Travel Demand Model
2006 Update

TransCAD Model Results

Travel Model Run Procedures for FY2007

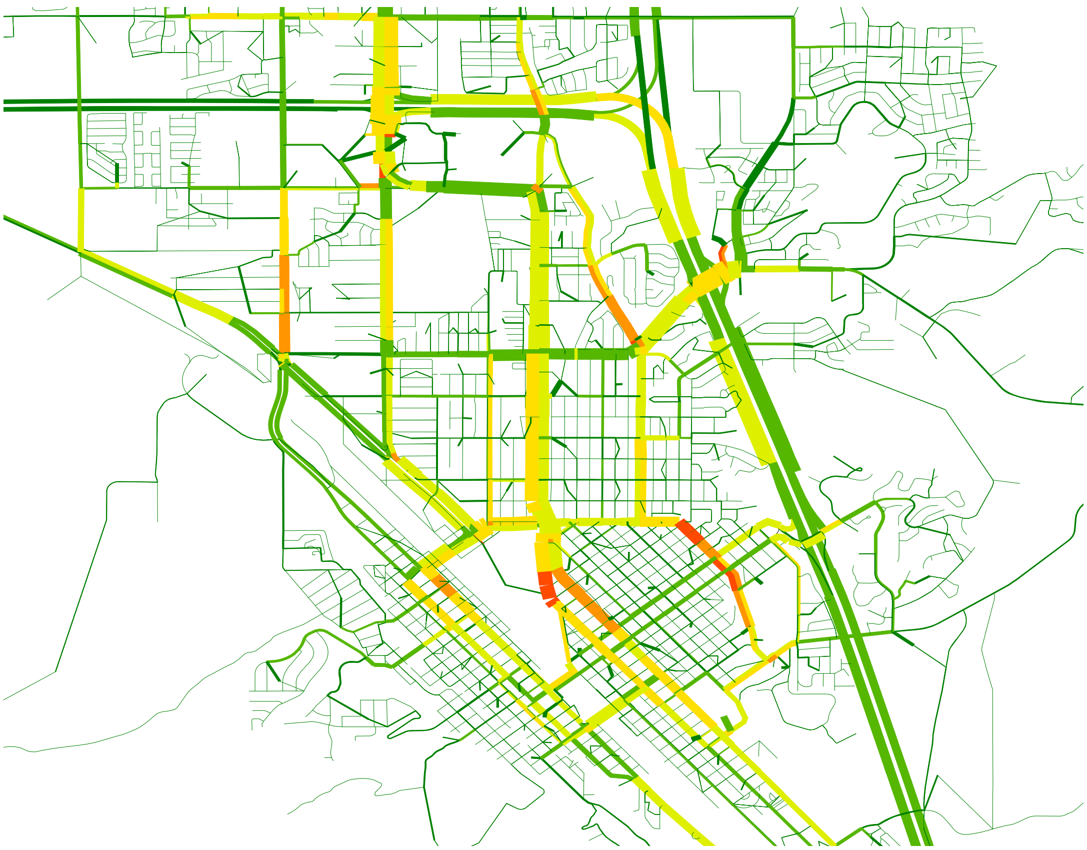

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Table of Contents

List of Figures

List of Tables

Travel Demand Model Update

Bannock Planning Organization's (BPO) planning area encompasses the communities of Pocatello and Chubbuck, Idaho. These communities along with parts of Bannock County comprise a small-sized urban region of 77,000 people. TransCAD is the software used for the region's travel demand modeling. The initial model was developed in 1997 by the University of North Carolina at Charlotte. Three major updates have taken place since 1997 including: 1998 update which included demographic changes and modification to gamma function; and 2002 update by BWR which replace the existing center line file with geographically correct centerlines, and automated the modeling process.

This update's primary purposes are: 1) Update the demographic data for 2035; 2) Modify the Traffic Analysis Zone (TAZ) structure; and 3) Continue development of peak hour model.

Network

The connectivity of all links were checked and corrected. All links are functionally classified as follows:

- Freeway
- Principal Arterial
- Minor Arterial
- Collector
- Local Road
- Centroid Connector

Table 1 lists the stable structure of the network file. Some of the data listed in Table 1 are for modeling and the remainder are primary basic geographic features that help us manage and plan for the transportation needs in the community.

According to the above functional classification and number of lanes contained in the network, free flow speeds and capacities were determined and added to each link. Figure 1 shows the road network and classification.

Traffic Analysis Zones

The road network is critical for the modeling of travel within the urban area. The other critical component are the Traffic Analysis Zones (TAZ). A Traffic Analysis Zone is the unit of geography most commonly used in conventional transportation planning models. The size of a zone varies, but typically made up of census blocks. The spatial extent of zones typically varies in models, ranging from very large areas in the exurbs to as small as city blocks or buildings in central business districts. In this update the TAZs were divided from the 2002 models; 198 zones to the current 323. The reason was to create better traffic flow by having smaller zones in the central area.

Table 1: Attribute Structure of Network

FIELD_NAME	TYPE	WIDTH	DECIMAL	DESCRIPTION
ID	Integer (4 bytes)	10	0	Unique Index
Length	Real (8 bytes)	10	2	Link length in miles
Dir	Integer (2 bytes)	2	0	Direction of travel 0 = both AB and BA Direction 1 = travel in AB direction -1 = travel in BA direction
Prefix	Character	10	0	Street Prefix (ex. E,N, S, W)
CName	Character	35	0	Address Match Name
FName	Character	25	0	Street Name
FDSUF	Character	2	0	Suffix item of a street
FTYPE	Character	4	0	Street Type (ex. Ln, Dr, Ave)
Start Left	Integer (4 bytes)	10	0	Street address left beginning
Start Right	Integer (4 bytes)	10	0	Street Address Right Beginning
End Left	Integer (4 bytes)	10	0	Street Address Left End
End Right	Integer (4 bytes)	10	0	Street Address Right End
left zip	Integer (4 bytes)	8	0	ZIP code left side of street
Right zip	Integer (4 bytes)	8	0	ZIP code right side of street
Parity	Integer (4 bytes)	10	0	Parity is location of address 0 = address on both side of street 1 or -1 is all address on right or left side
ROADWIDTH	Real (8 bytes)	9	2	Road width
ROW	Integer (4 bytes)	10	0	ROW
Functional Class	Character	18	0	Classification of road
MSP Class	Character	18	0	BPO' Master Street Plan Classification
Ln_type	Integer (4 bytes)	5	0	Road functional classification Values 1-9. 1=Rural Principal Arterial; 2=urban Principal Arterial; 3=Rural Interstate; 4=Urban Interstate; 5=Rural Minor Arterial; 6=Urban Minor Arterial; 7 Centroid Connector;8=Collector; 9=Local
LANES_QUAN	Integer (4 bytes)	8	0	Numberof through lanes
Left_Turn_Lane	Integer (4 bytes)	6	0	Left turn lane
Lane/1way	Integer (4 bytes)	5	0	number of lanes per one way
URBAN_AREA	Integer (4 bytes)	8	0	1 indicates link is in urban area
Speed 00 AB	Integer (4 bytes)	10	0	Assigned Link Speed AB Direction
Speed 00 BA	Integer (4 bytes)	12	0	Assigned Link Speed BA Direction
SPEED_LIMI	Integer (4 bytes)	12	0	Posted speed limit
AB_Time	Real (8 bytes)	10	2	free-flow time for 2006 model (AB direction)
BA_Time	Real (8 bytes)	10	2	free-flow time for 2006 model (BA direction)
AB_Hourly_Capacity	Integer (4 bytes)	10	0	Peak-hour capacity (AB direction)
BA_Hourly_Capacity	Integer (4 bytes)	10	0	Peak-hour capacityl (BA direction)
AB_Capacity	Integer (4 bytes)	10	0	Daily capacity (AB direction)
BA_Capacity	Integer (4 bytes)	10	0	Daily capacity (BA direction)
Alpha	Real (8 bytes)	10	2	assignment parameter .15
Beta	Real (8 bytes)	10	2	assignment parameter 4.0 except Interstate
ONEWAY_DIR	Character	10	0	Direction of owe-way road
est06VMT	Integer (4 bytes)	10	0	Estimated VMT for 2006
EST06AB	Integer (4 bytes)	10	0	Estimate traffic count 2006 AB Direction
EST06BA	Integer (4 bytes)	10	0	Estimated Traffic Count 2006 BA Direction
EETADT06	Integer (4 bytes)	10	0	Estimated Traffic Count both directions
Agency	Integer (4 bytes)	8	0	Owner of Road 1= Pocatello, 2 = Chubbuck , 3 = Bannock County, 4 = ITD
Parking_Left	Integer (4 bytes)	10	0	Parking Allowed Left Side
Parking_RIght	Integer (4 bytes)	10	0	Parking Allowed Right Side
Model07_AB	Integer (4 bytes)	10	0	Daily Model Assignment AB direction
Model07_BA	Integer (4 bytes)	10	0	Daily Model Assignment BA direction
Model07	Integer (4 bytes)	10	0	Daily model assignment
VMT07	Integer (4 bytes)	10	0	Assigned VMT
VCAB_07	Real (8 bytes)	10	2	Volume to Capity Ratio AB Direction
VCBA_07	Real (8 bytes)	10	2	Volume to Capacity Ratio BA Direction
PerdifAB	Real (8 bytes)	10	2	Percent Dev = (Base Year Assignment - Base year Count)/ Base Year Count
PerdifBA	Real (8 bytes)	10	2	Percent Dev = (Base Year Assignment - Base year Count)/ Base Year Count
Perdiff	Real (8 bytes)	10	2	Percent Dev = (Base Year Assignment - Base year Count)/ Base Year Count
AB06_AM	Integer (4 bytes)	10	0	Traffic Count AM peak AB direction
BA06_AM	Integer (4 bytes)	10	0	Traffic Count AM peak BA Direction
AB06_PM	Integer (4 bytes)	10	0	Traffic Count PM peak AB Direction
BA06_PM	Integer (4 bytes)	10	0	Traffic Count PM peak BA Direction
ABass_AM	Integer (4 bytes)	10	0	Assigned AM peak AB direction
BAass_AM	Integer (4 bytes)	10	0	Assigned AM peak BA direction
ABass_PM	Integer (4 bytes)	10	0	Assigned PM peak AB direction
BAass_PM	Integer (4 bytes)	10	0	Assigned PM peak BA direction
AB_AM_per	Real (4 bytes)	10	3	Percent Dev = (Base Year Assignment - Base year Count)/ Base Year Count
BA_AM_per	Real (4 bytes)	10	2	Percent Dev = (Base Year Assignment - Base year Count)/ Base Year Count
AB_PM_per	Real (4 bytes)	10	2	Percent Dev = (Base Year Assignment - Base year Count)/ Base Year Count
BA_PM_per	Real (4 bytes)	10	2	Percent Dev = (Base Year Assignment - Base year Count)/ Base Year Count
AB_PM_VC	Real (8 bytes)	10	2	Volume to Capity Ratio AB Direction PM Peak
BA_PM_VC	Real (8 bytes)	10	2	Volume to Capity Ratio BA Direction PM Peak

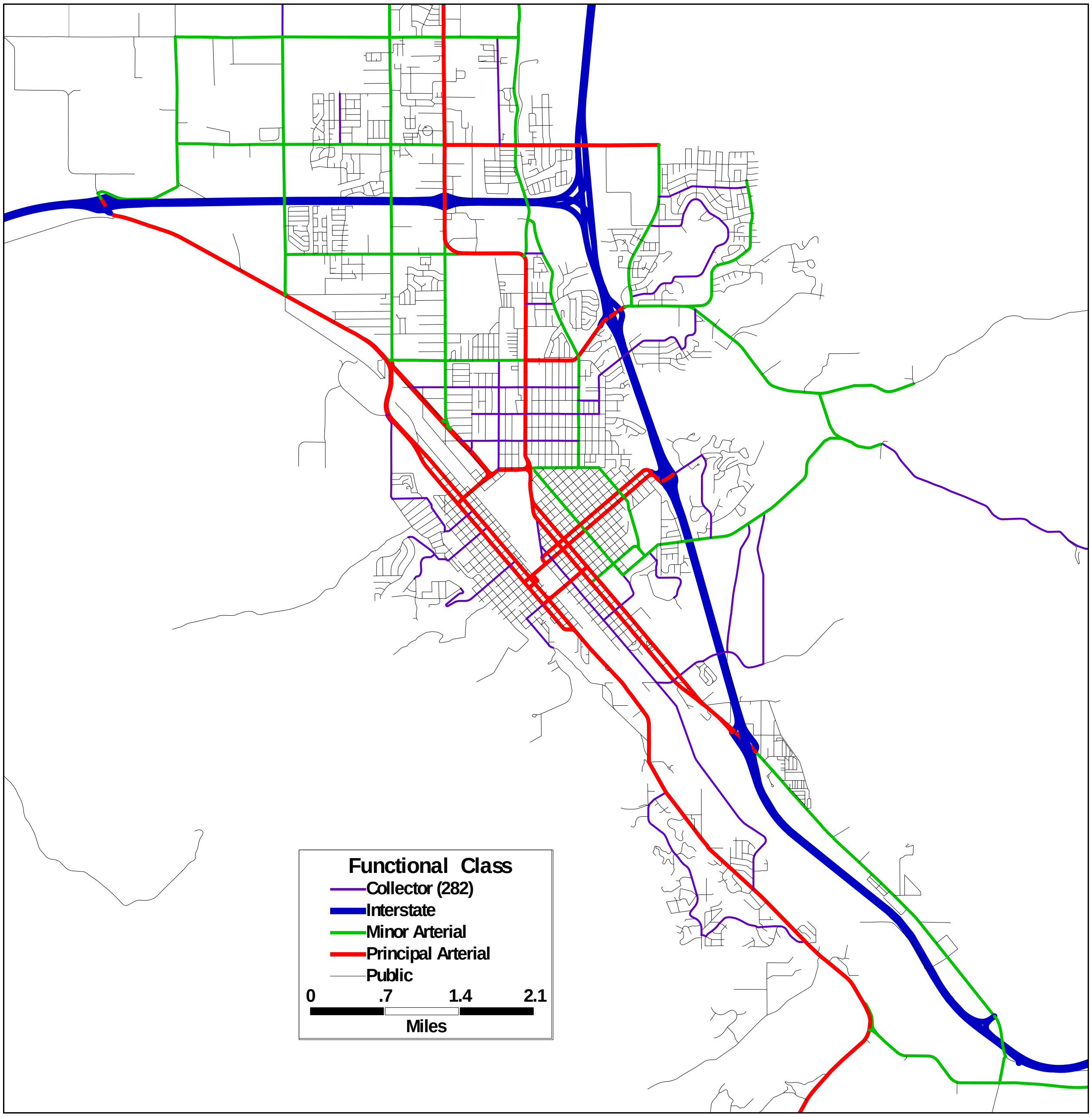

Figure 1: Model Network

Figure 2 shows the boundaries of the 2006 Traffic Analysis Zones.

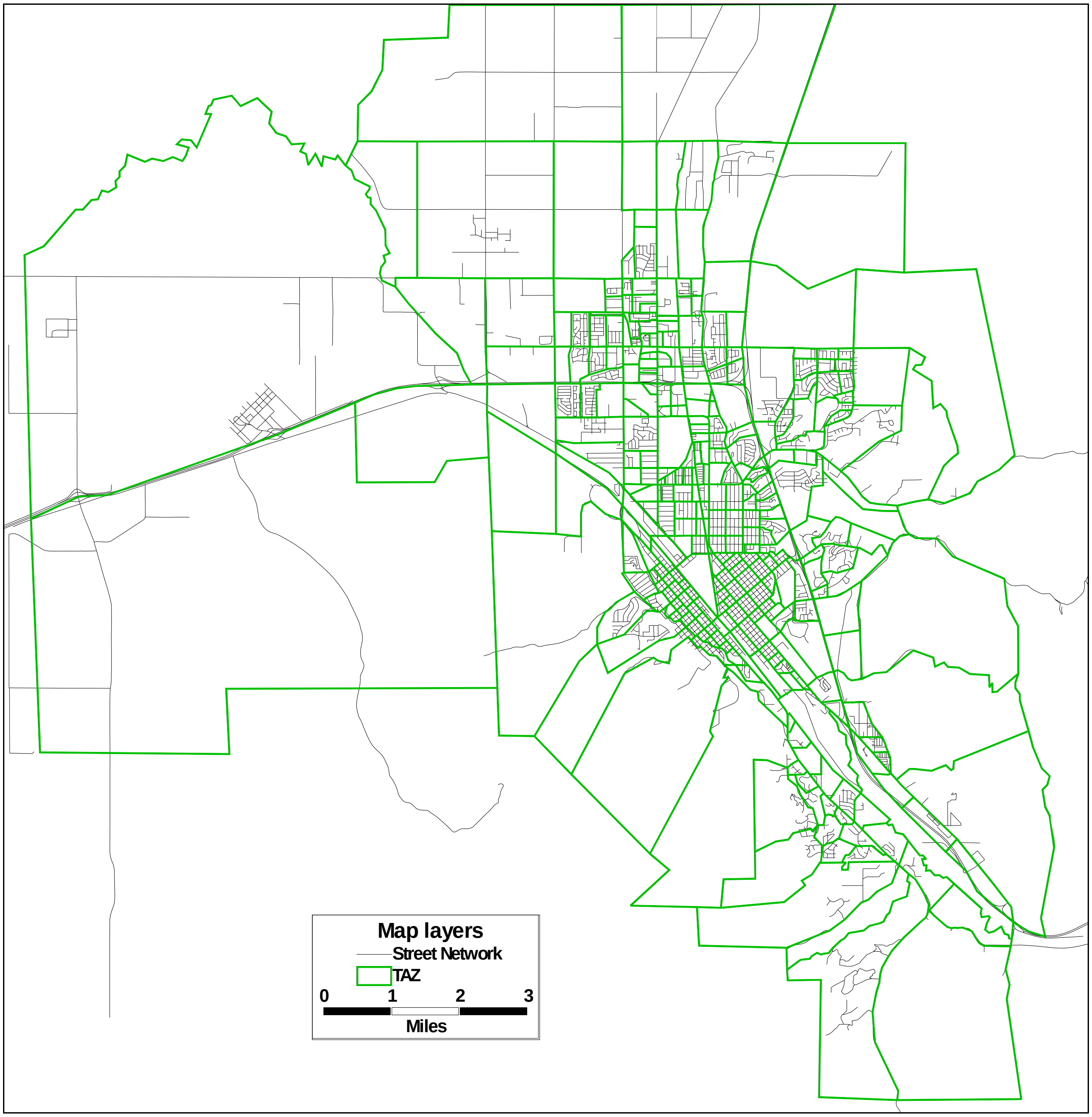

Figure 2: Traffic Analysis Zones

Traffic Counts

An important feature in transportation planning is Average Annual Daily Traffic (AADT). BPO has an extensive historical traffic counting file which is updated annually. These counts are used in the validation stage of the model update process. In addition Idaho Transportation Department maintains 17 permanent traffic counters throughout the urban area. These historic files are used to establish an estimated AADT for each link of a collector and above. The actual year count or growth rate established by the permanent traffic counters and locations with multiyear counts are used to grow the existing conditions. 136 links were counted in 2006.

Peak hour counts are also used in the validation process for the peak hour model. The AM peak 07:00 to 08:00 and PM peak 17:00 to 18:00 are the two time periods of interest.

Daily Model Approaches and Results

Basic Approach

Traditional travel demand modeling uses a four-step process. The steps are trip generation, trip distribution, mode split, and traffic assignment. The trip generation step produces estimates of the trip productions and trip attractions for each TAZ in the planning area. The trip distribution links the trip productions and attractions for each pair of TAZs in the planning area. Mode choice splits the trips by available transportation modes between each TAZ pair. In the BPO model only vehicle mode is used. The assignment step loads trips onto the network. In other words, the trip assignment selects paths from origins to destinations and loads trips onto the corresponding selected paths.

Trip generation is functionally related to land use as well as some socioeconomic factors described in terms of the character, intensity and location of activities. The inputs to the trip generation are population, dwelling units, and employment. The outputs are the trip production and attraction by trip purposes. The BPO model employs the quick respond method for estimating trip attractions while each TAZ has a set of trip production rates from a travel survey conducted several year ago. Balancing of total productions and attractions is required for each trip purpose.

Estimation of external trips is an important step in the modeling process. The inputs to this step are the ADT at all external stations, population of the planning area, and the connectivity between each external station pair. The outputs are the through trip matrix and the Internal-External and External-Internal (IE_EE) trips for all external stations.

The inputs to trip distribution are the time distance between each TAZ pair, the balanced production and attraction table and distribution parameters that can be obtained from a travel survey or other studies for the area. The time distance between each TAZ pair can be measured and calculated from the shortest path linking the TAZ pair. After the P-A trip matrix is obtained; it needs to be converted into the origin-destination trip matrix. TransCAD software provides the functionality to perform this conversion.

Before the assignment, it is necessary to combine the through trip matrix with the trip matrix from the distribution. The link attributes such as capacity and travel time should be well prepared. Once this is accomplished, the vehicles trips are loaded onto the network using route choice principles.

Trip Purpose Classification and Generation

Trip purposes are categorized as home-based-work (HBW), home-based-other (HBO), and non-home-based (NHB). For trip production, the following equations are used. The output of these equations is the production of vehicle trips. Trip production by purpose is: HBW = 21%, HBO = 56% and NHB = 23% - these are national average percentages. These proportions are then multiplied by zone-specific total trip rates (from travel survey) and total households. Total productions are equal to the sum of the three categories:

$$TotalProductions = HBWP + HBWO + NHB \quad (1)$$
$$HBWProductions = (DU) * (TripRate) * (0.21) \quad (2)$$
$$HBOProductions = (DU) * (TripRate) * (0.56) \quad (3)$$
$$NHBProductions = (DU) * (TripRate) * (0.23) \quad (4)$$

Where:

DU = Dwelling units

Trip Rate = Trip rate calculated form household survey

For trip attraction, the estimation uses the general equations listed in the NCHRP Report 187. Attractions are based on retail and non-retail employment and dwelling units. The outputs of these equations are the attractions of vehicle trips.

The total attractions are equal to the sum of the three categories:

$$TotalAttractions = (HBWA + HBOA + NHBA) \quad (5)$$
$$HBWAttractions = 1.45 * TotalEmployment \quad (6)$$
$$HBOAttractions = (2.0 * RE) + (1.1 * NON - RE) + (0.9 * DU) \quad (7)$$
$$NBHA = (4.1 * RE) + (0.85NON - RE) + (0.5 * DU) \quad (8)$$

Where:

RE = retail employment

NON-RE = non-retail employment

DU = Dwelling Units

Estimation of Through and IE-EI Trips

Through trips in small urban areas, such as the BPO planning area with two interstates are often an important issue. NCHRP Report 365 estimates that 67% of all external interstate trips pass through such areas without stopping. The average number of through trips for arterials is lower at 30%. Caliper Corporation and BWR used the approach documented in NCHRP Report365 and is employed in the BPO model for estimating the external travel pattern. It requires the following steps.

- Estimation of the percents of through and IE-EI trips at each external station,
- Calculation of through trips and IE-EI trips for each external station,
- Estimation and normalization of the percent of through trips between stations,
- Calculation and balancing of the through trip table, and
- Distribution of IE-EI trips between internal zones and external stations.

The inputs of this approach are traffic counts of all external stations, the composition of traffic counts, the route connectivity between each external station pair, the AADT at the station, the population of the study area, and the vehicle composition at the external station. Formula (9) is used in the automated procedure.

$$Y_i = 76.76 + 11.22I_i - 25.74PA_i - 42.18MA_i + 0.00012ADT_i + 0.59PTK_i - 0.48P \quad (9)$$

Where:

Yi = percentage of the AADT at the external station i, through trips,
Ii = 1 if external station i is on an interstate; otherwise 0,
PAi = 1 if external station i is on a principal arterial; otherwise 0,
MAi = 1 if external station i is on an a minor arterial; otherwise 0,
AADTi = AADT at external station i,
PTKi = percentage of truck excluding vans and pickups at external station i,
PVPi = percentage of vans and pickups at external station i, and
POP = population inside the planning area.

The EE and EI-IE trips at each external station can be calculated using equations (10) – (13). These equations assume that the two-way traffic is balanced.

$$EEP_i = (Y_i/100) * (ADT_i/2) \quad (10)$$
$$EEA_i = Y_i/100) * (ADT_i/2) \quad (11)$$
$$IEP_i = (1 - Y_i/100) * (ADT_i/2) \quad (12)$$
$$IEA_i = (1 - Y_i/100) * (ADT_i/2) \quad (13)$$

Where:

EEP_i = EE trip production at external station i,
EEA_i = EE trip attractions at external station i,
IEP_i = IE-EI trip production at external station i, and
IEA_i = IE-EI trip attraction at external station i,

The BPO model has 15 external stations. In order to apply equations (10) – (13) to the model the external stations on local roads or collectors have to be classified as the minor arterial external stations. The inputs and calculation results are shown in Table 2.

Table 2: EE and EI-IE trips at all external Stations

TAZ	Population	[Road Type]	Interstate	[Minor Artery]	ADT	[Percent Trucks]	[Perc. Vans and Pkups]	[Perc. Through]	[EE Trips]	[IE and EI Trips]	EE_P	EE_A
901	77000	Public	0	1	111.52	1.00	5.00	0.67	3.99	107.53	0.38	0.38
902	77000	Interstate	1	0	15000.00	9.00	5.00	60.58	7833.64	4236.36	4543.58	4543.58
903	77000	Public	0	1	111.52	1.00	5.00	0.67	3.99	107.53	0.38	0.38
904	77000	Interstate	1	0	35000.00	9.00	5.00	62.98	13215.72	6850.28	11021.68	11021.68
905	77000	Public	0	1	111.52	1.00	5.00	0.67	3.99	107.53	0.38	0.38
906	77000	Public	0	1	510.00	1.00	5.00	0.72	18.49	491.51	1.84	1.84
907	77000	Public	0	1	911.52	1.00	5.00	0.77	33.48	878.04	3.51	3.51
908	77000	Public	0	1	106.90	1.00	5.00	0.67	3.82	103.08	0.36	0.36
909	77000	Collector	0	1	4420.00	5.00	5.00	3.55	209.61	3106.41	78.49	78.49
910	77000	Public	0	1	442.25	1.00	5.00	0.71	15.99	426.26	1.58	1.58
911	77000	Interstate	1	0	20000.00	9.00	5.00	61.18	9368.71	5005.29	6118.10	6118.10
912	77000	Public	0	1	1266.23	1.00	5.00	0.81	47.04	1219.19	5.15	5.15
913	77000	Public	0	1	552.11	1.00	5.00	0.73	20.04	532.07	2.01	2.01
914	77000	Public	0	1	863.00	1.00	5.00	0.76	0.99	26.70	3.30	3.30

The estimation of the percentage pf through trips from each external station (origin) to the other stations between stations (destinations) is the next step in the development of the matrix of through trips among stations. The estimations are categorized by the functional classification of destinations.

Interstate:

$$Y_{ij} = -2.70 + 0.21Y_j - 67.87RTECON_{ij} \tag{14}$$

Principal Arterial:

$$Y_{ij} = -7.4 + 0.55Y_j + 24.68RTECON_{ij} + \frac{45.62ADT_j}{\sum_{j-1}^{n} ADT_j} \tag{15}$$

Minor Arterial:

$$Y_{ij} = -0.63 + 30.04RTECON_{ij} + \frac{86.68ADT_j}{\sum_{j=1}^{n} ADT - j} \tag{16}$$

Where:

Yi = percentage distribution of through-trip ends from origin station I to destination j,
Yj = percentage of the AADT at destination station j, that are through trips,
AADTj = AADT at destination station j, and
RTECONij = 1 if stations i and j on a continuous route; otherwise 0; i.e. route continuity between stations i and j.

These estimation figures have to be normalized for the calculation:

$$Y_{ij} = \frac{Y - i_j}{\sum_{j=1}^{n} Y_{ij}} \tag{17}$$

Then a symmetric table can be obtained by

$$EET_{ij} = EET_{ij} + (EEP_i\overline{Y}_{ij} + EEP_j\overline{Y}_{ij})/2 \tag{18}$$

Where:

EET_{ij} = through trips from external stations j to j.

However, this table may not fit with the EEP and EEA. To remedy this, the Fratar balancing (growth factor) method has to be used for balancing the trip table. TransCAD provides the standard function for the Fratar balancing approach. The through trip matrix of the BPO model is given in Table 3.

Table 3: Through Trip Matrix

TAZ	[Road Type]	ADT	[Perc. Through]	[EE Trips]	[IE and EI Trips]	IE_P	IE_A	HBW_IE_P	HBW_IE_A	HBO_IE_P	HBO_IE_A	NHB_IE_P	NHB_IE_A
901	Public	111.52	0.67	3.99	107.53	53.77	53.77	22.15	22.15	22.15	22.15	11.08	11.08
902	Interstate	15000.00	60.58	7833.64	4236.36	2118.18	2118.18	1182.57	1182.57	1182.57	1182.57	591.28	591.28
903	Public	111.52	0.67	3.99	107.53	53.77	53.77	22.15	22.15	22.15	22.15	11.08	11.08
904	Interstate	35000.00	62.98	13215.72	6850.28	3425.14	3425.14	2591.33	2591.33	2591.33	2591.33	1295.66	1295.66
905	Public	111.52	0.67	3.99	107.53	53.77	53.77	22.15	22.15	22.15	22.15	11.08	11.08
906	Public	510.00	0.72	18.49	491.51	245.76	245.76	101.26	101.26	101.26	101.26	50.63	50.63
907	Public	911.52	0.77	33.48	878.04	439.02	439.02	180.90	180.90	180.90	180.90	90.45	90.45
908	Public	106.90	0.67	3.82	103.08	51.54	51.54	21.24	21.24	21.24	21.24	10.62	10.62
909	Collector	4420.00	3.55	209.61	3106.41	1553.20	1553.20	852.61	852.61	852.61	852.61	426.30	426.30
910	Public	442.25	0.71	15.99	426.26	213.13	213.13	87.82	87.82	87.82	87.82	43.91	43.91
911	Interstate	20000.00	61.18	9368.71	5005.29	2502.64	2502.64	1552.76	1552.76	1552.76	1552.76	776.38	776.38
912	Public	1266.23	0.81	47.04	1219.19	609.59	609.59	251.19	251.19	251.19	251.19	125.59	125.59
913	Public	552.11	0.73	20.04	532.07	266.04	266.04	109.62	109.62	109.62	109.62	54.81	54.81
914	Public	863.00	0.76	0.99	26.70	13.35	13.35	171.28	171.28	171.28	171.28	85.64	85.64
915	Public	1272.00	0.81	0.99	26.64	13.32	13.32	252.33	252.33	252.33	252.33	126.17	126.17

The IE-EI P and A table from equations (12)-(13) can be categorized by trip purpose. The equations use the trip proportions suggested in NCHRP 365 and produce the IE-EI production and attraction by trip purposes. The results of the BPO model are listed in Table 4.

$$HBW\text{production (or attractions)} = IEP(\text{or IEA}) * 0.4 \quad (19)$$

$$HBO\text{production (or attraction)} = IEP(\text{or IEA}) * 0.4 \quad (20)$$

$$NHB\text{production (or attraction)} = IEP(\text{or IEA}) * 0.2 \quad (21)$$

Table 4: IE-EI Trips by Trip Purpose

TAZ	[Road Type]	ADT	[Perc. Through]	[EE Trips]	[IE and EI Trips]	IE_P	IE_A	HBW_IE_P	HBW_IE_A	HBO_IE_P	HBO_IE_A	NHB_IE_P	NHB_IE_A
901	Public	111.52	0.67	3.99	107.53	53.77	53.77	22.15	22.15	22.15	22.15	11.08	11.08
902	Interstate	15000.00	60.58	7833.64	4236.36	2118.18	2118.18	1182.57	1182.57	1182.57	1182.57	591.28	591.28
903	Public	111.52	0.67	3.99	107.53	53.77	53.77	22.15	22.15	22.15	22.15	11.08	11.08
904	Interstate	35000.00	62.98	13215.72	6850.28	3425.14	3425.14	2591.33	2591.33	2591.33	2591.33	1295.66	1295.66
905	Public	111.52	0.67	3.99	107.53	53.77	53.77	22.15	22.15	22.15	22.15	11.08	11.08
906	Public	510.00	0.72	18.49	491.51	245.76	245.76	101.26	101.26	101.26	101.26	50.63	50.63
907	Public	911.52	0.77	33.48	878.04	439.02	439.02	180.90	180.90	180.90	180.90	90.45	90.45
908	Public	106.90	0.67	3.82	103.08	51.54	51.54	21.24	21.24	21.24	21.24	10.62	10.62
909	Collector	4420.00	3.55	209.61	3106.41	1553.20	1553.20	852.61	852.61	852.61	852.61	426.30	426.30
910	Public	442.25	0.71	15.99	426.26	213.13	213.13	87.82	87.82	87.82	87.82	43.91	43.91
911	Interstate	20000.00	61.18	9368.71	5005.29	2502.64	2502.64	1552.76	1552.76	1552.76	1552.76	776.38	776.38
912	Public	1266.23	0.81	47.04	1219.19	609.59	609.59	251.19	251.19	251.19	251.19	125.59	125.59
913	Public	552.11	0.73	20.04	532.07	266.04	266.04	109.62	109.62	109.62	109.62	54.81	54.81
914	Public	863.00	0.76	0.99	26.70	13.35	13.35	171.28	171.28	171.28	171.28	85.64	85.64
915	Public	1272.00	0.81	0.99	26.64	13.32	13.32	252.33	252.33	252.33	252.33	126.17	126.17

Balancing Trip Productions and Attractions

When production and attractions are used in modeling, it is necessary for their total sum to be balanced as inputs to the trip distribution (gravity) model. The balancing procedure for all internal (II), External to Internal (EI), and External to Internal (IE) trips was conducted using TransCAD’s Weighted Sum (50% to 50%) function for each trip purpose.

Production and attraction of special generators are withheld at this time as they are not being factored.

Free-flow Speed and Travel Impedance

Travel impedance is the resistance of trips from one node to another. Time impedance can be calculated using link length, and its free-flow speed. In general, time impedance is in minutes, length in miles, and free-flow speed in miles per hour. Since some operating speeds were permitted above the posted speed limited, the BPO model uses the free-flow speed for computing the shortest path impedance.

Every link in the network was coded into one of nine link type categories. Link type 7 is a special type of link that connects the TAZ centroids to the existing network. The free-flow speeds of all categories are listed in Table 5.

Table 5: Free-Flow Speeds

LN_Type (Link Type)	Classification	Free-Flow Speed
1	Rural Principal Arterial	50 – 55
2	Urban Principal Arterial	35 – 45
3	Rural Interstate	70
4	Urban Interstate	55 - 65
5	Rural Minor Arterial	45 – 50
6	Urban Minor Arterial	35 – 45
7	Centroid Connector	20
8	Collector	30 – 35
9	Local	20 - 35

The travel impedance of each TAZ pair is the impedance sum of all links along the shortest path. It is one of the inputs for trip distribution of all TAZ pairs which can be computed using the shortest path algorithm and is stored in a matrix with a TAZ index as its column and row headers.

Intra-zonal Travel Time and Terminal Time

The average travel time within each TAZ is called the internal travel time. For the BPO model, it is assumed that the intrazonal travel time of a TAZ is equal to one-half the average travel time to the three nearest adjacent TAZs. TransCAD has a module that applies this assumption. Terminal times represent impedance at both ends of a trip such as the amount of time required to park or access a car. The BPO model assumes that the terminal time of an urban centroid connector is two (2) minutes while that of a rural centroid connector is one (1) minute. The terminal times are applied at both the origin and destination ends of a trip.

Trip Distribution and PA-to-OD Conversion

The most widely used trip distribution is the gravity model. This model estimates the relative number of trips, proportional to the number of productions (dwelling units) and attractions (dwelling units, and employment), made between two TAZs, and inversely proportional to a function of travel time between the TAZs. For gravity models, inputs are the balanced Productions and Attractions table and time impedance matrix. The outputs are a PA matrix of all trip purposes.

Shortest path travel time is used as impedance between TAZs. The travel time is the time distance between each pair of TAZ centroids. The time impedance between each pair of external stations is set to 999 so that no EE trips will be distributed in this process. This is because the EE trip table has already been generated.

The friction factor is used to provide realism to the process. Friction factors limit the average trip length and are used to help distribute the trip lengths. The friction factor enables the model to reproduce the varying trip length. BPO's model uses the gamma function with the following parameters resulting in an average trip length of close to five (5) miles. This is close to the travel survey conducted in the 1990's. The equation for the gamma function is:

$$f(C_{ij}) = a * C_{IJ}^{-b} * e^{-c*(C_{ij})} \tag{22}$$

Table 6: Parameters for Trip Distribution

Trip Purpose	A	B	C
HBW	28507	0.0320	0.0197
HBO	139173	0.2056	0.0151
NHB	219113	0.2131	0.0160

Along with the average trip length, another indication that the model is performing correctly is trips length distribution. The distribution curve of trip length frequency shows the percent of trips within each time period. Figure 3 shows three frequency distribution curves for HBW, HBO, and NHB trips. The average trip length in minutes is eight (8) minutes which is in the middle of the recommended time listed in Federal Highway Administration's Calibration and Adjustment of System Planning Models.

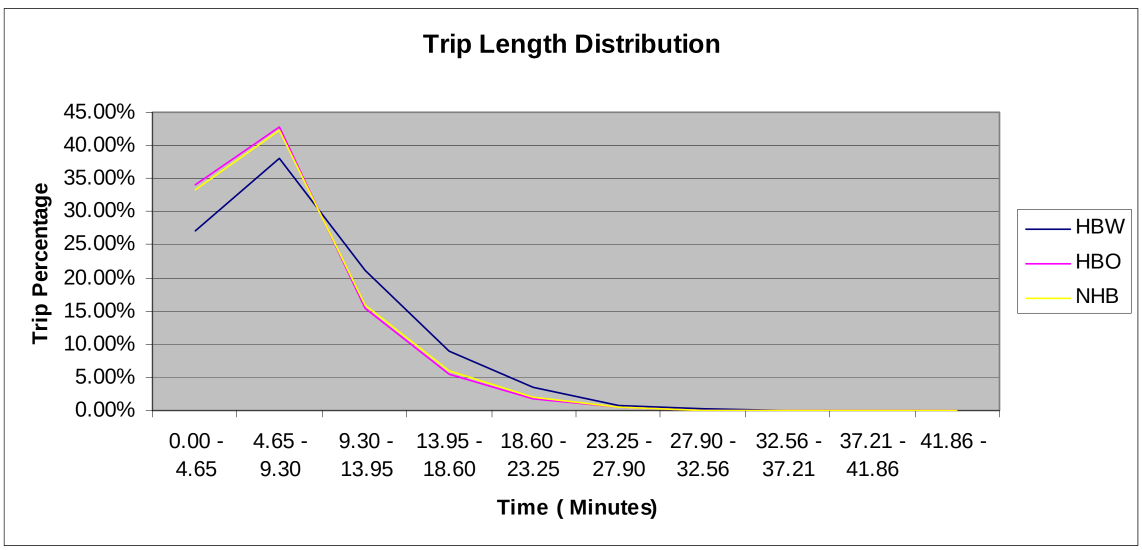

Figure 3: Trip Length Distribution

Traffic Assignment

The primary input for trip assignment is the Origin-Destination (O-D) matrix from the gravity model. Flows for each O-D pair are assigned onto the network using the "stochastic user equilibrium" principles which makes the assumption that all travelers have perfect information of the nature and condition of the network and will always choose the shortest path with consideration of congestion. The principle of the solution is that no user can improve their travel time by changing his or her path.

The other inputs for trip assignment are the relationship of volume and delay caused by congestion and the related link attributes, such as free-flow speed and capacity. The trip assignment process is driven by the relationship of assigned volumes and the resulting delays. The following Bureau of Public Roads (BPR) equation is frequently used to describe the volume-delay relationship and is adopted of the BPO model.

$$t - t_{ff}(1 + \alpha(v/c)^{\beta} \qquad (23)$$

Where:

T = congested link travel time,
T ff = link free-flow time,
V = assigned link volume,
C = daily link capacity,
Alpha = .15, and
Beta = 4 for all links except interstate where Beta = 6.

Capacities are a local derivation of the procedures found in the Highway Capacity Manual. The saturation flow rate was modified by using variables such as percent heavy trucks, lanes, left turn bay, and peak hour factor.

Table 7: Link Capacity Values

Capacity Adjustment	Local	Collector		Minor Arterial		Principal Arterial		Interstate Ramp	Interstate
Lanes	1	1	With Left	1	With Left	1	With Left	1	
Data									
Base Saturation flow rate	1400	1700	1700	1750	1750	1850	1850	1900	1900
Lanes	1	1	1	1	1	1	1	1	1
Lane width	1	1	1	1	1	1	1	1	1
Heavy Vehicles	0.99	0.99	0.99	0.97	0.97	0.97	0.97	0.98	0.91
Grade	1	1	1	1	1	1	1	1	1
Parking	0.86	0.86	0.86	0.885	0.885	0.95	0.95	1	1
Left Turn Bay	0.95	0.95	1	0.95	1	0.95	1	1	1
Right Turn Bay	1	1	1	1	1	1	1	1	1
g/C	0.4	0.4	0.45	0.45	0.45	0.45	0.45	1	1
Peak-hour Factor	0.88	0.92	0.92	0.92	0.92	0.92	0.92	1	1
Capacity(Veh/h)	399	506	599	591	622	670	706	1862	1729
Daily Capacity	4286	5441	6443	6353	6688	7210	7589	20022	18591

A turn penalty table was built and used in the assignment. Turn penalties decrease the traffic flow on links. The primary reason is to not allow turns where a free right turn existed. Some other reasons were to induce a delay from one street to another where speed was not used.

Model Calibration, Validation and Results

The calibration procedure is based on an available traffic counts. The goal of calibration is to check the network setting and model parameters with the objective of producing volumes and lengths within accepted ranges. Validation is a similar process where the assigned traffic is compared to actual traffic counts. As mentioned earlier, BPO uses an estimated count for each link on collectors and above. The annual count program updates those links every five years with a growth rate in the interim. As Table 8 shows all four classes are within the acceptable range. An overall error rate of 6.20% is very good. A word of caution, traffic counts vary over time and season. Although we use a seasonal correction factor, counts can vary at the same intersection by 20 percent on the same day from year to year. Also the equipment used has an error rate of 10 percent. With that word of caution the four classes performed within the acceptable range for distribution (% of total) and error rate (difference).

Table 8: Actual VMT vs. Assigned VMT

Functional Class	VMT		Model Results		Standard	
	Actual	Model	Difference	% of Total	Difference	% of Total
Collector	75,828	77,088	1.66%	6.61%	25%	33-38%
Minor Arterial	211,211	231,035	9.39%	18.41%	15%	27-33%
Principal Arterial	395,076	423,059	7.08%	34.43%	10%	18-22%
Interstate	465,272	487,348	4.74%	40.55%	7%	8- 12%
Total	1,147,387	1,218,530	6.20%	100.00%		

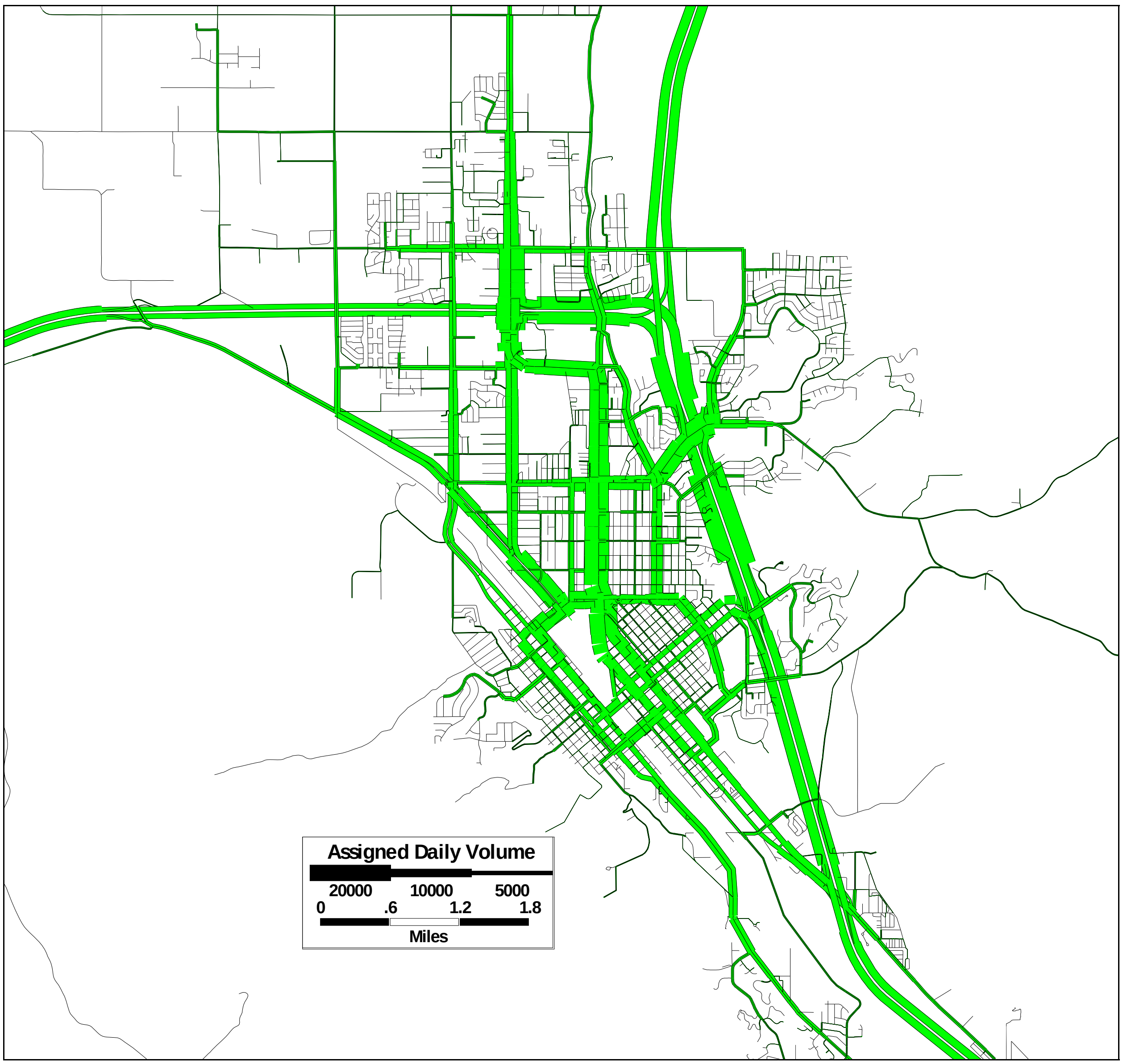

Figure 4: Assignment Results

Figure 4 shows the assignment results for the BPO planning area.

Figure 5 and Table 9 show the screen line analysis. Screen lines show what the traffic flow from the model and the expected flow (counts) for the area. BPO uses five screen lines, four are along man made barriers (downtown, railroad, I86, and I15) and in the middle of the planning area at Alameda. These are areas where traffic counts are taken annually with the exception of Alameda. Overall the results are good (within 14%) with the exception of Alameda where the difference is 30%. This could relate to older counts but also due to model's tendency to over predict north-south travel in the core.

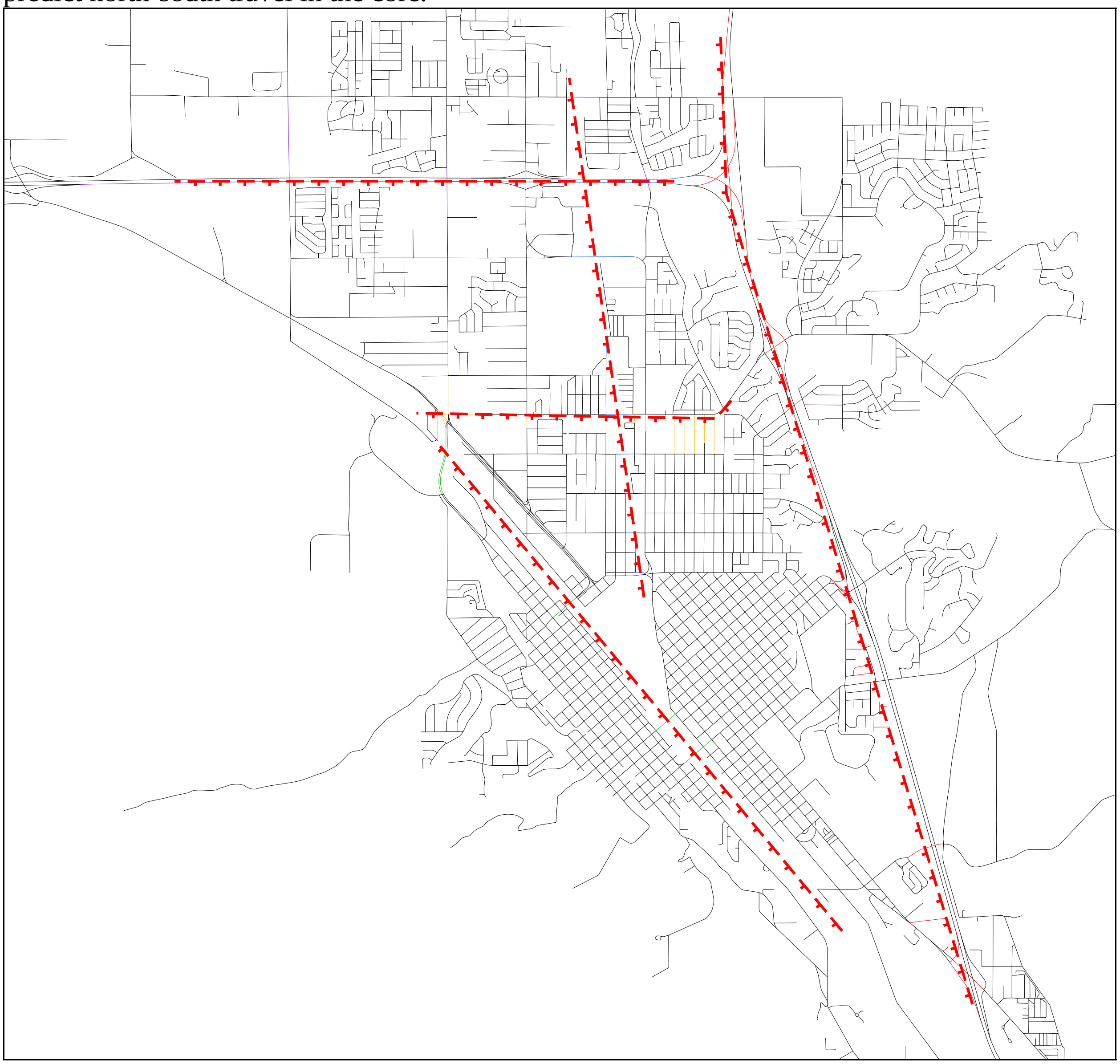

Figure 5: Screen lines

Table 9: Screen Line Results

SCREENLINE	NAME	IN_FLOW	IN_COUNT	IN_RATIO	OUT_FLOW	OUT_COUN	OUT_RATIO	TOT_FLOW	TOT_COUNT	TOT_RATIO
1	Downtown E/W	27,685	23,003	1.20	28,176	24,643	1.14	55,861	47,646	1.17
2	Railroad	42,656	37,369	1.14	55,869	48,605	1.15	98,525	85,974	1.15
3	Alameda	54,963	42,782	1.28	53,122	40,203	1.32	108,085	82,985	1.30
4	I-86	23,684	22,315	1.06	32,622	28,125	1.16	56,306	50,440	1.12
5	I-15	87,891	74,601	1.18	91,358	85,280	1.07	179,249	159,881	1.12

PM Peak Hour Model: Approach and Results

The daily model usually takes account of total travel over the full 24-hour period. For many applications, travel information must be estimated for specific periods of the day. In the BPO area the model has an AM and PM peak but for our area only the PM peak will be shown.

The main task for peak hour is to convert the 24-hour production and attraction trip matrix to hourly trip origin-destination matrices. The transformation requires a table of time-of-day factors that are the percentage of traffic which departs during each hour, and the percentage of traffic which return during each hour. These time-of-day factors typically vary by trip purpose. By applying the time-of-day factors table to the daily matrix, Peak –hour O-D matrices can be produced and then assigned to the highway network. The P-A matrices for all trip purposes are used as inputs. The time-of-day factors table from NCHRP Report 187 is used.

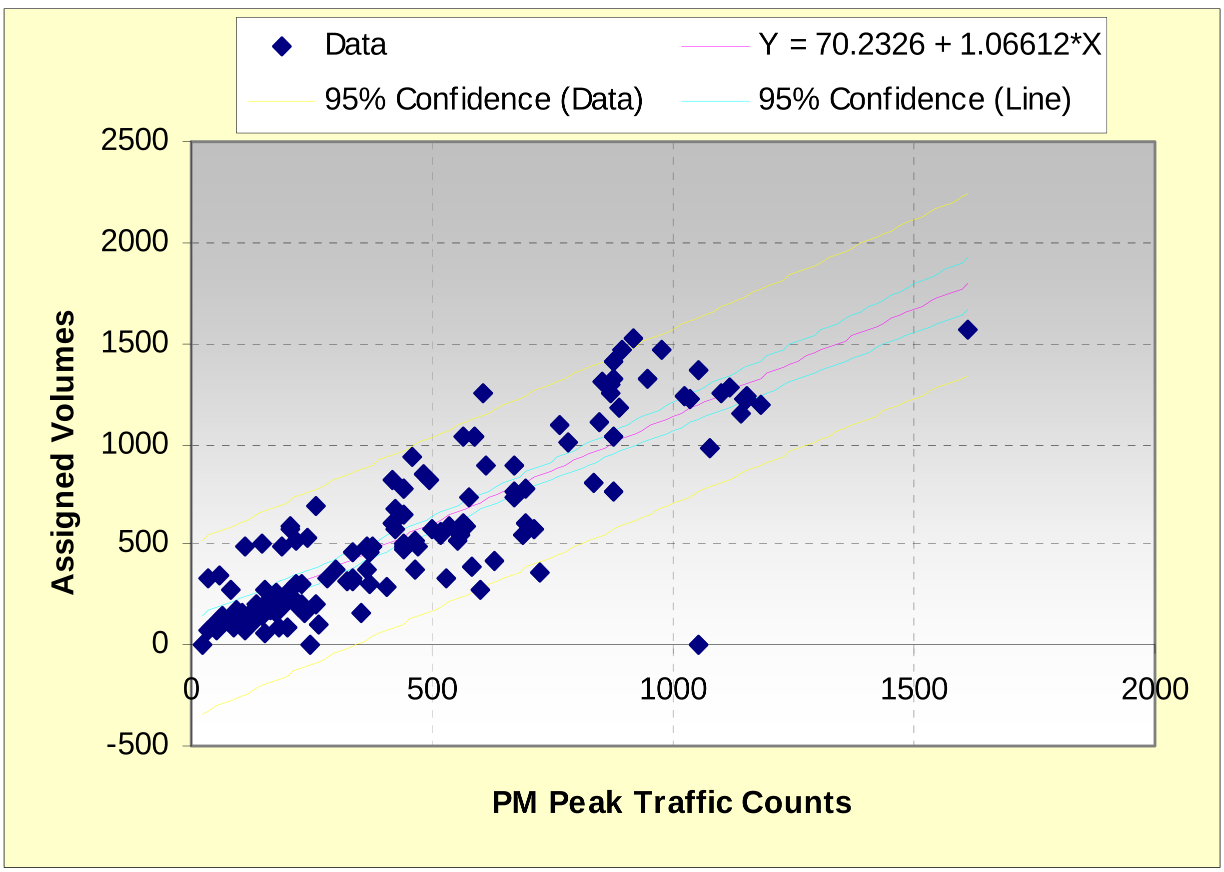

Figure 6: Peak Hour vs. Assigned Volumes

The assignment employed the user equilibrium method. The comparison of traffic counts and results of peak hour model runs are presented in Figure 6. With a R^2 of .77 the assignment for PM is not as good as the overall model. However, the results produce a reasonable approximation of travel between 17:00 – 18:00 hours. Figure 7 show the peak PM hour assignment.

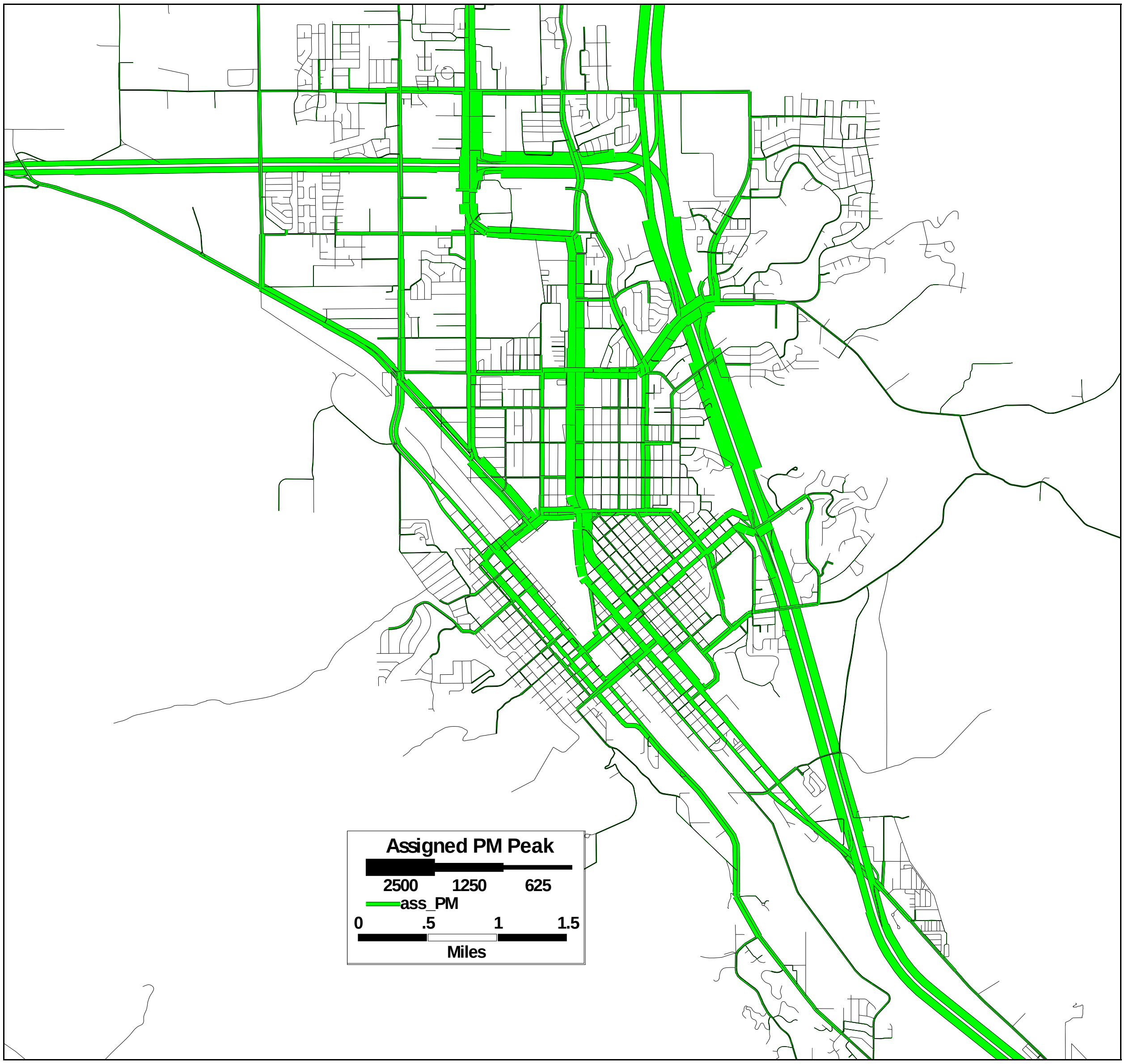

Figure 7: PM Peak Hour Assignment