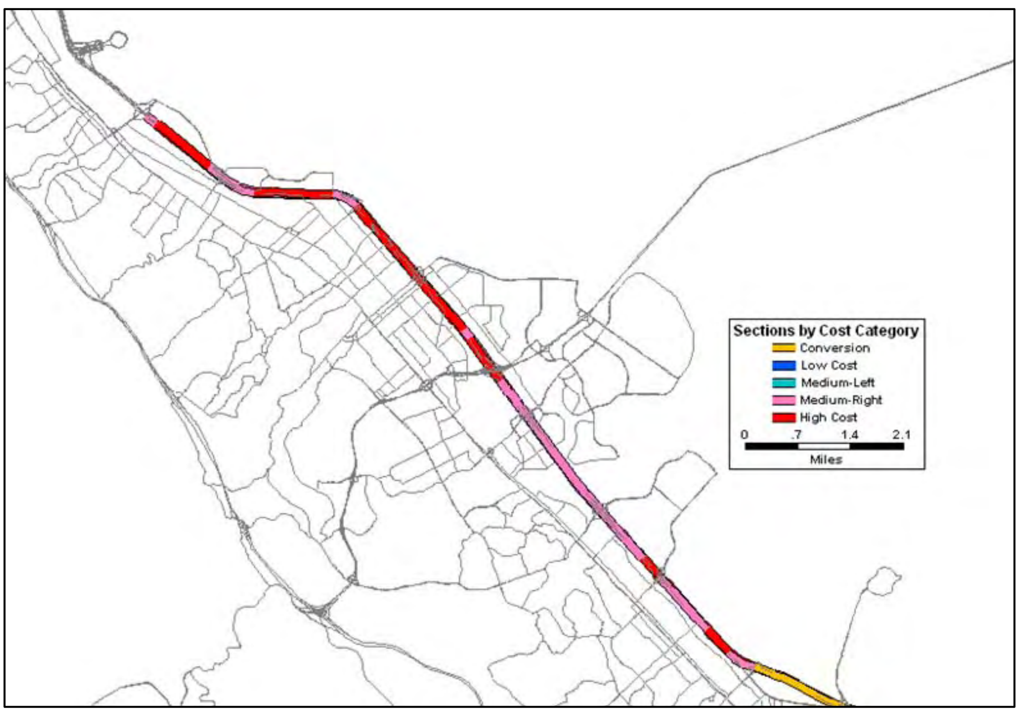


Figure 8: San Mateo County US-101 HOT Lanes by "Rapid Delivery" Category

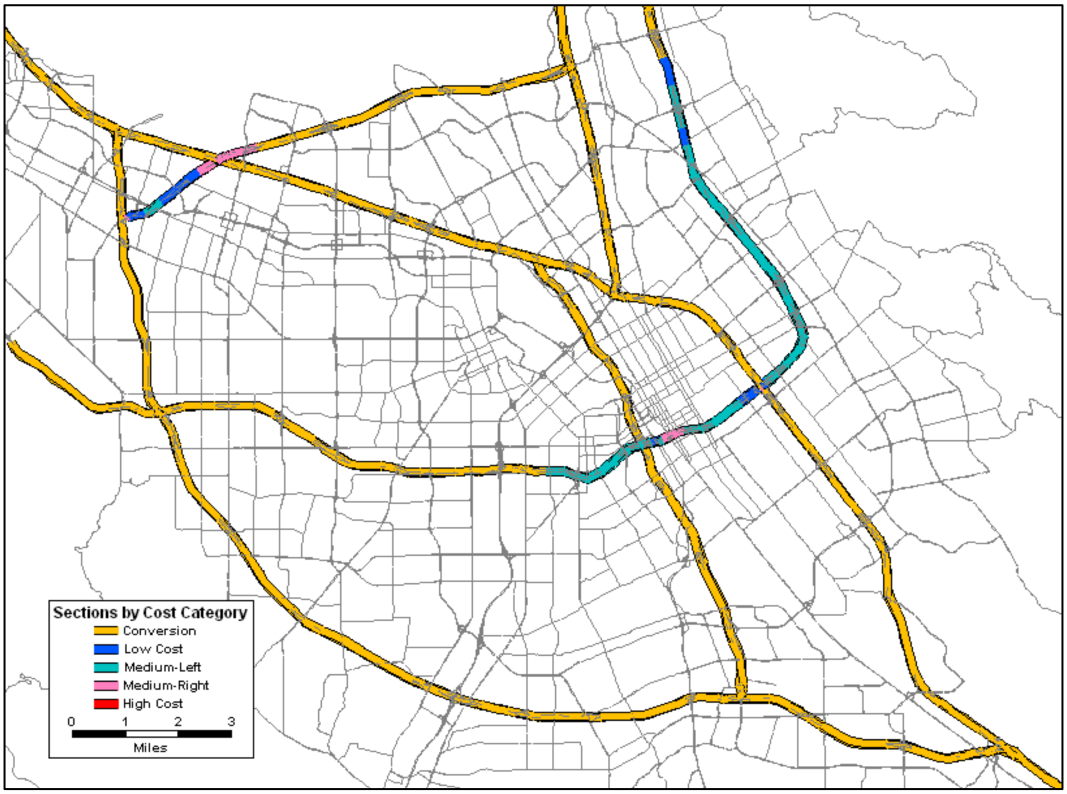


Figure 9: North Santa Clara Co. HOT Lanes by "Rapid Delivery" Category

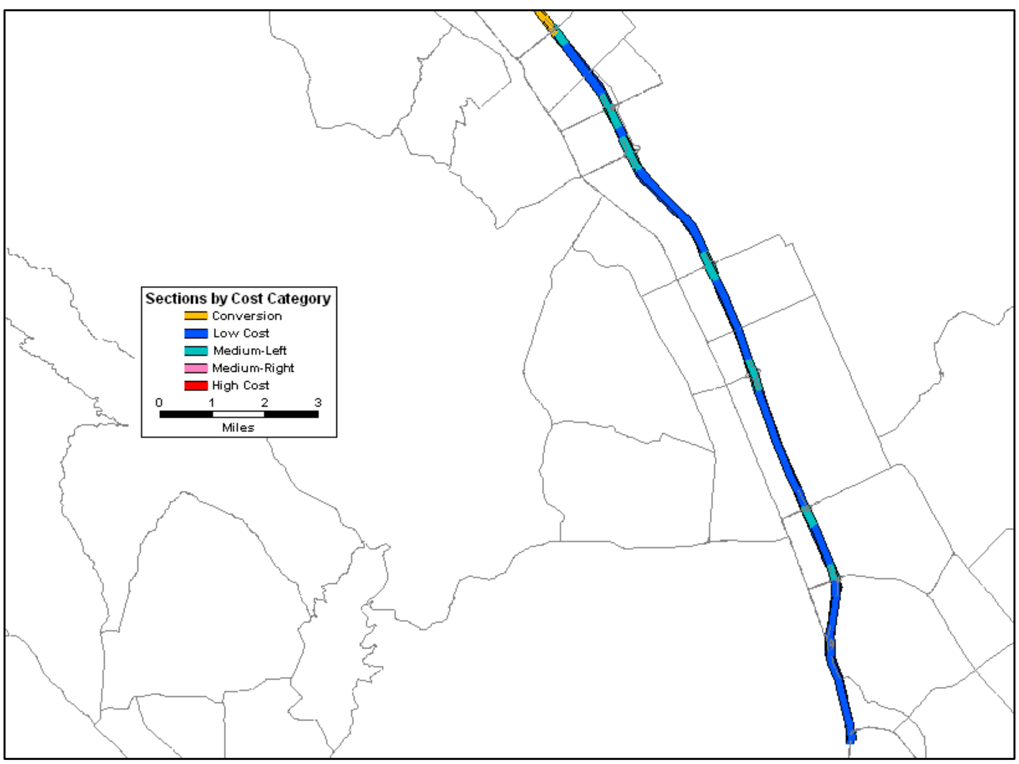


Figure 10: South Santa Clara Co. HOT Lanes by "Rapid Delivery" Category

Table 1: Lane-Miles by Project and Cost Category[5]

	Description	Convert HOV Lanes: Existing	Convert HOV Lanes: Funded	Convert HOV Lanes: Under Constr.	Widen for New Lanes by Cost category: Low	Widen: Medium (left)	Widen: Medium (right)	Widen: High	Total Lane-Miles
I-680 Group									
A)	I-680 SB from SR-84 to Calaveras	13.8	0.0	0.0	0.0	0.0	0.0	0.0	13.8
B)	I-580 EB from Hacienda to Greenville	0.0	10.3	0.0	0.0	0.0	0.0	0.0	10.3
C)	I-680 NB from SR-84 to Calaveras	0.0	14.0	0.0	0.0	0.0	0.0	0.0	14.0
D)	SR-4 from SR-160 to Port Chicago	12.1	18.7	0.0	0.0	0.0	0.0	0.0	30.8
E)	I-680 from Benicia Bridge to Alcosta	47.8	1.6	0.0	0.0	2.4	0.7	0.0	52.6
F)	I-580 WB from SJ Line to I-680	0.0	9.4	0.0	0.0	8.3	1.9	0.0	19.6
G)	I-580 EB from Greenville to SJ Line	0.0	0.0	0.0	0.0	7.4	0.0	0.0	7.4
H)	SR-4 from Port Chicago to I-680	0.0	0.0	0.0	1.9	4.1	0.0	0.0	5.9
I)	SR-4/I-680 Connector	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9
J)	I-680 from Alcosta to SR-84	0.0	0.0	0.0	17.1	0.0	4.3	0.0	21.4
K)	I-580/I-680 Connector	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7
L)	I-680 from I-80 to I-780	0.0	0.0	0.0	0.8	18.8	4.1	1.1	24.8
M)	I-680/I-80 Connector	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
I-80 Group									
A)	I-80 from Central to Bridge Toll Plaza	15.2	0.0	0.0	0.0	0.0	0.0	0.0	15.2
B)	I-80 from Carquinez Bridge to Central	17.7	11.1	0.0	0.0	0.0	0.0	0.0	28.8
C)	I-80 from Airbase Pkwy to SR-12	0.0	14.7	0.0	0.0	0.0	0.0	0.0	14.7
D)	I-80 from SR-37 to Carquinez Bridge	0.0	0.0	0.0	0.0	0.0	0.0	8.4	8.4
E)	I-80 from SR-37 to SR-12 & Airbase to Yolo Line	0.0	0.0	0.0	19.9	29.0	15.2	0.0	64.1
I-880 Group									
A)	SR-84 WB Bridge Approach	2.8	0.0	0.0	0.0	0.0	0.0	0.0	2.8
B)	SR-92 WB Bridge Approach	1.4	0.0	0.0	0.0	0.0	0.0	0.0	1.4
C)	I-880 from 16th Street to I-80 Merge	11.8	0.0	0.0	0.0	0.0	0.0	0.0	11.8
D)	I-880 from Marina to SR-237	44.3	0.0	2.8	0.0	0.0	0.0	0.0	47.1
E)	I-880 from 98th Street to Marina	0.0	0.0	0.0	0.0	0.0	6.2	0.0	6.2
Marin-Sonoma Group									
A)	US-101 from Seminary to SR-37	23.1	4.0	1.5	0.0	0.0	0.0	0.0	28.5
B)	US-101 from SR-37 to San Antonio Rd	0.0	0.0	0.0	10.6	4.8	1.2	1.1	17.6
C)	US-101 from San Antonio Rd to Old Redwood	0.0	0.0	0.0	6.7	7.9	0.0	0.0	14.6
D)	US-101 from Old Redwood to Winsor River Rd	9.2	20.2	2.4	0.0	12.2	0.0	0.0	44.0
Santa Clara - San Mateo Group									
A)	SR-85	50.3	0.0	0.0	0.0	0.0	0.0	0.0	50.3
B)	US-101 from San Mateo Line to Cochrane	70.0	0.0	0.0	0.0	0.0	0.0	0.0	70.0
C)	SR-87 from US-101 to SR-85	18.4	0.0	0.0	0.0	0.0	0.0	0.0	18.4
D)	SR-237 from I-880 to Mathilda	12.3	0.0	0.0	0.0	0.0	0.0	0.0	12.3
E)	I-880 from SR-237 to US-101	0.0	8.1	0.0	0.0	0.0	0.0	0.0	8.1
F)	SR-237 from Mathilda to SR-85	0.0	0.0	0.0	2.5	0.7	2.4	0.0	5.6
G)	US-101 from Whipple to County Line	13.5	0.0	0.0	0.0	0.0	0.0	0.0	13.5
H)	I-280 from Magdalena to Leland Ave.	21.7	0.0	0.0	0.0	0.0	0.0	0.0	21.7
I)	US-101 from Cochrane to SR-25	0.0	0.0	0.0	22.8	7.0	0.0	0.0	29.7
J)	US-101 from Whipple to Milbrae	0.0	0.0	0.0	0.0	0.0	11.3	11.0	22.3
K)	I-680 from Calaveras to US-101	0.0	0.0	0.0	0.9	11.6	1.7	0.0	14.2
L)	I-280 from Leland to US-101	0.0	0.0	0.0	1.5	6.6	1.0	0.0	9.1
	System Total	385.4	111.9	6.6	84.7	120.7	50.0	23.5	782.8
	Percent of System Total	49%	14%	1%	11%	15%	6%	3%	100%
	Percent of System Total		64%				36%		100%

Source: *Estimations prepared by PB, January 2008, utilizing GIS and aerial assessments.*

[5] Some additional segments, including I-580 and I-238 west of I-680 in Alameda County and I-880 and Route 17 south of US 101 in Santa Clara County, are under study as part of continuing technical analysis. These may ultimately be incorporated into the regional network.

Cost Assumptions

Unit costs for each category were estimated based on the twenty-eight cost components shown in Attachment G. These components include:

- The costs associated with demolishing existing shoulder pavement and installing new pavement for the HOT lane and shoulder
- Guardrails, k-rails, and concrete barriers
- Signing and striping
- Sound walls
- ITS elements
- Traffic management
- Cost contingencies ranging from approximately 40% for low-cost modifications to 60% for high-cost modification

Appendix 9: "Rapid Delivery" Approach Costs, Revenue and Phasing by Corridor

(all figures in millions of escalated dollars)

County	Route	From	To	Conv Or New	Start Year	Year to 3+	Gross Revenue	Capital Cost	Financing Cost	O&M Cost	Net Revenue
SR 4							**$93.2**	**$171.4**	**$262.8**	**$103.5**	
CC	SR4	SR 160	Port Chicago Hwy	Conv	2011	2040	$81.1	$37.2	$57.1	$66.3	($42.3)
CC	SR4	Port Chicago Hwy	I-680	New	2013	2040	$12.1	$39.0	$59.8	$27.4	($75.1)
CC	SR4	I-680/SR4 Connector		New	2016	2020	$0.0	$95.2	$145.9	$9.8	($155.7)
I-80							**$1,115.8**	**$767.7**	**$1,176.7**	**$308.2**	
ALA	I-80	ALA/CC Co Line	Bay Bridge	Conv	2011	at start	$110.1	$18.2	$27.8	$67.9	$14.4
CC	I-80	Carquinez Bridge	ALA/CC Co Line	Conv	2011	at start	$101.9	$34.7	$53.2	$71.0	($22.3)
SOL	I-80	SR 37	Carquinez Bridge	New	2016	2040	$36.0	$131.3	$201.2	$25.7	($190.9)
SOL	I-80	SOL/YOL Co Line	SR 37 (excluding below	New	2016	2040	$833.1	$565.8	$867.2	$107.4	($141.5)
SOL	I-80	Airbase Pkwy	SR 12	Conv	2011	2040	$34.7	$17.8	$27.3	$36.2	($28.8)
US 101 SM/SCL							**$2,442.3**	**$608.3**	**$932.3**	**$262.7**	**$1,247.3**
SCL	US 101	Cochrane	SR25	New	2013	2050	$59.8	$172.6	$264.6	$65.2	($270.0)
SCL	US 101	SM/SCL Co Line	Cochrane	Conv	2011	2035	$1,574.9	$84.5	$129.5	$125.6	$1,319.7
SM	US 101	Whipple	SM/SCL Co Line	Conv	2011	2035	$358.8	$16.2	$24.9	$32.2	$301.7
SM	US 101	Millbrae	Whipple	New	2016	2040	$448.9	$334.9	$513.3	$39.7	($104.2)
US 101 MRN/SON							**$774.2**	**$387.3**	**$593.6**	**$247.1**	
MRN	US 101	SR 37	Corte Madera	Conv	2011	2025	$332.9	$34.5	$52.8	$81.2	$198.9
MRN	US 101	SON/MRN Co Line	SR 37	New	2016	2025	$54.2	$133.9	$205.3	$42.6	($193.7)
SON	US 101	Old Redwood Hwy	SON/MRN Co Line	New	2013	2030	$116.1	$92.4	$141.7	$40.9	($66.4)
SON	US 101	Windsor River Rd	Old Redwood Hwy	Conv/New	2013	2030	$271.0	$126.5	$193.8	$82.4	($5.2)
I-580							**$249.2**	**$166.1**	**$254.5**	**$78.5**	
ALA	I-580 WB	ALA/SJ Co Line	I-680	Conv/New	2014	2035	$166.1	$100.9	$154.7	$34.0	($22.6)
ALA	I-580 EB	Greenville Rd	ALA/SJ Co Line	New	2013	2035	$29.5	$52.7	$80.8	$25.0	($76.3)
ALA	I-580 EB	Hacienda	Greenville	Conv	2011	2035	$53.6	$12.4	$19.0	$19.4	$15.2
I-680							**$4,421.9**	**$1,182.4**	**$1,812.2**	**$368.8**	**$2,240.9**
SCL	I-680	Calaveras	US 101	New	2014	2035	$304.9	$115.0	$176.2	$41.2	$87.5
SCL	I-680	ALA/SCL Co Line	Calaveras	Demo/Coı	2011	2035	$101.6	$6.2	$9.5	$52.9	$39.2
ALA	I-680	SR 84	ALA/SCL Co Line	Demo/Coı	2011	2035	$914.6	$27.4	$42.0	$50.9	$821.8
ALA	I-680	Alcosta	SR 84	New	2014	2020	$372.6	$156.0	$239.1	$48.6	$85.0
ALA	I-680	I-680/I-580 Connector		New	2016	2020	$18.8	$412.6	$632.4	$17.3	($630.9)
CC	I-680	Benicia Bridge	Alcosta	Conv/New	2014	2020	$2,661.3	$91.5	$140.2	$97.6	$2,423.4
SOL	I-680	I-80	I-780	New	2016	2050	$47.7	$227.8	$349.1	$42.1	($343.4)
SOL	I-680	I-80/I-680 Connector		New	2016	2025	$0.4	$146.0	$223.8	$18.3	($241.6)
I-880							**$3,063.9**	**$166.6**	**$255.3**	**$165.7**	**$2,642.8**
SCL	I-880	ALA/SCL Co Line	US 101	Conv	2011	2025	$1,041.3	$9.7	$14.9	$37.2	$989.2
ALA	I-880	Marina	ALA/SCL Co Line	Conv	2011	2025	$1,929.6	$56.9	$87.2	$78.2	$1,764.2
ALA	I-880	98th Street	Marina/Lewelling	Conv/New	2014	2025	$91.9	$85.7	$131.4	$29.9	($69.4)
ALA	I-880	Bay Bridge Appr	16th Street	Conv	2011	at start	$1.1	$14.3	$21.8	$20.5	($41.2)
Dumbarton and San Mateo Bridge Approaches							**$19.1**	**$1.8**	**$2.8**	**$17.7**	
ALA	SR92	San Mateo Bridge Approach		Conv	2011	2050	$0.6	$1.1	$1.8	$12.9	($14.1)
ALA	SR84	Dumbarton Bridge Approach		Conv	2011	2025	$18.5	$0.7	$1.0	$4.8	$12.7
SCL - multiple							**$1,198.2**	**$247.1**	**$378.7**	**$317.9**	**$501.6**
SCL	SR85	US 101 (Mtn View)	US 101 (S San Jose)	Conv	2011	2020	$546.1	$60.8	$93.1	$111.8	$341.2
SCL	SR 87	US 101	SR 85	Conv	2011	2040	$143.0	$22.2	$34.0	$54.3	$54.6
SCL	SR237	I-880	Mathilda	Conv	2011	2035	$343.1	$14.9	$22.9	$47.6	$272.6
SCL	SR237	Mathilda	SR 85	New	2014	2035	$7.0	$52.3	$80.1	$23.6	($96.7)
SCL	I-280	Magdalena	Leland	Conv	2011	2035	$60.4	$26.2	$40.1	$59.9	($39.6)
SCL	I-280	Leland	US 101	New	2014	2035	$98.6	$70.8	$108.5	$20.7	($30.5)
Subtotal - Without Toll Bridges							***$13,377.8***	***$3,698.7***	***$5,668.8***	***$1,870.1***	***$5,838.9***
Toll Bridges											
Benicia Bridge					2014	at start	$13.4	$1.9	$2.9	$2.0	$8.5
Carquinez Bridge					2011	at start	$66.5	$0.1	$0.2	$0.2	$66.2
Bay Bridge					2011	at start	$129.1	$0.2	$0.3	$0.7	$128.2
San Mateo Bridge					2011	2050	$27.7	$0.5	$0.8	$5.8	$21.1
Dumbarton Bridge					2011	2025	$90.5	$2.7	$4.1	$19.2	$67.2
Subtotal - Toll Bridges							***$327.2***	***$5.3***	***$8.2***	***$27.9***	***$291.1***
Total - Entire System							**$13,705.0**	**$3,704.0**	**$5,677.0**	**$1,898.0**	**$6,130.0**

Notes and Assumptions

- “Conv. or New” indicates whether HOT lane is developed by converted an existing (or funded) carpool lane or requires a new travel lane.
- “Start Year” refers to the year in which the segment would begin operating as a HOT Lane. The timing is based on project delivery timelines documented in Appendix 9.
- “Year to 3+” refers to the year at which the carpool occupancy requirement would increase from 2-persons to three persons. At that time, 2-person carpools would not longer be eligible to use the HOT lanes for free. Timing for increasing carpool occupancy requirements is the same under “rapid delivery” as under the “full feature” approach described in Section I. Further, timing is based on when lanes crowd with carpools and is not accelerated as a result of HOT network implementation. In other words, even without the HOT network, carpool lanes would become crowded by the dates shown and merit an increase in occupancy requirement.
- Gross revenue estimates pivot off the low-end demand and revenue forecasts conducted during Phases 1 and 2 of the Regional HOT Network Study. (See Section I of the report). Travel demand and revenue forecasts were developed for years 2015, 2030 and 2050. Interpolation was used to estimate annual revenues in intermediate years.
- Capital costs are based on unit costs documented in Appendix 8. Construction costs are assumed to escalate at 3.5% annually.
- “Financing Cost” refers to the proportional share (based on share of total capital cost) of total estimated cost to finance the complete network. This is not representative of the cost associated with financing a particular segment on a stand-alone basis. The amounts shown are for the period between 2009 and 2033 only and do not reflect payments made after 2033. The total debt service is the financing cost plus the capital cost. The financing analysis assumes a 6.5% interest rate and 40-year term.
- “O&M Cost” refers to operating and maintenance cost including: enforcement by the California Highway Patrol, toll equipment maintenance, communications, utilities, administration, FasTrak® toll tags and processing of toll transactions. The operating and maintenance cost estimate does not include the costs of roadway maintenance
- “Net Revenue” is net after capital cost, financing cost and O&M cost.

Appendix 10: Carpool Pay-As-You-Go Implementation Scenario

For purposes of understanding the benefits of the Regional HOT Network, MTC staff estimated the schedule for completing the region's carpool system based on traditional funding sources such as State Transportation Improvement Program (STIP) funds (including Proposition 42 funds) and local sales tax measures.

This "carpool pay-as-you-go" scenario assumes carpool lanes continue to operate as free carpool lanes and are not converted to HOT lanes. For all gaps and extensions included in the financially constrained portion of the Transportation 2030 Plan, MTC staff used the funding and phasing assumptions in the Transportation 2030 Plan, including sales taxes and federal earmarks.[1] MTC staff consulted county congestion management agency staff on the latest cost estimates for projects not included in the financially constrained portion of the Transportation 2030 Plan. Funding availability was assumed to dictate the timing of projects not included in the Transportation 2030 Plan. Additional assumptions include:

- Costs, Revenue and Funding
    - Capital costs are escalated to year of expenditure at 4% annual rate.
    - Revenue estimates through FY 2027-28 are consistent with those in the Transportation 2030 Plan
    - STIP and Prop 42 funds beginning in FY 2028-2029 are straight-lined using the average annual growth in the Transportation 2030 revenue estimate from FY 06-07 to FY 20027-28
    - The Prop 42 estimate does not include ITIP
    - Beyond FY 2027-28, ITIP funds are applied in Solano County only where STIP revenues are otherwise not sufficient to complete the system prior to 2050. ITIP funds are assumed to decrease due to a declining Bay Area population share.
    - HOV projects are assumed to receive priority for STIP funding to the exclusion of other projects.

- Phasing for Projects not in Financially Constrained Transportation 2030 Plan
    - Projects are assumed to come on-line when sufficient STIP funding has accumulated.
    - Projects are implemented in the following priority: 1) those in Tier 1 of the 2002 HOV Master Plan Update; 2) those in Tier 2 of the 2002 HOV Master Plan Update; 3) other projects

[1] At the time this analysis was undertaken (November 2007), project sponsors had not yet submitted update project costs, funding or phasing assumptions for the Transportation 2035 Plan.

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HOV Pay as You Go Summary (costs in year of expenditure dollars)

updated 12-4-07

Alameda

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 3,335,076
Total		**$ 3,335,076**

HOV Expenditures	RTP ID	T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP	Post T-2030 STIP FY 2030-2050 ITIP	T-2030 Existing Funds	Total Cost	Opening Year	Occupancy at Opening	Year of Occupancy Increase
I-680 Alcosta to SR 84		$ -	$ -	$ 473,092	$ -	$ -	$ 473,092	FY 39-40	3+	na
I-580 Greenville Rd to San Joaquin Co. line (EB)		$ -	$ -	$ 289,190	$ -	$ -	$ 289,190	FY 34-35	3+	na
I-580 Greenville Rd to San Joaquin Co. line (WB)		$ -	$ -	$ 316,385	$ -	$ -	$ 316,385	FY 35-36	3+	na
I-580 SB 680 & NB 680 Interchange	22013	$ -	$ -	$ 420,533	$ -	$ -	$ 420,533	FY 14-15	2+	2035 with I-580 opening
I-880 Lewelling to 98th Ave (NB)		$ -	$ -	$ 89,686	$ -	$ -	$ 89,686	FY 39-40	3+	na
Total		**$ -**	**$ -**	**$ 1,588,886**	**$ -**	**$ -**	**$ 1,588,886**			

Contra Costa

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 2,186,501
Total		**$ 2,186,501**

HOV Expenditures	RTP ID	T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP	Post T-2030 STIP FY 2030-2050 ITIP	T-2030 Existing Funds	Total Cost	Opening Year	Occupancy at Opening	Year of Occupancy Increase
I-680 Noth Main to Livorna		$ -	$ -	$ 72,581	$ -	$ -	$ 72,581	FY 34-35	3+	na
I-680 N/O Waterfront (Benicia Bridge) to Alcosta		$ -	$ -	$ 122,466	$ -	$ -	$ 122,466	FY 37-38	3+	na
Rte-4 Port Chicago Hwy to I-680		$ -	$ -	$ 218,934	$ -	$ -	$ 218,934	FY 34-35	2+	2040
Rte-4/I-680 HOV connector facility	22350	$ -	$ 143,652	$ -	$ -	$ -	$ 143,652	100% ITIP fu	2+	2040 when SR 4 goes to 3+
Total		**$ -**	**$ 143,652**	**$ 413,981**	**$ -**	**$ -**	**$ 557,632**			

Marin

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 619,727
Total		**$ 619,727**

HOV Expenditures	RTP ID	T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP	Post T-2030 STIP FY 2030-2050 ITIP	T-2030 Existing Funds	Total Cost	Opening Year	Occupancy at Opening	Year of Occupancy Increase
US 101 Marin County Line to Old Redwood Highway	98154	$ 146,462	$ 146,216	$ -	$ -	$ 76,343	$ 369,021	FY 22-23	3+	na
Total		**$ 146,462**	**$ 146,216**	**$ -**	**$ -**	**$ 76,343**	**$ 369,021**			

Santa Clara

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 3,881,603
Total		**$ 3,881,603**

HOV Expenditures	RTP ID	T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP	Post T-2030 STIP FY 2030-2050 ITIP	T-2030 Existing Funds	Total Cost	Opening Year	Occupancy at Opening	Year of Occupancy Increase
US 101 Rte 25 to Cochrane		$ -	$ -	$ 539,300	$ -	$ -	$ 539,300	FY 35-36	2+	2050
I-680 Calaveras to US 101		$ -	$ -	$ 171,093	$ -	$ -	$ 171,093	FY 39-40	3+	na
Rte 237 Mathilda to Rte 85	21716	$ 11,387	$ 46,582	$ -	$ -	$ -	$ 57,969	FY 14-15	2+	2035
I-280 Leigh Ave to US 101		$ -	$ -	$ 79,603	$ -	$ -	$ 79,603	FY 38-39	3+	na
Total		**$ 11,387**	**$ 46,582**	**$ 789,995**	**$ -**	**$ -**	**$ 847,964**			

Solano

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 1,030,540
ITIP		$ 594,710
Total		**$ 1,625,250**

HOV Expenditures	RTP ID	T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP & ITIP	Post T-2030 STIP FY 2030-2050	T-2030 Existing Funds	Total Cost	Opening Year	Occupancy at Opening	Year of Occupancy Increase
I-80 Airbase Parkway to Yolo County Line*		$ -	$ -	$ 2,153,845	$ -	$ -	$ 2,153,845	FY 49-50	3+	na
I-80 Rte 12 Suisun Valley to Rte 37		$ -	$ -	$ 416,142	$ -	$ -	$ 416,142	FY 40-41	3+	na
I-680 I-80 to I-780 Connector		$ -	$ -	$ 1,049,309	$ -	$ -	$ 1,049,309	FY 49-50	3+	connecting segments @ 3+
I-80 Rte 37 to Carqinez Bridge		$ -	$ -	$ 208,670	$ -	$ -	$ 208,670	FY 33-34	3+	opens at 3+ b/c I-80 CC is at
I-80/I-680/SR-12 HOV Direct Connector		$ -	$ -	$ 610,681	$ -	$ -	$ 610,681	FY 49-50	3+	connecting segments @ 3+
Total		**$ -**	**$ -**	**$ 4,438,647**	$ -	**$ -**	**$ 4,438,647**			

* Assumes that $167 M in ITIP (estimated amt available for HOV projects FY 29-30 through 49-50) goes to Solano.
I-80 Airbase Prkwy to the County line and I-80/I-680 direct connector still not fully funded under this assumption and require additional funding

Sonoma

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 1,248,627
Total		**$ 1,248,627**

HOV Expenditures	RTP ID	T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP	Post T-2030 STIP FY 2030-2050 ITIP	T-2030 Existing Funds	Total Cost	Opening Year	Occupancy at Opening	Year of Occupancy Increase
US 101 Old Redwood to Rohnert Park Expwy	21902	$ 63,403	$ -	$ -	$ -	$ 11,646	$ 75,049	FY 14-15	2+	2025
US 101 Marin County line to Old Redwood Hwy	98117	$ 74,984	$ 146,216	$ -	$ -	$ 76,343	$ 297,543	FY 14-15	2+	2025
Total		**$ 138,388**	**$ 146,216**	**$ -**	$ -	**$ 87,988**	**$ 372,592**			

San Mateo

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 1,722,698
Total		**$ 1,722,698**

HOV Expenditures	RTP ID	T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP	Post T-2030 STIP FY 2030-2050 ITIP	T-2030 Existing Funds	Total Cost	Opening Year	Occupancy at Opening	Year of Occupancy Increase
US 101 from Milbrae to Whipple		$ -	$ -	$ 637,458	$ -	$ -	$ 637,458	FY 39-40	3+	na
Total		**$ -**	**$ -**	**$ 637,458**	$ -	**$ -**	**$ 637,458**			

TOTAL ALL COUNTIES

STIP Revenue	T-2030 FY 2005-2029	Post T-2030 FY 2030-2050
RTIP & Prop 42		$ 14,024,773
ITIP		$ 594,710
Total		**$ 14,619,482**

HOV Expenditures		T-2030 STIP FY 2005-2029 RTIP	T-2030 STIP FY 2005-2029 ITIP	Post T-2030 STIP FY 2030-2050 RTIP & ITIP*	Post T-2030 STIP FY 2030-2050	T-2030 Existing Funds	Total Cost
TOTAL ALL PROJECTS		**$ 296,236**	**$ 482,666**	**$ 7,868,967**	$ -	**$ 164,331**	**$ 8,812,200**

* ITIP included to fund projects in Solano County between FY 29-30 and 49-50.
To fully fund Solano County Projects, also need $353M in sales tax (or other funding) not shown here
Thus

The total cost for all projects in T-2030 is	$ 943,233	RTIP + ITIP+ Existing Funds
And the total cost for all project after T-2030 is	$ 8,221,666	RTIP + ITIP (Solano) + Solano sales tax

Appendix 11: Analysis of Travel Time Savings

To understand the potential benefits of the Regional HOT Network, and of faster implementation in particular, MTC compared projected person hours of travel under three scenarios: [1]

1. **Carpool Pay-As-You-Go Network.** Complete the 800-mile network as a system of carpool lanes, funded principally through State Transportation Improvement Funds and local sales tax contributions. The implementation schedule is driven by available funding, and does not assume advances through Grant Anticipation Revenue Vehicles (GARVEE) or bond financing. Under this funding approach, the network could be completed in year 2050 at a capital cost of $8.8 billion (escalated). [2]

2. **“Full Feature” HOT Network.** Complete the network as a system of HOT lanes based on the design and phasing described in Section I of this report. Under this approach the network could be completed by 2026 at a capital cost of $8.3 billion (escalated, does not reflect cost of debt service).

3. **“Rapid Delivery” HOT Network.** Complete the network as a system of HOT lanes based on the design and phasing described above in Section II of this report. Under this approach the network could be completed as soon as 2016 at a capital cost of $3.7 billion (escalated, does not reflect cost of debt service).

The travel time savings reported in this appendix are the differences in vehicle hours traveled (VHT) or person hours of travel and the value of that time savings for three horizon years, and the cumulative travel time savings between 2009 and 2050.

The estimates/forecasts were developed for the previously-developed travel and revenue forecast model results (from Phase 2 and documented in Section I) and are based on travel forecasts using the MTC travel forecasting model and revenue forecasts using the ECO Northwest Rapid Toll Optimization Model (Rapid TOM) model.

Presented below in Tables 1 and 2 are estimates of annual vehicle hours traveled and person hours traveled. Individual horizon years, as well as a cumulative amount for the 2010 to 2050 period are presented. The results reflect the entire regional carpool or HOT networks, which consist of approximately 800 lane-miles at build-out. (Note: year of build-out varies by scenario based on phasing described in: Section I for the “full feature” HOT network scenario, Appendix 9 for the “rapid delivery” HOT network scenario and Appendix 10 for the pay-as-you-go carpool scenario)

[1] As with other results presented in this report, estimates are based on a first-order analysis and should be considered preliminary. This analysis does not reflect, as more detailed forecasts in the future will, feedback between the travel demand and tolling models that would project changes in travel modes or routes. In addition, estimates of travel time and emissions presented here reflect travel only on that portion of the freeway system associated with the regional HOT network (approximately 800 directional miles). For example, travel on parallel arterials or freeways that do not have carpool or HOT lanes is not included in the totals. In effect, this approach holds vehicle miles of travel constant. Future, more detailed analysis will reflect feedback between the tolling and travel demand models; it will address impacts on vehicle miles traveled and will revisit travel time and greenhouse gas emissions, as described under “Next Steps” below.

[2] Note that this is a different approach than in the comparison in Section 1 between a carpool network and HOT network. The analysis in Section I compares HOT and carpool systems assuming the same number of lane miles in both scenarios in any given year. This analysis assumes the carpool system is built out more slowly so the number of lane miles in the carpool system is smaller than that in the HOT system in any given year. See Appendix 10.

Table 2 converts VHT to person hours of travel, assuming an average vehicle occupancy of 1.15.

Table 1: Vehicle Hours Traveled 2010 through 2050

	Millions of VHT				
	Annual				Cumulative
Scenario	**In Year 2010**	**In Year 2015**	**In Year 2030**	**In Year 2050**	**2010 through 2050**
Carpool Pay-As-You-Go Network	427	425	425	434	17,528
"Full Feature" HOT Network	427	411	357	342	15,296
"Rapid Delivery" HOT Network	427	381	350	342	14,605

Source: PB based on MTC model outputs and ECONW Rapid TOM outputs

Table 2: Person Hours Traveled 2010 through 2050

	Millions of Person Hours of Travel*				
	Annual				Cumulative
Scenario	**In Year 2010**	**In Year 2015**	**In Year 2030**	**In Year 2050**	**2010 through 2050**
Carpool Pay-As-You-Go Network	491	489	489	499	20,157
"Full Feature" HOT Network	491	473	411	393	17,590
"Rapid Delivery" HOT Network	491	438	403	393	16,796

Source: PB based on MTC model outputs and ECONW Rapid TOM outputs

Table 3 shows the annual person hours traveled that can be saved by implementing one scenario over another. The savings shown in Table 3 are a derivative of the total person hours of travel in each scenario (see Table 2).

Table 3: Savings in Person Hours Traveled 2010 through 2050

	Millions of Person Hours of Travel				
	Annual				Cumulative
	In Year 2010	**In Year 2015**	**In Year 2030**	**In Year 2050**	**2010 through 2050**
Compared to Carpool Pay-As-You-Go Network					
"Full Feature" HOT Network	0	16	78	106	2,567
"Rapid Delivery" HOT Network	0	51	86	106	3,361
Compared to "Full Feature" HOT Network					
"Rapid Delivery" HOT Network	0	35	8	0	795

Note: Numbers may not total due to rounding
Source: PB based on MTC model outputs and ECONW Rapid TOM outputs

As illustrated in the tables above, the development of a HOT system provides varying levels of travel depending upon the scenario employed in the region. The Carpool Pay-As-You-Go scenario results in the highest travel times both because the capacity in the HOV-only lanes cannot be used as efficiently as the managed HOT lanes and because the HOV network is extended more slowly due to funding limitations.

The “Full Feature” HOT and “Rapid Delivery” HOT scenarios both result in lower travel times than the Pay-As-You-Go Carpool scenario. The “Full Feature” HOT and “Rapid Delivery” HOT scenarios have the same travel times in 2010, before any HOT lanes are open, and in 2050, after all HOT lanes are open. They differ, however, in the intermediate years where the accelerated implementation has lower travel times due to earlier opening of facilities. By 2050, the “Full Feature” HOT scenario is forecast to provide cumulative savings of 2.5 billion person hours of travel relative to the Pay-As-You-Go Carpool scenario. By implementing the “Rapid Delivery” HOT Scenario, an additional 795 million person hours of travel time can be saved, for a total savings of 3.4 billion person hours of travel relative to the Pay-As-You-Go Carpool scenario.

The *dollar value of the savings* of users of the regional network with each of these implementation strategies has also been estimated. The results are shown in Table 4 on the following page in terms of the “value of travel time saved”. The dollar amounts presented for each scenario in Table 4 are *escalated dollars* based on an assumed inflation rate of 3% as noted below.

Table 4: Value of Travel Time Savings 2010 through 2050

		Millions of Escalated Dollars			
		Annual			**Cumulative**
		In Year 2015	**In Year 2030**	**In Year 2050**	**2010 through 2050**
Compared to Carpool Pay-As-You-Go Network					
“Full Feature” HOT Network	Auto	$ 243	$ 1,913	$ 4,698	$ 79,350
	Truck	$ 54	$ 429	$ 1,055	$ 17,816
	Total	**$ 297**	**$ 2,342**	**$ 5,753**	**$ 97,166**
“Rapid Delivery” HOT Network	Auto	$ 805	$ 2,098	$ 4,693	$ 94,008
	Truck	$ 181	$ 471	$ 1,054	$ 21,107
	Total	**$ 986**	**$ 2,569**	**$ 5,746**	**$ 115,115**
Compared to “Full Feature” HOT Network					
“Rapid Delivery” HOT Network	Auto	$ 562	$ 185	None	$ 14,658
	Truck	$ 126	$42	None	$ 3,291
	Total	**$ 689**	**$ 227**	**None**	**$ 17,949**

Source: PB based on MTC model outputs and assumptions previously noted.

The “value of travel time saved” as presented in Table 4 has been estimated by applying the following assumptions:

- The savings in person hours traveled are taken from Table 3 for each scenario;
- For planning purposes only, and based on other MTC model forecasts, it was assumed that 90% of the total travel time savings could be attributable to passenger vehicle travel benefits. The remaining 10% would be attributable to truck-related travel savings;

- The value of time is assumed to be $13.45 per person hour traveled in constant (2006) dollars;[3]

- The value of "truck travel time savings" was estimated to be $31.26 per truck vehicle hour in constant (2006) dollars;[4]

- The per-passenger vehicle savings values and the truck vehicle VHT savings values have then been escalated by 3% per year to reflect an assumed annual inflation rate and applied to each of the horizon years – 2015, 2030 and 2050. These horizon years were developed from the original travel forecasts;

- The per hour "values" were then multiplied by the passenger vehicle savings and the truck vehicle savings for each horizon year to determine the "value of passenger-vehicle travel time savings" and "value of truck-vehicle travel time savings" respectively. These two values were then added together to provide an estimated total value of the travel time savings attributable to each scenario. As previously noted, all values are in escalated dollars for that horizon year;

As shown in Table 4, the value of the travel time saved increases with the more-aggressive implementation scenarios. Both HOT network scenarios show a substantial value of travel time savings over the Pay-As-You-Go Carpool scenario, and the "rapid delivery" HOT scenario also has benefits over the "full feature" HOT Scenario due to the more rapid accumulation of travel time savings.

[3] This per capita value is ½ the mean hourly wage rate taken from the March 2006 San Francisco-Oakland-San Jose, California National Compensation Survey (Bulletin 3135-33), published by the U.S. Department of Labor in January 2007.

[4] The amount $31.26 is derived from the latest Caltrans Cal-B/C (benefit cost) model.

Appendix 12: Analysis of Greenhouse Gas Emissions

To understand the potential benefits of the Regional HOT Network, and of faster implementation in particular, MTC compared projected greenhouse gas emissions under three scenarios: [1]

- **Carpool Pay-As-You-Go Network.** Complete the 800-mile network as a system of carpool lanes, funded principally through State Transportation Improvement Funds and local sales tax contributions. The implementation schedule is driven by available funding, and does not assume advances through Grant Anticipation Revenue Vehicles (GARVEE) or bond financing. Under this funding approach, the network could be completed in year 2050 at a capital cost of $8.8 billion (escalated). [2]

- **"Full Feature" HOT Network.** Complete the network as a system of HOT lanes based on the design and phasing described in Section I of this report. Under this approach the network could be completed by 2026 at a capital cost of $8.3 billion (escalated, does not reflect cost of debt service).

- **"Rapid Delivery" HOT Network.** Complete the network as a system of HOT lanes based on the design and phasing described above in Section II of this report. Under this approach the network could be completed as soon as 2016 at a capital cost of $3.7 billion (escalated, does not reflect cost of debt service).

MTC staff conducted a preliminary assessment of greenhouse gas emissions associated with each scenario using the following approach:

- The existing AM peak period travel forecasts for years 2015, 2030 and 2050 provided the basis for estimating AM peak hour greenhouse gas emissions. Emissions for intervening years were estimated based on straight line interpolation.

- MTC used emission factors from the California Air Resources Board (CARB) emissions model (EMFAC2007) for hour from 7 to 8 AM. The factors were adjusted per information provided by CARB to reflect fuel economy standards consistent with Phase I of the Pavley legislation (AB 1493). This assumes that by 2030, 75 percent of the overall Bay Area passenger fleet is consistent with either the short-term or mid-range technology included in AB 1493. Under Phase II of the Pavley legislation, which sets forth higher fuel efficiency standards, the total carbon dioxide emissions would be reduced under all

[1] As with other results presented in this report, estimates are based on a first-order analysis and should be considered preliminary. This analysis does not reflect, as more detailed forecasts in the future will, feedback between the travel demand and tolling models that would project changes in travel modes or routes. In addition, estimates of travel time and emissions presented here reflect travel only on that portion of the freeway system associated with the regional HOT network (approximately 800 directional miles). For example, travel on parallel arterials or freeways that do not have carpool or HOT lanes is not included in the totals. In effect, this approach holds vehicle miles of travel constant. Future, more detailed analysis will reflect feedback between the tolling and travel demand models; it will address impacts on mode of travel and vehicle miles traveled and will also revisit travel time and greenhouse gas emissions, as described under "Next Steps" below.

[2] Note that this is a different approach than in the comparison in Section 1 between a carpool network and HOT network. The analysis in Section I compares HOT and carpool systems assuming the same number of lane miles in both scenarios in any given year. This Section II analysis assumes the carpool system is built out more slowly so the number of lane miles in the carpool system is smaller than that in the HOT system in any given year. See Appendix 10.

scenarios. Further, the savings from the Regional HOT Network are likely to be smaller as due to smaller reductions in emissions with improved in travel speeds.

- AM peak hour emissions were expanded to daily estimates using a factor of 12.3 (based on San Francisco Bay Area Travel Survey (BATS) 2000 data) and to annual estimates using a factor of 352.7 (based on Freeway Performance Measurement System (PeMS) and BATS 2000 data).

In this analysis, carbon dioxide emissions are largely a function of travel speeds. By completing the network sooner, thereby expanding capacity and using existing lanes more efficiently, the Regional HOT Network improves congested travel speeds and reduces carbon dioxide emissions. Since carbon dioxide emissions are lowest at speeds of approximately 46 miles per hour, the biggest gains occur where the carpool or HOT lanes alleviate some but not all congestion.

Table 1 below shows the estimated carbon dioxide emissions associated with each scenario and Table 2 shows the differences between the scenarios. The "rapid delivery" scenario, which completes the network by 2016, is projected to have the lowest cumulative carbon dioxide emissions over the period between 2009 and 2050, while the carpool pay-as-you-go scenario, which completes the network by 2050 and may not maximize use of the carpool lane, is projected to have the highest emissions.

Table 1: Carbon Dioxide Emissions 2010 through 2050

	Carbon Dioxide Emissions (thousands of tons)				
	Annual				**Cumulative**
Scenario	**In Year 2010**	**In Year 2015**	**In Year 2030**	**In Year 2050**	**2010 through 2050**
Carpool Pay-As-You-Go Network	8,862	8,500	7,788	7,474	335,290
"Full Feature" HOT Network	8,862	8,500	7,415	7,176	325,647
"Rapid Delivery" HOT Network	8,809	8,460	7,415	7,176	325,029

Source: MTC forecast

Table 2: Savings in Carbon Dioxide Emissions 2010 through 2050

	Millions of Person Hours of Travel				
	Annual				**Cumulative**
	In Year 2010	**In Year 2015**	**In Year 2030**	**In Year 2050**	**2010 through 2050**
Compared to Carpool Pay-As-You-Go Network					
"Full Feature" HOT Network	0	0	372	298	9,643
"Rapid Delivery" HOT Network	53	40	372	298	10,261
Compared to "Full Feature" HOT Network					
"Rapid Delivery" HOT Network	53	40	0	0	617

Note: Numbers may not total due to rounding

Source: MTC forecast

Emissions savings are projected to grow rapidly between 2015 and 2030, when the carpool network would be expanding very slowly but the HOT Network would be complete (under the “rapid delivery” approach) or expanding quickly (under the “full feature” approach). After 2030, emissions savings are projected to decline as the fleet becomes significantly more fuel efficient.

Attachment G: Unit Costs for “Rapid Delivery” HOT Network Approach

MTC UNIT COST COMPARISON FOR HOT LANE NETWORK - Conversion, Low, Medium, and High Range Costs Per Lane Mile

	Converted HOV to HOT Lanes[1]		Added HOT Lanes/Low Cost[2]		Added HOT Lanes/Medium Cost to inside[3]		Medium Cost-widening includes to outside[4]		High Cost[5]	
Item	Lane Mile Cost	Comments/Assumptions	Lane Mile Cost	Comments/Assumptions	Lane Mile Cost	Comments/Assumptions	Lane Mile Cost	Comments/Assumptions	Lane Mile Cost	Comments/Assumptions
Roadway Excavation			$ 220,000		$ 150,000		$ 135,000		$ 135,000	
Aggregate Base			$ 420,000		$ 300,000		$ 265,000		$ 265,000	
Asphalt Concrete			$ 640,000		$ 450,000		$ 400,000		$ 400,000	
Drainage Modifications			$ 65,000		$ 65,000	Inlet modifications	$ 65,000	Inlet modifications	$ 65,000	Inlet modifications etc. along shoulder
Metal Beam Guardrailing							$ 42,000	Replace 25% per lane mile	$ 42,000	Replace 25% per lane mile
Concrete Barrier[5]	$ -		$ 175,000	Remove/Replace	$ 175,000	Remove/Replace				
Temporary K-rail			$ 22,500	0.25 mile of placement per mile	$ 22,500	0.25 mile of placement per mile	$ 45,000	0.5 mile of placement per mile	$ 45,000	0.5 mile of placement per mile
Temporary Striping	$ -		$ 2,000		$ 4,000		$ 5,000		$ 5,000	
Remove Striping			$ 3,000		$ 8,000		$ 10,000		$ 10,000	
Permanent Striping	$ -				$ 16,000		$ 20,000		$ 20,000	
Traffic Markings for HOT lanes	$ 3,000		$ 3,000		$ 3,000		$ 3,000		$ 3,000	
HOT Lane Striping	$ 15,000		$ 15,000		$ 15,000		$ 15,000		$ 15,000	
Enforcement Area	$ 40,000	Use of median shoulder every 4 miles	$ 40,000	Use of median shoulder every 4 miles	$ 40,000	Use of median shoulder every 4 miles	$ 40,000	Use of median shoulder every 4 miles		Assume no room for enforcement areas
Misc.Sign Allowance	$ 10,000	Small signs posted on median barrier	$ 10,000	Small signs posted on median barrier	$ 10,000	Small signs posted on median barrier	$ 10,000	Small signs posted on median barrier	$ 10,000	Small signs posted on median barrier
Guide Sign Allowance	$ 22,500	3 prior to start of each HOT every 10 miles	$ 22,500	3 prior to start of each HOT every 10 Miles	$ 22,500	3 prior to start of each HOT every 10 Miles	$ 22,500	3 prior to start of each HOT every 10 Miles	$ 22,500	3 prior to start of each HOT every 10 miles
CMS/VMS	$ 37,500	1 per 4 lane mile @ 150,000 ea.	$ 37,500	1 per 4 lane miles @ 150,000 ea.	$ 37,500	1 per 4 lane miles @ 150,000 ea.	$ 37,500	1 per 4 lane miles @ 150,000 ea.	$ 37,500	1 per 4 lane miles @ 150,000 ea.
Utility Relocation Allowance							$ 40,000		$ 40,000	
Sign Relocation/Adjustment Allowance							$ 30,000		$ 30,000	
Structure Modification	$ -		$ -	None Assumed	$ 1,000,000	$500/sq.ft due to addition of substructure, assume 2000 sq ft widening/mile	$ 1,250,000	$500/sq.ft due to addition of substructure, assume 2500 sq ft widening/mile	$ 1,250,000	$500/sq.ft due to addition of substructure, assume 2500 sq ft widening/mile
Sound Walls	$ -		$ -	None Assumed	$ -	None Assumed	$ 2,300,000	70% of corridor	$ 2,300,000	70% of corridor
Retaining Walls							$ 50,000	Assume 500 sq ft/mile	$ 50,000	Assume 500 sq ft/mile
ITS Elements	$ 400,000		$ 400,000		$ 400,000		$ 400,000		$ 400,000	
Sub-total	**$ 528,000**		**$ 2,075,500**		**$ 2,718,500**		**$ 5,185,000**		**$ 5,145,000**	
Mobilization 10%	$ 52,800		$ 207,550		$ 271,850		$ 518,500		$ 514,500	
Contingency	$ 116,160	Assume 20%	$ 684,915	Assume 30%	$ 897,105	Assume 30%	$ 1,711,050	Assume 30%	$ 2,263,800	40% Contingency; greater uncertainty with ROW acquisition and structure replacement
Total	**$ 696,960**		**$ 2,967,965**		**$ 3,887,455**		**$ 7,414,550**		**$ 7,923,300**	
Traffic Management	$ 69,696	Assume 10% of total	$ 296,797	Assume 10% of total	$ 388,746	Assume 10% of total	$ 519,019	Assume 7% of total	$ 554,631	Assume 7% of total
BMP/Erosion Control	$ 6,970	Assume 1% of total	$ 59,359	Assume 2% of total	$ 77,749	Assume 2% of total	$ 148,291	Assume 2% of total	$ 158,466	Assume 2% of total
Design and Construction Management	$ 139,392	Assume 20% of total	$ 593,593	Assume 20% of total	$ 777,491	Assume 20% of total	$ 1,482,910	Assume 20% of total	$ 1,584,660	Assume 20% of total
Contingency	$ 181,210	Assume 20%	$ 771,671	Assume 20%	$ 1,010,738	Assume 20%	$ 1,883,296	Assume 20%	$ 2,012,518	Assume 20%
Grand Total	**$ 1,094,000**		**$ 4,689,000**		**$ 6,142,000**		**$ 11,448,000**		**$ 12,234,000**	

[1] Assumes no additional pavement or structure widening required, no buffer is accounted for between HOT lane and GP Lanes
[2] Assumes 12' lane, 10' shoulder, 4' buffer (total widening 27')
[3] Assumes 12' lane, 2' shoulder, 4' buffer (total widening 19')
[4] Assumes 12' lane, 2' shoulder, 4' buffer, general purpose lanes reduced to 11' (total widening 17')
[5] 50% of Cost, Assumes companion side will include other 50%
Costs of environmental mitigation not included.