APPENDIX E

MODEL METHODOLOGY

Model System

The existing YVCOG Urban Area Model was one of the tools used in the analysis of the Transportation Improvements in the M/RTP. The model, which covers the MPO boundary, is a PM Peak hour model. The model system is currently configured to forecast vehicle demand only.

Network

The existing YVCOG Urban Area model area is shown in Figure 1.

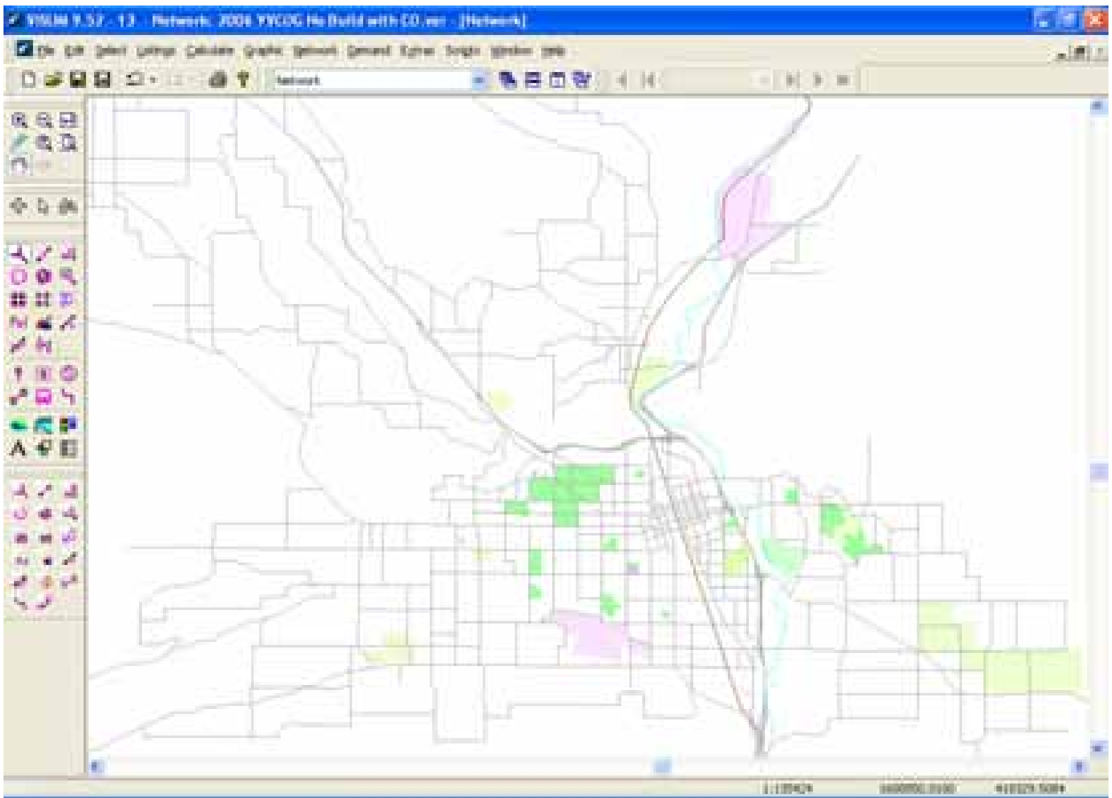

Figure 1. YVCOG Urban Area Model Area

The model contains a fairly extensive network for the urban area. There are 383 zones, 1689 nodes and 4104 links in the model. The links include facilities down to the collector level; local streets are not included. A summary of the link types and their base capacities are shown in Table 1.

Table 1. Link Types

Type #	Base Capacity (per lane)	Number of Links	Description
10	2000	150	Freeway
20	1600	195	Ramps
30	1800	203	Multi-Lane Highway
40	1600	176	Arterial Class I
50	1400	862	Arterial Class II
60	1200	562	Arterial Class III
70	1000	354	Arterial Class IV
80	800	774	Collector
90	1600	828	Rural Two-Lane Highway

The model also contains node capacity as well. The node capacity is based upon the incoming link capacity and an assumption of the green time for a signalized intersection or the amount of stop time for a two or four way stop.

The entire model process of Trip Generation, Distribution and Trip Assignment takes place in one software platform. As such, all land use inputs are contained within the model for ease of review and presentation. Since the model only predicts vehicle trips, there is no Mode Choice component in the model.

Trip Generation

Trip Generation is the model step that takes the land use inputs and creates the trip ends that are eventually assigned to the model network as vehicle trips. The results of Trip Generation are total productions and attractions for each zone in the network. These values are stored in attributes on each zone in the model file.

Trips are stratified by five trip purposes for the PM Peak Hour:
1. Home to Work
2. Work to Home
3. Home to Other
4. Other to Home
5. Non-Home Based

Trip Generation uses several land use categories along with trip generation rates to calculate the overall Productions and Attractions for each zone by trip purpose. Each value of the land use category is multiplied by its corresponding trip rate to create either a production or an attraction. The trip rates do not change amongst the model forecast years and are shown by trip purpose below.

Table 2. Home Based Work Trip Rates

Model Attribute	Home to Work Production Rate	Home to Work Attraction Rate	Work to Home Production Rate	Work to Home Attraction Rate
Single Family Units	0.0520	0.0000	0.0000	0.3050
Multi-Family Units <=4	0.0400	0.0000	0.0000	0.2530
Multi-Family Units >4	0.0320	0.0000	0.0000	0.2070
Industrial	0.0000	0.0180	0.1130	0.0000
Retail	0.0000	0.1210	0.5670	0.0000
Services	0.0000	0.0150	0.2040	0.0000
Public Use	0.0000	0.0220	0.1710	0.0000
Agriculture	0.0000	0.0110	0.1130	0.0000
School Administration	0.0000	0.0000	0.0040	0.0000
Elementary School	0.0000	0.0110	0.0390	0.0000
High School	0.0000	0.0090	0.0390	0.0000
Community College	0.0000	0.0100	0.0230	0.0000
Park & Rides	0.0000	0.0140	0.4300	0.0000
External to Internal	0.0500	0.0000	0.4000	0.0000
Internal to External	0.0000	0.0500	0.0000	0.4000

Table 3. Home Based Other Trip Rates

Model Attribute	Home to Other Production Rate	Home to Other Attraction Rate	Other to Home Production Rate	Other to Home Attraction Rate
Single Family Units	0.2330	0.0000	0.0000	0.2300
Multi-Family Units <= 4	0.1810	0.0000	0.0000	0.1870
Multi-Family Units >4	0.1420	0.0000	0.0000	0.1530
Industrial	0.0000	0.0360	0.0530	0.0000
Retail	0.0000	0.7080	0.6240	0.0000
Services	0.0000	0.0440	0.1000	0.0000
Public Use	0.0000	0.0630	0.0840	0.0000
Agriculture	0.0000	0.0300	0.0560	0.0000
School Administration	0.0000	0.0010	0.0020	0.0000
Elementary School	0.0000	0.0320	0.0180	0.0000
High School	0.0000	0.0260	0.0180	0.0000
Community College	0.0000	0.0310	0.0100	0.0000
Park & Rides	0.0000	0.0000	0.0000	0.0000
External to Internal	0.1200	0.0000	0.1400	0.0000
Internal to External	0.0000	0.1200	0.0000	0.1400

Table 4. Non-Home Based Trip Rates

Model Attribute	Non-Home Based Production Rate	Non-Home Based Attraction Rate
Single Family Units	0.0390	0.0400
Multi-Family Units <=4	0.0300	0.0280
Multi-Family Units >4	0.0240	0.0230
Industrial	0.0440	0.0360
Retail	0.6990	0.7810
Services	0.0960	0.0410
Public Use	0.0810	0.0590
Agriculture	0.0560	0.0340
School Administration	0.0010	0.0010
Elementary School	0.0140	0.0280
High School	0.0140	0.0230
Community College	0.0080	0.0270
Park & Rides	0.0480	0.1280
External to Internal	0.2900	0.0000
Internal to External	0.0000	0.2900

Trip Productions and Attractions for each zone are the result of Trip Generation. Productions and attractions are then linked together in Trip Distribution to create the overall zone to zone travel demand by trip purpose.

Trip Distribution

Trip Distribution is performed using a Gravity Model formulation with the zone to zone travel times on the highway network as the measure of impedance between zones. In much the same way that gravity works, two zones are attracted to each other based upon their size (in this case a production and attraction by purpose) with the travel time between the zones being the pull of gravity between the two. Trip Distribution takes the trip ends from Trip Generation and creates zone to zone travel demand by trip purpose. In this process, each production is matched to an attraction. The gravity model equation is:

$$f(u) = \frac{1}{u^b + cu^a}$$

The parameters for the trip distribution function by trip purpose are shown in Table 5.

Table 5. Trip Distribution Parameters

	Trip Distribution Parameters		
Trip Purpose	alpha (a)	beta (b)	constant (c)
Home to Work	-0.5	1.9	25
Work to Home	-0.5	1.9	25
Home to Other	-0.5	2.8	25
Other to Home	-0.5	2.8	25
Non-Home Based	-0.5	2.7	25

The results of Trip Distribution are matrices of zone to zone travel demand by the five trip purposes.

Highway Assignment

Trip tables, which have total zone to zone travel demand, are assigned to the model links and nodes to calculate the travel time and volumes on every link, node and turn in the network. The routes that trips use to get from one zone to another zone are calculated using a multi-equilibrium assignment process.

The calculation of the travel time on a link uses a volume delay function (VDF). The volume delay function can vary by link type. In the YVCOG model, freeways and ramps use one VDF and arterials and collectors use another. The basic formulations of the link volume delay functions in the YVCOG model are:

For Sat <= Critical Sat

$$t_{cur} = (t_0 + a) * (1 + d * (sat + f)^b)$$

			Less than SatCrit		
Link Type	a	b	d	f	SatCrit
Freeway & Ramps	0	4	0.25	0.15	0.85
Arterials	0	4	0.25	0.25	0.75
Collectors	0	4	0.25	0.25	0.75

For Sat > Critical Sat

$$t_{cur} = (t_0 + a') * (1 + d' * (sat + f')^{b'})$$

			Greater than SatCrit		
Link Type	a'	b'	d'	f'	SatCrit
Freeway & Ramps	0	10	0.25	0.15	0.85
Arterials	0	10	0.25	0.25	0.75
Collectors	0	10	0.25	0.25	0.75

The YVCOG model also implements node volume delay functions as well. These functions, which are identical in function to the link functions, add delay to the intersection based on the incoming volume and capacity of the intersection. The parameters in the node volume delay functions are shown below.

For Sat <= Critical Sat

	Less than SatCrit				
Node Type	a	b	d	f	SatCrit
Merge	0	3.8	30	0.15	0.85
All Way Stop	3	3.6	30	0.20	0.80
2-Way Stop	3	3.6	30	0.20	0.80
Railroad Crossing	6	3.6	30	0.20	0.80
Signal	1.2	3.6	30	0.20	0.80

For Sat > Critical Sat

	Greater than SatCrit				
Node Type	a'	b'	d'	f'	SatCrit
Merge	0	5.8	30	0.15	0.85
All Way Stop	3	5.8	30	0.20	0.80
2-Way Stop	6	6	30	0.20	0.80
Railroad Crossing	9	6	30	0.20	0.80
Signal	1.2	5	30	0.20	0.80

By including delays at nodes, the model is better able to replicate travel delay experienced by users in a corridor.

Multi-Point Assignment (MPA)

The YVCOG model also implements the Multi-Point Assignment (MPA) technique first developed in the TModel software. The MPA technique allows a user to set the percentage of demand that should use each connector leaving a zone. The effect of MPA is very similar to splitting zones. In fact, the 379 zones in the model become over 1170 "equivalent" zones once the MPA technique is used. By setting proper connector shares, the routes into zones are more representative of real world conditions and in turn both link and turn movement count validation is improved.

Level of Service Analysis with Traffix

Intersection detail for signalized intersections in the YVCOG model was added to the model network to enable the Level of Service calculations to be performed directly in the model stream. The inputs, which included turn pockets and lengths, were added for 110 intersections in the model area. An example of the lane inputs is shown in Figure 2.

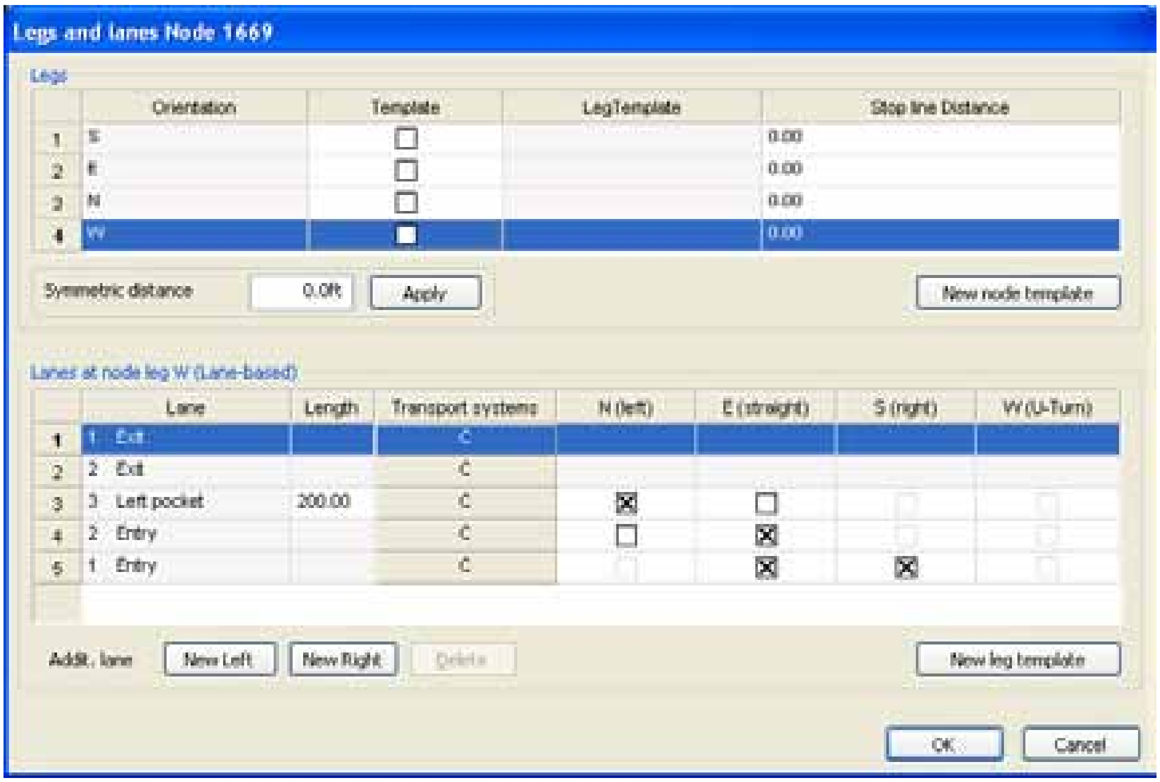

Figure 2. Intersection Lane Configuration

Along with the intersection geometry, the existing signal timings were also added to the model. By having both the timings and lane configurations, Level of Service calculations could be calculated for all the signalized intersections directly after any model scenario run. An example of the signal timing inputs are shown in Figure 3.

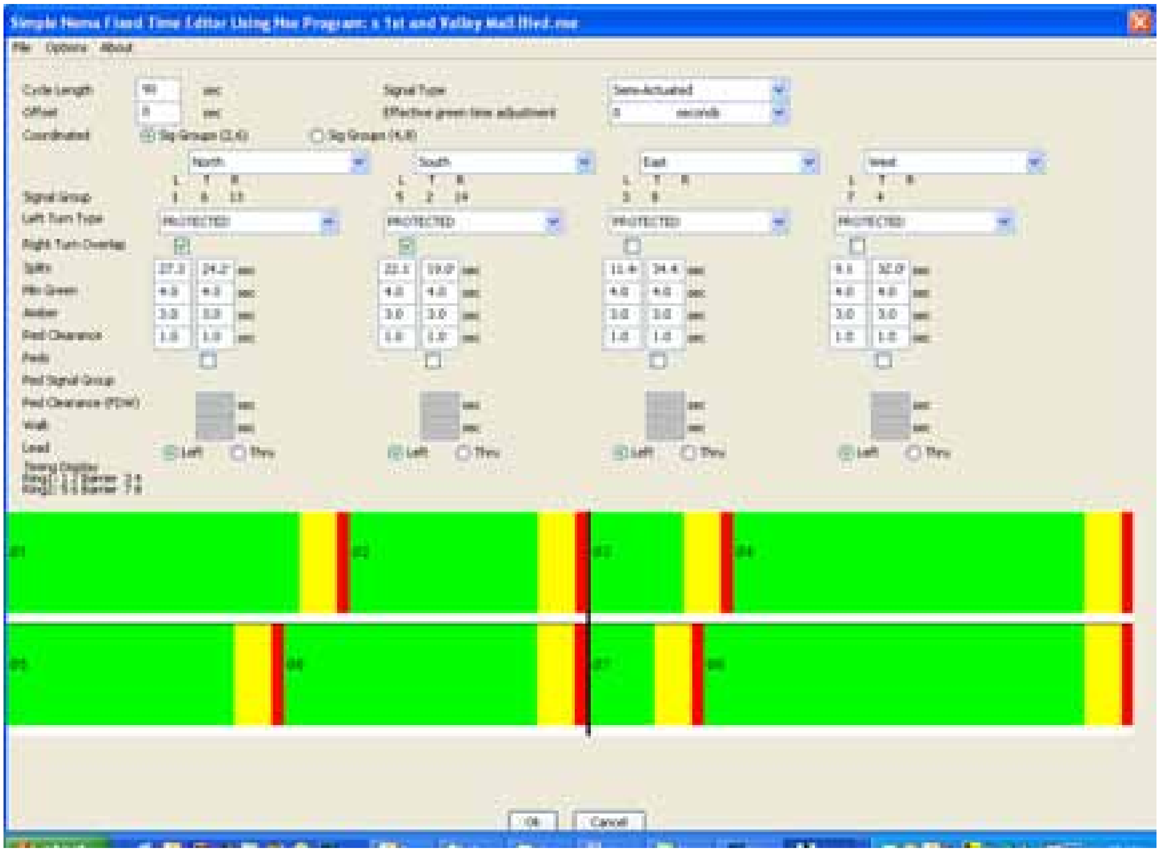

Figure 3. NEMA Editor Signal Timings

This Level of Service calculation was combined with basic link level statistics to help the Project Team develop and analyze the performance of the various model scenario packages. In all future scenarios, the signal timings were automatically optimized in the software.

Model Update and Validation Statistics

The previous model had last been updated for a 2003 base year. For purposes of the YVCOG M/RTP update, the model was updated to a 2006 Base Year with land use inputs and traffic counts. The model was then re-validated to the new counts. This validation effort consisted of refinements to the multi-point assignment weights on some connectors. Table 6 shows the overall model validation results.

Table 6. Model Validation Statistics

Class	# of Counts	RMSE	R2	Slope	Functional Classification
1	41	0.16	0.97	1.11	Freeway & Ramps
2	95	0.24	0.90	0.88	Arterials
3	87	0.36	0.89	1.02	Collectors
Total	223	0.24	0.95	1.00	All Facilities

According to Transportation Model Improvement Program (TMIP) Guidelines produced by FHWA, a travel demand model should have an overall R^2 of 0.88, an RMSE of 30 or less and a slope as close to 1.0 as possible. As seen in Table 6, the YVCOG Urban area model meets these guidelines and as such is considered a validated travel demand model. Figure 4 is a Scattergram of the link volumes versus the link counts which also shows the correlation of the model to the traffic counts. The orange bars show the bandwidth for the desired variation of the counts and the model.

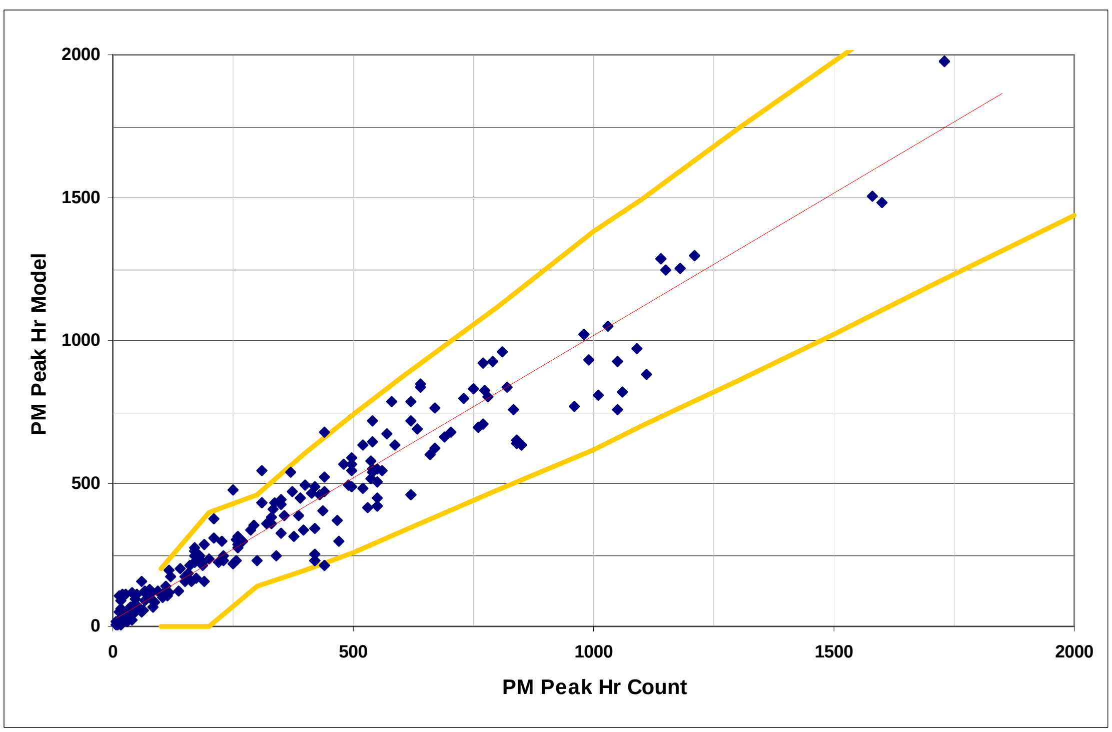

Figure 4 2006 Model Validation Link Scattergram