Appendix H

Transportation Analysis

TJKM
Vision That Moves Your Community
Transportation Consultants

TECHNICAL MEMORANDUM

Date: January 13, 2010 *Project No.:* 074-021, Task 3

To: John Miller, Humboldt County

From: Gary Kruger, T.E.
Traffic Engineering Consultant *Jurisdiction:* Humboldt County

Subject: Recommended MOE for Humboldt County Roads

The literature on appropriate Measures of Effectiveness (MOE) is extensive for highways. For highway planning, design and operations, the concept of Level of Service (LOS) has been developed and refined for at least sixty years. While there are many aspects of traffic operations related to various facility types, such as accident rates, comfort and convenience, directness of route, gradient, widths of lanes and shoulders, smoothness of flow, etc., LOS is used by almost all jurisdictions as the best single indicator of system performance. LOS is essentially a letter grade that extends from the best levels of service (LOS A) through the poorest (LOS F), and the letter rankings are intuitively and easily understood by citizens and public agencies. Appendix A has more detailed descriptions of LOS calculation methods and standards.

Most cities and counties as well as state highway agencies have adopted LOS standards for performance. In major urban areas, LOS D or even LOS E is considered acceptable during peak hours, while in rural areas and smaller communities, LOS C is considered to be the minimum acceptable LOS.

The methods for calculating LOS have changed over time. For many years, the volume to capacity ratio (v/c) was used for freeways as well as city and county roads and streets and for intersections. Extensive research has shown that the actual quality of traffic flow is poorly related to the v/c ratio, and alternative calculation methods are now used. However, the most recent methods are more data intensive, and they are not useful in planning applications where many of the required variables are unknown. Planning estimates are generally directed to future conditions. The State of Florida has completed research that relates traffic forecasts to LOS, and the latest *Highway Capacity Manual* also has standard routines for assessing the LOS of traffic forecasts as related to various types of facilities.

The recommendations by TJKM for application in Humboldt County are based upon three sources: the *2000 Highway Capacity Manual*, the Florida Method, and the current values in the Humboldt County Regional Transportation Plan (RTP). Essentially, the required information is only the type of facility (two-lane road, four-lane freeway, rural or urban, for example), and the maximum daily volume that can be accommodated at LOS C. The designation for these values is "service volumes," or how many vehicles can be carried by a facility, generally, at LOS C. The countywide model has the type of facility and its resulting capacity already coded in the database. However, the countywide model forecasts future a.m. and p.m. peak hour directional volumes. It is a simple matter to then apply default values to relate model forecasts to daily LOS volume standards for a direct reporting of future LOS for any planning scenario. Generally, the method is to take the sum of a.m. and p.m. peak forecasts for both directions on a link and multiply by 5 for a

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good estimate for daily volumes on that link. If the daily volumes are higher than the LOS C service volumes for that type of facility, mitigation is required; otherwise, not.

There is little risk in using daily values and LOS C service volumes. If future traffic has a higher than expected proportion of peak hour traffic to daily traffic, there are several design and operational strategies short of additional lanes that can be used to offset a slight mismatch. These can be incorporated into an improvement project in the design stage. Typical strategies include use of higher technology in traffic signal control, improved intersection design, turn lanes and auxiliary lanes, truck climbing lanes, medians, wider shoulders, access control, and other similar measures to reduce friction and delays in traffic flows.

The recommended MOE's for LOS on Humboldt County roads, in urban and rural areas is included as Appendix B to this technical memorandum. As can be seen, most of the recommended values are consistent with current values in the RTP. However, higher values are recommended for two-lane road capacity in rural areas. Use of the current value of 5,500 may result in an unreasonable and unnecessary planning and programming of improvements that would yield few, if any benefits in actual quality of traffic operations.

Appendix C has the results of HCS software calculations for Service Volume C for various types of facilities as well as additional information including Florida Capacity tables for daily service volumes for LOS A through LOS F.

Appendix A: LOS Standards

APPENDIX A
LEVEL OF SERVICE

The description and procedures for calculating capacity and level of service (LOS) are found in Transportation Research Board, *Highway Capacity Manual 2000*. *Highway Capacity Manual 2000* represents the latest research on capacity and quality of service for transportation facilities.

Quality of service requires quantitative measures to characterize operational conditions within a traffic stream. LOS is a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience.

Six levels of service are defined for each type of facility that has analysis procedures available. Letters designate each level, from A to F, with LOS A representing the best operating conditions and LOS F the worst. Each LOS represents a range of operating conditions and the driver's perception of these conditions. Safety is not included in the measures that establish service levels.

A general description of service levels for various types of facilities is shown in Table A-I

Table A-I: Level of Service Description

	Uninterrupted Flow	***Interrupted Flow***
Facility Type	Freeways Multi-lane Highways Two-lane Highways Urban Streets	Signalized Intersections Unsignalized Intersections Two-way Stop Control All-way Stop Control
LOS		
A	Free-flow	Very low delay.
B	Stable flow. Presence of other users noticeable.	Low delay.
C	Stable flow. Comfort and convenience starts to decline.	Acceptable delay.
D	High-density stable flow.	Tolerable delay.
E	Unstable flow.	Limit of acceptable delay.
F	Forced or breakdown flow.	Unacceptable delay

Source: *Highway Capacity Manual 2000*

Urban Streets

The term "urban streets" refers to urban arterials and collectors, including those in downtown areas.

Arterial streets are roads that primarily serve longer through trips. However, providing access to abutting commercial and residential land uses is also an important function of arterials.
Collector streets provide both land access and traffic circulation within residential, commercial and industrial areas. Their access function is more important than that of arterials, and unlike arterials their operation is not always dominated by traffic signals.

Downtown streets are signalized facilities that often resemble arterials. They not only move through traffic but also provide access to local businesses for passenger cars, transit buses, and trucks.

Pedestrian conflicts and lane obstructions created by stopping or standing buses, trucks and parking vehicles that cause turbulence in the traffic flow are typical of downtown streets.

The speed of vehicles on urban streets is influenced by three main factors, street environment, interaction among vehicles and traffic control. As a result, these factors also affect quality of service.

The street environment includes the geometric characteristics of the facility, the character of roadside activity and adjacent land uses. Thus, the environment reflects the number and width of lanes, type of median, driveway density, spacing between signalized intersections, existence of parking, level of pedestrian activity and speed limit.

The interaction among vehicles is determined by traffic density, the proportion of trucks and buses, and turning movements. This interaction affects the operation of vehicles at intersections and, to a lesser extent, between signals.

Traffic control (including signals and signs) forces a portion of all vehicles to slow or stop. The delays and speed changes caused by traffic control devices reduce vehicle speeds, however, such controls are needed to establish right-of-way.

The average travel speed for through vehicles along an urban street is the determinant of the operating LOS. The travel speed along a segment, section or entire length of an urban street is dependent on the running speed between signalized intersections and the amount of control delay incurred at signalized intersections.

LOS A describes primarily free-flow operations. Vehicles are completely unimpeded in their ability to maneuver within the traffic stream. Control delay at signalized intersections is minimal.

LOS B describes reasonably unimpeded operations. The ability to maneuver within the traffic stream is only slightly restricted, and control delays at signalized intersections are not significant.

LOS C describes stable operations, however, ability to maneuver and change lanes in midblock location may be more restricted than at LOS B. Longer queues, adverse signal coordination, or both may contribute to lower travel speeds.

LOS D borders on a range in which in which small increases in flow may cause substantial increases in delay and decreases in travel speed. LOS D may be due to adverse signal progression, inappropriate signal timing, high volumes, or a combination of these factors.

LOS E is characterized by significant delays and lower travel speeds. Such operations are caused by a combination of adverse progression, high signal density, high volumes, extensive delays at critical intersections, and inappropriate signal timing.

LOS F is characterized by urban street flow at extremely low speeds. Intersection congestion is likely at critical signalized locations, with high delays, high volumes, and extensive queuing.

The methodology to determine LOS stratifies urban streets into four classifications. The classifications are complex, and are related to functional and design categories. Table A-II describes the functional and design categories, while Table A-III relates these to the urban street classification.

Once classified, the urban street is divided into segments for analysis. An urban street segment is a one-way section of street encompassing a series of blocks or links terminating at a signalized intersection. Adjacent segments of urban streets may be combined to form larger street sections, provided that the segments have similar demand flows and characteristics.

Levels of service are related to the average travel speed of vehicles along the urban street segment or section.

Travel times for existing conditions are obtained by field measurements. The maximum-car technique is used. The vehicle is driven at the posted speed limit unless impeded by actual traffic conditions. In the maximum-car technique, a safe level of vehicular operation is maintained by observing proper following distances and by changing speeds at reasonable rates of acceleration and deceleration. The maximum-car technique provides the best base for measuring traffic performance.

An observer records the travel time and locations and duration of delay. The beginning and ending points are the centers of intersections. Delays include times waiting in queues at signalized intersections. The travel speed is determined by dividing the length of the segment by the travel time. Once the travel speed on the arterial is determined, the LOS is found by comparing the speed to the criteria in Table A-IV. LOS criteria vary for the different classifications of urban street, reflecting differences in driver expectations.

Table A-II: Functional and Design Categories for Urban Streets

<table>
<tr><th rowspan="2">Criterion</th><th colspan="4">Functional Category</th></tr>
<tr><th colspan="2">Principal Arterial</th><th colspan="2">Minor Arterial</th></tr>
<tr><td>Mobility function</td><td colspan="2">Very important</td><td colspan="2">Important</td></tr>
<tr><td>Access function</td><td colspan="2">Very minor</td><td colspan="2">Substantial</td></tr>
<tr><td>Points connected</td><td colspan="2">Freeways, important activity centers, major traffic generators</td><td colspan="2">Principal arterials</td></tr>
<tr><td>Predominant trips served</td><td colspan="2">Relatively long trips between major points and through trips entering, leaving, and passing through city</td><td colspan="2">Trips of moderate length within relatively small geographical areas</td></tr>
<tr><th rowspan="2">Criterion</th><th colspan="4">Design Category</th></tr>
<tr><th>High-Speed</th><th>Suburban</th><th>Intermediate</th><th>Urban</th></tr>
<tr><td>Driveway access density</td><td>Very low density</td><td>Low density</td><td>Moderate density</td><td>High density</td></tr>
<tr><td>Arterial type</td><td>Multilane divided; undivided or two-lane with shoulders</td><td>Multilane divided: undivided or two-lane with shoulders</td><td>Multilane divided or undivided; one way, two lane</td><td>Undivided one way; two way, two or more lanes</td></tr>
<tr><td>Parking</td><td>No</td><td>No</td><td>Some</td><td>Usually</td></tr>
<tr><td>Separate left-turn lanes</td><td>Yes</td><td>Yes</td><td>Usually</td><td>Some</td></tr>
<tr><td>Signals per mile</td><td>0.5 to 2</td><td>1 to 5</td><td>4 to 10</td><td>6 to 12</td></tr>
<tr><td>Speed limits</td><td>45 to 55 mph</td><td>40 to 45 mph</td><td>30 to 40 mph</td><td>25 to 35 mph</td></tr>
<tr><td>Pedestrian activity</td><td>Very little</td><td>Little</td><td>Some</td><td>Usually</td></tr>
<tr><td>Roadside development</td><td>Low density</td><td>Low to medium density</td><td>Medium to moderate density</td><td>High density</td></tr>
</table>

Source: *Highway Capacity Manual 2000*

Table A-III: Urban Street Class based on Function and Design Categories

Design Category	*Functional Category*	
	Principal Arterial	*Minor Arterial*
High-Speed	I	Not applicable
Suburban	II	II
Intermediate	II	III or IV
Urban	III or IV	IV

Source: *Highway Capacity Manual 2000*

Table A-IV: Urban Street Levels of Service by Class

Urban Street Class	*I*	*II*	*III*	*IV*
Range of Free Flow Speeds (mph)	45 to 55	35 to 45	30 to 35	25 to 35
Typical Free Flow Speed (mph)	50	40	33	30
LOS	*Average Travel Speed (mph)*			
A	>42	>35	>30	>25
B	>34	>28	>24	>19
C	>27	>22	>18	>13
D	>21	>17	>14	>9
E	>16	>13	>10	>7
F	≤16	≤13	≤10	≤7

Source: *Highway Capacity Manual 2000*

Interrupted Flow

One of the more important elements limiting, and often interrupting the flow of traffic on a highway is the intersection. Flow on an interrupted facility is usually dominated by points of fixed operation such as traffic signals, stop and yield signs. These all operate quite differently and have differing impacts on overall flow.

Signalized Intersections

The capacity of a highway is related primarily to the geometric characteristics of the facility, as well as to the composition of the traffic stream on the facility. Geometrics are a fixed, or non-varying, characteristic of a facility.

At the signalized intersection, an additional element is introduced into the concept of capacity: time allocation. A traffic signal essentially allocates time among conflicting traffic movements seeking use of the same physical space. The way in which time is allocated has a significant impact on the operation of the intersection and on the capacity of the intersection and its approaches.

LOS for signalized intersections is defined in terms of control delay, which is a measure of driver discomfort, frustration, fuel consumption, and increased travel time. The delay experienced by a motorist is made up of a number of factors that relate to control, traffic and incidents. Total delay is the difference between the travel time actually experienced and the reference travel time that would result during base conditions, *i. e.*, in the absence of traffic control, geometric delay, any incidents, and any other vehicles. Specifically, LOS criteria for traffic signals are stated in terms of average control delay per vehicle, typically for a 15-minute analysis period. Delay is a complex measure and depends on a number of variables, including the quality of progression, the cycle length, the ratio of green time to cycle length and the volume to capacity ratio for the lane group.

For each intersection analyzed the average control delay per vehicle per approach is determined for the peak hour. A weighted average of control delay per vehicle is then determined for the intersection. A LOS designation is given to the control delay to better describe the level of operation. A description of levels of service for signalized intersections can be found in Table A-V

Table A-V: Description of Level of Service for Signalized Intersections

LOS	*Description*
A	Very low control delay, up to 10 seconds per vehicle. Progression is extremely favorable, and most vehicles arrive during the green phase. Many vehicles do not stop at all. Short cycle lengths may tend to contribute to low delay values.
B	Control delay greater than 10 and up to 20 seconds per vehicle. There is good progression or short cycle lengths or both. More vehicles stop causing higher levels of delay.
C	Control delay greater than 20 and up to 35 seconds per vehicle. Higher delays are caused by fair progression or longer cycle lengths or both. Individual cycle failures may begin to appear. Cycle failure occurs when a given green phase doe not serve queued vehicles, and overflow occurs. The number of vehicles stopping is significant, though many still pass through the intersection without stopping.
D	Control delay greater than 35 and up to 55 seconds per vehicle. The influence of congestions becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high volumes. Many vehicles stop, the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.
E	Control delay greater than 55 and up to 80 seconds per vehicle. The limit of acceptable delay. High delays usually indicate poor progression, long cycle lengths, and high volumes. Individual cycle failures are frequent.
F	Control delay in excess of 80 seconds per vehicle. Unacceptable to most drivers. Oversaturation, arrival flow rates exceed the capacity of the intersection. Many individual cycle failures. Poor progression and long cycle lengths may also be contributing factors to higher delay.

Source: *Highway Capacity Manual 2000*

The use of control delay, which may also be referred to as signal delay, was introduced in the 1997 update to the *Highway Capacity Manual*, and represents a departure from previous updates. In the third edition, published in 1985 and the 1994 update to the third edition, delay only included stopped delay. Thus, the LOS criteria listed in Table A-V differs from earlier criteria.

Unsignalized Intersections

The current procedures on unsignalized intersections were first introduced in the 1997 update to the *Highway Capacity Manual* and represent a revision of the methodology published in the 1994 update to the 1985 *Highway Capacity Manual*. The revised procedures use control delay as a measure of effectiveness to determine LOS. Delay is a measure of driver discomfort, frustration, fuel consumption, and increased travel time. The delay experienced by a motorist is made up of a number of factors that relate to control, traffic and incidents. Total delay is the difference between the travel time actually experienced and the reference travel time that would result during base conditions, *i. e.*, in the absence of traffic control, geometric delay, any incidents, and any other vehicles. Control delay is the increased time of travel for a vehicle approaching and passing through an unsignalized intersection, compared with a free-flow vehicle if it were not required to slow or stop at the intersection.

Two-Way Stop Controlled Intersections

Two-way stop controlled intersections in which stop signs are used to assign the right-of-way, are the most prevalent type of intersection in the United States. At two-way stop-controlled intersections the stop-controlled approaches are referred as the minor street approaches and can be either public streets or private driveways. The approaches that are not controlled by stop signs are referred to as the major street approaches.

The capacity of movements subject to delay are determined using the "critical gap" method of capacity analysis. Expected average control delay based on movement volume and movement capacity is calculated. A LOS designation is given to the expected control delay for each minor movement. LOS is not defined for the intersection as a whole. Control delay is the increased time of travel for a vehicle approaching and passing through a stop-controlled intersection, compared with a free-flow vehicle if it were not required to slow or stop at the intersection. A description of levels of service for two-way stop-controlled intersections is found in Table A-VI.

Table A-VI: Description of Level of Service for Two-Way Stop Controlled Intersections

LOS	*Description*
A	Very low control delay less than 10 seconds per vehicle for each movement subject to delay.
B	Low control delay greater than 10 and up to 15 seconds per vehicle for each movement subject to delay.
C	Acceptable control delay greater than 15 and up to 25 seconds per vehicle for each movement subject to delay.
D	Tolerable control delay greater than 25 and up to 35 seconds per vehicle for each movement subject to delay.
E	Limit of tolerable control delay greater than 35 and up to 50 seconds per vehicle for each movement subject to delay.
F	Unacceptable control delay in excess of 50 seconds per vehicle for each movement subject to delay.

Source: *Highway Capacity Manual 2000*

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Freeway Level of Service

A freeway is a divided highway with full control of access and two or more lanes for the exclusive use of traffic in each direction. Freeways provide uninterrupted flow. There are no signalized or stop-controlled at-grade intersections, and direct access to and from adjacent property is not permitted. Access to and from the freeway is limited to ramp locations. Opposing directions of flow are continuously separated by a raised barrier, an at-grade median, or a continuous raised median.

The freeway system is the sum total of all freeway facilities in a given area (the Study Area in this report). A freeway segment interacts with other freeway segments in the system as well as local streets, and to fully express a freeway level of service, the analysis must determine the controlling capacity for any one segment, and this could be an interchange or freeway segment far removed from a segment in question. Freeway level of service can be impacted by ramp intersections with the local street system where traffic backs up onto the mainline freeway from the ramp intersection with the local street. For proper analysis of freeway level of service impacts, free-flow conditions must exist upstream and downstream of the facility being analyzed.

Freeway capacity is defined as the maximum sustained 15-minute flow rate, expressed in passenger cars per hour per lane, that can be accommodated by a uniform freeway segment under prevailing traffic and roadway conditions in one direction of flow.

Freeway level of service (LOS) is determined by the density of vehicles per mile of lane. If density and volume are known for a particular segment, speed can also be estimated. Only density provides a singular value when considering the main variables of speed, volume and density.

Once traffic is queued on a freeway due to a bottleneck, the queue will become longer and longer until the rate of flow into the queue drops below the flow rate for the discharge of the queue. The discharge flow rate is typically about 5 percent lower than the maximum flow rate into the queue. Queuing of freeway traffic occurs once the maximum density at LOS E is exceeded (approximately 45 vehicles per lane per mile). Freeway LOS is calculated by subtracting speed reduction factors from the ideal free-flow speed for a freeway segment (for urban freeways, free-flow speeds range from 63 to 68 mph for 2 to 5 lanes/direction segments, and rural is typically 75 mph for all freeway widths). Speeds at maximum densities at LOS E range from 50 to 53 mph. Table 1 defines basic freeway segment LOS.

LOS	Density Range (pc/mi/ln)
A	0-11
B	>11 - 18
C	>18 - 26
D	>26 - 35
E	>35 - 45
F	>45

Appendix B – Recommended MOE's

Humboldt County General Plan Update

Recommended Measures of Effectiveness - Roadway Capacity

TJKM: January 2010

Class of Roadway	24 Hour, Two-way LOS C Service Volumes						
	HCS 2000*	County RTP Urban Areas	County RTP Rural Areas	Florida Capacity Urban Areas	Florida Capacity Rural Areas**	Recommended Urban Areas	Recommended Rural Areas**
Two-lane undivided	12000	13500	5500	13800	12700	13500	12700
Four-lane divided	42000**	26700	31900	34700	41800	26700	41800
Six-lane divided	63500**	40200	N/A	52100	62700	40200	62700
Couplet - 2 lanes each way	?	30900	N/A	34700	N/A	30900	N/A
Couplet - 3 lanes each way	?	46200	N/A	52100	N/A	46200	N/A
Freeway - 4 lanes	61000	58200	49200	55200	47900	58200	49200
Freeway - 6 lanes	94000	87300	73800	85300	73900	87300	73800

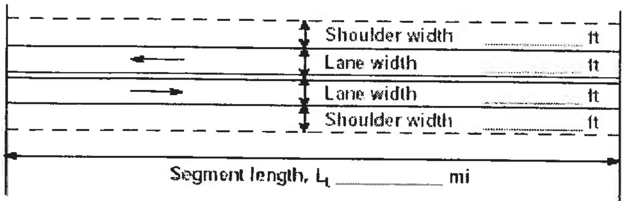
* K = 0.10, D = 0.60

** Assumes uninterrupted flow

Appendix C – Calculations for LOS Based on Daily Volumes

TWO-WAY TWO-LANE HIGHWAY SEGMENT WORKSHEET			
General Information		***Site Information***	
Analyst	Kruger	Highway	Two-Lane Rural (to Standard)
Agency or Company	TJKM	From/To	A <--> B
Date Performed	8/19/2009	Jurisdiction	Humboldt County
Analysis Time Period	Peak Hour	Analysis Year	2009

Input Data



☐ Class I highway	☑ Class II highway
Terrain ☐ Level	☑ Rolling
Two-way hourly volume	1030 veh/h
Directional split	60 / 40
Peak-hour factor, PHF	0.88
No-passing zone	25
% Trucks and Buses , P_T	5 %
% Recreational vehicles, P_R	2%
Access points/ mi	8

Average Travel Speed

Grade adjustment factor, f_G (Exhibit 20-7)	0.99
Passenger-car equivalents for trucks, E_T (Exhibit 20-9)	1.5
Passenger-car equivalents for RVs, E_R (Exhibit 20-9)	1.1
Heavy-vehicle adjustment factor, f_{HV} f_{HV}=1/ (1+ $P_T(E_T$-1)+$P_R(E_R$-1))	0.974
Two-way flow rate[1], v_p (pc/h) v_p=V/ (PHF * f_G * f_{HV})	1214
v_p * highest directional split proportion[2] (pc/h)	728

Free-Flow Speed from Field Measurement		Estimated Free-Flow Speed	
Field Measured speed, S_{FM}	mi/h	Base free-flow speed, $BFFS_{FM}$	60.0 mi/h
Observed volume, V_f	veh/h	Adj. for lane width and shoulder width[3], f_{LS} (Exhibit 20-5)	0.0 mi/h
Free-flow speed, FFS FFS=S_{FM}+0.00776(V_f/ f_{HV})	58.0 mi/h	Adj. for access points, f_A (Exhibit 20-6)	2.0 mi/h
		Free-flow speed, FFS (FSS=BFFS-f_{LS}-f_A)	58.0 mi/h

Adj. for no-passing zones, f_{np} (mi/h) (Exhibit 20-11)	0.9
Average travel speed, ATS (mi/h) ATS=FFS-0.00776v_p-f_{np}	47.7

Percent Time-Spent-Following

Grade Adjustment factor, f_G (Exhibit 20-8)	1.00
Passenger-car equivalents for trucks, E_T (Exhibit 20-10)	1.0
Passenger-car equivalents for RVs, E_R (Exhibit 20-10)	1.0
Heavy-vehicle adjustment factor, f_{HV} f_{HV}=1/ (1+ $P_T(E_T$-1)+$P_R(E_R$-1))	1.000
Two-way flow rate[1], v_p (pc/h) v_p=V/ (PHF * f_G * f_{HV})	1170
v_p * highest directional split proportion[2] (pc/h)	702
Base percent time-spent-following, BPTSF(%) BPTSF=100(1-$e^{-0.000879v_p}$)	64.2
Adj. for directional distribution and no-passing zone, $f_{d/hp}$(%)(Exh. 20-12)	5.7
Percent time-spent-following, PTSF(%) PTSF=BPTSF+$f_{d/np}$	70.0

Level of Service and Other Performance Measures

Level of service, LOS (Exhibit 20-3 for Class I or 20-4 for Class II)	C
Volume to capacity ratio v/c v/c=V_p/ 3,200	0.38
Peak 15-min veh-miles of travel,VMT_{15} (veh- mi) VMT_{15}= 0.25L_t(V/PHF)	0
Peak-hour vehicle-miles of travel, VMT_{60} (veh- mi) VMT_{60}=V*L_t	0
Peak 15-min total travel time, TT_{15}(veh-h) TT_{15}= VMT_{15}/ATS	0.0

Notes

1. If v_p >= 3,200 pc/h, terminate analysis-the LOS is F. 2. If highest directional split v_p>= 1,700 pc/h, terminated anlysis-the LOS is F.

HCS2000[TM] Version 4.1f

HCS2000: Multilane Highways Release 4.1f

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PLANNING ANALYSIS

Analyst:	Kruger
Agency/Co:	TJKM
Date:	1/13/2010
Analysis Period:	24-Hour
Highway:	Typical Four-Lane Divided
From/To:	
Jurisdiction:	Humboldt County
Analysis Year:	2010
Project ID:	General Plan Update

INPUT DATA

Total AADT volume, AADT	42000	vpd
Proportion AADT during peak hour, K	0.10	
Percent peak-hour traffic in heaviest direction, D	60	%
Trucks	2	%
Terrain type	Rolling	
Base free-flow speed, BFFS	60.0	mph

ANALYSIS

DDHV = AADT x D x K
DDHV = 42000 x 0.60 x 0.10 = 2520

Volume for :			LOS
4-lane highway = 2520	vph/2 lanes = 1260	vphpl	C
6-lane highway = 2520	vph/3 lanes = 840	vphpl	B

LEVEL OF SERVICE

		Free-Flow Speed = 60 mph					Free-Flow Speed = 50 mph				
		Percent Trucks					Percent Trucks				
Terrain	LOS	0	5	10	15	20	0	5	10	15	20
Level	A	560	550	530	520	510	440	430	420	410	400
	B	920	900	870	850	840	710	700	680	660	650
	C	1310	1280	1250	1220	1190	1030	1000	980	960	940
	D	1680	1640	1600	1570	1530	1350	1320	1290	1260	1230
	E	1870	1820	1780	1740	1700	1610	1570	1530	1500	1460
Rolling	A	560	520	490	460	430	440	410	380	360	340
	B	920	850	800	750	710	710	660	620	580	550
	C	1310	1220	1140	1070	1010	1030	960	900	840	790
	D	1680	1570	1470	1380	1300	1350	1260	1180	1100	1040
	E	1870	1740	1620	1520	1440	1610	1500	1400	1310	1240
Mountain	A	560	480	420	370	330	440	370	320	290	260

B	920	780	680	600	540	710	610	530	470	420
C	1310	1120	970	860	770	1030	880	760	680	610
D	1680	1430	1250	1100	990	1350	1150	1000	890	800
E	1870	1590	1380	1220	1100	1610	1370	1190	1050	950

Assumptions: highway with 60 mi/h FFS has 8 access points/mi; highway with 50 mi/h FFS has 25 access points/mi; lane width = 12 ft; shoulder width > 6 ft; divided highway; PHF = 0.88; all heavy vehicles are trucks and regular commuters

HCS2000: Multilane Highways Release 4.1f

Gary Kruger
TJKM Transportation Consultants

Phone: Fax:
E-mail:

PLANNING ANALYSIS

Analyst:	Kruger
Agency/Co:	TJKM
Date:	1/13/2010
Analysis Period:	24-Hour
Highway:	Typical ~~Four~~ Six-Lane Divided
From/To:	
Jurisdiction:	Humboldt County
Analysis Year:	2010
Project ID:	General Plan Update

INPUT DATA

Total AADT volume, AADT	63500	vpd
Proportion AADT during peak hour, K	0.10	
Percent peak-hour traffic in heaviest direction, D	60	%
Trucks	2	%
Terrain type	Rolling	
Base free-flow speed, BFFS	60.0	mph

ANALYSIS

DDHV = AADT x D x K
DDHV = 63500 x 0.60 x 0.10 = 3810

Volume for :				LOS
4-lane highway = 3810	vph/2 lanes = 1905	vphpl		F
6-lane highway = 3810	vph/3 lanes = 1270	vphpl		C

LEVEL OF SERVICE

		Free-Flow Speed = 60 mph					Free-Flow Speed = 50 mph				
		Percent Trucks					Percent Trucks				
Terrain	LOS	0	5	10	15	20	0	5	10	15	20
Level	A	560	550	530	520	510	440	430	420	410	400
	B	920	900	870	850	840	710	700	680	660	650
	C	1310	1280	1250	1220	1190	1030	1000	980	960	940
	D	1680	1640	1600	1570	1530	1350	1320	1290	1260	1230
	E	1870	1820	1780	1740	1700	1610	1570	1530	1500	1460
Rolling	A	560	520	490	460	430	440	410	380	360	340
	B	920	850	800	750	710	710	660	620	580	550
	C	1310	1220	1140	1070	1010	1030	960	900	840	790
	D	1680	1570	1470	1380	1300	1350	1260	1180	1100	1040
	E	1870	1740	1620	1520	1440	1610	1500	1400	1310	1240
Mountain	A	560	480	420	370	330	440	370	320	290	260

B	920	780	680	600	540	710	610	530	470	420
C	1310	1120	970	860	770	1030	880	760	680	610
D	1680	1430	1250	1100	990	1350	1150	1000	890	800
E	1870	1590	1380	1220	1100	1610	1370	1190	1050	950

Assumptions: highway with 60 mi/h FFS has 8 access points/mi; highway with 50 mi/h FFS has 25 access points/mi; lane width = 12 ft; shoulder width > 6 ft; divided highway; PHF = 0.88; all heavy vehicles are trucks and regular commuters

HCS2000: Basic Freeway Segments Release 4.1f

Gary Kruger
TJKM Transportation Consultants

Phone: Fax:
E-mail:

Operational Planning Analysis

Analyst:	Kruger
Agency or Company:	TJKM
Date Performed:	1/13/2010
Analysis Time Period:	24-Hour
Freeway/Direction:	Typical Four-Lane
From/To:	
Jurisdiction:	Humboldt County
Analysis Year:	2010

Description: Humboldt County General Plan Update

Flow Inputs and Adjustments

Annual average daily traffic, AADT	61000	veh/day
Peak-hour proportion of AADT, K	0.09	
Peak-hour direction percent, D	55	%
Volume, DDHV	3020	veh/h
Peak-hour factor, PHF	0.90	
Trucks and buses	5	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicles PCE, ER	1.2	
Heavy Vehicle adjustment, fHV	0.976	
Driver population factor, fp	1.00	
Flow rate, vp	1720	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	2	
Free-flow speed:	Measured	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	4.5	mi/h
Free-flow speed	70.0	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1720	pc/h/ln
Free-flow speed, FFS	70.0	mi/h

Average passenger-car speed, S	68.6	mi/h
Number of lanes, N	2	
Density, D	25.1	pc/mi/ln
Level of Service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

HCS2000: Basic Freeway Segments Release 4.1f

Gary Kruger
TJKM Transportation Consultants

Phone: Fax:
E-mail:

Operational Planning Analysis

Analyst:	Kruger
Agency or Company:	TJKM
Date Performed:	1/13/2010
Analysis Time Period:	24-Hour
Freeway/Direction:	Typical Six-Lane
From/To:	
Jurisdiction:	Humboldt County
Analysis Year:	2010
Description:	Humboldt County General Plan Update

Flow Inputs and Adjustments

Annual average daily traffic, AADT	94000	veh/day
Peak-hour proportion of AADT, K	0.09	
Peak-hour direction percent, D	55	%
Volume, DDHV	4653	veh/h
Peak-hour factor, PHF	0.90	
Trucks and buses	5	%
Recreational vehicles	0	%
Terrain type:	Level	
Grade	0.00	%
Segment length	0.00	mi
Trucks and buses PCE, ET	1.5	
Recreational vehicles PCE, ER	1.2	
Heavy Vehicle adjustment, fHV	0.976	
Driver population factor, fp	1.00	
Flow rate, vp	1766	pc/h/ln

Speed Inputs and Adjustments

Lane width	12.0	ft
Right-shoulder lateral clearance	6.0	ft
Interchange density	0.50	interchange/mi
Number of lanes, N	3	
Free-flow speed:	Measured	
FFS or BFFS	70.0	mi/h
Lane width adjustment, fLW	0.0	mi/h
Lateral clearance adjustment, fLC	0.0	mi/h
Interchange density adjustment, fID	0.0	mi/h
Number of lanes adjustment, fN	3.0	mi/h
Free-flow speed	70.0	mi/h
	Urban Freeway	

LOS and Performance Measures

Flow rate, vp	1766	pc/h/ln
Free-flow speed, FFS	70.0	mi/h

Average passenger-car speed, S	68.2	mi/h
Number of lanes, N	3	
Density, D	25.9	pc/mi/ln
Level of Service, LOS	C	

Overall results are not computed when free-flow speed is less than 55 mph.

TABLE 4 - 1
GENERALIZED **ANNUAL AVERAGE DAILY** VOLUMES FOR FLORIDA'S **URBANIZED AREAS***

UNINTERRUPTED FLOW HIGHWAYS

Lanes	Divided	A	B	C	D	E
2	Undivided	2,000	7,000	13,800	19,600	27,000
4	Divided	20,400	33,000	47,800	61,800	70,200
6	Divided	30,500	49,500	71,600	92,700	105,400

STATE TWO-WAY ARTERIALS

Class I (>0.00 to 1.99 signalized intersections per mile)

Lanes	Divided	A	B	C	D	E
2	Undivided	**	4,200	13,800	16,400	16,900
4	Divided	4,800	29,300	34,700	35,700	***
6	Divided	7,300	44,700	52,100	53,500	***
8	Divided	9,400	58,000	66,100	67,800	***

Class II (2.00 to 4.50 signalized intersections per mile)

Lanes	Divided	A	B	C	D	E
2	Undivided	**	1,900	11,200	15,400	16,300
4	Divided	**	4,100	26,000	32,700	34,500
6	Divided	**	6,500	40,300	49,200	51,800
8	Divided	**	8,500	53,300	63,800	67,000

Class III (more than 4.5 signalized intersections per mile and not within primary city central business district of an urbanized area over 750,000)

Lanes	Divided	A	B	C	D	E
2	Undivided	**	**	5,300	12,600	15,500
4	Divided	**	**	12,400	28,900	32,800
6	Divided	**	**	19,500	44,700	49,300
8	Divided	**	**	25,800	58,700	63,800

Class IV (more than 4.5 signalized intersections per mile and within primary city central business district of an urbanized area over 750,000)

Lanes	Divided	A	B	C	D	E
2	Undivided	**	**	5,200	13,700	15,000
4	Divided	**	**	12,300	30,300	31,700
6	Divided	**	**	19,100	45,800	47,600
8	Divided	**	**	25,900	59,900	62,200

NON-STATE ROADWAYS

Major City/County Roadways

Lanes	Divided	A	B	C	D	E
2	Undivided	**	**	9,100	14,600	15,600
4	Divided	**	**	21,400	31,100	32,900
6	Divided	**	**	33,400	46,800	49,300

Other Signalized Roadways (signalized intersection analysis)

Lanes	Divided	A	B	C	D	E
2	Undivided	**	**	4,800	10,000	12,600
4	Divided	**	**	11,100	21,700	25,200

Source: Florida Department of Transportation 02/22/02
Systems Planning Office
605 Suwannee Street, MS 19
Tallahassee, FL 32399-0450
http://www11.myflorida.com/planning/systems/sm/los/default.htm

FREEWAYS

Interchange spacing ≥ 2 mi. apart

Lanes	A	B	C	D	E
4	23,800	39,600	55,200	67,100	74,600
6	36,900	61,100	85,300	103,600	115,300
8	49,900	82,700	115,300	140,200	156,000
10	63,000	104,200	145,500	176,900	196,400
12	75,900	125,800	175,500	213,500	237,100

Interchange spacing < 2 mi. apart

Lanes	A	B	C	D	E
4	22,000	36,000	52,000	67,200	76,500
6	34,800	56,500	81,700	105,800	120,200
8	47,500	77,000	111,400	144,300	163,900
10	60,200	97,500	141,200	182,600	207,600
12	72,900	118,100	170,900	221,100	251,200

BICYCLE MODE

(**Note**: Level of service for the bicycle mode in this table is based on roadway geometrics at 40 mph posted speed and traffic conditions, not number of bicyclists using the facility.) (Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Paved Shoulder/ Bicycle Lane Coverage	A	B	C	D	E
0-49%	**	**	3,200	13,800	>13,800
50-84%	**	2,500	4,100	>4,100	***
85-100%	3,100	7,200	>7,200	***	***

PEDESTRIAN MODE

(**Note**: Level of service for the pedestrian mode in this table is based on roadway geometrics at 40 mph posted speed and traffic conditions, not number of pedestrians using the facility.) (Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine two-way maximum service volumes.)

Sidewalk Coverage	A	B	C	D	E
0-49%	**	**	**	6,400	15,500
50-84%	**	**	**	9,900	19,000
85-100%	**	2,200	11,300	>11,300	***

BUS MODE (Scheduled Fixed Route)

(Buses per hour)

(**Note:** Buses per hour shown are only for the **peak hour** in the **single direction** of the higher traffic flow.)

Sidewalk Coverage	A	B	C	D	E
0-84%	**	>5	≥4	≥3	≥2
85-100%	>6	>4	≥3	≥2	≥1

ARTERIAL/NON-STATE ROADWAY ADJUSTMENTS

DIVIDED/UNDIVIDED

(alter corresponding volume by the indicated percent)

Lanes	Median	Left Turns Lanes	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

ONE-WAY FACILITIES

Decrease corresponding two-directional volumes in this table by 40% to obtain the equivalent one directional volume for one-way facilities.

*This table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are two-way annual average daily volumes (based on K_{100} factors) for levels of service and are for the automobile/truck modes unless specifically stated. Level of service letter grade thresholds are probably not comparable across modes and, therefore, cross modal comparisons should be made with caution. Furthermore, combining levels of service of different modes into one overall roadway level of service is not recommended. The table's input value defaults and level of service criteria appear on the following page. Calculations are based on planning applications of the Highway Capacity Manual, Bicycle LOS Model, Pedestrian LOS Model and Transit Capacity and Quality of Service Manual, respectively for the automobile/truck, bicycle, pedestrian and bus modes.
**Cannot be achieved using table input value defaults.
***Not applicable for that level of service letter grade. For automobile/truck modes, volumes greater than level of service D become F because intersection capacities have been reached. For bicycle and pedestrian modes, the level of service letter grade (including F) is not achievable, because there is no maximum vehicle volume threshold using table input value defaults.

TABLE 4 – 3
GENERALIZED **ANNUAL AVERAGE DAILY** VOLUMES FOR FLORIDA'S **RURAL UNDEVELOPED AREAS AND CITIES** OR **DEVELOPED AREAS LESS THAN 5,000 POPULATION***

RURAL UNDEVELOPED AREAS

FREEWAYS

Lanes	A	B	C	D	E
	Level of Service				
4	21,300	35,300	47,900	56,600	63,000
6	33,100	54,300	73,900	87,400	97,200
8	44,700	73,600	100,000	118,400	131,400

UNINTERRUPTED FLOW HIGHWAYS

Lanes	Divided	A	B	C	D	E
		Level of Service				
2	Undivided	2,600	5,300	8,600	13,800	22,300
4	Divided	17,500	28,600	40,800	52,400	58,300
6	Divided	26,200	42,800	61,200	78,600	87,400

PASSING LANE ADJUSTMENTS
(alter corresponding two-lane LOS A-D volumes indicated percent)

Passing Lane Spacing	Adjustment Factors
5 mi.	+25%
10 mi.	+10%

ISOLATED SIGNALIZED INTERSECTIONS

Lanes	A	B	C	D	E
	Level of Service				
2	**	1,900	8,000	10,700	12,100
4	**	2,900	17,400	23,000	25,200
6	**	4,500	27,100	35,500	43,100

BICYCLE MODE

(Note: Level of service for the bicycle mode in this table is based on roadway geometrics at 55 mph posted speed and traffic conditions, not number of bicyclists using the facility.) (Multiply motorized vehicle volumes shown below by directional roadway lanes to determine maximum service volume.)

Paved Shoulder/ Bicycle Lane Coverage	A	B	C	D	E
0-49%	**	**	**	**	6,200
50-84%	**	**	**	**	17,600
85-100%	**	**	3,900	>3,900	***

CITIES OR RURAL DEVELOPED AREAS LESS THAN 5000

FREEWAYS

Lanes	A	B	C	D	E
	Level of Service				
4	21,300	35,300	47,900	56,600	63,000
6	33,100	54,300	73,900	87,400	97,200
8	44,700	73,600	100,000	118,400	131,400

UNINTERRUPTED FLOW HIGHWAYS

Lanes	Divided	A	B	C	D	E
		Level of Service				
2	Undivided	2,500	7,200	12,700	17,300	23,500
4	Divided	17,800	28,900	41,800	54,100	61,500
6	Divided	26,800	43,300	62,700	81,200	92,200

INTERRUPTED FLOW ARTERIALS

Lanes	Divided	A	B	C	D	E
		Level of Service				
2	Undivided	**	2,200	11,000	13,900	14,900
4	Divided	**	5,300	25,500	29,400	31,200
6	Divided	**	8,400	39,400	44,200	46,800

NON-STATE SIGNALIZED ROADWAYS
(signalized intersection analysis)

Lanes	A	B	C	D	E
	Level of Service				
2	**	**	1,900	7,600	10,100

BICYCLE MODE

(Note: Level of service for the bicycle mode in this table is based on roadway geometrics at 45 mph posted speed and traffic conditions, not number of bicyclists using the facility.) (Multiply motorized vehicle volumes shown below by number of directional roadway lanes to determine maximum service volumes.)

Paved Shoulder/ Bicycle Lane Coverage	A	B	C	D	E
	Level of Service				
0-49%	**	**	2,800	6,900	>6,900
50-84%	**	2,100	3,500	>3,500	***
85-100%	2,800	4,000	>4,000	***	***

PEDESTRIAN MODE

(Note: Level of service for the pedestrian mode in this table is based on roadway geometric at 45 mph posted speed and traffic conditions, not number of pedestrian using the facility.) (Multiply motorized vehicle volumes shown by number of directional roadway lanes to determine maximum service volumes.)

Sidewalk Coverage	A	B	C	D	E
	Level of Service				
0-49%	**	**	**	4,400	14,200
50-84%	**	**	**	8,000	18,000
85-100%	**	**	9,400	>9,400	***

02/22/02

Source: Florida Department of Transportation
Systems Planning Office
605 Suwannee Street, MS 19
Tallahassee, FL 32399-0450

http://www11.myflorida.com/planning/systems/sm/los/default.htm

NON-FREEWAY AND SIGNALIZED INTERSECTION ANALYSES DIVIDED/UNDIVIDED ADJUSTMENTS
(alter corresponding volumes by the indicated percent)

Lanes	Median	Left Turn Lanes	Adjustment Factors
2	Divided	Yes	+5%
2	Undivided	No	-20%
Multi	Undivided	Yes	-5%
Multi	Undivided	No	-25%

*This table does not constitute a standard and should be used only for general planning applications. The computer models from which this table is derived should be used for more specific planning applications. The table and deriving computer models should not be used for corridor or intersection design, where more refined techniques exist. Values shown are two-way annual average daily volumes (based on K_{100} factors) for levels of service and are for the automobile/truck modes unless specifically stated. Level of service letter grade thresholds are probably not comparable across modes and, therefore, cross modal comparisons should be made with caution. Furthermore, combining levels of service of different modes into one overall roadway level of service is not recommended. The table's input value defaults and level of service criteria appear on the following page. Calculations are based on planning applications of the Highway Capacity Manual, Bicycle LOS Model, and Pedestrian LOS Model, respectively for the automobile/truck, bicycle and pedestrian modes.
**Cannot be achieved using table input value defaults.
***Not applicable for the level of service letter grade. For bicycle and pedestrian modes, the level of service letter grade (including F) is not achievable, because there is no maximum vehicle volume threshold using table input value defaults.

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The level of service (LOS) criteria reflect average travel speeds, which are affected by the varying terrain segments as shown in table II-1. Roadways in Humboldt County traverse varying degrees of flat, rolling, and mountainous terrain and provide for limited passing opportunities in many areas. The level of service criteria for general terrain segments is given in Table II-3.

Table II-3: Generalized Speeds (MPH) by Level of Service and Terrain

Level of Service (LOS)	Level Terrain	Rolling Terrain	Mountainous Terrain
A	58 mph or greater	57 mph or greater	56 mph or greater
B	55 – 57 mph	54 – 56 mph	54 -55 mph
C	52 – 54 mph	51 – 53 mph	49 – 53 mph
D	50 – 51 mph	49 – 50 mph	45 -48 mph
E	45 – 49ph	40 – 48 mph	35 – 44 mph
F	Less than 45 mph	Less than 40 mph	Less than 35 mph

Source: Highway Capacity Manual

Table II-4 shows estimated levels of service for various types of roadway configurations that exist in Humboldt County or may be built in the future. This table was based on information contained in the Highway Capacity Manual (Highway Capacity Manual, Special Report 209, Transportation Research Board, 1997). The Highway Capacity Manual provides methodologies for operational analyses of various types of roadway facilities under peak hour conditions. By using generalized assumptions for input values, it is possible to create a table that estimates levels of service based for typical roadways in Humboldt County based on average daily traffic.

Table II-4: Humboldt County RTP Level of Service by Roadway Classification

Roadway Classification	# of Lanes	Maximum ADT at				
		LOS A	LOS B	LOS C	LOS D	LOS E
Rural Conventional	2	1,300	3,100	5,500	9,300	15,600
Rural Conventional	3	3,100	5,500	8,700	13,000	20,300
Rural Conventional	4	13,700	23,000	31,900	38,100	44,300
Rural Expressway	2	2,500	4,800	7,700	11,800	18,800
Rural Expressway	3	3,700	6,600	10,500	15,600	24,400
Rural Expressway	4	15,500	25,900	35,900	42,900	49,800
Urban Conventional	2	10,100	11,800	13,500	15,200	16,900
Urban Conventional	4	20,000	23,400	26,700	30,100	33,400
Urban Conventional	6	30,100	35,100	40,200	45,200	50,200
Urban Couplet	4	23,200	27,000	30,900	34,700	38,600
Urban Couplet	6	34,700	40,500	46,200	52,000	57,800
Rural Freeway	4	36,900	43,100	49,200	55,400	61,500
Rural Freeway	6	55,400	64,600	73,800	83,100	92,300
Urban Freeway	4	43,600	50,900	58,200	65,400	72,700
Urban Freeway	6	65,500	76,400	87,300	98,200	109,100

For Eureka routes away from US 101, a factor of 0.0030 is a reasonable estimator of transit demand along corridors served by transit within the city.

For locations away from Eureka, I would use a flat 0.0020 for estimating transit patronage along corridors served by transit.

I would not bother to estimate transit demand for dial-a-ride service, and of course, more than ½ mile away from routes with transit service, the transit patronage would be zero.

I have attached information I used in this exercise. Generally, in low-density areas with basic (minimum) transit service where parking is generally free, transit patronage rarely exceeds 0.5 percent of total travel in a corridor.

Note that this method bases transit patronage estimates on vehicle trips. For person trips in vehicles, simply multiply vehicle volumes by the average vehicle occupancy. If the average occupancy along US 101 near Wabash (in Eureka) is 1.2 persons per vehicle, then the total person trips on US 101 is [35,000 ADT X 1.2 = 42,000] in both directions per day plus [35,000 X 0.0075 X 2 for both directions = 525] for a total of 42,525 total person trips. Additional trips in the corridor can include bicycles and pedestrians.

The calculation of total person trips is of value in the evaluation of various types of corridor improvements that benefit transit operations or route coverage.

The comparison of annual passengers for the major transit services with the results of calculating transit patronage along corridors that are served shows reasonable internal consistency.

attachments

Figure II-3:

HCAOG 2006 RTP Update - Humboldt County Transit Routes

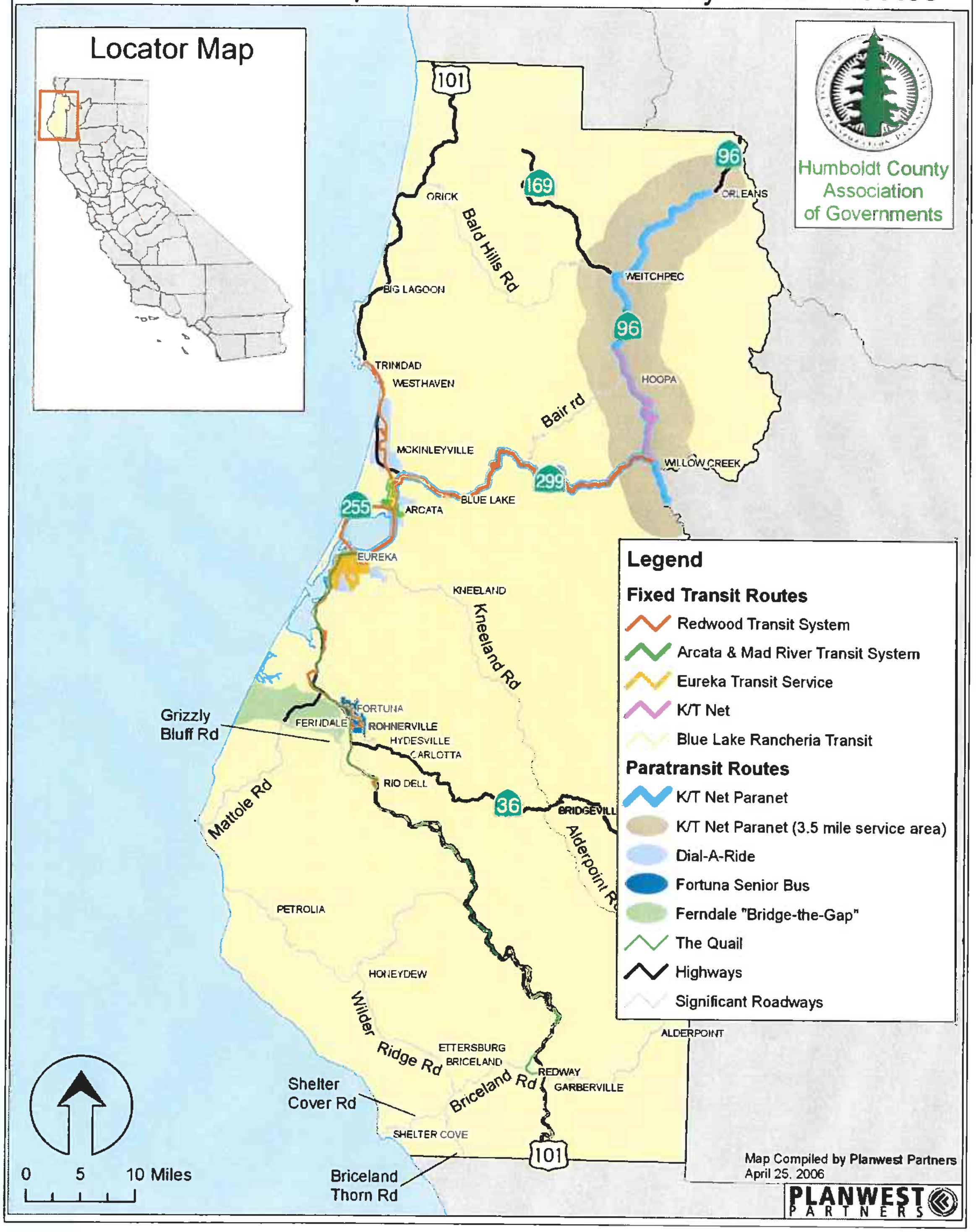


Figure II-5:

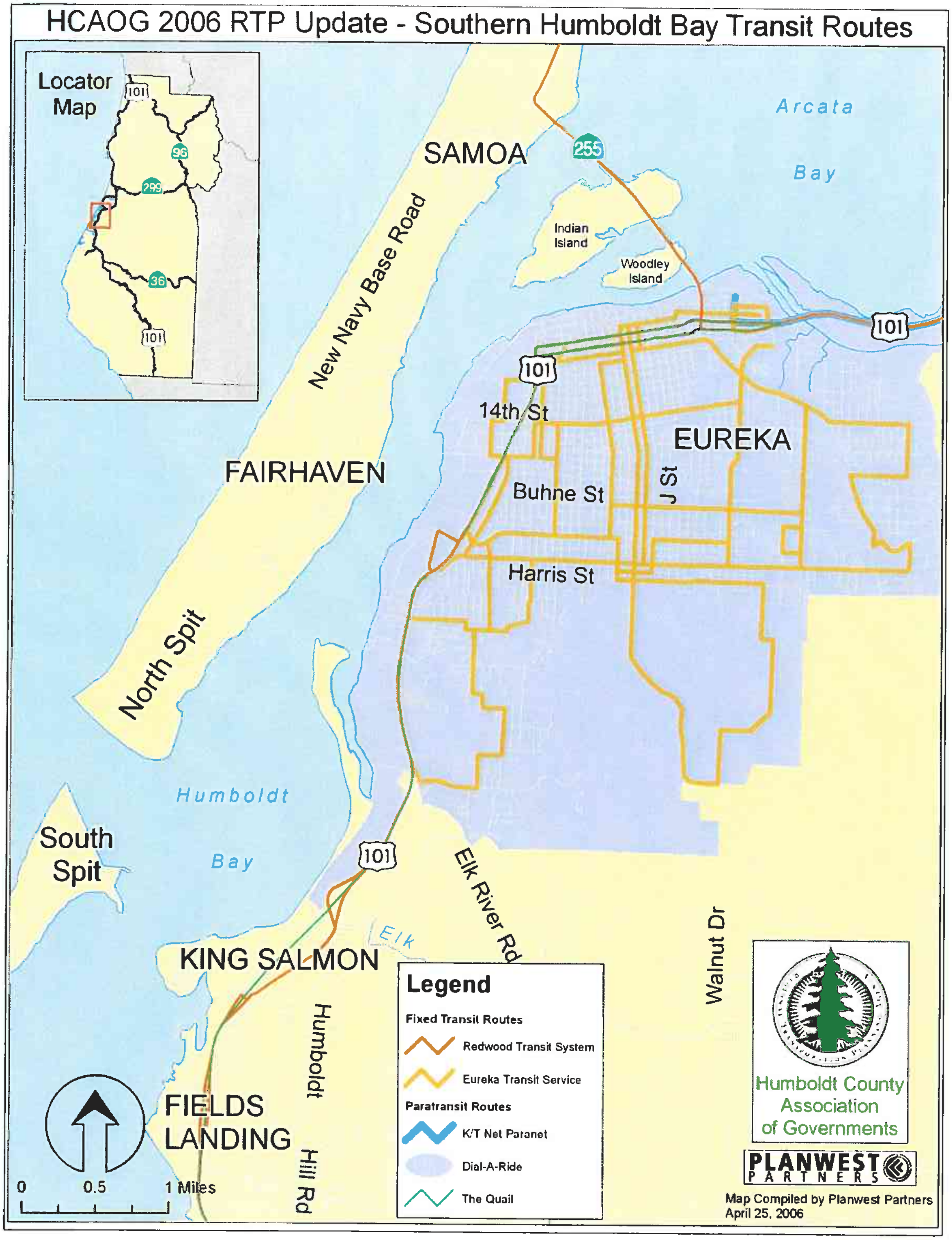
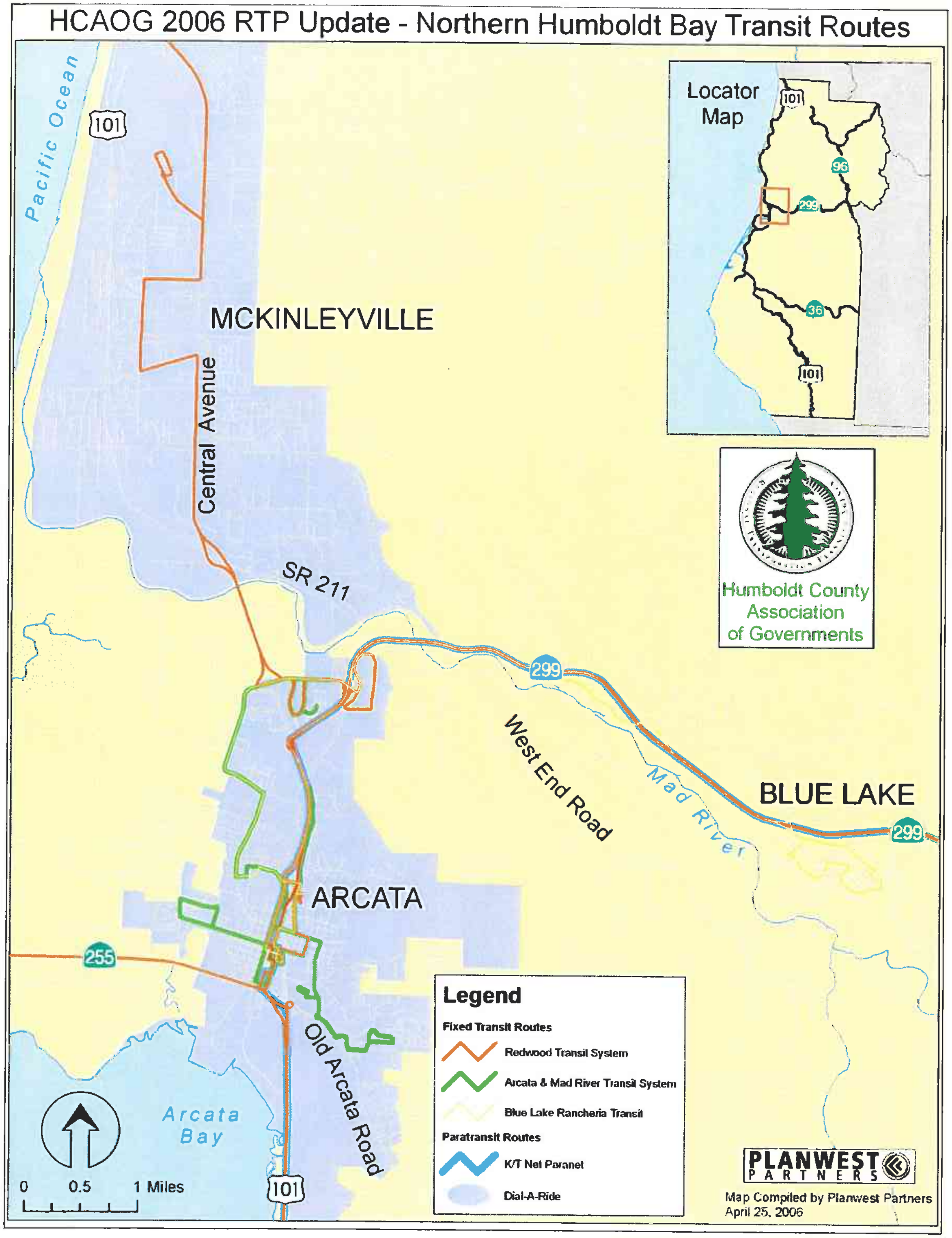

HCAOG 2006 RTP Update - Southern Humboldt Bay Transit Routes
Locator Map
SAMOA
Arcata Bay
Indian Island
Woodley Island
New Navy Base Road
14th St
EUREKA
FAIRHAVEN
Buhne St
J St
Harris St
North Spit
Humboldt Bay
South Spit
Elk River Rd
Walnut Dr
KING SALMON
Humboldt Hill Rd
FIELDS LANDING
0 0.5 1 Miles
Legend
Fixed Transit Routes
Redwood Transit System
Eureka Transit Service
Paratransit Routes
K/T Net Paratransit
Dial-A-Ride
The Quail
Humboldt County Association of Governments
PLANWEST PARTNERS
Map Compiled by Planwest Partners
April 25, 2006

Figure II-4:


HCAOG 2006 RTP Update - Northern Humboldt Bay Transit Routes
Pacific Ocean
101
MCKINLEYVILLE
Central Avenue
SR 211
299
West End Road
Mad River
BLUE LAKE
299
ARCATA
255
Old Arcata Road
Arcata Bay
101
0 0.5 1 Miles
Locator Map
101
96
299
36
101
Humboldt County Association of Governments
Legend
Fixed Transit Routes
Redwood Transit System
Arcata & Mad River Transit System
Blue Lake Rancheria Transit
Paratransit Routes
K/T Net Paranet
Dial-A-Ride
PLANWEST PARTNERS
Map Compiled by Planwest Partners
April 25, 2006

B. TRANSIT SERVICE

The HCAOG has formally pledged its policy support for public transportation programs including their continued funding as a necessary public service. Public transit programs have existed in Humboldt County dating back to the Union Plank Walk and Wharf Track Railroad in Arcata, and surface street trolley cars in Eureka.

The Humboldt Transit Authority (HTA) was established in 1975 to provide transit services along the US 101 corridor in Humboldt County. A joint powers agreement (JPA) was signed by Humboldt County and the cities of Rio Dell, Fortuna, Eureka, Arcata, and Trinidad to, "finance, acquire, construct, manage, operate and maintain public transit systems and related property and facilities."

Funding for support of the operations and maintenance of HTA is obtained primarily through fares and the Transportation Development Act that accrues to each entity of HTA. The County provides 50 percent of the funding, and the participating cities provide the other 50 percent based on census population of each city compared to the population of all the cities. HTA operates and maintains the Redwood Transit System, Eureka Transit Service and the Southern Humboldt Rural Transit System (QUAIL). In addition, HTA is under contract to the Arcata & Mad River Transit System to provide maintenance services. It also provides the Willow Creek Service.

Fixed Route and Commuter Service

Humboldt County is currently served by three public transit systems: the Eureka Transit Service (ETS), Arcata & Mad River Transit System (A&MRTS), and the Redwood Transit System (RTS). The general service areas for each system are depicted in Figure II-3, II-4, and II-5.

Redwood Transit System (RTS):
Redwood Transit System provides commuter service along the US 101 corridor between Trinidad and Scotia. RTS routes along the US 101 corridor are funded by the members of the JPA. The RTS fleet consists of 15 vehicles, all of which are lift equipped. Three diesel/electric hybrid buses have been ordered for the Redwood Transit System; delivery of the three hybrid buses is expected early in 2007. Bike racks are available on all RTS buses, but passengers are responsible for loading, securing and unloading their own bikes. RTS makes 39 weekday trips per day, (17 south bound and 18 north bound, and 4 east bound), and 18 Saturday trips per day, (9 north bound and 9 south bound). RTS operates from 5:45 a.m. until 10:46 p.m. Monday through Friday and 8:00 a.m. until 8:30 p.m. on Saturday (with the exception of observed holidays). When College of the Redwoods (CR) is in session, RTS provides an express bus service that runs between the Arcata Transit Center and College of the Redwoods, Monday through Thursday.

In addition to the commuter service that runs along the US 101 corridor, RTS also provides a commuter service along Highway 299 between Willow Creek and Arcata. The Willow Creek commuter service is funded by Humboldt County and managed by HTA. The Willow Creek route is served by two smaller buses purchased specifically for the Willow Creek route, both of which are lift equipped and have snow chains. The Willow Creek route has four runs per day, two in the morning between 5:00 and 11:00 a.m. and two in the afternoon/evening between 3:00 and 8:00 p.m. Monday through Friday. RTS routes are shown in figures three, four, and five.

Fares for RTS are shown in table II-8 and are based on the following zone structure:

- Zone 1 – Anywhere between McKinleyville/Arcata Airport and the Fortuna Overlook.
- Zone 2 – Anywhere between Trinidad and School Road.
- Zone 3 – Anywhere between Palmer Blvd in Fortuna and Scotia.
- All Zone – from Scotia to Trinidad and Willow Creek to Arcata

Table II – 8: RTS Fare Structure

Zone	Cash Fare	10 – Ride Pass	Monthly Pass
Regular Adult			
Zone 1	$1.95	$14.00	$50.00
Zone 2 & 3	$1.45	$10.00	$50.00
All Zone	$2.20	$16.00	$50.00
Reduced (ages 3-17, above the age of 62, and persons with disabilities			
Zone 1	$1.70	$12.00	$45.00
Zone 2 & 3	$1.20	$8.50	$45.00
All Zone	$1.95	$14.00	$45.00

Table II-09 provides a comparison of 2003/2004 and 2004/2005 performance measures for Redwood Transit System commuter service that runs along the US 101 corridor between Scotia and Trinidad.

Table II-9: RTS 2003/04, and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	295,577	319,162	8%
Total Vehicle Miles	494,562	506,501	2.4%
Total Vehicle Hours	21,478.78	22,100	2.9%
Total Operating Cost	$1,266,638.02	$1,426,871.90	12.7%
Farebox Revenues	$429,533.12	$483,305.38	12.5%
Farebox Recovery Ratio	33.91%	33.87%	-0.12%
Cost Per Vehicle Mile	$2.78	$3.04	9.4%
Cost Per Vehicle Hour	$63.68	$69.93	9.8%
Cost Per Passenger	$4.29	$4.47	4.2%

Redwood Transit System experienced an eight percent increase in total passengers even though total vehicle miles and total vehicle hours only increased by 2.4 percent and 2.9 percent respectively. Farebox revenues rose by 12.5 percent, but the farebox recovery ratio decreased by -0.12 percent. Table II-10 provides a comparison of 2003/2004 and 2004/2005 performance measures for Redwood Transit System commuter service that runs along the Highway 299 corridor between Willow Creek and Arcata.

Table II-10: RTS *Willow Creek Route* 2003/04 and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	5,264	7,447	41.5%
Total Vehicle Miles	68,030	72,727	6.9%
Total Vehicle Hours	2,060.50	2,040.00	-1%
Total Operating Cost	$107,484.56	$117,201.56	9%
Farebox Revenues	$17,972.12	$24,502.02	36.3%
Farebox Recovery Ratio	16.72%	20.91%	25.1%
Cost Per Vehicle Mile	$1.58	$1.61	1.9%
Cost Per Vehicle Hour	$52.16	$57.45	10.1%
Cost Per Passenger	$20.42	$15.74	-22.9%

The Highway 299 RTS route experienced a 41.5 percent increase in total passengers between the 2003/2004 and 2004/2005 fiscal year. Farebox revenues experienced a 36.3 percent increase, but cost per passenger decreased by 22.9 percent.

A five-year Transit Development Plan (TDP) was prepared for the RTS service in August 2002. Key operational and capital needs identified in the plan include the following:

- Implementation of additional service or new service will require additional staff.
- Consideration of Sunday and holiday service when funds are available.
- Better synchronization to accommodate student travel needs, with Humboldt State University and College of the Redwoods classes beginning on the hour and half hour, to coordinate with RTS service.
- Improved transferability between RTS and ETS, through schedules coordination.

RTS is involved in the development of the 2006 Transit Development Plan (TDP), which will focus on five-year transit needs and identify opportunities for long-term transit improvements. The RTS 2006 TDP is expected to be released in June of 2006.

Eureka Transit Service (ETS):
Eureka Transit Service provides fixed route transit service to the City of Eureka. The City of Eureka and Humboldt County provide funding for ETS and the costs are split, (73 percent of system costs funded by the City of Eureka and 27 percent of system costs are funded by Humboldt County), based on the amount of the service area that falls outside the Eureka City limits. The ETS fleet consists of eight buses all of which are lift equipped. Two diesel/electric hybrid buses have been ordered for the Eureka Transit System; delivery of the two hybrid buses is expected early in 2007. ETS operates 6:45 a.m. until 7:00 p.m. Monday through Friday and 10:00 a.m. through 5:00 p.m. on Saturday (with the exception of observed Holidays). Current passenger fares are illustrated in Table II-11.

Table II-11: ETS Fare Structure

Passenger	Cash Fare	Day Pass	10 – Ride Pass	Monthly Passes
Adult (18-61)	$1.20	$3.00	$9.00	$35.00
Seniors (62+)	$.90	$2.50	$6.50	$30.00
Children (3-17)	$.90	$2.50	$6.50	$30.00
Disabled	$.90	$2.50	$6.50	$30.00

Free transfers are available from the bus driver for travel between ETS routes. Transfers to/from the Redwood Transit System are free if the entire trip is inside the city of Eureka. Transfers are worth $0.15 toward the next fare when traveling outside of the city.

ETS provides four different transit routes. During the week, 12 round trips are made on the red, green, gold, and purple routes. On Saturday, seven round trips are made on each of the gold and rainbow routes. Hours of service and area of coverage for each route are as follows:

- Route 1 Red – The Red Route begins service at H Street and Manzanita at 6:28 a.m. and ends service at Harris and F Street at 6:40 p.m. The route provides service to the northwest and southeast quadrant of the city. Connections can be made to the Green, Purple, and Gold routes at F Street and Harris.
- Route 2 Green – The Green Route begins service at 6:38 a.m. at Bayshore Mall and ends service at 6:40 p.m. at Harris and F Street. The route predominately serves the Northeastern quadrant of the city. Connections can be made to the Red, Purple, and Gold routes at F Street and Harris.
- Route 3 Gold – The Gold Route begins *weekday* service at Allard and Utah at 6:15 a.m. and ends service at 3rd and H Street at 7:00 p.m. The route provides service to the Northwest and Southwest quadrants of the city. Connections can be made to the Red, Green, and Purple routes at F Street and Harris. The Gold Route begins *Saturday* service at 10:00 a.m. at 3rd and H Street and ends service at 5:00 p.m.
- Route 4 Purple – The Purple route begins service at 9th and H Street at 6:39 a.m. and ends service at 3rd and H Street at 7:00 p.m. The route provides service to the Northeast quadrant of the city. Connections can be made to the Red, Green, and Gold routes at F Street and Harris.
- Rainbow Route – This route operates Saturdays between 10:00 a.m. and 5:00 p.m. It begins at 3rd and H Street and provides service to the Bayshore Mall, Sequoia Park, and General Hospital.

ETS transit routes are depicted in figures three and five.

Table II-12 provides a comparison of 2003/2004 and 2004/2005 performance measures for Eureka Transit Service.

Table II-12: ETS 2003/04 and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	229,937	247,170	7.5%
Vehicle Service Miles	184,307.00	185,018.00	.4%
Vehicle Service Hours	16,790.50	16,584.50	-1.2%
Total Operating Cost	$686,810.07	$775,592.82	12.9%
Farebox Revenues	$214,261.31	$191,151.91	-10.8%
Farebox Recovery Ratio	31.20%	24.65%	-21%
Cost Per Vehicle Mile	$3.92	$4.40	12.2%
Cost Per Vehicle Hour	$42.92	$48.98	14.1%
Cost Per Passenger	$2.99	$3.14	5%

Total passengers increased 7.5 percent while both farebox revenues and vehicle service miles declined. Cost per vehicle mile increased by 12.2 percent and cost per vehicle hour increased by 14.1 percent.

During February 2001, an onboard survey of passengers riding ETS and Eureka Dial-A-Ride services was conducted for the ETS 2002 Transit Development Plan. ETS passengers indicated the following as their most important needs:

- Additional bus service to Humboldt Hill, Cutten and Ridgewood.
- Evening service to 8 and/or 10 p.m.
- More frequent service
- More convenient stop locations
- More direct routing

ETS is involved in the development of the 2006 Transit Development Plan (TDP), which will focus on five-year transit needs and identify opportunities for long-term transit improvements. The ETS 2006 TDP is expected to be released in June of 2006.

Arcata & Mad River Transit System (A&MRTS):

The A&MRTS was initiated by the Arcata City Council to provide an alternative form of transportation within the city limits, with the objectives of saving energy and serving groups such as college students, senior citizens, young people, and others without automobile transportation. The City of Arcata began providing fixed-route transit in 1975. A&MRTS is operated by the City of Arcata Public Works Department. The Department employs a Transportation Superintendent who functions as Transit Manager and oversees all transit operations, planning and support services, which includes the Arcata Transit center. When HSU is in session, 135 busses pass through the Arcata transit center in one day. The cost of the system is offset by fares (25 percent) and revenues obtained from a portion of the state sales tax on gasoline (75 percent). Humboldt State University rates are subsidized by university parking fines. The A&MRTS fleet consists of six vehicles, all of which are lift equipped. .

A&MRTS hours of operation vary by the Humboldt State University's (HSU) academic calendar. During the Fall and Spring semesters the hours of operation are 7:00 a.m. thru 10:00 p.m. Three weekday routes, Gold, Red, and Express, operate hourly during the Fall and Spring semesters. Saturday bus service consists of the Gold and Red routes, with the Gold route operating during even hours and the Red route operating on odd hours. During the HSU summer and winter breaks the hours of operation are 7:00 a.m. thru 7:00 p.m. Two weekday routes, Gold and Red, operate hourly during the winter and summer break. Express route bus service is not offered. A&MRTS routes are shown in figures three and four.

- Gold Route – Provides service to G and F streets in the downtown area, Northtown, Humboldt State University, Mad River Hospital, and Valley West.
- Red Route – Provides service to the downtown area, Greenview Market, Humboldt State University, Union Street, and Sunny Brae.
- Express Route – Provides service quickly from Valley West and Sunny Brae to Humboldt State University.

Table II-13 provides the fare structure for the Arcata and Mad River Transit System.

Table II-13: A&MRTS Fare Structure

Passenger	Cash Fare	Fare Book (10 Rides)
Adult (18-64)	$1.00	$7.00
Seniors (62+)	$.50	$5.00
Children (0-2)	Free	N/A
Children (3-17)	$.60	$5.00
HSU Students, Staff & Faculty	Free	N/A

Table II-14 provides a comparison of 2003/2004 and 2004/2005 fiscal year performance measures for the Arcata and Mad River Transit System.

Table II-14: A&MRTS 2003/04 and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	176,063	178,327	1.3%
Vehicle Service Miles	93,014	94,163	1.2%
Vehicle Service Hours	7,352	7,488	1.8%
Total Operating Cost	$351,146.33	$404,272.00	15.1%
Farebox Revenues	$99,534.50	$137,934.50	38.6%
Farebox Recovery Ratio	28.35%	33.99%	19.9%
Cost Per Vehicle Mile	$3.78	$4.29	1.5%
Cost Per Vehicle Hour	$47.76	$53.99	13%
Cost Per Passenger	$1.99	$2.27	14.1%

A&MRTS experienced a 1.3 percent increase in passengers between fiscal years 2003/2004 and 2004/2005. Farebox revenues rose by 38.6 percent, but the farebox recovery ratio only rose by 19.9 percent. Cost per passenger increased by 14.1 percent and cost per vehicle hour increased by 13 percent.

The City of Arcata conducted an Unmet Transit Needs public hearing on April 20, 2005. The following needs were identified during that process:

- Shuttle bus between HSU and downtown
- Investigate service south of Samoa Boulevard
- Sunday service in Arcata and to Eureka

As a result of needs addressed in the City of Arcata 2001 Transit Development Plan and Unmet Transit Needs public hearings, A&MRTS expanded their service hours additional three hours until 10:00 p.m. and added an express shuttle bus to increase frequency of bus service when HSU is in session.

A&MRTS is currently involved in the development of the City of Arcata's 2006 Transit Development Plan, which will focus on five-year transit needs and identify opportunities for long-term transit improvements. The City of Arcata 2006 TDP will be completed in June of 2006. The City Council held a goal setting session in March of 2006 and identified interest in establishing Aldergrove bus service.

Klamath/Trinity Non Emergency Transportation (K/T NET)

Klamath Trinity Non Emergency Transportation K/T Net commenced transit operations on January 2003. K/T Net is a non-profit community based organization in Eastern Humboldt County. They were organized to provide needed bus service in underserved areas such as the Hoopa Valley Indian Reservation. Their fixed route service travels between Hoopa and Willow Creek four times daily, Monday through Friday (see figures three , four, and five). It connects with the HTA bus from the Coast twice daily. The K/T Net transit bus is also available for special contracts in the local area. This service has shown to meet a transit need for citizens who need to travel upwards of 120 miles roundtrip for work, school or training from the Willow Creek area to the North Coast. As the system develops, continued coordination is required for timely funding and implementation service. It was this coordination among concerned stakeholders and community groups that enabled K/T Net to be implemented four years after initial development. This service also has demonstrated the coordination between tribal communities and local stakeholders to work together and develop a much needed service. Table II-15 provides the fare structure for K/T Net's fixed route transit service.

Table II-15: K/T Net One-way fare schedule

Passenger	Cash Fare	Fare Book (10 Rides)
Adult (18-61)	$1.75	$10.50
Seniors (62+)	$1.50	$9.50
Children (3-12)	$1.50	$9.50
Calworks participants	$1.50	$9.50

Riders can also purchase a K/T Net Day Pass for $2.50. Children, seniors and Calworks participants can purchase a reduced fare Day pass for $2.25.

In 2005, K/T Net had a total passenger count of 2,775, traveled a total of 21,181 miles, made 887 total trips, and had a farebox recovery of $34,366.17.

TJKM
Vision That Moves Your Community
Transportation Consultants

Technical Memorandum

Date: January 13, 2010

To: John Miller, Humboldt County *Project No.:* 074-021, Task 3

From: Gary Kruger, T.E.
Traffic Engineering Consultant *Jurisdiction:* Humboldt County

Subject: Generalized Estimates of Transit Demand, Humboldt Countywide Model

Since there is no mode-split model within the countywide model, there is a need to estimate transit patronage based upon volume forecasts in the model. The volume forecasts are for vehicles, and person-trips are higher.

Annual passengers for the following transit services are given in the documentation for the *Humboldt County 2006 Regional Transportation Plan Update*:

- Redwood Transit System (commuter service along US 101, Trinidad to Scotia)
- Eureka Transit Service serving the City of Eureka
- Arcata & Mad River Transit System

Additional services such as dial a ride are also available, generally along the US 101 corridor and within McKinleyville, Arcata, Eureka, Fortuna and Ferndale as well as along SR 36 and the Hoopa Indian Reservation. No ridership data are provided for these additional services, but they are assumed to represent an insignificant fraction of total travel within any corridor of Humboldt County.

I have assumed that most transit patronage occurs on weekdays rather than weekends and holidays. The latest figures provided in the RTP documentation are for 2005. The Redwood Transit System carries approximately 1,250 person trips per day, or roughly 625 in either direction along the US 101 corridor. The Eureka Transit System carries approximately 1,000 person trips per day, or 500 in each direction on several corridors within the city. The Arcata & Mad River Transit System carries about 750 person trips daily, or 375 in each direction.

If a mode split of 0.75 percent for transit person trips is assumed for US 101, we would have about 300 transit trips within Eureka on any day in each direction (Broadway and the 4th/5th couplets). This may be a little high, but is a reasonable approximation since most of the trip destinations within the city are along this corridor. Thus, simply multiplying vehicle volumes on US 101 by 0.0075 is a means of estimating transit demand for a given level of transit service (fare/headway/route coverage structure). If fares are changed or if headways are changed, patronage is likely to change, either positively or negatively, about 20 percent as much as the percentage change in the fare or headway. For example, if headways are reduced from an hour to 30 minutes along US 101, then patronage would increase by 10 percent (50 percent reduction in headway for a reciprocal increase of 10 percent [1.00 + (0.2 X 0.50) = 0.10] in patronage. This assumes an elasticity of .2 for both fare and headway changes.

Pleasanton
3875 Hopyard Road
Suite 200
Pleasanton, CA
94588-8526
925.463.0611
925.463.3690 fax

Fresno
516 W. Shaw Avenue
Suite 200
Fresno, CA
93704-2515
559.325.7530
559.221.4940 fax

Sacramento
980 Ninth Street
16th Floor
Sacramento, CA
95814-2736
916.449.9095

Santa Rosa
1400 N. Dutton Avenue
Suite 21
Santa Rosa, CA
95401-4643
707.575.5800
707.575.5888 fax

tjkm@tjkm.com
www.tjkm.com

For Eureka routes away from US 101, a factor of 0.0030 is a reasonable estimator of transit demand along corridors served by transit within the city.

For locations away from Eureka, I would use a flat 0.0020 for estimating transit patronage along corridors served by transit.

I would not bother to estimate transit demand for dial-a-ride service, and of course, more than ½ mile away from routes with transit service, the transit patronage would be zero.

I have attached information I used in this exercise. Generally, in low-density areas with basic (minimum) transit service where parking is generally free, transit patronage rarely exceeds 0.5 percent of total travel in a corridor.

Note that this method bases transit patronage estimates on vehicle trips. For person trips in vehicles, simply multiply vehicle volumes by the average vehicle occupancy. If the average occupancy along US 101 near Wabash (in Eureka) is 1.2 persons per vehicle, then the total person trips on US 101 is [35,000 ADT X 1.2 = 42,000] in both directions per day plus [35,000 X 0.0075 X 2 for both directions = 525] for a total of 42,525 total person trips. Additional trips in the corridor can include bicycles and pedestrians.

The calculation of total person trips is of value in the evaluation of various types of corridor improvements that benefit transit operations or route coverage.

The comparison of annual passengers for the major transit services with the results of calculating transit patronage along corridors that are served shows reasonable internal consistency.

attachments

Figure II-3:

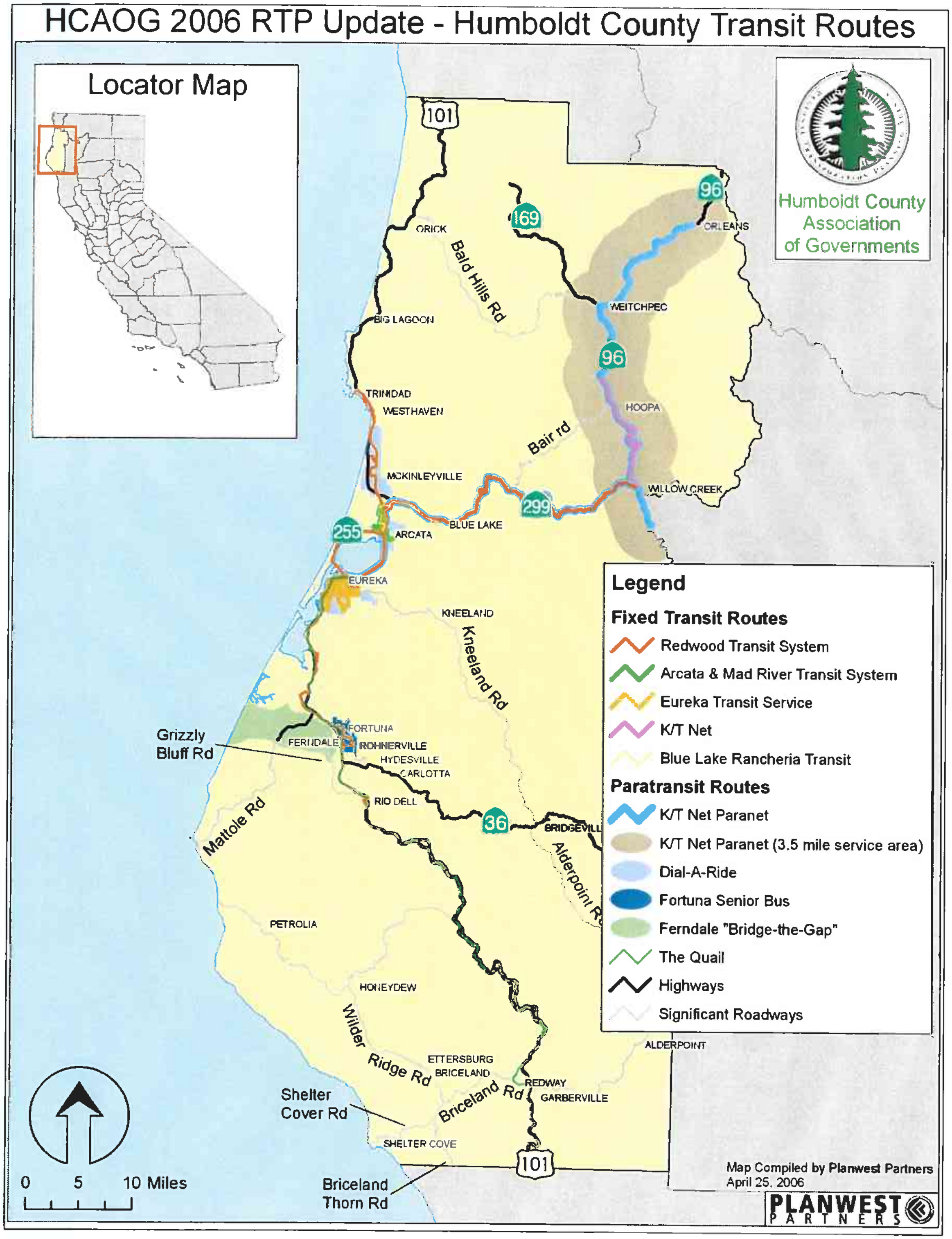

HCAOG 2006 RTP Update - Humboldt County Transit Routes
Locator Map
Humboldt County Association of Governments
101
169
96
ORICK
Bald Hills Rd
ORLEANS
WEITCHPEC
BIG LAGOON
TRINIDAD
WESTHAVEN
HOOPA
Bair rd
MCKINLEYVILLE
WILLOW CREEK
299
BLUE LAKE
255
ARCATA
EUREKA
KNEELAND
Kneeland Rd
Grizzly Bluff Rd
FORTUNA
FERNDALE
ROHNERVILLE
HYDESVILLE
CARLOTTA
RIO DELL
36
BRIDGEVILLE
Alderpoint Rd
Mattole Rd
PETROLIA
HONEYDEW
Wilder Ridge Rd
ETTERSBURG
BRICELAND
REDWAY
GARBERVILLE
Briceland Rd
Shelter Cover Rd
SHELTER COVE
Briceland Thorn Rd
ALDERPOINT
0 5 10 Miles
Legend
Fixed Transit Routes
Redwood Transit System
Arcata & Mad River Transit System
Eureka Transit Service
K/T Net
Blue Lake Rancheria Transit
Paratransit Routes
K/T Net Paranet
K/T Net Paranet (3.5 mile service area)
Dial-A-Ride
Fortuna Senior Bus
Ferndale "Bridge-the-Gap"
The Quail
Highways
Significant Roadways
Map Compiled by Planwest Partners April 25, 2006
PLANWEST PARTNERS

Figure II-5:

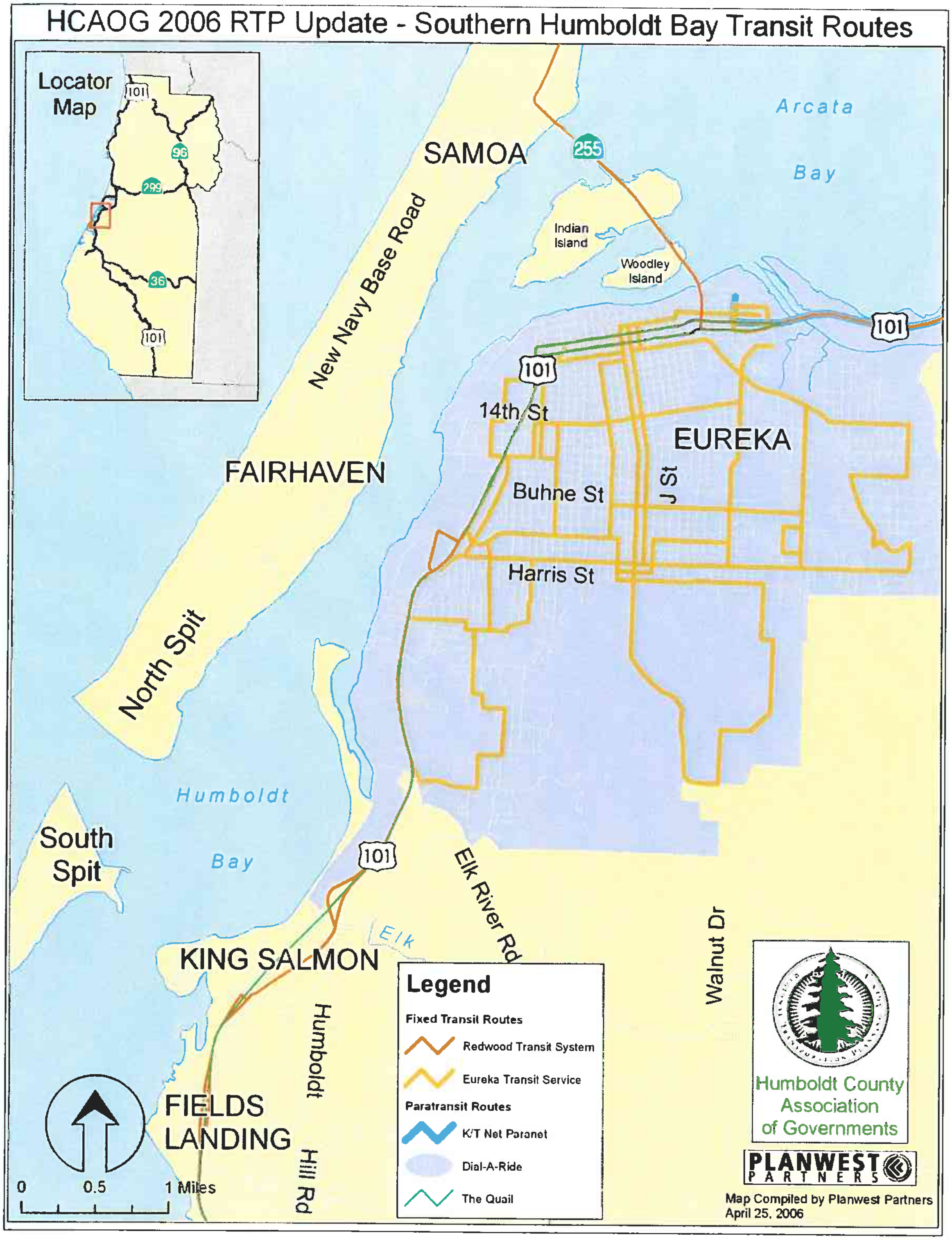
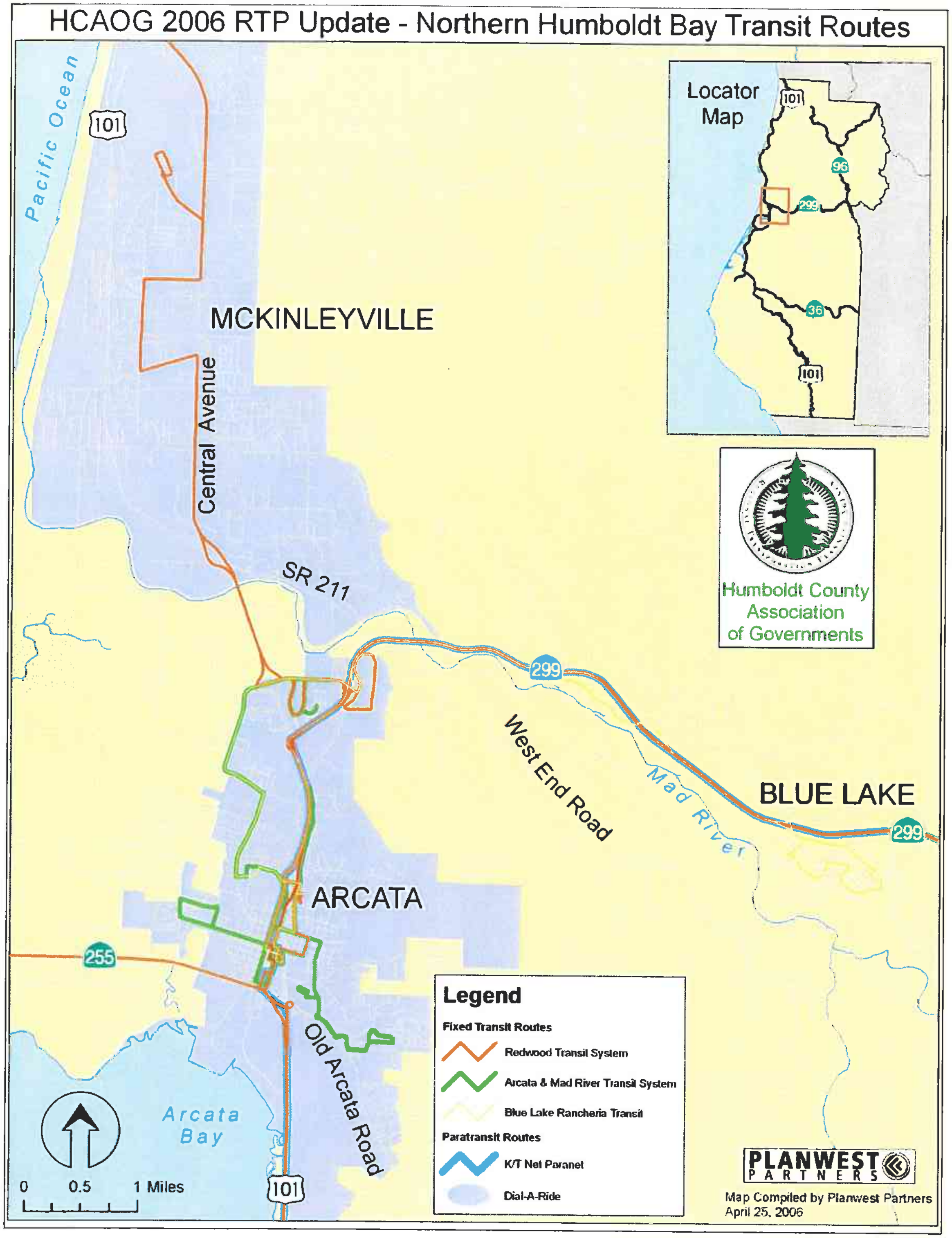

HCAOG 2006 RTP Update - Southern Humboldt Bay Transit Routes
Locator Map
SAMOA
Arcata
Bay
Indian Island
Woodley Island
New Navy Base Road
14th St
EUREKA
FAIRHAVEN
Buhne St
J St
Harris St
North Spit
Humboldt
Bay
South Spit
Elk River Rd
Elk
KING SALMON
Walnut Dr
Humboldt Hill Rd
FIELDS LANDING
0
0.5
1 Miles
Legend
Fixed Transit Routes
Redwood Transit System
Eureka Transit Service
Paratransit Routes
K/T Net Paranet
Dial-A-Ride
The Quail
Humboldt County Association of Governments
PLANWEST PARTNERS
Map Compiled by Planwest Partners
April 25, 2006

Figure II-4:


HCAOG 2006 RTP Update - Northern Humboldt Bay Transit Routes
Pacific Ocean
101
MCKINLEYVILLE
Central Avenue
SR 211
299
West End Road
Mad River
BLUE LAKE
299
ARCATA
255
Old Arcata Road
Arcata Bay
101
0 0.5 1 Miles
Locator Map
101
96
299
36
101
Humboldt County Association of Governments
Legend
Fixed Transit Routes
Redwood Transit System
Arcata & Mad River Transit System
Blue Lake Rancheria Transit
Paratransit Routes
K/T Net Paranet
Dial-A-Ride
PLANWEST PARTNERS
Map Compiled by Planwest Partners
April 25, 2006

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Zone	Cash Fare	10 – Ride Pass	Monthly Pass
Regular Adult			
Zone 1	$1.95	$14.00	$50.00
Zone 2 & 3	$1.45	$10.00	$50.00
All Zone	$2.20	$16.00	$50.00
Reduced (ages 3-17, above the age of 62, and persons with disabilities			
Zone 1	$1.70	$12.00	$45.00
Zone 2 & 3	$1.20	$8.50	$45.00
All Zone	$1.95	$14.00	$45.00

Table II-09 provides a comparison of 2003/2004 and 2004/2005 performance measures for Redwood Transit System commuter service that runs along the US 101 corridor between Scotia and Trinidad.

12.50/weekday 6.25 each way

Table II-9: RTS 2003/04, and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	295,577	319,162	8%
Total Vehicle Miles	494,562	506,501	2.4%
Total Vehicle Hours	21,478.78	22,100	2.9%
Total Operating Cost	$1,266,638.02	$1,426,871.90	12.7%
Farebox Revenues	$429,533.12	$483,305.38	12.5%
Farebox Recovery Ratio	33.91%	33.87%	-0.12%
Cost Per Vehicle Mile	$2.78	$3.04	9.4%
Cost Per Vehicle Hour	$63.68	$69.93	9.8%
Cost Per Passenger	$4.29	$4.47	4.2%

Redwood Transit System experienced an eight percent increase in total passengers even though total vehicle miles and total vehicle hours only increased by 2.4 percent and 2.9 percent respectively. Farebox revenues rose by 12.5 percent, but the farebox recovery ratio decreased by -0.12 percent. Table II-10 provides a comparison of 2003/2004 and 2004/2005 performance measures for Redwood Transit System commuter service that runs along the Highway 299 corridor between Willow Creek and Arcata.

Table II-10: RTS *Willow Creek Route* 2003/04 and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	5,264	7,447	41.5%
Total Vehicle Miles	68,030	72,727	6.9%
Total Vehicle Hours	2,060.50	2,040.00	-1%
Total Operating Cost	$107,484.56	$117,201.56	9%
Farebox Revenues	$17,972.12	$24,502.02	36.3%
Farebox Recovery Ratio	16.72%	20.91%	25.1%
Cost Per Vehicle Mile	$1.58	$1.61	1.9%
Cost Per Vehicle Hour	$52.16	$57.45	10.1%
Cost Per Passenger	$20.42	$15.74	-22.9%

The Highway 299 RTS route experienced a 41.5 percent increase in total passengers between the 2003/2004 and 2004/2005 fiscal year. Farebox revenues experienced a 36.3 percent increase, but cost per passenger decreased by 22.9 percent.

A five-year Transit Development Plan (TDP) was prepared for the RTS service in August 2002. Key operational and capital needs identified in the plan include the following:

- Implementation of additional service or new service will require additional staff.
- Consideration of Sunday and holiday service when funds are available.
- Better synchronization to accommodate student travel needs, with Humboldt State University and College of the Redwoods classes beginning on the hour and half hour, to coordinate with RTS service.
- Improved transferability between RTS and ETS, through schedules coordination.

RTS is involved in the development of the 2006 Transit Development Plan (TDP), which will focus on five-year transit needs and identify opportunities for long-term transit improvements. The RTS 2006 TDP is expected to be released in June of 2006.

Eureka Transit Service (ETS):

Eureka Transit Service provides fixed route transit service to the City of Eureka. The City of Eureka and Humboldt County provide funding for ETS and the costs are split, (73 percent of system costs funded by the City of Eureka and 27 percent of system costs are funded by Humboldt County), based on the amount of the service area that falls outside the Eureka City limits. The ETS fleet consists of eight buses all of which are lift equipped. Two diesel/electric hybrid buses have been ordered for the Eureka Transit System; delivery of the two hybrid buses is expected early in 2007. ETS operates 6:45 a.m. until 7:00 p.m. Monday through Friday and 10:00 a.m. through 5:00 p.m. on Saturday (with the exception of observed Holidays). Current passenger fares are illustrated in Table II-11.

Table II-11: ETS Fare Structure

Passenger	Cash Fare	Day Pass	10 – Ride Pass	Monthly Passes
Adult (18-61)	$1.20	$3.00	$9.00	$35.00
Seniors (62+)	$.90	$2.50	$6.50	$30.00
Children (3-17)	$.90	$2.50	$6.50	$30.00
Disabled	$.90	$2.50	$6.50	$30.00

Free transfers are available from the bus driver for travel between ETS routes. Transfers to/from the Redwood Transit System are free if the entire trip is inside the city of Eureka. Transfers are worth $0.15 toward the next fare when traveling outside of the city.

ETS provides four different transit routes. During the week, 12 round trips are made on the red, green, gold, and purple routes. On Saturday, seven round trips are made on each of the gold and rainbow routes. Hours of service and area of coverage for each route are as follows:

- Route 1 Red – The Red Route begins service at H Street and Manzanita at 6:28 a.m. and ends service at Harris and F Street at 6:40 p.m. The route provides service to the northwest and southeast quadrant of the city. Connections can be made to the Green, Purple, and Gold routes at F Street and Harris.
- Route 2 Green – The Green Route begins service at 6:38 a.m. at Bayshore Mall and ends service at 6:40 p.m. at Harris and F Street. The route predominately serves the Northeastern quadrant of the city. Connections can be made to the Red, Purple, and Gold routes at F Street and Harris.
- Route 3 Gold – The Gold Route begins *weekday* service at Allard and Utah at 6:15 a.m. and ends service at 3rd and H Street at 7:00 p.m. The route provides service to the Northwest and Southwest quadrants of the city. Connections can be made to the Red, Green, and Purple routes at F Street and Harris. The Gold Route begins *Saturday* service at 10:00 a.m. at 3rd and H Street and ends service at 5:00 p.m.
- Route 4 Purple – The Purple route begins service at 9th and H Street at 6:39 a.m. and ends service at 3rd and H Street at 7:00 p.m. The route provides service to the Northeast quadrant of the city. Connections can be made to the Red, Green, and Gold routes at F Street and Harris.
- Rainbow Route – This route operates Saturdays between 10:00 a.m. and 5:00 p.m. It begins at 3rd and H Street and provides service to the Bayshore Mall, Sequoia Park, and General Hospital.

ETS transit routes are depicted in figures three and five.

Table II-12 provides a comparison of 2003/2004 and 2004/2005 performance measures for Eureka Transit Service.

Table II-12: ETS 2003/04 and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	229,937	247,170	7.5%
Vehicle Service Miles	184,307.00	185,018.00	.4%
Vehicle Service Hours	16,790.50	16,584.50	-1.2%
Total Operating Cost	$686,810.07	$775,592.82	12.9%
Farebox Revenues	$214,261.31	$191,151.91	-10.8%
Farebox Recovery Ratio	31.20%	24.65%	-21%
Cost Per Vehicle Mile	$3.92	$4.40	12.2%
Cost Per Vehicle Hour	$42.92	$48.98	14.1%
Cost Per Passenger	$2.99	$3.14	5%

Total passengers increased 7.5 percent while both farebox revenues and vehicle service miles declined. Cost per vehicle mile increased by 12.2 percent and cost per vehicle hour increased by 14.1 percent.

During February 2001, an onboard survey of passengers riding ETS and Eureka Dial-A-Ride services was conducted for the ETS 2002 Transit Development Plan. ETS passengers indicated the following as their most important needs:

- Additional bus service to Humboldt Hill, Cutten and Ridgewood.
- Evening service to 8 and/or 10 p.m.
- More frequent service
- More convenient stop locations
- More direct routing

ETS is involved in the development of the 2006 Transit Development Plan (TDP), which will focus on five-year transit needs and identify opportunities for long-term transit improvements. The ETS 2006 TDP is expected to be released in June of 2006.

Arcata & Mad River Transit System (A&MRTS):

The A&MRTS was initiated by the Arcata City Council to provide an alternative form of transportation within the city limits, with the objectives of saving energy and serving groups such as college students, senior citizens, young people, and others without automobile transportation. The City of Arcata began providing fixed-route transit in 1975. A&MRTS is operated by the City of Arcata Public Works Department. The Department employs a Transportation Superintendent who functions as Transit Manager and oversees all transit operations, planning and support services, which includes the Arcata Transit center. When HSU is in session, 135 busses pass through the Arcata transit center in one day. The cost of the system is offset by fares (25 percent) and revenues obtained from a portion of the state sales tax on gasoline (75 percent). Humboldt State University rates are subsidized by university parking fines. The A&MRTS fleet consists of six vehicles, all of which are lift equipped. .

A&MRTS hours of operation vary by the Humboldt State University's (HSU) academic calendar. During the Fall and Spring semesters the hours of operation are 7:00 a.m. thru 10:00 p.m. Three weekday routes, Gold, Red, and Express, operate hourly during the Fall and Spring semesters. Saturday bus service consists of the Gold and Red routes, with the Gold route operating during even hours and the Red route operating on odd hours. During the HSU summer and winter breaks the hours of operation are 7:00 a.m. thru 7:00 p.m. Two weekday routes, Gold and Red, operate hourly during the winter and summer break. Express route bus service is not offered. A&MRTS routes are shown in figures three and four.

- Gold Route – Provides service to G and F streets in the downtown area, Northtown, Humboldt State University, Mad River Hospital, and Valley West.
- Red Route – Provides service to the downtown area, Greenview Market, Humboldt State University, Union Street, and Sunny Brae.
- Express Route – Provides service quickly from Valley West and Sunny Brae to Humboldt State University.

Table II-13 provides the fare structure for the Arcata and Mad River Transit System.

Table II-13: A&MRTS Fare Structure

Passenger	Cash Fare	Fare Book (10 Rides)
Adult (18-64)	$1.00	$7.00
Seniors (62+)	$.50	$5.00
Children (0-2)	Free	N/A
Children (3-17)	$.60	$5.00
HSU Students, Staff & Faculty	Free	N/A

Table II-14 provides a comparison of 2003/2004 and 2004/2005 fiscal year performance measures for the Arcata and Mad River Transit System.

Table II-14: A&MRTS 2003/04 and 2004/05 Fiscal Year Performance Measures

Performance Measures	FY 03/04	FY 04/05	Percent Change
Total Passengers	176,063	178,327	1.3%
Vehicle Service Miles	93,014	94,163	1.2%
Vehicle Service Hours	7,352	7,488	1.8%
Total Operating Cost	$351,146.33	$404,272.00	15.1%
Farebox Revenues	$99,534.50	$137,934.50	38.6%
Farebox Recovery Ratio	28.35%	33.99%	19.9%
Cost Per Vehicle Mile	$3.78	$4.29	1.5%
Cost Per Vehicle Hour	$47.76	$53.99	13%
Cost Per Passenger	$1.99	$2.27	14.1%

A&MRTS experienced a 1.3 percent increase in passengers between fiscal years 2003/2004 and 2004/2005. Farebox revenues rose by 38.6 percent, but the farebox recovery ratio only rose by 19.9 percent. Cost per passenger increased by 14.1 percent and cost per vehicle hour increased by 13 percent.

The City of Arcata conducted an Unmet Transit Needs public hearing on April 20, 2005. The following needs were identified during that process:

- Shuttle bus between HSU and downtown
- Investigate service south of Samoa Boulevard
- Sunday service in Arcata and to Eureka

As a result of needs addressed in the City of Arcata 2001 Transit Development Plan and Unmet Transit Needs public hearings, A&MRTS expanded their service hours additional three hours until 10:00 p.m. and added an express shuttle bus to increase frequency of bus service when HSU is in session.

A&MRTS is currently involved in the development of the City of Arcata's 2006 Transit Development Plan, which will focus on five-year transit needs and identify opportunities for long-term transit improvements. The City of Arcata 2006 TDP will be completed in June of 2006. The City Council held a goal setting session in March of 2006 and identified interest in establishing Aldergrove bus service.

Klamath/Trinity Non Emergency Transportation (K/T NET)

Klamath Trinity Non Emergency Transportation K/T Net commenced transit operations on January 2003. K/T Net is a non-profit community based organization in Eastern Humboldt County. They were organized to provide needed bus service in underserved areas such as the Hoopa Valley Indian Reservation. Their fixed route service travels between Hoopa and Willow Creek four times daily, Monday through Friday (see figures three , four, and five). It connects with the HTA bus from the Coast twice daily. The K/T Net transit bus is also available for special contracts in the local area. This service has shown to meet a transit need for citizens who need to travel upwards of 120 miles roundtrip for work, school or training from the Willow Creek area to the North Coast. As the system develops, continued coordination is required for timely funding and implementation service. It was this coordination among concerned stakeholders and community groups that enabled K/T Net to be implemented four years after initial development. This service also has demonstrated the coordination between tribal communities and local stakeholders to work together and develop a much needed service. Table II-15 provides the fare structure for K/T Net's fixed route transit service.

Table II-15: K/T Net One-way fare schedule

Passenger	Cash Fare	Fare Book (10 Rides)
Adult (18-61)	$1.75	$10.50
Seniors (62+)	$1.50	$9.50
Children (3-12)	$1.50	$9.50
Calworks participants	$1.50	$9.50

Riders can also purchase a K/T Net Day Pass for $2.50. Children, seniors and Calworks participants can purchase a reduced fare Day pass for $2.25.

In 2005, K/T Net had a total passenger count of 2,775, traveled a total of 21,181 miles, made 887 total trips, and had a farebox recovery of $34,366.17.

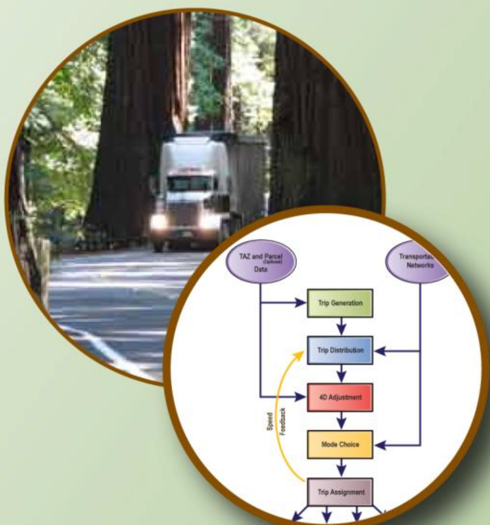
Humboldt County Association of Governments

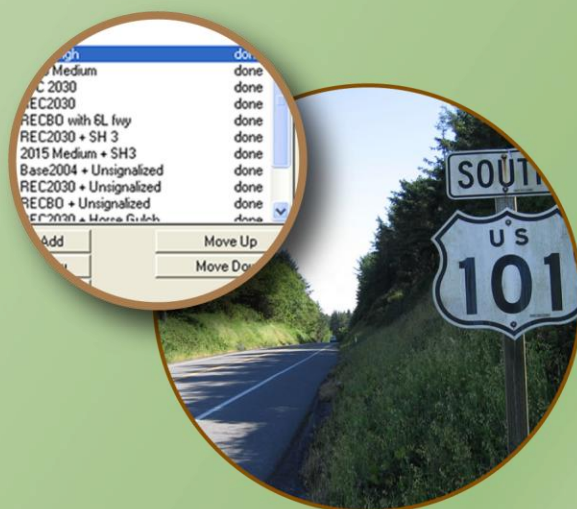
Rural Regional Blueprint Planning Phase III

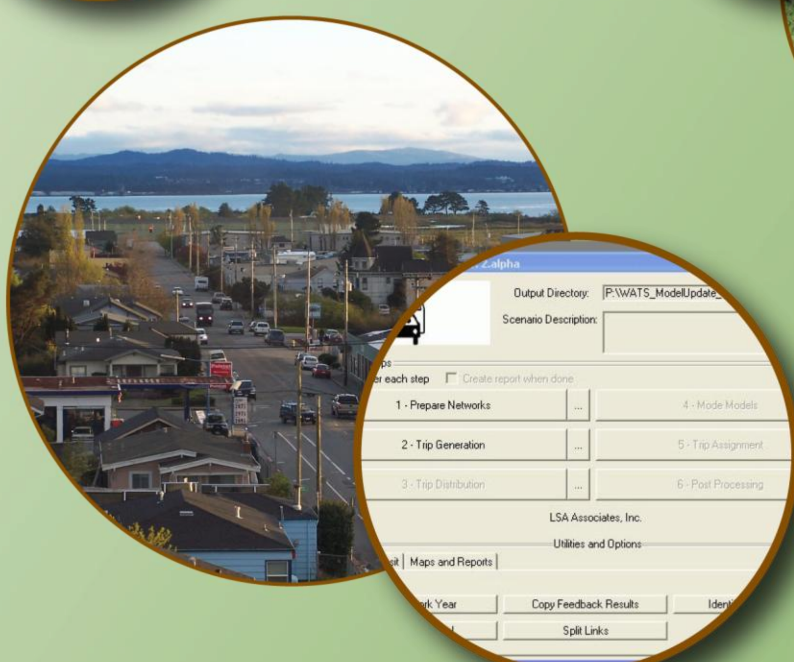
Travel Model Update

Technical Documentation

January 2013







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CAMBRIDGE SYSTEMATICS

Humboldt County Travel Model

TECHNICAL DOCUMENTATION

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INTRODUCTION

The HCAOG Travel Model is a tool used by the Humboldt County Association of Governments (HCAOG) and the California Department of Transportation (Caltrans) to forecast travel patterns in both rural and urbanized portions of Humboldt County. The primary purposes of the travel model are to support the Regional Blueprint planning process, to evaluate potential improvements to the roadway system, and evaluate the impacts of land use changes in the county. The model also includes limited transit and non-motorized analysis capabilities. The base year selected for the model is 2010, with a forecast year of 2040.

The HCAOG Travel Model utilizes a traditional four-step modeling process, consisting of trip generation, trip distribution, mode split, and traffic assignment. This process addresses all person trips, including trips made using transit and non-motorized modes (walk and bicycle). The updated model includes AM and PM peak periods and an off-peak period, which are combined to produce total daily traffic volumes. Post processing tools produce useful information, such as a summary report, adjusted model volumes, and maps of model results. The entire process is automated and can be managed from a scenario management system within the TransCAD software platform. Automation has been implemented using GISDK, TransCAD's programming language.

This document provides detailed information about the processes and parameters contained in the HCAOG Travel Model. Each chapter focuses on a specific model input or model step, beginning with the input roadway network and continuing with descriptions of the four-step modeling process. Base year model validation measures associated with each of the four model steps are discussed in the corresponding chapters, with a sensitivity testing process described in a separate chapter. In addition, a User's Guide is provided under a separate cover. The User's Guide provides detailed information about using the travel model software and datasets.

Humboldt County Travel Model

1. Roadway Network

Context and Background

The roadway network contains basic input information for use in the travel demand model and represents real-world conditions for the 2010 base year. The roadway networks are used in the model to distribute trips and route automobile trips. The networks in the GIS environment used by the model are databases in which all kinds of information can be stored and managed. In addition, the networks provide a foundation for system performance analysis including vehicle miles of travel, congestion delay, level of service, and other performance criteria. This chapter provides a description of the network attributes and lookup tables for the roadway networks. The assumptions and parameters identified herein were identified during the development of the model's 2010 base year network, but they generally apply to all model year networks.

The roadway network is a GIS-based representation of the street and highway system in Humboldt County. It operates both as an input database containing roadway characteristics (such as facility type, number of lanes, area type, etc.) and as a data repository that can be used to store and view travel model results. The roadway network is one of the foundational components of the Humboldt County Model as it serves to represent the supply side of the travel demand/transportation system relationship. As such, the establishment and review of detailed network attribute data was very important to the model's development.

The roadway network is structured to contain data for multiple timeframes. The roadway network prepared for the Humboldt County Model contains the 2010 base year network and can be expanded to include forecast year improvements or alternatives. It is designed to accommodate future horizon year networks, including 2040 and other interim years as desired. The model includes the capability to represent the 2010 base year, existing plus committed networks, plan forecast networks, interim horizon year networks, and any other network scenarios that are desired within a single network database. In addition, the network is structured so that localized alternatives can be represented within the same file. These alternatives can be activated and deactivated based on the year of analysis and infrastructure scenario desired using the scenario management system that forms the basis of the travel model user interface.

Roadway Network Structure

The Humboldt County roadway network structure was designed to be a flexible data repository and to host input and output data required by the travel model. This section describes the network file structure and defines attributes that are populated on the network. Input attributes and some output attributes are discussed herein. Additional output variables created by subsequent model steps are discussed in the associated chapters.

Input network attributes used by the travel model include facility type, area type, number of lanes, speed limit, parking availability, pavement status, and direction of flow. Each of these variables is addressed in the sections that follow. Values for these attributes have been populated on the roadway network file for the year 2010.

The roadway network is structured to consolidate data from multiple years and scenarios in a single TransCAD geographic file. A description of the organizational scheme used to accomplish this consolidation is provided. In addition, several illustrative examples are provided.

Year-specific input data is used to compute freeflow speed, travel time, and capacity on each link in the roadway network. Methods used to develop and compute these values are discussed and specific values are documented herein. Information computed as part of the modeling process is placed on a copy of the network rather than the original input file.

Input and Output Networks

The roadway network file contains travel model input data, and it also acts as a repository for both intermediate (e.g., calculated capacity) and final (e.g., traffic volumes) model data. For this reason, a separate output model network is created for each model scenario. The model macros create this output network by making a copy of the input network and then modifying the copy to contain data and results specific to each model run. This copy of the roadway is created and modified automatically by the network initialization step when the travel model is run.

The model's directory structure allows multiple model output directories to exist alongside a single input directory. Each time the travel model is run, files located in the input directory are not modified by model macros. Instead, if a file is to be modified it will be copied to an output directory and only the copy is modified.

This approach has several benefits, including the following:

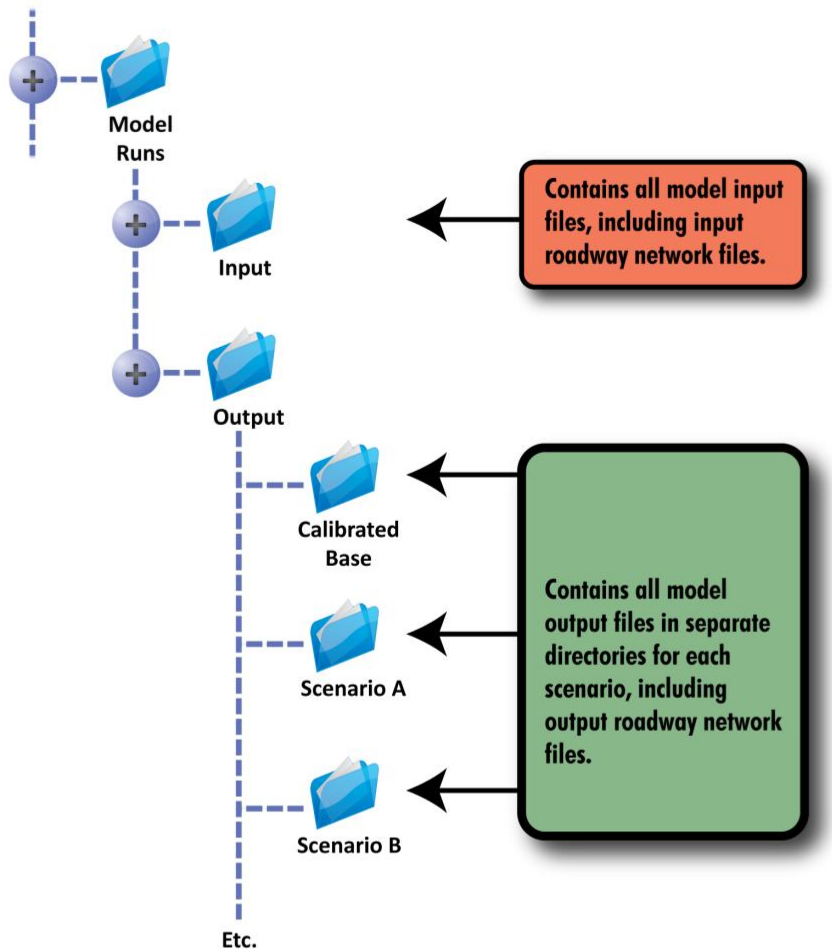
1. All input files are located in one standardized location, making identification of files easy when edits are required.

2. Because input files are not modified by the travel model macros, it is unlikely that important data present within input files will be inadvertently overwritten by travel model macros.

3. Since all output files related to a particular model run will be maintained in a single directory, there will be no confusion about which model scenario is represented by each file.

An example directory structure that would contain travel model input and output files is shown in Figure 1.1.

FIGURE 1.1: EXAMPLE MODEL RUN DIRECTORY STRUCTURE



Multi-Year and Alternative Network Structure

The Humboldt County roadway network is designed to store roadway data representing different years in one consolidated network layer. To accomplish this, selected network attribute names are appended with a two- through four-digit suffix representing a particular year. By representing multiple networks in one network file, consistency between baseline and forecast networks is enforced. Furthermore, this approach eliminates the need to edit multiple network files when making a change in a baseline or interim year network.

In addition, the network structure allows for the representation of alternative roadway projects such as roadway widening, realignments, and new facilities that are not tied to a specific network year. These alternatives can be activated or deactivated individually or in groups, regardless of the network year that has been selected. While there are some limitations with respect to alternatives sharing the same link, this capability can be a valuable tool when performing alternatives with the travel model. These limitations and strategies to overcome them are described below.

Representation of Networks by Year

Each attribute that can vary from year to year (e.g., facility type, area type, number of lanes, direction of flow, etc.) is represented in the roadway network by an attribute containing a two- through four-digit numerical suffix. When a particular network is selected for use in the travel model, only attributes with a suffix matching the selected year are used by the travel model. Of utmost importance is the facility type attribute. If this attribute is blank on a link for a particular year, that link will be "closed" to traffic (i.e., will not exist) in the network when that year is selected. If a valid facility type value is found, then the remaining attributes specified for that year will be referenced by the travel model.

The roadway network initially contains data only for the year 2010; ultimately, the network can include forecast year data representing planned improvements within the county. It is often necessary to consider multiple interim or buildout year networks (e.g., 2012 or 2050) in addition to the existing and plan forecast networks. Additional network years can be added at any time through the following steps:

1. Add new columns to the network link and node tables that will represent the additional network year (e.g., FT_12, AT_12, etc.);

2. Move these columns so that they are in a convenient location (e.g., after the 2010 data columns);

3. Fill these columns with data from the corresponding attributes for either 2010 or 2040; and

4. Adjust the data as necessary.

Because this is a commonly performed task, a utility is available to automatically perform steps 1 thorough 3 listed above. If alternatives are present in the network file, the utility will also allow the user to select alternatives to be included in a newly created network year. The utility can also delete all attributes associated with a particular year. The "Edit Network Year" utility is accessible from the model dialog box.

Representation of New Facilities

This network structure can represent roadway facilities that do not exist in the current network but are planned for future construction. For example, if a new roadway is planned to be built by 2040, it can be represented in the 2040 roadway network but not in the base year roadway network. To implement this, the roadway is added as a new link to the network layer, but is not assigned a facility type for the base year. A 2040 facility type is assigned for this link, along with all other year-specific attributes for 2040.

Representation of Network Alternatives

Roadway network alternatives provide a mechanism for testing localized network changes individually or in combination without the need to create an additional network. Roadway network alternatives are specified by a set of attributes with the suffix AL (e.g., FT_AL, AT_AL, etc.) and by attributes named ALT and ALT2, as follows:

- The fields with an AL suffix represent the network attributes used when an alternative is activated.
- The "ALT" and "ALT2" fields identify the alternative number associated with each link.

Prior to running the model, one or more alternatives can be activated by number. The values in fields containing the AL suffix will override other network attributes on links where ALT or ALT2 match a selected alternative. The network structure example sidebar further illustrates application of network alternatives. The Network Attribute Selection section describes the stepwise procedure used to process network attributes.

NETWORK STRUCTURE EXAMPLE

To illustrate the concept behind the network structure, a simplified example link data table is shown below. This table only shows facility type information. Other year-specific attributes follow a similar theme. In this example network:

- Link 100 exists as a principal arterial (FT = 3) in 2010 and all subsequent years.
- Link 200 is programmed as a principal arterial (exists in 2014 and later).
- Link 300 is planned to be built as a minor arterial (FT = 4) by 2040.
- Link 300 is instead built as a collector (FT = 5) if Alternative 1 is activated.
- Link 400 is a new facility to be built as a minor arterial if Alternative 2 is activated.
- Link 500 exists in 2010 and all future years as a minor arterial, but is closed if Alternative 3 is activated.

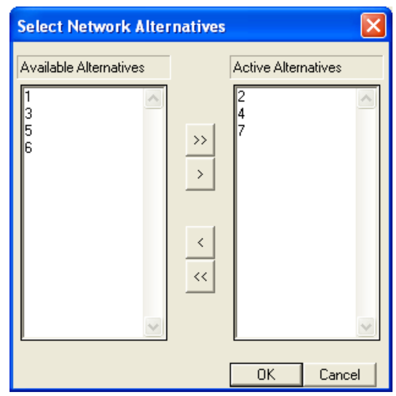
EXAMPLE LINK DATASET

ID	FT_10	FT_14	FT_40	FT_AL	ALT
100	3	3	3	--	--
200	--	3	3	--	--
300	--	--	4	5	1
400	--	--	--	4	2
500	4	4	4	--	3

Network alternatives can represent scenarios in which roadway attributes differ or scenarios in which roadways are constructed or removed. For example, an alternative might represent a proposed roadway widening project that is not included in the 2040 roadway network. This improvement could be included as an alternative for testing purposes. After adding this one alternative, model scenarios could then be created that:

1. Represent the base-year network without the roadway widening,
2. Represent the base-year network plus the roadway widening,
3. Represent the 2040 network without the roadway widening, or
4. Represent the 2040 network plus the roadway widening.

As with network attributes that vary by year, absence of facility type data will result in a link being omitted from consideration in the travel model. It is possible to represent the closure of a roadway by activating an alternative with a null value for FT_AL on a particular roadway link. This is also useful when simulating a roadway that is realigned.



This structure does have some limitations. Only two alternatives can occupy the same link, as limited by the two fields “ALT” and “ALT2.” Also, only one set of alternative attributes can occupy the same link, limited by the one set of attributes with an “AL” suffix.

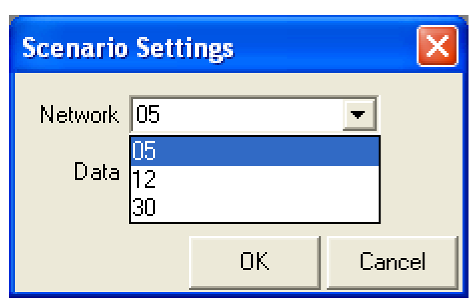
These limitations are of particular concern in a scenario where a road exists as a 2-lane facility and consideration is being given as to whether it should be widened to 4 lanes or 6 lanes. While this scenario cannot be readily represented in the network alternative structure, this scenario can be represented through use of either of two suggested options:

1. Create a separate network year (e.g., “10W4” or "40W4”) that represents the road as a 4-lane facility. Create an alternative that represents the road as a 6-lane facility; or

2. Create an alternative that represents the facility as a 4-lane facility. To run the alternative as a 6-lane facility, make a copy of the network and change the number of lanes (in the “AL” attributes) to six before running the model.

Network Attribute Selection

Year and alternative specific network attributes are selected for use in the travel model based on user selections. The scenario manager interface maintains user selections regarding network year and network alternatives. Once these selections have been made, the network initialization step will apply attributes according to user selections. The following process is used to assign attribute values to the network for use in the travel model.



When running the travel model, the user must select a network year. The scenario manager will allow selection of any year where a complete set of data is present in the roadway network. Specifically, the user will be able to select any year for which all of the required year-specific fields are present in the roadway network file. User selections are saved with a model scenario that is accessible from the model interface.

1. The user may optionally select to activate specific numbered alternatives present in the roadway network. A list of available alternatives is generated by identifying unique values present in the ALT and ALT2 fields. Each unique value is initially identified as an inactive alternative, but may be set to active by the user. Alternative selections made by the user are saved with a model scenario that is accessible from the model interface.

2. The network initialization step makes a copy of the input network file and places it in an output directory specified by the user. One new field is created for each year-specific attribute, but without the year-specific suffix (e.g., FT, AT, etc.). The field Dir is already present in the network, so it is not recreated. However, it is modified in the next step.

3. Each new field is populated with data from the corresponding year-specific field matching the network year selected by the user. For example, if the network year is set to 2012, the field FT will be filled with data in the field FT_12. Remaining fields will be populated in a similar manner.

4. If any alternatives have been activated, a selection set consisting only of links where either ALT or ALT2 matches an active alternative is created. Attributes for links in the selection set are filled with data from the corresponding field ending in _AL. This overwrites any data previously populated from the year-specific fields. For example, if Alternative 1 is selected, all links where ALT = 1 or ALT2 = 1 will be selected. For these links only, data in the FT field will be replaced with data in the FT_AL attribute. This overwrites data previously read from the FT_12 attribute. Remaining fields are populated in a similar manner.

5. Data in the fields that do not include a suffix (e.g., FT, AT, etc.) are referenced for all subsequent model steps, including the speed, capacity, and volume-delay lookup procedures.

DIRECTION OF FLOW

Direction of flow does not fit within the attribute management scheme as well as other variables. This is due to the requirement in the TransCAD software that direction of flow be maintained in the network field "Dir" at all times. While this fits within the process used to run the model, this requirement can cause difficulties when editing the network if not addressed. It is important to remember the following points if the direction of flow varies on a link in different year or alternative networks:

- To display directional arrows for a particular network year, fill the column "Dir" with the value from the appropriate attribute (e.g., Dir_10).
- The Dir field and year-specific Dir fields should be populated with a 1, -1, or 0 – even for network years for which links are not active (i.e., year-specific FT is null). The Dir_AL field can be null, but only if FT_AL is also null.

Note that these concerns apply only if the Dir attribute varies from year to year.

Network Attribute List

By virtue of the discussions above, the roadway network contains the input attributes listed in Table 1.1. Additional fields can be added to the network as desired using the standard tools available in the TransCAD software. Such fields will not be referenced by the travel model, but can be used to aid in analysis of results.

TABLE 1.1: INPUT NETWORK LINK FIELDS

Field Name	Description	Comments
ID	TransCAD Unique ID	Maintained automatically by TransCAD
Length	Link Length in miles	Maintained automatically by TransCAD
Dir	Link Direction of Flow	Direction of Flow
STREETNAME	Street Name	
STREETTYPE	Street Type (St., Ave., Blvd. etc)	
Dir_yyyy	Direction Field	yyyy represents a two through four-digit year code (e.g., 09, 12, 35, 35AA) or the string "AL"
FT_yyyy	Facility type (see table 1.7 for definition)	
AT_yyyy	Area type (see Table 1.8 for definition)	
AB_LN_yyyy BA_LN_yyyy	Directional number of through lanes *(lanes that are used for parking in the off-peak periods are included in this value)*	
CTLMED_yyyy	Presence of a center turn lane or median (1 indicates the presence of a center turn lane)	
SPLM_yyyy	Posted speed limit	
FFOR_yyyy	Free flow override	
AB_FBAM_yyyy AB_FBAM_yyyy BA_FBOP_yyyy BA_FBOP_yyyy	Scenario-specific fields used to hold speed feedback results. These fields are managed by the travel model interface.	Fields ending in "AL" are not present for these fields.
ALT	Primary Alternative Number	
ALT2	Secondary Alternative Number	
SUB_REGION	Subregion ID	
VAL_Count	Traffic count value selected for model validation	
VAL_YEAR	Year validation traffic count was taken	
VAL_Source	Source of validation traffic count	
VAL_AMcount	AM peak hour validation count	
VAL_PMcount	PM peak hour validation count	
Screenlines	Screenline number for links crossed by a screenline	
Eureka_Count Eureka_DATE Eureka_CntID	Information about traffic count data provided by the city of Eureka and coded on the roadway network	
Caltrans_Count Caltrans_DATE Caltrans_CntID Caltrans_Yr	Information about traffic count data provided by Caltrans and coded on the roadway network	
HCAOG_Count HCAOG_Date HCAOG_CntID SiteCode	Information about traffic count data collected for HCAOG by the model consultant and coded on the roadway network	

Field Name	Description	Comments
County_Count County_DATE County_CntID County_Yr	Information about traffic count data provided by Humboldt County and coded on the roadway network	
DOT_ROUTE, PREFIX, SUFFIX, AR1FROM, AR1TO, AR2FROM, AR2TO, CITY, COMMUNITY, ZIP_RIGHT, ZIP_LEFT, STROADNO, SYS, FA_NO, Functional_Class		These fields are not required by the travel model and are not specifically documented here.
FT, IntermediateTAZ, AB_LANE, BA_LANE, AB_SPEED, BA_SPEED, LANE_CAPACITY, ALPHA, BETA, Facility_Type, SCREEN_LOC, TOPO_DIRECTION, DAILY_CNT, AM_2WY_CNT, PM_2WY_CNT, MAX_DEV_24, MAX_DEV_AM, MAX_DEV_PM, RD_NAME, FROM_ID, TO_ID, EDIT, SG_ID, T63_ID, T63_CFCC, TEMP_ID, AB_AM Traffic Counts, AB_PM Traffic Counts, BA_AM Traffic Counts, BA_AM Traffic Counts, BA_PM Traffic Counts, From ID, To ID, FTchange, 2005Cnt, 2006Cnt, 2007Cnt, 2008Cnt, 2009Cnt, 2010Cnt		These fields were included on the network from the previous travel mode, but are no longer used. They have been removed from the model network.

In addition to link attributes, several attributes are required on the node layer of the roadway network file. Centroid nodes are identified by the ZONE attribute on the node layer. Node attributes are listed in Table 1.2. The node layer does not include any scenario-specific fields.

TABLE 1.2: INPUT NETWORK NODE FIELDS

Field Name	Description	Comments
ID	TransCAD Unique ID	Maintained automatically by TransCAD
Longitude	TransCAD Coordinate	Maintained automatically by TransCAD
Latitude	TransCAD Coordinate	Maintained automatically by TransCAD
TAZ	Traffic Analysis Zone Number	Populated only for centroid nodes (including external station nodes). Null for all non-centroid nodes.
Study_Intersection	Identifies intersections for detailed analysis	This field is not used by the travel model, but can be used to track intersections for further analysis.

WHY SUCH SHORT FIELD NAMES?

Many of the recommended field names (e.g., FT_yy and AT_yy) are very short. This is to facilitate efficient use of the travel model network and to ensure compatibility with GIS software.

- When exporting TransCAD data for use in ArcMAP and other software packages, an ESRI shapefile is often used. This file type is limited to 10-digit attribute names. Longer attribute names would are truncated and can lead to confusion.
- When working with the roadway network, a common task is to select all links with a particular facility type or area type (e.g., all centroid connectors). It is much more efficient to type “FT=99” than to type “FAC_TYPE=99, as shown by the keystroke examples below:
  - <shift> F T <end shift> = 99 → 6 keystrokes
  - <CAPS> F A C <shift> _ <end shift> T Y P E <CAPS> = 99 → 15 keystrokes

  While this may seem trivial, the increase in efficiency and convenience allowed by short attribute names is invaluable.

Functional Classification / Facility Type

The functional classification of each roadway link reflects its role in the system of streets and highways. The term "functional classification" has specific implications with regards to the administration of federal-aid highway programs; but travel model networks do not always adhere to these definitions. Functional classification information present on the previous model network has been retained on current model network under the variable Functional_Class.

The roadway network includes an additional variable named Facility Type (FT) for use in the model to look up speed, capacity, and volume delay parameters. This allows facility type to be changed as needed while keeping a record of the functional class. Facility type values used in the Humboldt County Model are listed in Table 1.3. Base year facility type values in the updated model are shown in Figures 1.2a through 1.2c.

TABLE 1.3: FACILITY TYPE VALUES

FT Code	Facility Type
1	Freeway
2	Expressway
3	Principal Arterial
4	Minor Arterial
5	Major Collector
6	Minor Collector
7	Local Road
8	Ramp
9	Centroid Connector

FIGURE 1.2A: 2010 FACILITY TYPE DESIGNATIONS (REGIONWIDE)

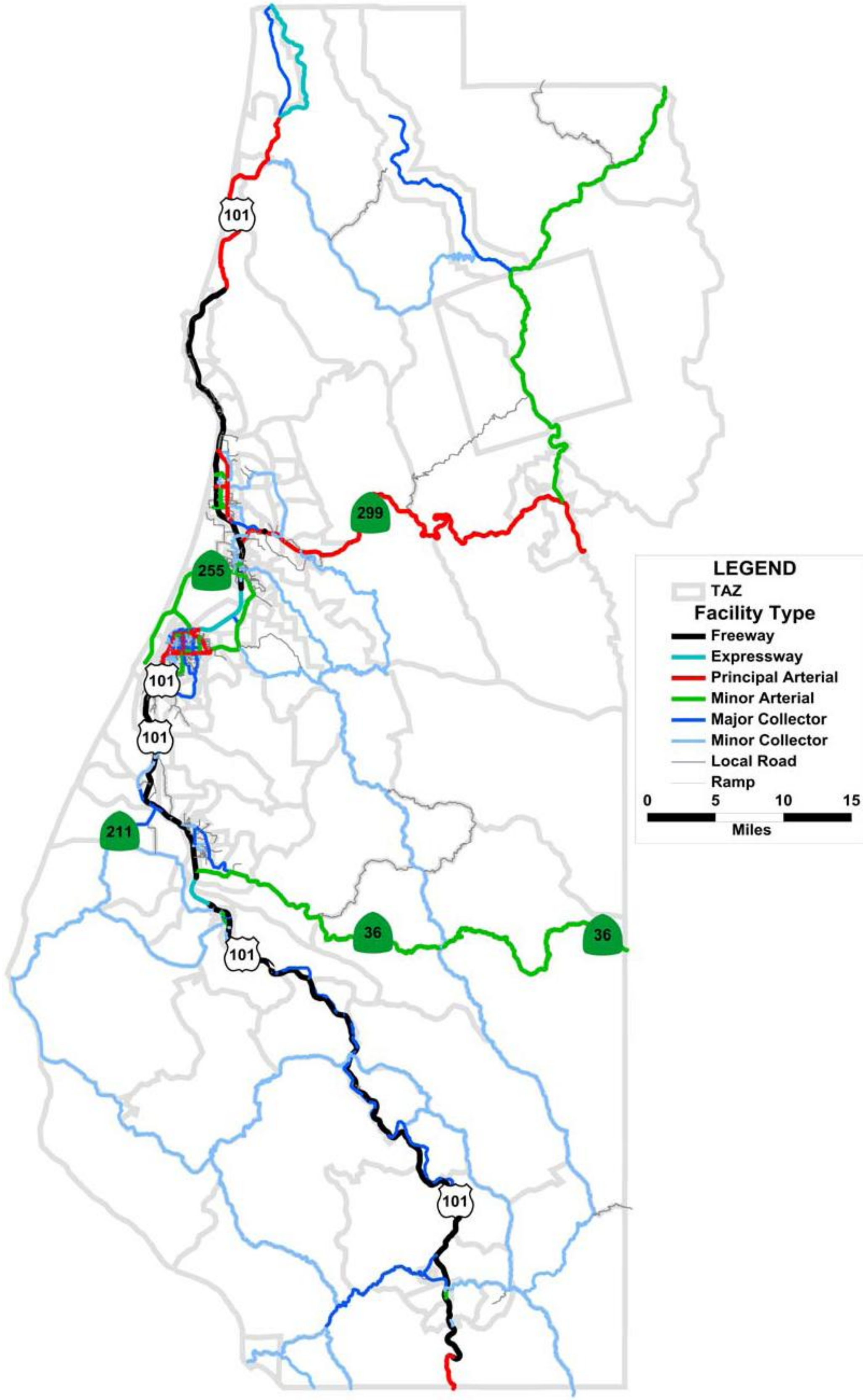


FIGURE 1.2B: 2010 FACILITY TYPE DESIGNATIONS (EUREKA)

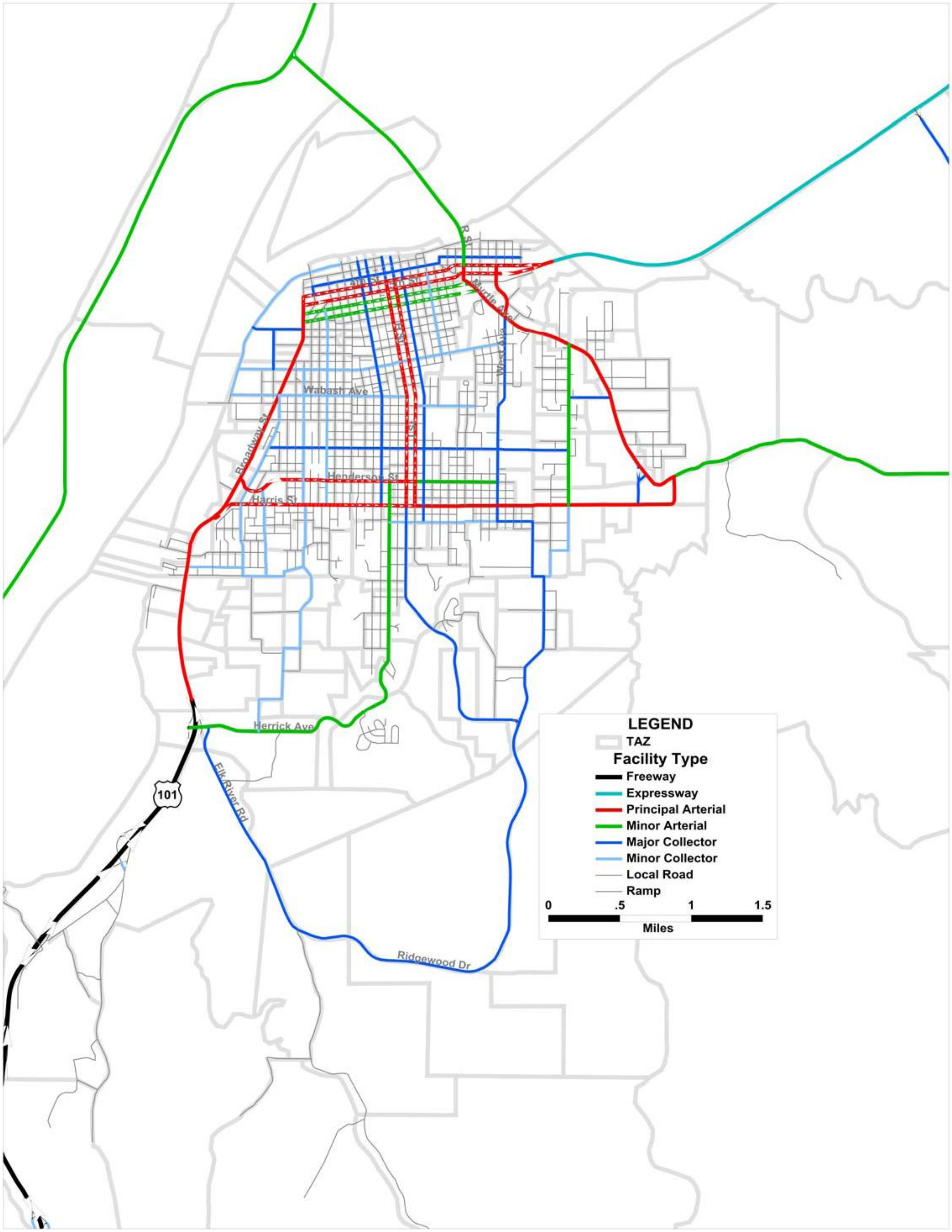


FIGURE 1.2C: 2010 FACILITY TYPE DESIGNATIONS (ARCATA/MCKINLEYVILLE)

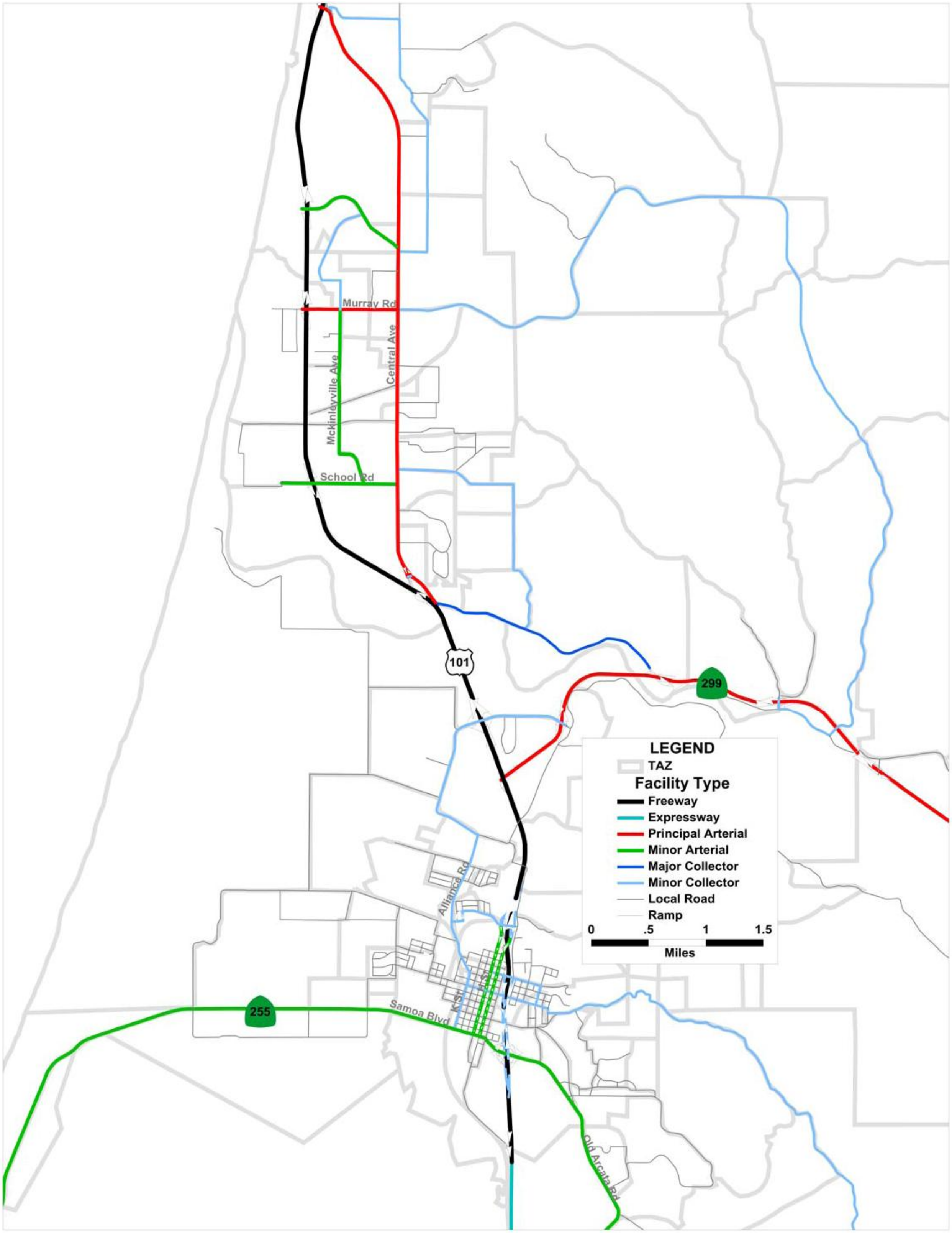


FIGURE 1.2D: 2010 FACILITY TYPE DESIGNATIONS (FORTUNA/RIO DELL)

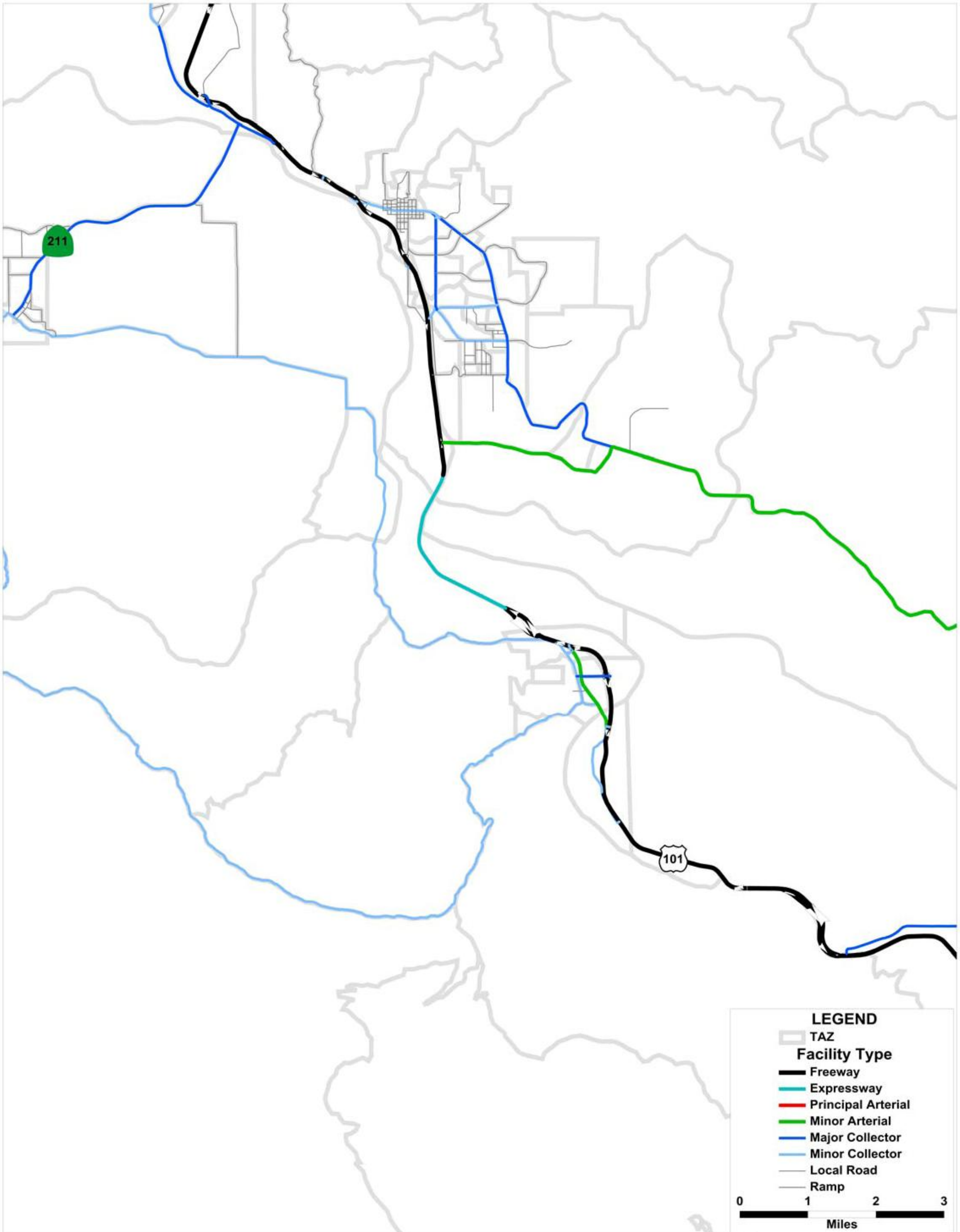
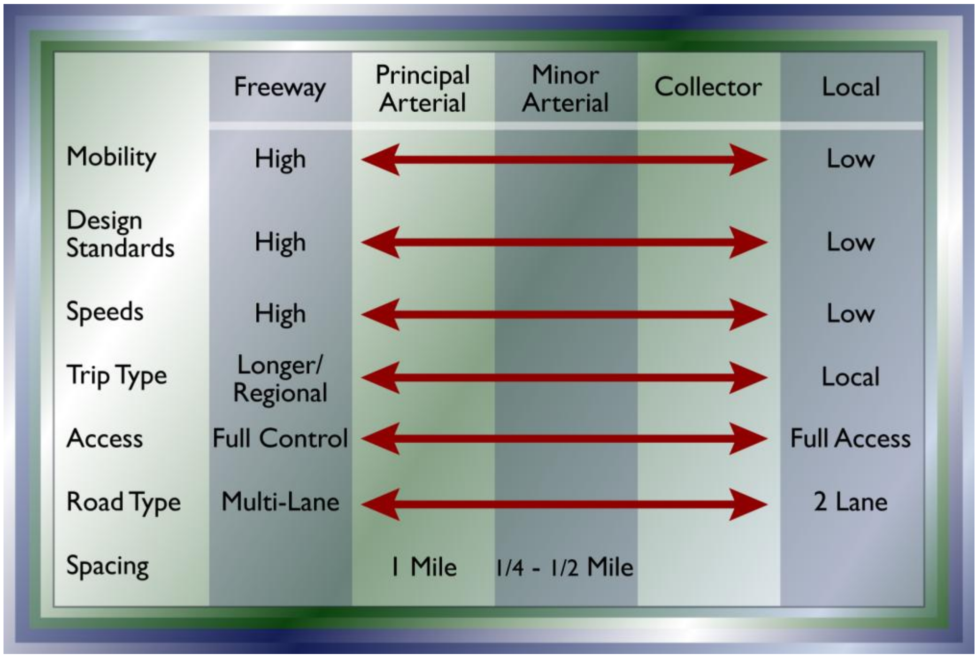


Figure 1.3 demonstrates the relationship between the freeway, arterial, collector, and local facility types. A description of each facility type follows.

FIGURE 1.3: ROADWAY FACILITY TYPE HIERARCHY



- **<u>Freeway</u>** – A divided, restricted access facility with no direct land access and no at-grade crossings or intersections. Freeways are intended to provide the highest degree of mobility serving higher traffic volumes and longer-length trips. Sections of US 101 are designated as a freeway.

- **<u>Expressway</u>** – Expressway facilities can are sometimes classified as divided principal arterials, but experience many features common to freeways. Expressways utilize a higher level of access control than other arterials and may include some grade-separated intersections. Expressways have higher speed limits than other principal arterials (e.g., 55 or 65 MPH), provide little or no direct access to local businesses, may have frontage roads or access roads, and limit signal spacing to at least ½ mile. The section of US 101 between Arcata and Eureka featuring at-grade intersections is designated as an expressway.

- **<u>Ramp</u>** – A link that provides connections to freeways. On freeway to non-freeway ramps, traffic usually accelerates or decelerates to or from a stop. Therefore, the freeflow speed on ramps is often coded as much slower than the ramp speed limit.

- **<u>Principal Arterial / Major Arterial</u>** – These permit traffic flow through and within urbanized areas and between major destinations. These are of great importance in the transportation system since they provide local land access by connecting major traffic generators, such as central business districts and universities, to other major activity centers. Principal/Major arterials carry a high proportion of the total travel on a minimum of roadway mileage. They typically receive priority in traffic signal systems (i.e., have a high level of coordination and receive longer green times than other facility types). Divided principal arterials have turn bays at intersections, include medians or center turn lanes, and sometimes contain grade separations and other higher-type design features.

- **Minor Arterial** – Minor arterials collect and distribute traffic from principal arterials, freeways, and expressways to streets of lower classification and, in some cases, allow traffic to directly access destinations. They serve secondary traffic generators, such as community business centers, neighborhood shopping centers, multifamily residential areas, and traffic between neighborhoods. Access to land use activities is generally permitted, but tends to be consolidated, shared, or limited to larger-scale users. Minor arterials generally have slower speed limits than major arterials, may or may not have medians and center turn lanes, and receive lower signal priority than other facility types (i.e., are only coordinated to the extent that major arterials are not disrupted and receive shorter green times than major arterials). Some rural state highways are also designated as minor arterials.

- **Collector Street** – Collectors provide for land access and traffic circulation within and between residential neighborhoods and commercial and industrial areas. They distribute traffic movements from these areas to the arterial streets. Except in rural areas, collectors do not typically accommodate long through trips and are not continuous for long distances. The cross-section of a collector street may vary widely depending on the scale and density of adjacent land uses and the character of the local area. Left turn lanes sometimes occur on collector streets adjacent to nonresidential development. Collector streets should generally be limited to two lanes, but sometimes have 4-lane sections. The Humboldt County model uses two sub-classifications: major and minor collectors. Links identified as minor collectors tend to carry less through traffic than major collectors and may have slower speeds and capacities. In rural areas, some county roads that can serve through movements are designated as collectors.

- **Centroid Connector** – These facilities represent local and/or residential street systems that are too detailed for modeling purposes. Centroid connectors are usually not coded along actual streets, but rather they are the means through which the trip and other data at the traffic analysis zone (TAZ) level are attached to the street system.

- **Local Streets** – Local streets are included in the travel model, but are primarily included to provide access to zone centroids. Use of the travel model to forecast or analyze traffic on local streets is not recommended.

Area Type

Area type is an attribute assigned to each TAZ and roadway that is based on the activity level and character of the zone. Terminal times, roadway speed, roadway capacity, and volume-delay characteristics are dependent on area type. Area type is first defined at the TAZ level based on socioeconomic and land use characteristics and then transferred to the roadway network.

Area type is an attribute that can vary with time. Therefore, it is important that area type definitions are specified in a manner that can be updated for future conditions based on available forecast data. While area type definitions based on external information such as corridor characteristics (e.g., commercial vs. residential) or the U.S. Census urbanized area boundary are useful in defining existing area type, this information is not very useful in defining future year area types. Area type definitions were instead specified so that area type forecasts can be developed using forecast socioeconomic data. Area type designations used in the Humboldt County Model are listed in Table 1.4.

TABLE 1.4: AREA TYPES

Code	Area Type
1	Central Business District (CBD)
2	Urban
3	Suburban
4	Rural

Area Type Specification

Specification of existing area types was carried through from the previous version of the model and reviewed by Humboldt County Staff. The central business district (CBD) area type is defined as the densest part of the City with a distinctly different characteristic that the surrounding area. The area surrounding the CBD that includes a higher density of buildings and a denser street grid has been classified as urban. The suburban area type was assigned to areas with lower building and street density. Undeveloped areas, or areas with very sparse development, were identified as rural. Resulting area type definitions are shown in Figures 1.4a and 1.4b. All areas not shown in these figures are designated as rural.

For forecast year model datasets, it may be necessary to update area type designations. In cases where rural areas are forecast to become developed, they can be changed to suburban or urban area types. Likewise, infill development may result in zones designated as suburban being upgraded to urban. It is unlikely areas defined as urban would be downgraded to suburban, or that suburban areas would be downgraded to rural. It is also unlikely that the CBD area type would change for future year model runs. Preliminary future year model datasets included with the model do not assume any area type changes in forecast years.

FIGURE 1.4A: AREA TYPE DESIGNATIONS (COUNTYWIDE)

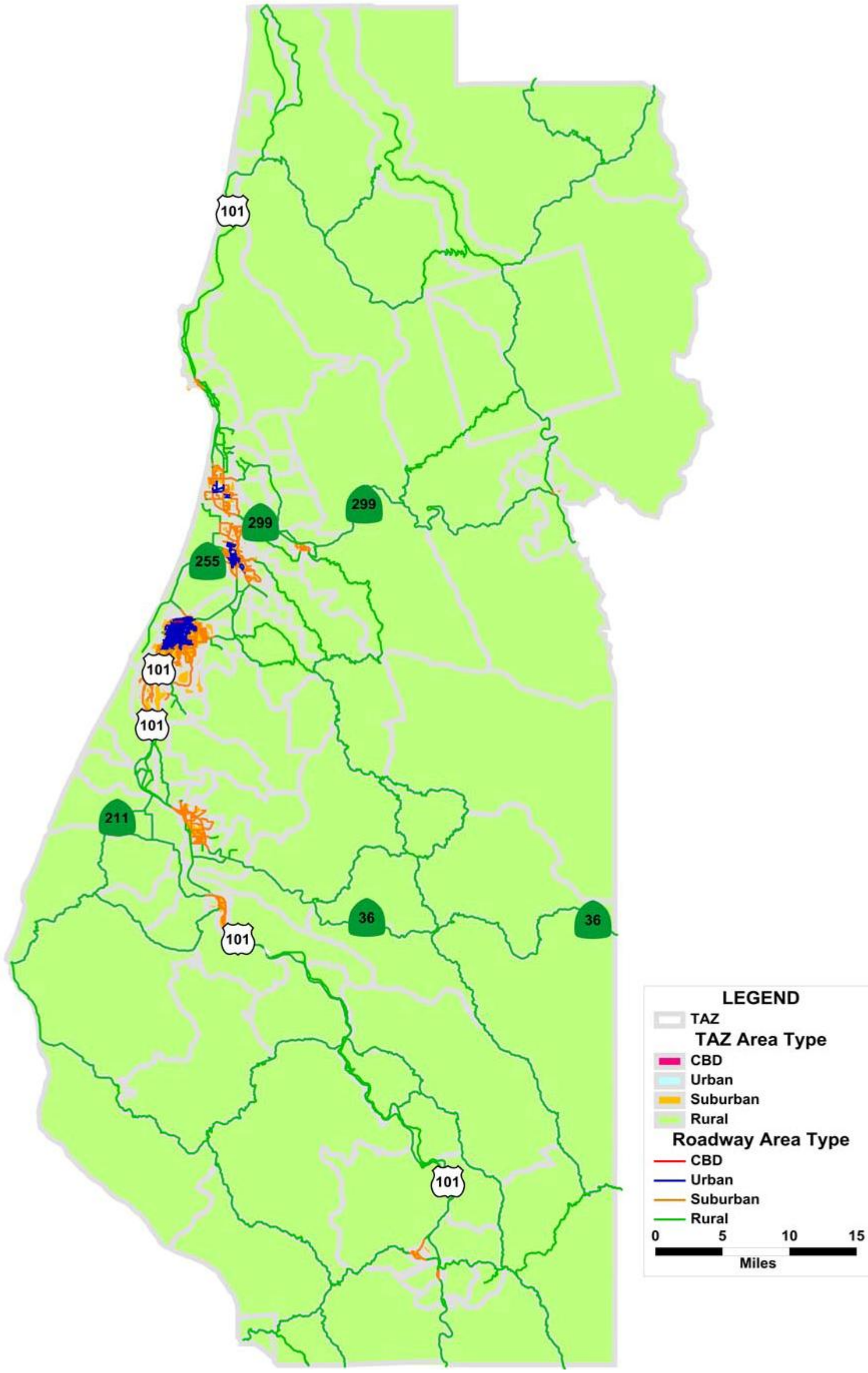


FIGURE 1.4B: AREA TYPE DESIGNATIONS (EUREKA)

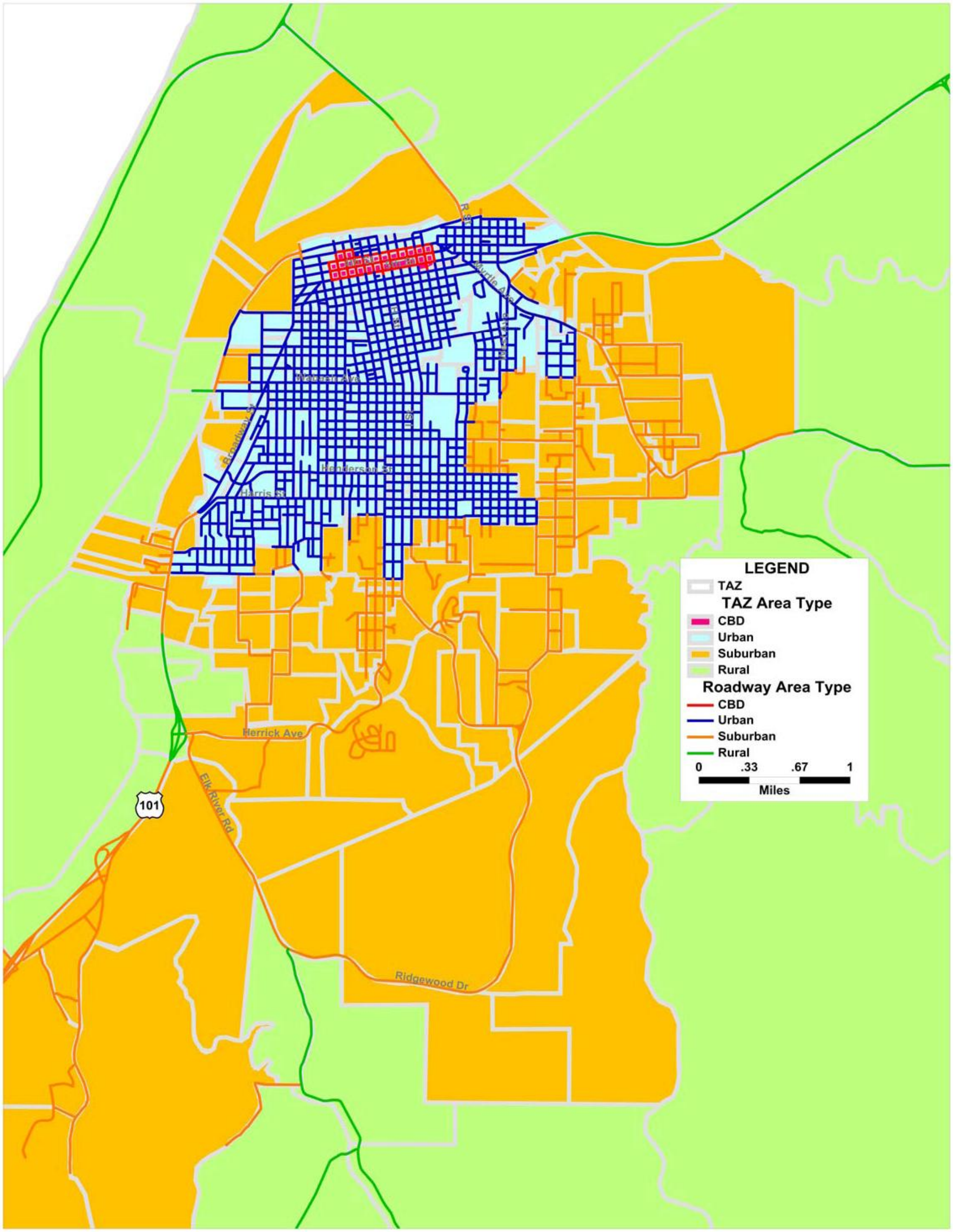


FIGURE 1.4C: AREA TYPE DESIGNATIONS (ARCATA/MCKINLEYVILLE)

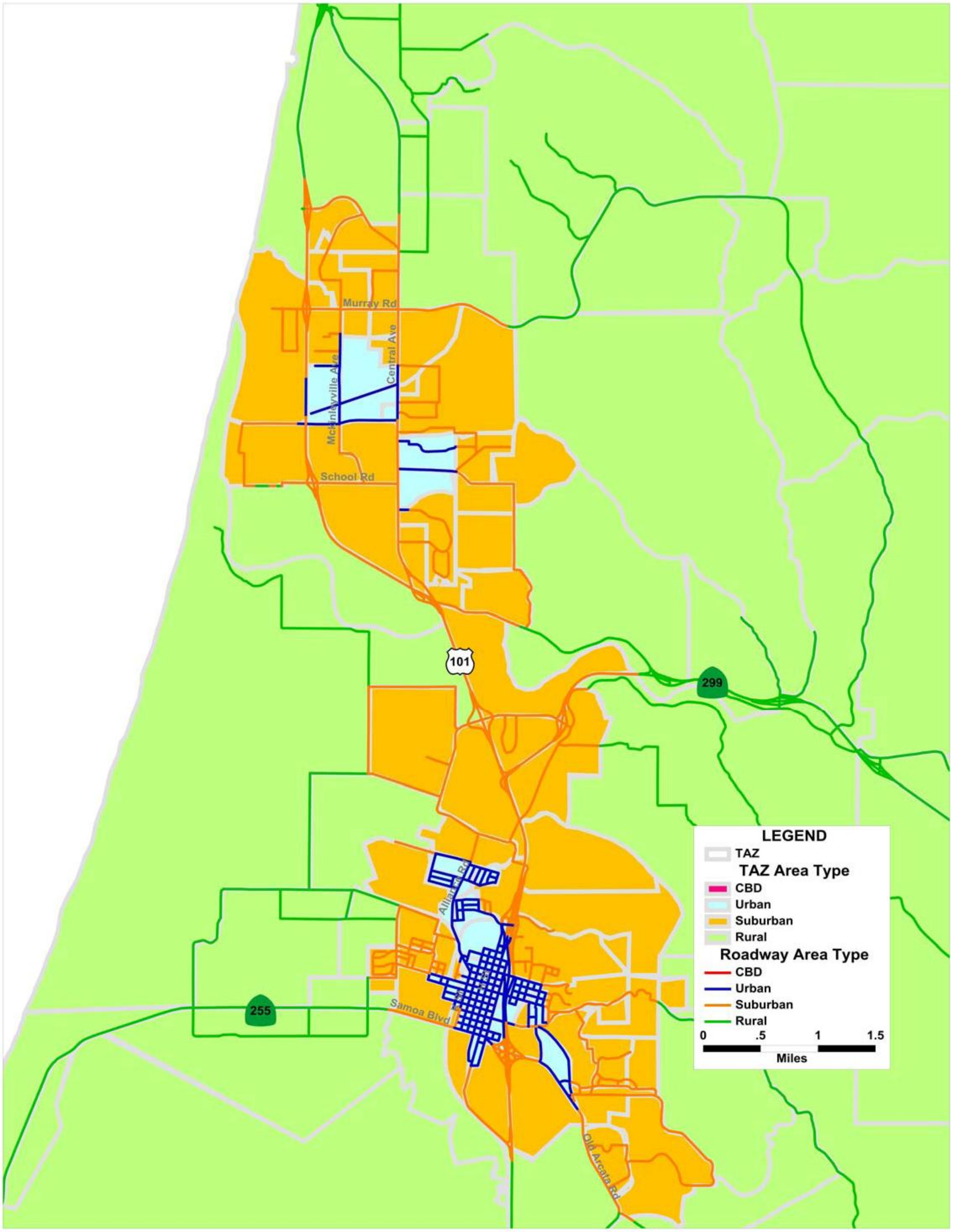
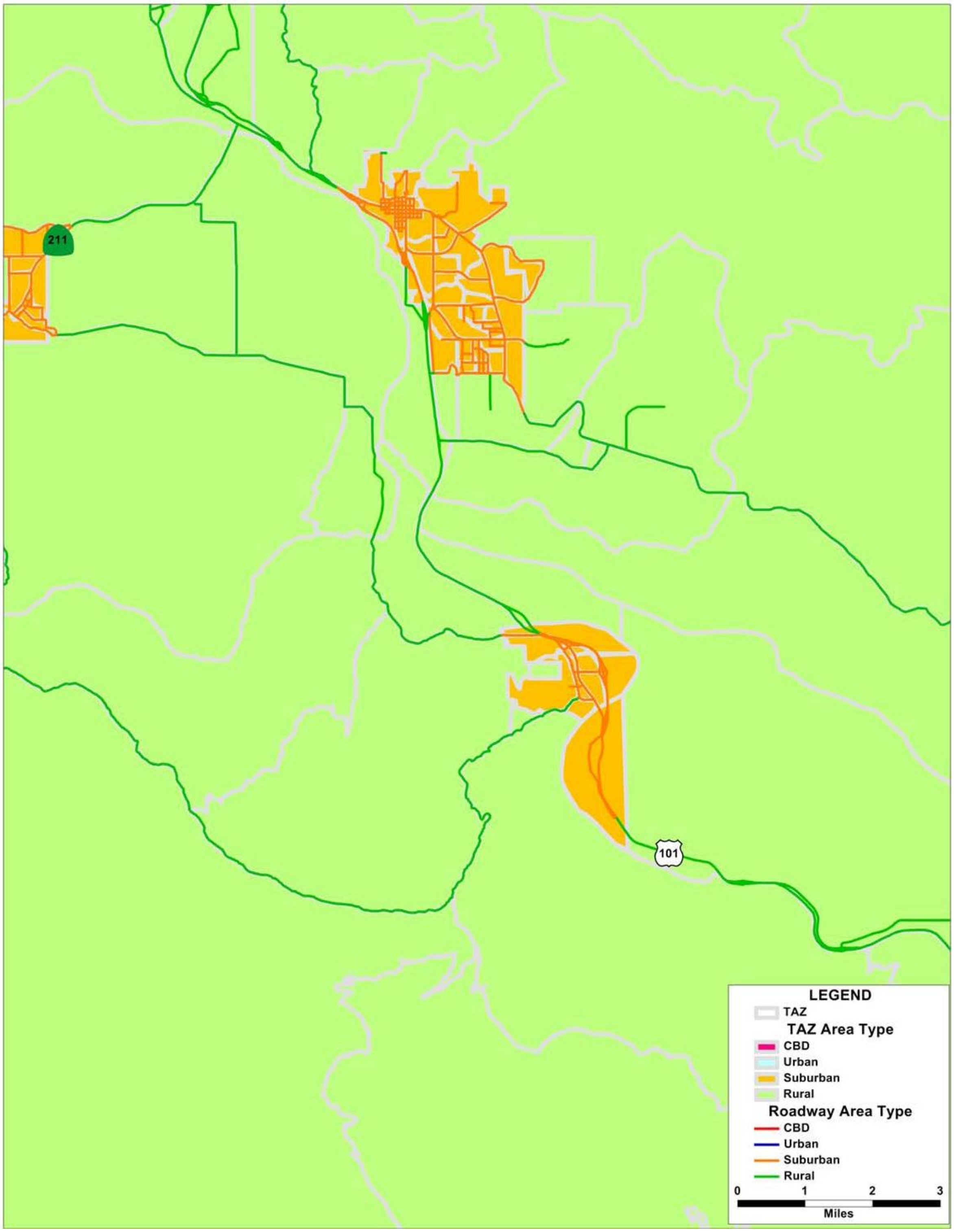


Figure 1.4d: Area Type Designations (Fortuna/Rio Dell)



Link Speeds

Network speeds are used in the trip distribution model to distribute trips throughout the region and in the trip assignment model to route traffic on the roadway network.

Link freeflow speeds represent average travel time, including intersection delay, needed to traverse the distance of a link with little or no traffic (i.e., no congestion effects). These speeds are generally similar to the speed limit and are calculated as a function of the speed limit, functional class, and area type. Freeflow speeds are typically lower than the speed limit to account for intersection delay on arterials, collectors, and ramps. On other facility types, the speed limit and freeflow speed may be the same.

Estimating Link Speeds

Speed limit data is available for roadway links in the network. This speed limit data can be used in combination with corridor travel time survey data to approximate a freeflow speed on each network link. Because the travel model freeflow speed must include intersection delay experienced in uncongested conditions, freeflow speed is typically lower than the posted speed limit. The relationship between speed limit and freeflow speed has been observed to vary by characteristics such as facility type and area type. Conversion factors shown in Table 1.5 are multipled by speed limit on each link to compute freeflow speed. These factors were adjusted during model validation to balance VMT by facility type and area type, and to match modeled speeds to observed speeds collected on key corridors.

Table 1.5: Speed Limit to Freeflow Speed Conversion Factors

ID	Functional Class	Area Type			
		CBD	Urban	Suburban	Rural
1	Freeway	1 (no adjustment)			
2	Expressway	0.90	0.95	1	
3	Principal Arterial	0.80	0.95		
4	Minor Arterial				
5	Major Collector				
6	Minor Collector		0.90		
7	Local / Other	0.50			
8	Ramp	0.80			
9	Centroid Connectors	1 (no adjustment, values may be specified or obtained from lookup table)			

On links where speed limit data is missing, default speed limit values are obtained based on the values in Table 1.6. In practice, speed limits should be provided for all non-centroid links in the travel model. Speed limit data should not be posted on centroid connectors.

Table 1.6: Default Freeflow Speeds (Used when data is missing)

ID	Functional Class	Area Type			
		CBD	Urban	Suburban	Rural
1	Freeway	75			
2	Expressway	40	45	50	60
3	Principal Arterial	30	40	45	50
4	Minor Arterial	25	35	35	40
5	Major Collector	25	30	35	40
6	Minor Collector	25	30	35	40
7	Local / Other	25	30	35	40
8	Ramp	30	30	30	30
9	Centroid Connector	15	20	20	35

Link Capacities

Constrained traffic assignment requires roadway capacity values, which are used in the model to measure congestion and to determine route diversion due to congestion. This is accomplished through the use of volume-delay equations that are defined and applied in the traffic assignment model.

In the model, per-lane capacity values are retrieved from a lookup table based on the facility type and area type of each link in the roadway network. This approach eliminates opportunities for error in defining capacities at the link level and enforces consistent application of capacity values. Hourly per-lane capacities are retrieved from a lookup table. These hourly per-lane capacities are used in combination with the number of lanes attribute present on the network to define hourly directional capacity.

The Highway Capacity Manual (HCM or HCM 2000)[1] provides guidance on the definition of roadway capacity. The HCM provides link-level capacity guidelines for freeways and rural highways, but does not provide detailed link-level capacity guidelines for urban and suburban collector and arterial streets. Therefore, HCM intersection capacity was used in place of link capacity to develop capacities for these other facilities.

Freeways

Capacity guidelines for freeways and expressways are provided in Chapters 21 and 23 of HCM 2000. Unadjusted, or ideal, per-lane capacities based on freeflow speed are provided. These capacities must then be adjusted for various conditions. The conditions for which adjustments can be applied are described below.

- **Heavy Vehicle Adjustment Factor** – The heavy vehicle adjustment factor accounts for passenger car equivalents for trucks, buses, and recreational vehicles. HCM 2000 recommends default values of 10% heavy vehicles in rural areas and 5% heavy vehicles in non-rural areas unless additional data is available. However, due to the low amount of truck traffic in Humboldt County, capacities in the Humboldt County Model assume 5% heavy vehicles on all facilities.

- **Driver Population Factor** – The driver population factor represents the familiarity of drivers with roadway facilities. Because the model represents traffic on a typical weekday when school

[1] Highway Capacity Manual. Transportation Research Board, 2000.

is in session, normal driver familiarity was assumed. Driver population factors are typically used for weekend conditions or in areas with a high amount of tourist/recreational activity.

- **Peak Hour Factor** – A peak hour factor (PHF) represents the variation of traffic volumes within an hour. Default values of 0.88 for rural area types and 0.92 for non-rural area types were applied[2].

The HCM suggests adjusting flow rate (traffic volume) according to equation (1).

$$V_P = \frac{V}{PHF \cdot N \cdot f_{HV} \cdot f_P} \quad (1)$$

Where:

V_P	= 15-min passenger equivalent flow rate (pc/hr/ln)
V	= hourly volume (veh/hr)
PHF	= peak-hour factor
N	= number of lanes
f_{HV}	= heavy-vehicle adjustment factor
f_P	= driver population factor

For travel model application, it is more practical to adjust capacity than vehicle flow rate. This eliminates the need to adjust vehicle trip tables prior to and subsequent to traffic assignment. By replacing V_P with ideal capacity (C_I) and V with hourly capacity (C), Equation (1) can be used to adjust ideal capacity to effective hourly capacity. Furthermore, it is useful to consider capacity on a per lane (veh/hr/ln) basis, allowing number of lane calculations to be applied at the link level. The resulting Equation (2) can be used to compute per lane capacity for freeways and expressways. Equation (2) was used to compute hourly capacities for rural and freeway facilities.

$$C = C_I \cdot PHF \cdot f_{HV} \cdot f_P \quad (2)$$

Where:

C_I	= Ideal (unadjusted) capacity (pc/hr/ln)
C	= link capacity (veh/hr)
PHF	= peak-hour factor
f_{HV}	= heavy-vehicle adjustment factor
f_P	= driver population factor

Ideal capacities are defined in HCM according to freeflow speed[3]. Ideal capacities based on typical freeflow speeds are shown in Table 1.7, along with adjusted capacities computed using Equation (2). Adjusted capacities have been rounded to 100 vehicles per hour. It is noted that these calculations result in a lower capacity on rural freeways than on suburban and urban freeways. This is due to the difference in peaking factors associated with rural facilities. In practice, it is unlikely that rural freeway facilities will reach capacity. Instead, rural facilities are likely to become suburban or urban facilities before nearing capacity. As this occurs peaking characteristics should be adjusted. This is accomplished by using updated area type information in forecast-year model runs.

[2] HCM 2000, p. 13-11
[3] HCM 2000, p. 23-5

TABLE 1.7: IDEAL AND ADJUSTED CAPACITIES FOR FREEWAYS AND EXPRESSWAYS BASED ON HCM 2000

Facility Type	Area Type	Freeflow Speed (mph)	Ideal Capacity (Upper Limit LOS E, pc/h/ln)	PHF	F_{HV}	FP	Adjusted Capacity (Upper Limit LOS E, pc/h/ln)
Freeway	Rural	70	2,400	0.88	0.9	1	1,900
Freeway	Suburban	70	2,400	0.92	0.9	1	2,000
Freeway	Urban	65	2,350	0.92	0.9	1	2,000

Note: F_{HV} assumes 5% heavy vehicle traffic with a passenger car equivalent of 3.

Collectors and Arterials

For non-rural arterial and collector streets, HCM recommends identifying capacity on an intersection basis, with the intersection with the lowest capacity determining the overall arterial link capacity. The link capacity at each intersection can be computed using equation (4a)[4].

$$c = S_0 \cdot N \cdot f_w \cdot f_{hv} \cdot f_g \cdot f_p \cdot f_{bb} \cdot f_a \cdot f_{LU} \cdot F_{LT} \cdot F_{RT} \cdot F_{Lpb} \cdot F_{Rbp} \cdot PHF \cdot g/C \quad (4a)$$

Where:

- c = Capacity
- S_0 = base saturation flow per lane (pc/h/ln) – *assumed at 1900*
- N = number of lanes in lane group (intersection approach lanes, not bid-block lanes)
- f_w = adjustment factor for lane width– *assumed at 1.0*
- F_{HV} = adjustment factor for heavy vehicles in traffic stream *assumed at 1.0*
- f_g = adjustment factor for approach grade – *assumed at 1.0*
- f_p = adjustment factor for existing of a parking lane and parking activity
- f_{bb} = adjustment factor for blocking effect of local busses – *assumed at 1.0*
- f_a = adjustment factor for CBD area type
- f_{LU} = adjustment factor for lane utilization – *assumed at 0.95*
- f_{LT} = adjustment factor for left turns in lane group – *assumed at 1.0*
- f_{RT} = adjustment factor for right turns in lane group – *assumed at 1.0*
- f_{Lpb} = pedestrian adjustment factor for left-turn movements – *assumed at 1.0*
- f_{Rpb} = pedestrian-bicycle adjustment factor for right turn movements – *assumed at 1.0*
- PHF = peak-hour factor – *assumed at 0.92*
- g/C = effective green time per cycle

The equations above account for details that are not practical to maintain in a regional travel model. Therefore, a number of adjustment factors can be assumed constant or set to 1.0 for all cases. Some variables that have been set to 1.0, such as lane width, turns, bus blocking, and pedestrian/bicycle effects are instead captured in the area type adjustment. Other variables can be approximated based on the facility type and area type of each link. Additionally, a regional travel model must rely on the number of through lanes on each link, rather than the number of approach lanes at each intersection.

4 HCM 2000, p. 30-5

This can be addressed by an intersection widening factor that varies by facility type and accounts for the presence of left and right turn lanes at intersection approaches.

Equation (4a) can be simplified to equation (4b) for use in a regional travel modeling context. Assumed values for adjustment factors that vary by facility type and area type are shown in Table 1.8, along with the resulting capacity values.

$$c = S_0 \cdot N_t \cdot f_a \cdot f_{LU} \cdot PHF \cdot g/C \quad (4b)$$

Where:

- c = Capacity
- S_0 = base saturation flow per lane (pc/h/ln) – *assumed at 1900*
- N_t = number of through (mid-block) lanes, excluding center turn lanes
- f_a = adjustment factor for area type
- f_{LU} = adjustment factor for lane utilization – *assumed at 0.95*
- PHF = peak-hour factor – *assumed at 0.92*
- g/C = effective green time per cycle
- f_w = adjustment factor for intersection widening

TABLE 1.8: LINK CAPACITY ADJUSTMENT FACTORS AND RESULTING CAPACITY

FT	AT	f_a	g/C	f_w	Capacity
Expressway	CBD	0.90	0.55	1.30	1,100
	Urban	0.97	0.55	1.30	1,200
	Suburban	0.99	0.55	1.30	1,200
Principal/Major Arterial	CBD	0.76	0.45	1.30	740
	Urban	0.95	0.45	1.30	920
	Suburban	0.99	0.45	1.30	960
Minor Arterial	CBD	0.76	0.45	1.15	650
	Urban	0.95	0.42	1.15	760
	Suburban	0.99	0.42	1.15	790
Major/Minor Collector	CBD	0.75	0.45	1.05	590
	Urban	0.95	0.41	1.05	680
	Suburban	0.99	0.41	1.05	710
Local/Other	CBD	0.74	0.45	1.00	550
	Urban	0.95	0.40	1.00	630
	Suburban	0.99	0.40	1.00	660

TURN LANE ADJUSTMENTS

Presence of a center left turn lane, median, or left turn prohibitions can also impact link capacity. The intersection widening factors assumed above account for the presence of frequent left turn lanes or medians on principal arterials, with occasional left turn lanes and medians on minor arterials. The Humboldt County roadway network contains a specific variable that identifies roadway corridors where medians or center left turn lanes are present. Any corridor where all possible left turns are served by a left turn lane is identified by this variable. To account for center left turn lanes, the number of lanes used to compute total directional flow is adjusted as follows:

- Principal/Major Arterial:
  - Left turn lane present: Add 0.25 lanes (0.125 lanes in each direction)
  - No left turn lane present: Subtract 0.5 lanes (0.25 lanes in each direction)
- Minor Arterial:

- Left turn lane present Add 0.5 lanes (0.25 lanes in each direction)
- No left turn lane present: Subtract 0.25 lanes (0.125 lanes in each direction)

No center turn lane or median adjustments are made on expressway, collector, or local facilities.

Resulting Capacity Model

The calculations above provide capacity values that can be applied based on the facility type, area type, number of lanes, and center turn lane presence of each link in the network. The model begins by applying the hourly lane capacities shown in Table 1.9. These capacities are then adjusted to account for the presence of a center turn lane.

The updated model utilizes hourly capacities similar to the capacities in the previous version of the model. The updated hourly capacities are consistent with HCM guidelines, to the extent possible in a link-based model. It is possible to generate and use a separate set of daily capacities for use in roadway system performance evaluation.

TABLE 1.9: ROADWAY CAPACITIES (VEHICLES PER HOUR PER LANE, UPPER-LIMIT LOS E)

	Facility Type	CBD	Urban	Suburban	Rural
1	Freeway	2,000	2,000	2,000	1,900
2	Expressway	1,100	1,200	1,200	1,200
3	Major Arterial	930	1,080	1,120	1,120
4	Minor Arterial	740	920	960	960
5	Major Collectors	650	760	790	790
6	Minor Collectors	590	680	710	710
7	Local / Other	590	680	710	710
8	Ramps	550	630	660	660
99	Centroid Connectors	10,000	10,000	10,000	10,000

Routable Network

Many functions in TransCAD require the creation of a routable network file, identified by a ".net" extension. Of particular interest for the Humboldt County Model, pathbuilding/skimming and traffic assignment procedures require a routable network. Length and travel time information for each link is stored in the routable network file, as are turn prohibitions. Specific turn prohibitions are initially stored in a separate file that is referenced when creating the routable network. An appropriate routable network file is created during the automated network initialization step. Routable network files are also required when performing interactive pathbuilding; these can be created using the TransCAD interface designed for these purposes.

The routable network file also contains information about centroid connectors. This prevents the pathbuilder and traffic assignment algorithms from routing trips through centroids. This is accomplished automatically in the model by creating a selection of centroid nodes and identifying these nodes as centroids in the routable network file.

Humboldt County Travel Model

2. Traffic Analysis Zones and Socioeconomic Data

Context and Background

Traffic analysis zones (TAZ) are boundaries that contain socioeconomic data that are used as the foundation for trip-making in the travel model. The TAZ layer is formatted as a polygon layer in TransCAD's GIS structure. The TAZs are attached to the networks using zone centroids and centroid connectors that allow travelers access to the transportation system by simulating local and neighborhood streets.

Socioeconomic data are the input activity-based information that provides the foundation for trip-making in the travel model. Data are recorded for retail, service, government, finance & insurance, wholesale, manufacturing, agricultural, medical, and other employment types and households by income groups and household sizes. Development of the employment and household data for the 2010 Base Year Humboldt County Travel Model is described in this chapter.

Traffic Analysis Zone Structure

TAZs are ideally but not always sized and shaped to provide a relatively homogeneous amount and type of activity within each zone. TAZ delineations traditionally follow the natural and manmade boundaries that tend to segregate different land uses. These boundaries include water features, roads, railroads, and other lines that form logical boundaries. Jurisdictional and census boundaries often do not make for good TAZ definitions because they can be arbitrary in relation to the needs of the model, but they are usually desirable for data development and reporting functions.

The definition of traffic analysis zones has implications throughout the travel model. For roadway model components, traffic analysis zone resolution affects the amount of precision that can be achieved when loading vehicles onto the collector and arterial roadway network. This precision is obtained by increasing detail in the roadway network, TAZ structure, and socioeconomic data. The desire for increased detail must however be balanced with increased computer processing times and the ability to develop and maintain the data at the increased level of detail.

The traffic analysis zones layer is a polygon layer that divides the Humboldt County modeling area into traffic analysis zones and external stations. While this layer is useful in developing socioeconomic data and as a guide when placing centroids and centroid connectors, it is not used directly by the travel model algorithms. Instead, TAZs are represented by centroids in the roadway network file.

The TAZ-based data are stored in an Access database rather than directly in the TAZ polygon layer. This allows data from different sources to be imported into the Access database quickly and efficiently. Furthermore, multiple datasets (e.g., 2010 data and 2040 data) can be stored within the same Access file allowing data selections to be made from the scenario manager in TransCAD.

Intermediate and output data at the TAZ level is stored in TransCAD binary table files or matrix files in the output directory for each scenario. Each of these output files can be joined to the TAZ polygon layer or to centroids in the roadway network. TAZ-based intermediate and output data includes terminal times, trip productions and attractions, trip matrices, and skim (shortest path) matrices. TAZ-based output data are discussed in detail in other subsequent chapters describing the respective model components.

In order to more accurately model detailed travel movements throughout the county for the base and horizon years, the TAZ structure of the Humboldt County Travel Model has been modified. The Humboldt County Model zone structure is based on the previous version of the model. The zone structure was modified and updated by splitting zones, modifying boundaries, and occasionally consolidating zones. The revised zone structure was created in coordination with Caltrans, Humboldt County, and cities participating in the Humboldt County traffic modeling group. A representative from Humboldt County also assisted in review of tribal lands to ensure adequate representation of tribal communities and reservation boundaries. The updated zone structure includes 775 internal zones, plus 10 external stations, for a total of 785 zones. The external station locations identified in the previous model reviewed, but modifications were not found to be necessary.

Adjustments made to the zone structure included:

- TAZ boundaries along rivers and streams have been smoothed and adjusted to align with the center of the waterway. An attempt was made to minimize the number of zones that contain only water or extend from a land area into the water except towards a centerline boundary;

- TAZ boundaries were adjusted to align with roadways. For example, TAZ boundaries that were offset from roadways were shifted to directly match the roadway;

- Very large zones were split into several smaller TAZs, particularly when the roadway network included arterials or collectors within a TAZ. When possible, zones were split along existing or planned roadway alignments;

- TAZ boundaries were defined in a manner such that discrete subareas could be identified. Where jurisdictions border unincorporated county, jurisdictional boundaries were not followed explicitly. Instead, TAZs were defined to summarize an area larger than the jurisdiction. Where two incorporated jurisdictions share a border, TAZ lines were drawn to explicitly separate the cities; and

- If a TAZ boundary was drawn through a single discrete activity, the boundary was adjusted to keep the activity within a single TAZ.

The resulting TAZ definitions and modeling domain are shown in Figure 2.1a through 2.1d.

FIGURE 2.1A: TRAFFIC ANALYSIS ZONES (COUNTYWIDE)

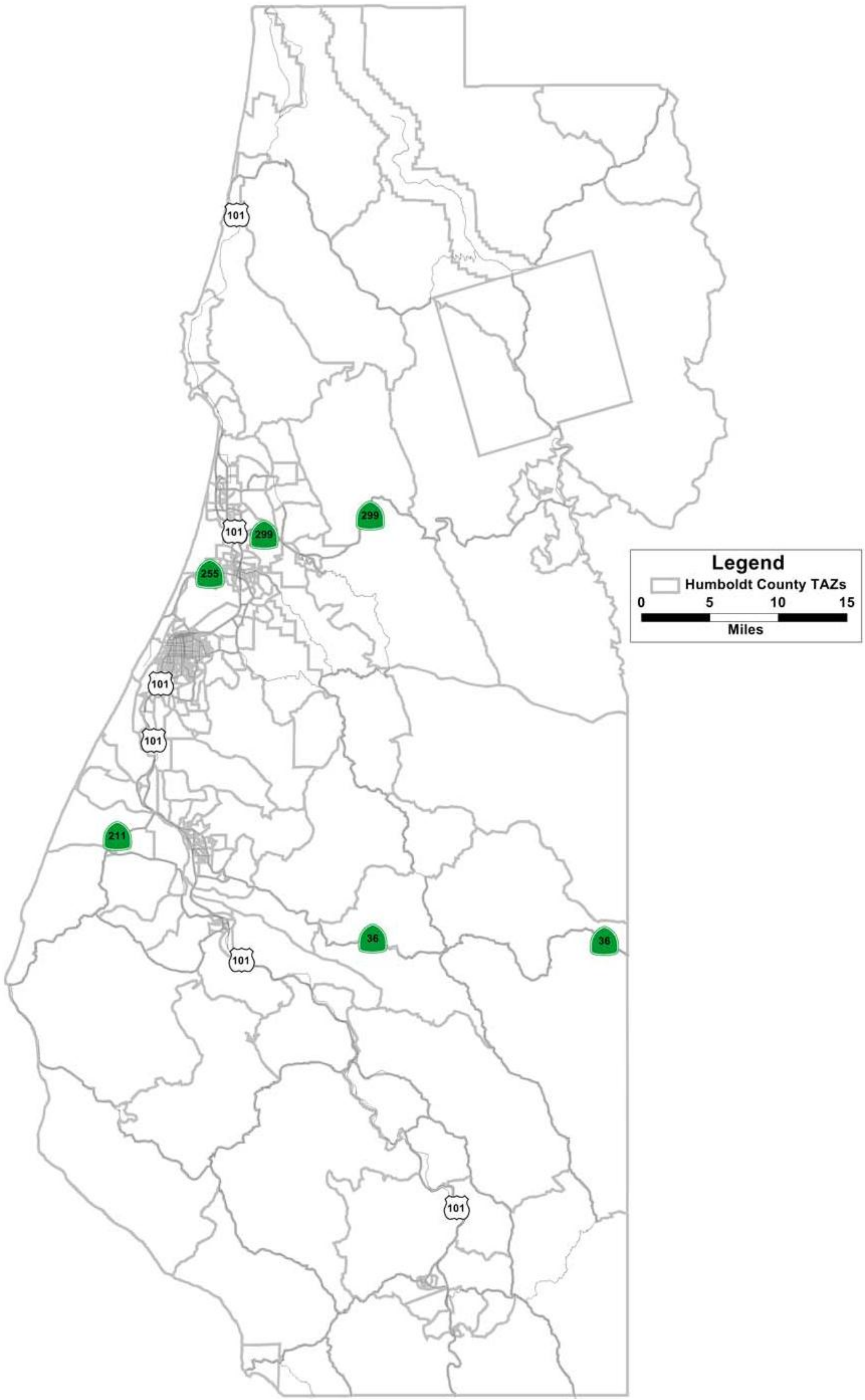


FIGURE 2.1B: TRAFFIC ANALYSIS ZONES (EUREKA)

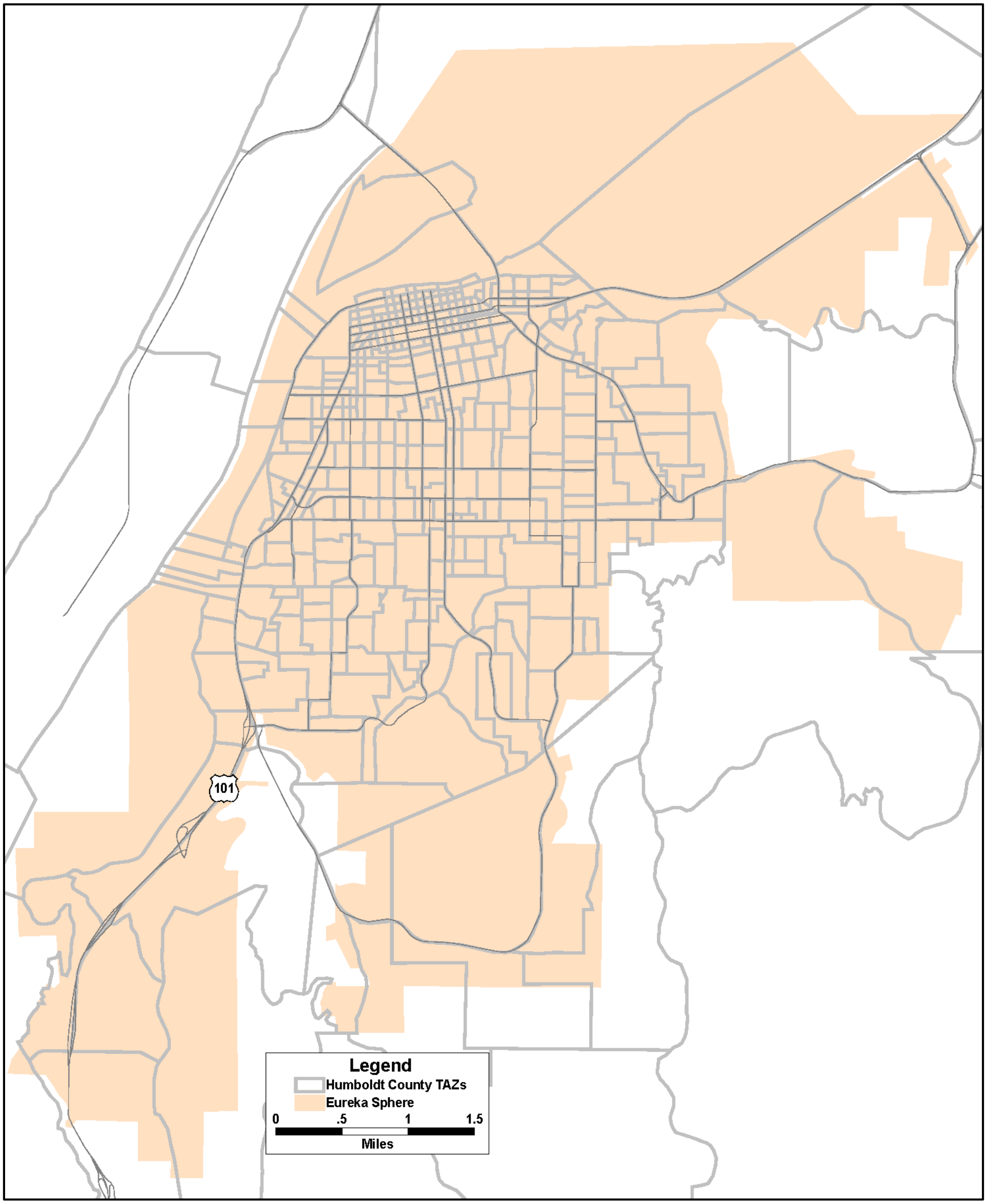


FIGURE 2.1C: TRAFFIC ANALYSIS ZONES (ARCATA/MCKINLEYVILLE)

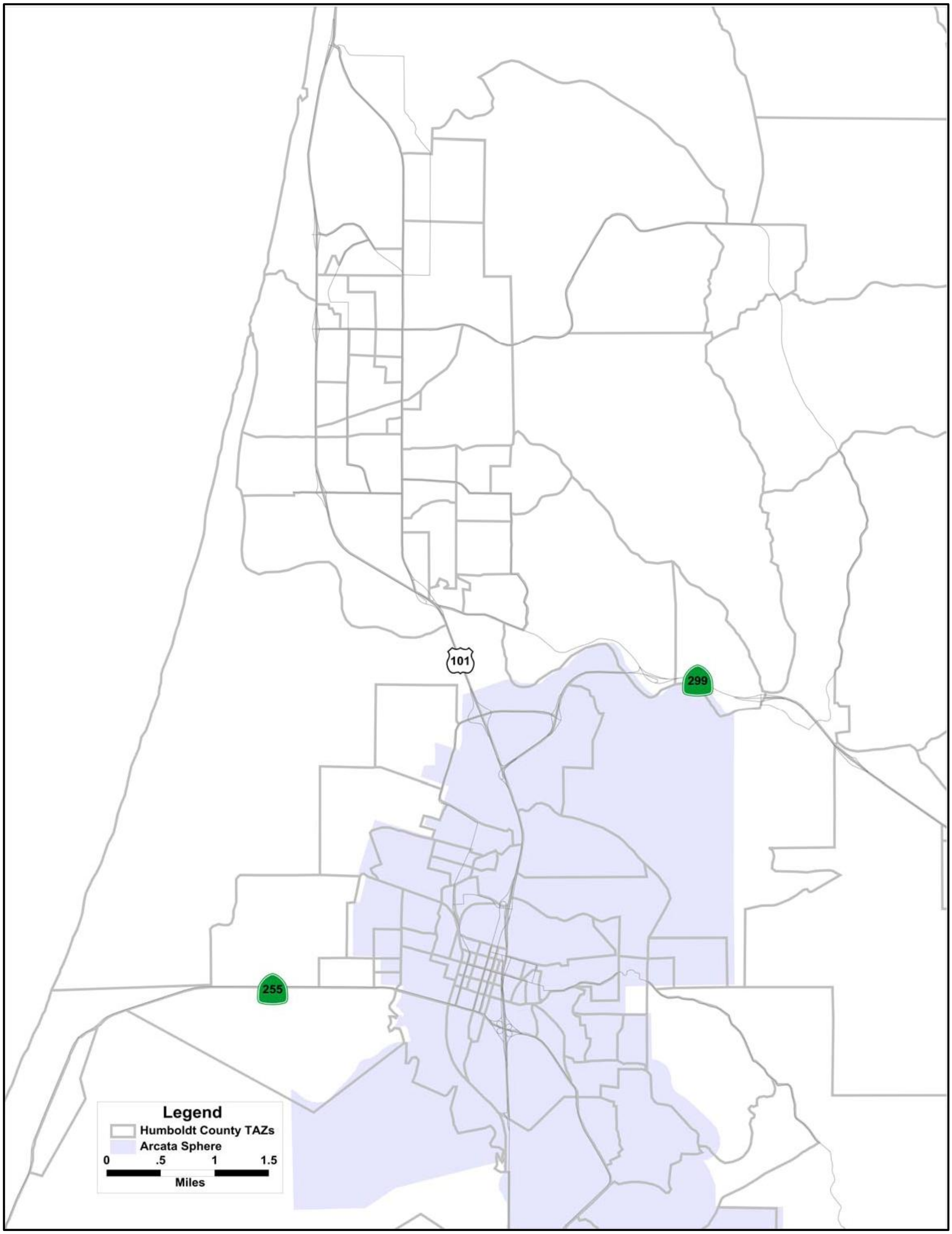
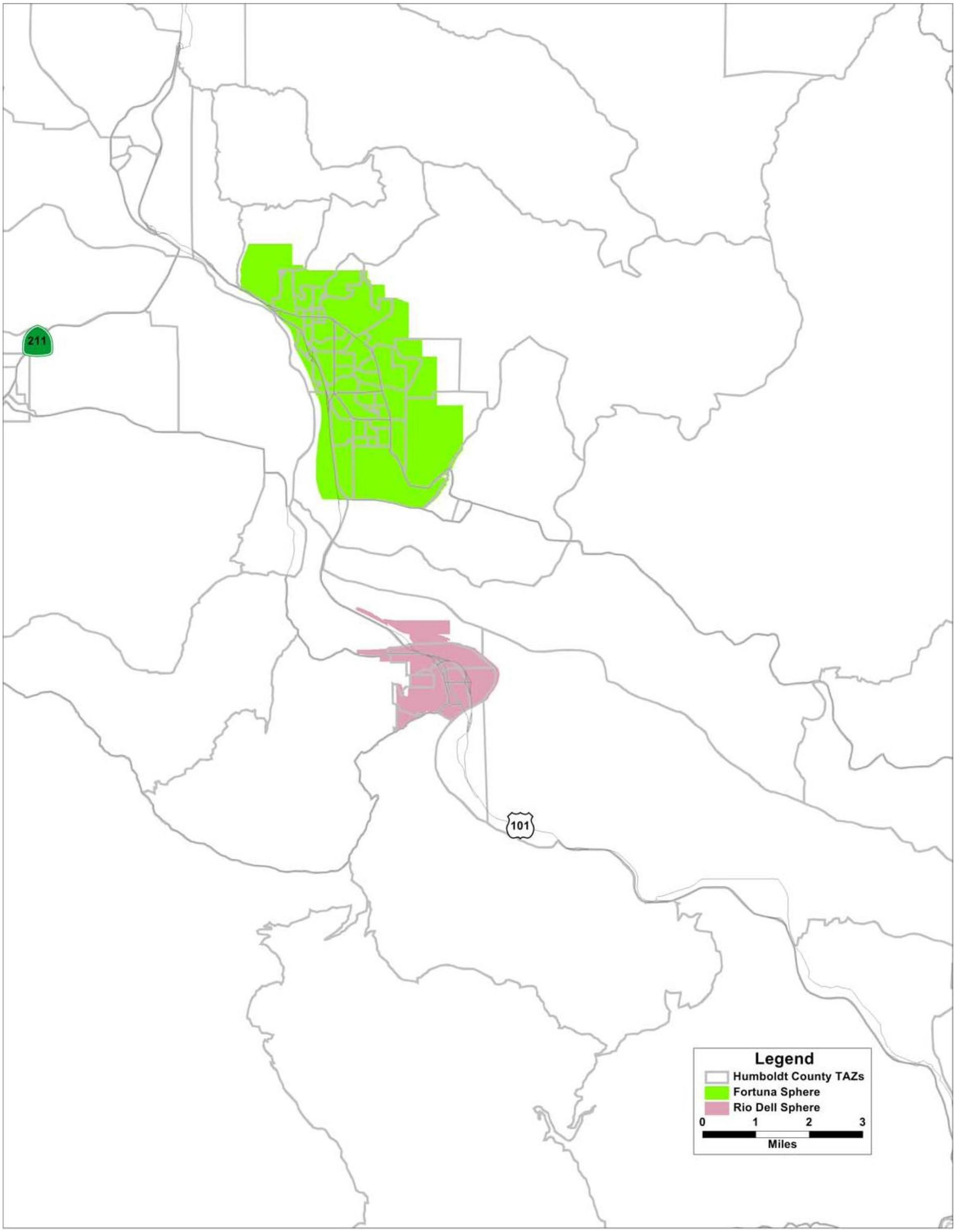


FIGURE 2.1D: TRAFFIC ANALYSIS ZONES (FORTUNA/RIO DELL)



Socioeconomic Data

In developing travel demand models, one of the important considerations is the development of the data representing the activities that promote trip-making. These activity data are typically either land use based or socioeconomic based, and some models incorporate elements of each. The Humboldt County Travel Model uses socioeconomic data, with key variables being households and employment. This section documents the methodology for developing household and employment datasets.

Household Data

Household data is used in the travel model primarily as a generator of trip productions. Households in each TAZ are multiplied by the appropriate trip production rates to determine the number of trip productions for the zone. It is desirable to use household characteristics to more accurately associate trip rates with household types. For example, a one-person, low income household will generate (or produce) significantly fewer trips than would a four-person, high income family. Common variables included in trip production models include household size, household workers, and a measure of wealth such as auto ownership or income. The San Luis Obispo Citywide Travel Model, from which production rates have been borrowed, uses household size and income. To apply these trip rates, it was necessary to develop household information at the TAZ level that includes not only the marginal distributions of size and income (i.e., distributions of each variable independent of the other), but the bi-variate (cross-classified) distributions as well.

Household data and the information necessary to further define them by size and income were obtained from the US Census and the American Community Survey (ACS). US Census data for the region are available for the year 2010. The latest ACS data, which were used to define income, are available for the 5-year period from 2005-2010.

Income Group Definition

Application of trip rates by household size and income requires definition of household size and income groups. Definition of household size is straightforward, as groups of 1, 2, 3, 4, and 5+ households transfer well from San Luis Obispo County to Humboldt County. Conversely, the income groups defined for San Luis Obispo County cannot be directly transferred to Humboldt County due to a difference in countywide median incomes. Instead, income group definitions were adjusted so that the cumulative percentage of households in each income group remains consistent.

The analysis in Table 2.1 shows income group definitions from the SLO Citywide Travel Model along with adjusted definitions used in Humboldt County. The cumulative household percentages resulting from the conversion are similar, but not identical, to the cumulative household percentages in the source model. This is because income group categories have been adjusted to match income categories that are reported in the American Community Survey.

TABLE 2.1: INCOME GROUPS

Income Group	Income Range (SLO)	Cumulative Households in Group (SLO)	Humboldt County Income Range	Cumulative Households in Group (Humboldt County)
Low	0 - $34,999	31%	0 - $24,999	33%
Medium	$35,000 - $99,999	76%	$25,000 - $74,999	79%
High	$100,000 +	100%	$75,000 +	100%

Household Disaggregation Models

At the TAZ level, the socioeconomic input data include average household size and median income as obtained from Census and ACS data. Household disaggregation models are used to estimate the univariate distribution of households by size and by income for each TAZ. The household size model is based on US Census data at the block level and the household income model is based on ACS data at the block-group level.

To apply these models, each known variable is used to look up a distribution of households by classification. For example, a zone with an average household size of 1 person would be comprised entirely of 1-person households (by definition). Conversely, a zone with an average household size of 4 people would be modeled as a combination of 1, 2, 3, 4, and 5+ person households. Distributions are represented by hand-fitted curves based on US Census and ACS data aggregated to TAZs.

It is important that the distribution curves always sum to 100% and that the results are consistent with the input values when averaged. Hand-fitted curves have been adjusted to fit the observed data points, sum to 100%, and produce the appropriate average.

Household Size Disaggregation Model

Trip production rates are classified by 5 household size groups. The distribution of households by group can be approximated for any given TAZ based on the average household size using the disaggregation curves shown in Figure 2.2. This figure also shows data points derived from US Census data used to develop the curves.

Household Income Disaggregation Model

The household income model was developed in a manner similar to the household size disaggregation model. However, the income size models are based on ACS data and use median rather than average income. Income disaggregation curves are shown along with data points derived from ACS data in Figure 2.3.

FIGURE 2.2: HOUSEHOLD SIZE DISTRIBUTIONS

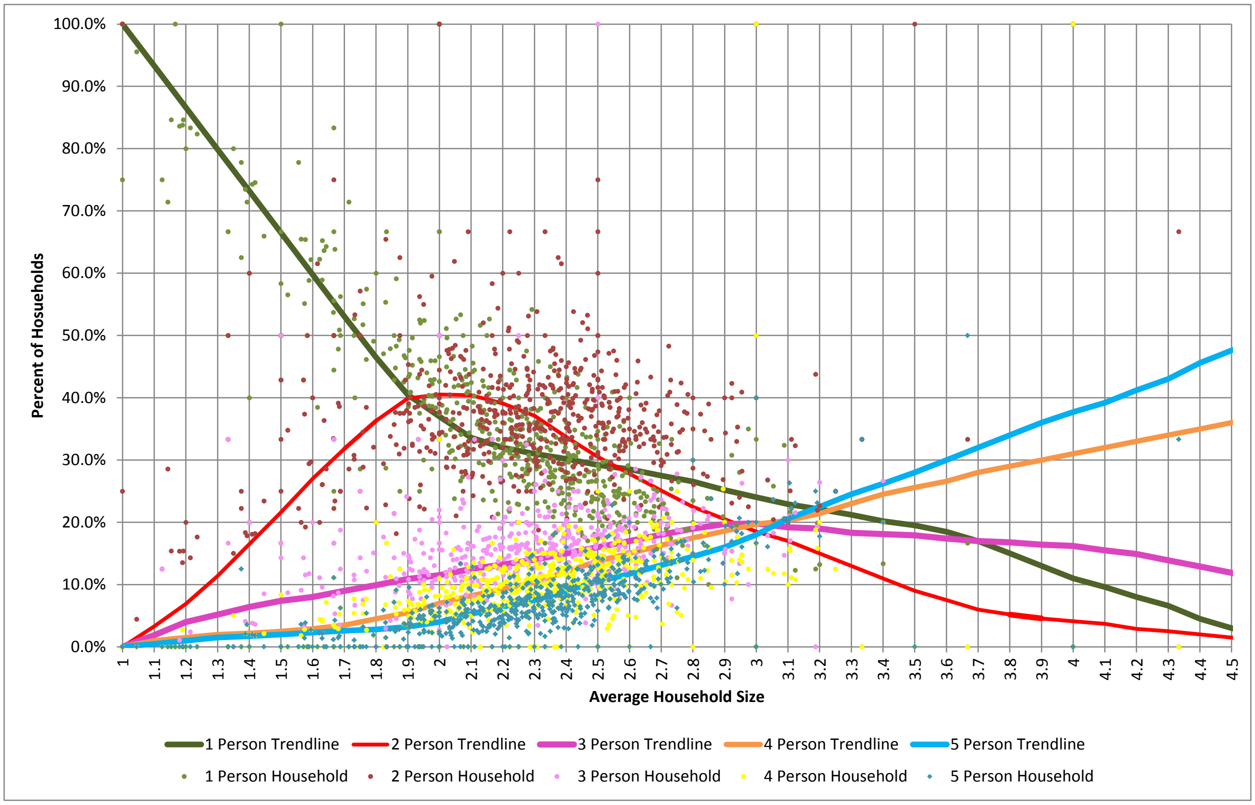
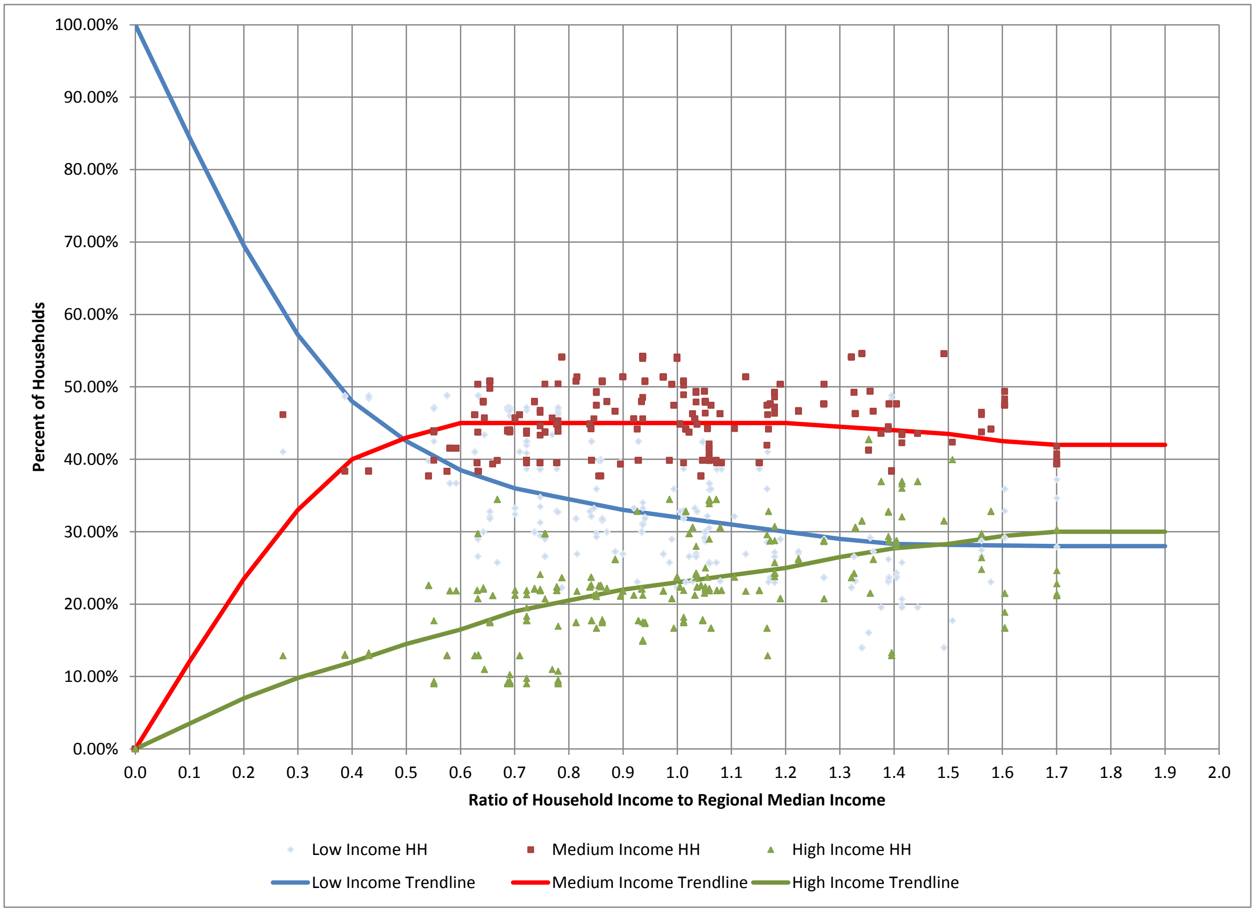


FIGURE 2.3: HOUSEHOLD INCOME DISTRIBUTIONS



TAZ-Level Bivariate Data

The household size and auto ownership disaggregation models produce *univariate* data for each TAZ. To apply trip production rates that vary by household size and income, *bivariate* household data is required at the TAZ level. The TAZ-level data resulting from the household disaggregation modes are used along with the regional bivariate distribution of households by size and income to estimate the bivariate distribution of households for each TAZ. The regional bivariate distribution of households by size and income, shown in Table 2.2, was obtained from the 2010 Public Use Microsample (PUMS) dataset.

The regional bivariate household distribution is adjusted to match the univariate distribution for each TAZ using an iterative proportional factor process (also called a Fratar process). This process is constrained so that the regional bivariate distribution of households is retained.

TABLE 2.2: BIVARIATE HOUSEHOLD DISTRIBUTION FOR HUMBOLDT COUNTY

Income Group	1 Person	2 Person	3 Person	4 Person	5+ Person	Total
Low	11071	4592	1629	904	460	**18,656**
Medium	6435	9367	4156	2970	1702	**24,630**
High	660	5084	2337	1827	1272	**11,180**
Total	**18,166**	**19,043**	**8,122**	**5,701**	**3,434**	**54,466**
Low	20.3%	8.4%	3.0%	1.7%	0.8%	**34.3%**
Medium	11.8%	17.2%	7.6%	5.5%	3.1%	**45.2%**
High	1.2%	9.3%	4.3%	3.4%	2.3%	**20.5%**
Total	**33.4%**	**35.0%**	**14.9%**	**10.5%**	**6.3%**	**100%**

Source: 2010 PUMS Data

Employment Data

Employment data are used in the travel model to generate trip attractions. Employees in each TAZ are multiplied by the appropriate trip attraction rates to determine the number of trip attractions for the zone. As is discussed in *Chapter 3 – Trip Generation*, it is desirable to separate employees into employment categories to better simulate the trip-making patterns associated with different types of employment. Because trip attraction rates are borrowed from the Whatcom Council of Governments Planning Model (Whatcom County, WA), employment categories in the Humboldt County Model are based on categories from the Whatcom Model.

The employment data for the model was derived from an employment dataset purchased from InfoUSA. This geocoded dataset includes several important variables, including business names, the number of employees present at each location, and North American Industry Classification System (NAICS) code. Geocoded employment locations are then matched and aggregated to the TAZs level. As a quality control measure, geocoded locations of the largest employers included in the dataset were verified manually. The resulting dataset lists the number of employees by NAICS code for each TAZ.

Employment data was grouped into categories using NAICS codes, which are standard numeric codes used by federal agencies to classify businesses. Employment in the Humboldt County Travel model is categorized into Retail, Service, Government, Finance & Insurance, Wholesale, Manufacturing, Agricultural, Medical, and Other categories according to the NAICS codes as defined in Table 2.3 below. Total employment in each of these eight categories at the TAZ level form the employment data required as a travel model input. 2010 regional employment totals are summarized in Table 2.4.

The total number of employees reported in the InfoUSA dataset, 48,816, is significantly lower than the total employment for the county reported in the Census 2010 ACS 3-year estimate of 60,533. However, the trip balancing procedure described in Chapter 3 accounts for this overall discrepancy.

ACS also reports employment by industry, so an attempt was made to reconcile employment type distributions represented by ACS and InfoUSA. Tests were performed with a modified employment dataset that was factored so that the distribution of employment was consistent with ACS data. This test dataset produced undesirable results, with resulting traffic volumes less similar to traffic counts than the original dataset. Therefore, the employment totals derived from the InfoUSA data were not factored for consistency with ACS employment totals in the final socioeconomic dataset.

During the model validation process, some small modifications were made to employment totals by TAZ based on a detailed review of data. Modifications typically consisted of moving data for specific large employers to the correct zone when the geocoding process failed to place a point in the correct TAZ. Adjustments were made in collaboration with representatives from Caltrans, the City of Eureka, and Humboldt County.

TABLE 2.3: EMPLOYMENT CATEGORIES AND NAICS CODE

Employment Type	NAICS Group Codes	Industry Examples
Retail	441 - 453	Retail Trade, Food Service
Service	511 – 519, 531 – 562, 611 – 624, 711 - 721	Real Estate, Services
Government	491, 921 – 922, 927, 928	Postal Services, Public Order, Justice
Finance & Insurance	521 - 525	Insurance, Banking, Securities
Wholesale	423 - 425	Wholesale Trade
Manufacturing	311, 312, 315 – 322, 324 - 339	Product Manufacturing, Apparel Manufacturing
Agricultural	111 - 115	Crop Agriculture, Forestry, Fishing
Medical	621, 622, 623	Hospitals, Ambulatory Health Care Services, Nursing, and Residential Care Facilities
Other	211 – 238, 313, 314, 323, 481 – 488, 492, 493	Transportation, Utilities, Construction

TABLE 2.4: EMPLOYMENT BY TYPE

Employment Type	Employees (2010)	Percent
Retail	10,286	21%
Service	17,950	37%
Government	1,870	4%
Finance, Insurance, and Real Estate (FIRE)	2,865	6%
Wholesale	1,537	3%
Manufacturing	1,970	4%
Agricultural	2,119	4%
Medical	3,143	7%
Other	6,463	13%
TOTAL	48,203	100%

Humboldt County Travel Model

3. Trip Generation

Context and Background

This chapter describes the process used to develop the Trip Generation component of the Humboldt County travel model. Trip production and attraction rates, special generators, allocation models, balancing methods, trip purpose, external travel, and other information related to the trip generation model are addressed herein. Trip generation rates are defined in units of daily person trips for all modes, including auto/truck, bus transit, pedestrian, and bicycle.

Trip generation is the first phase of the traditional 4-step travel demand modeling process. It identifies the trip ends (productions and attractions) that correspond to the places where activities occur as represented by socioeconomic data. Productions and attractions are estimated for each TAZ by trip purpose, and then balanced at the regional level so that total productions and attractions are equal. In some cases, production and attraction allocation sub-models are applied to better represent the geographic locations at which they occur. The resulting productions and attractions by trip purpose and TAZ are subsequently used by the Trip Distribution model to estimate zone-to-zone travel patterns.

The trip generation model is defined such that trips are produced at home and are generally attracted to other places of activity (places of employment). Hence, the terms “productions” and “attractions” are the fundamental variables for defining the trip ends associated with travel. Productions generally occur at the home end of a trip; and attractions are typically associated with non-residential activity. Some exceptions are described in the following sections, but this method of defining productions and attractions is generally used for trips internal to the modeling area. External travel is addressed as well. External trips are defined as: 1) external-external (EE) if both trip ends are outside of the modeling area, and 2) internal-external or external-internal (IE/EI) if one end of the trip is inside and the other end is outside of the modeling area.

Trip Purposes

Trip purpose is used in the travel model to categorize different types of household-based trips that have similar characteristics, such as location of production or attraction end, trip lengths, and auto occupancy. Trip rates for each trip purpose are sensitive to the specific socioeconomic data associated with each trip type. In general, it is advisable to disaggregate trips by trip purpose only to the point that the base and horizon year activity data can support them.

A trip is defined as a distinct travel movement from one clearly identifiable place or activity to another. In some cases, two or more trips may be linked, including convenience stops such as stopping for gas on the way from home to work. In these cases, the model represents the linked trip as two separate trips. The specific trip purpose definitions included in the Humboldt County Model are as follows:

- **Home-Based Work (HBW)**: Commute trips between home and work and vice versa (e.g., includes trips between work and home).
- **Home-Based Shop (HBS)**: Trips between home and shopping locations for the purpose of shopping.
- **Home-Based University (HBU):** Trips between home and the university campus for school related purposes by people not employed by the University (i.e., students and visitors).
- **Home-Based Other (HBO)**: All other trips that have one end at home. These can include trips between home and an appointment, school, home and recreation, etc.
- **Work-Based Other (WBO)**: Work-related trips without an end at home.
- **Other-Based Other (OBO):** Trips with neither an end at home nor a work-related purpose.

Production Rates

Trip production rates are borrowed from a model developed for the City of San Luis Obispo, CA. The borrowed trip rates are based records collected in San Luis Obispo County as part of the 2000 California Household Travel Survey. The survey included 648 households in San Luis Obispo County representing 5,297 unique weekday trips. The borrowed production rates vary by household size and household income, as trip production rates have been shown to be sensitive to both of these variables. As described in *Chapter 2 – Traffic Analysis Zones and Socioeconomic Data*, the income groups from the source model have been adjusted to represent similar percentiles in Humboldt County while household size categories remain unchanged.

Cross classified trip rates are computed as the mean number of trips per household for each combination of household size and income. However, a sufficient number of samples were not available for each combination. Development of the San Luis Obispo trip rates included a review of mean trip rates, trip rate standard deviations, and trip rate confidence intervals. As a result, some income and household combinations with small sample sizes and similar trip rates were grouped together to determine a group trip production rate. This trip production rate was then applied to each combination within the group for use in the model. Grouping was performed separately for each trip purpose. During model validation, raw trip rates from the San Luis Obispo model were factored for application in Humboldt County. The resulting factored trip rates as applied in Humboldt County are shown in Tables 3.1 through 3.7. Each trip rate table includes a row and column with the weighted average trip rates. These averages are weighted by the number of households in each individual cell (i.e., income/size combination).

Table 3.1: HBW Trip Production Rates (Person trips per household)

Household Income	Household Size					
	1	2	3	4	5+	*Weighted Average*
Low	0.78	1.38	2.16	2.71	5.5	**1.58**
Medium	1.11	2.13	3.3	3.3	3.3	**2.57**
High	1.11	2.13	3.28	2.79	2.79	**2.48**
Weighted Average	**0.90**	**1.76**	**2.83**	**3.06**	**3.57**	**2.07**

Table 3.2: HBS Trip Production Rates (Person trips per household)

Household Income	Household Size					
	1	2	3	4	5+	*Weighted Average*
Low	1.37	1.97	1.97	1.97	1.97	**1.64**
Medium	1.37	1.97	1.97	2.65	2.65	**2.15**
High	1.37	3.84	4.49	4.49	4.49	**4.08**
Weighted Average	**1.35**	**2.24**	**2.42**	**2.01**	**3.16**	**2.09**

Table 3.3: HBSc Trip Production Rates (Person trips per household)

Household Income	Household Size					
	1	2	3	4	5+	*Weighted Average*
Low	0.00	0.20	0.66	1.18	3.07	**0.54**
Medium	0.00	0.05	0.92	2.35	3.98	**1.30**
High	0.00	0.05	0.74	3.87	5.73	**1.94**
Weighted Average	**0.00**	**0.10**	**0.87**	**2.39**	**4.11**	**1.10**

Table 3.4: HBO Trip Production Rates (Person trips per household)

Household Income	Household Size					
	1	2	3	4	5+	*Weighted Average*
Low	1.38	2.08	3.63	6.43	16.71	**3.20**
Medium	1.38	3.15	5.92	9.12	15.48	**6.25**
High	1.38	3.81	3.12	13.4	19.82	**7.77**
Weighted Average	**1.58**	**2.91**	**4.73**	**9.36**	**16.72**	**5.16**

Table 3.5: WBO Trip Production Rates (Person trips per household)

Household Income	Household Size					
	1	2	3	4	5+	*Weighted Average*
Low	0.57	0.55	0.55	1.05	1.05	**0.62**
Medium	0.68	1.83	1.89	1.89	1.89	**1.70**
High	0.68	1.38	4.19	4.19	4.19	**2.89**
Weighted Average	**0.59**	**1.27**	**2.01**	**1.99**	**1.91**	**1.37**

Table 3.6: OBO Trip Production Rates (Person trips per household)

Household Income	Household Size					
	1	2	3	4	5+	*Weighted Average*
Low	2.24	1.48	1.48	2.55	2.55	**1.99**
Medium	1.19	2.55	4.27	5.67	10.78	**4.52**
High	1.19	3.12	3.12	5.93	18.66	**6.16**
Weighted Average	**1.89**	**2.26**	**3.12**	**4.72**	**9.93**	**3.53**

Table 3.7: Trip Production Rates – All Purposes (Person trips per household)

Household Income	Household Size					
	1	2	3	4	5+	*Weighted Average*
Low	6.34	7.66	10.45	15.89	30.85	**9.57**
Medium	5.73	11.68	18.27	24.98	38.08	**18.49**
High	5.73	14.33	18.94	34.67	55.68	**25.31**
Weighted Average	**6.30**	**10.53**	**15.97**	**23.54**	**39.39**	**15.31**

Attraction Rates

Attraction rates define the trip-ends that occur at locations other than the trip-maker's home. For home-based trips, the attraction end of a trip occurs at a non-residential location, or occasionally at another person's home. For WBO trips, trip productions occur at the trip maker's workplace and the trip attraction occurs at the non-work end of the trip. For OBO trips, the trip production and attraction are synonymous with trip origin and destination. For non-home-based trip purposes, allocation models and special procedures are used to properly locate the production and attraction end of each trip.

Trip attraction rates are borrowed from the Whatcom Council of Government (WCOG, Whatcom County, WA) model. The borrowed trip attraction rates were developed using linear regression analysis with a separate model for each trip purpose. Table 3.8 shows the trip attraction rates by trip purpose and employment types as documented for the WCOG Model.

In adapting these attraction rates for use in the Humboldt County Model, certain employment types were grouped due to similarity in the attraction rates across employment categories. The HBU trip attraction rates were not borrowed from the WCOG model because universities in Humboldt County are analyzed as special generators. Table 3.9 lists trip attraction rate as adapted for use in the Humboldt County Model.

During model development, two changes were made to the borrowed trip rates. First, attraction rates were factored by purpose so that results of the trip attraction model are regionally balanced with productions in the base year. Second, a separate healthcare employment type was created as a subset of the service employment type. The healthcare employment type was added during model validation after observing lower than observed traffic volumes in Eureka's medical district.

Table 3.8: Source Trip Attraction Rates (WCOG Model)

Variable	HBW	HBShop	HBSch	HBColl	HBO	NHBW	NHBO
Government Employment	1.016	-	-	-	1.530	0.875	1.495
Finance and Insurance Employment	1.016	-	-	-	1.593	0.937	-
Service Employment	1.043	-	-	-	1.940	0.842	0.873
Retail Employment	1.043	3.880	-	-	2.080	0.531	4.536
Wholesale Employment	0.848	-	-	-	-	1.970	-
Manufacturing Employment	0.848	-	-	-	-	1.320	-
Construction Employment	0.429	-	-	-	-	-	-
Educational Employment	-	-	-	-	-	-	-
Agricultural Employment	0.429	-	-	-	-	-	-
Telecommunications Employment	0.429	-	-	-	-	-	-
Mining Employment	-	-	-	-	-	-	-
Other Employment	0.429	-	-	-	-	-	-
Household Population	-	-	-	-	0.495	-	-
Grade School Enrollment	0.100	-	1.840	-	0.792	-	0.590
Middle School Enrollment	0.100	-	1.840	-	1.298	-	0.590
High School Enrollment	0.100	-	1.940	-	-	-	-
College Enrollment	0.208	-	-	0.250	-	0.082	0.075
Total Households	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Table 3.9: Humboldt County Trip Attraction Rates

WCOG Employment Type	HCAOG Employment Type	HBW	HBS	HBSc	HBO	WBO	OBO
Government Employment	Government Employment	1.930	-	-	2.907	1.663	2.841
Finance and Insurance Employment	Finance and Insurance Employment	1.930	-	-	3.027	1.780	-
Service Employment	Healthcare Employment	2.086	-	-	3.880	1.684	1.746
Educational Employment	Service Employment	1.565	-	-	2.910	1.263	1.310
Retail Employment	Retail Employment	1.565	5.820	-	3.120	0.797	6.804
Wholesale Employment	Wholesale Employment	1.611	-	-	-	3.743	-
Manufacturing Employment	Manufacturing Employment	1.611	-	-	-	2.508	-
Agricultural Employment	Agricultural Employment	0.815	-	-	-	-	-
Construction Employment	Other Employment	0.815	-	-	-	-	-
Telecommunications Employment							
Other Employment							
Household Population	Household Population	-	-	-	0.941	-	-
Grade School Enrollment	K-12 Enrollment	0.190	-	3.496	3.971	1.121	-
Middle School Enrollment							
High School Enrollment							

Non-Home-Based Production Allocation Models

While WBO and OBO trips are initially generated using household based production rates, these trip productions occur primarily at places of employment. The total number of WBO and OBO productions generated at households is used as a control total for trip balancing, but production allocation rates are used to move non-home-based productions to the appropriate work locations. For WBO trips, trip productions are defined as the work trip end and attractions are defined as the non-work trip end. WBO and OBO production allocation rates are based on rates borrowed from WCOG model. The WBO and OBO production allocation rates used in the updated model are shown in Table 3.10.

TABLE 3.10: PRODUCTION ALLOCATION RATES

Variable	WBO_P	OBO_P
Government Employment	1.649	2.841
Finance and Insurance Employment	2.238	-
Service Employment	0.972	1.310
Healthcare Employment	1.296	1.746
Retail Employment	1.233	6.804
Manufacturing Employment	1.839	-

College/University Special Generator and Production Allocation

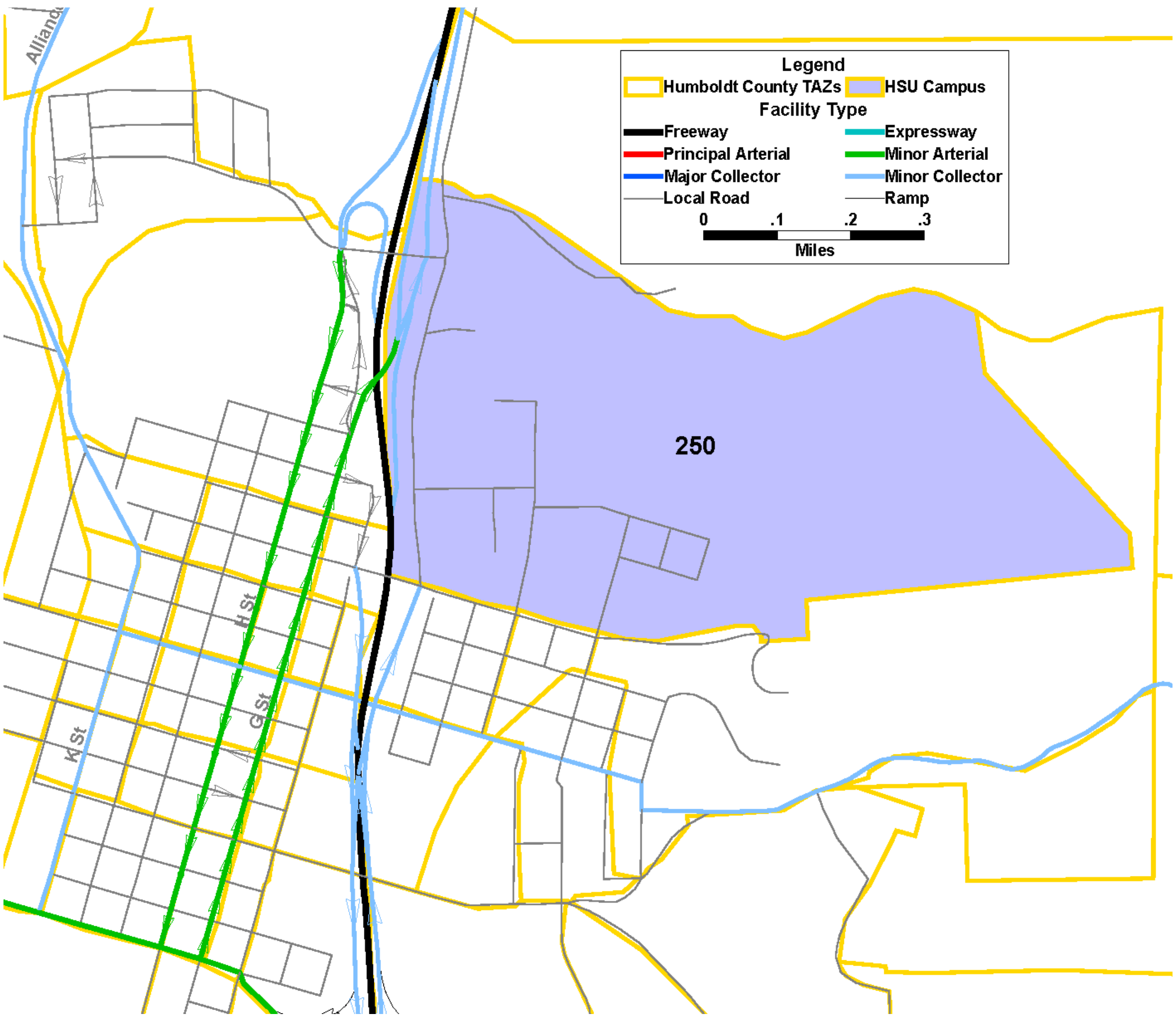
Humboldt County is home to Humboldt State University (HSU) and College of the Redwoods. HSU is a traditional 4-year university and College of the Redwoods is a community college, both of which generate a significant amount of trip activity. Furthermore, students attending HSU tend to be concentrated at households near the university or live on campus. This suggests that a special university trip purpose and allocation model can improve representation of HSU in the travel model.

At College of the Redwoods, students are expected to be more evenly spread across the county, but may still tend be located near the college. Past experience has shown that this type of facility can be well represented by the HBO trip purpose rather than a special college trip purpose. The possibility of including a special generator value for College of the Redwoods to accurately represent the amount of activity at the college was considered during model development and validation. After initial model runs, review of traffic count data near the college indicated that a special generator at this location was not necessary.

Humboldt State University Definition

HSU has one main campus located in Arcata. A single TAZ encompassing the campus is considered to be the HSU special generator. The HSU special generator is shown in Figure 3.1.

FIGURE 3.1: HUMBOLDT STATE UNIVERSITY, ARCATA CAMPUS LOCATION



University Trip Types

Because the university does not fall into the normal trip patterns used by the model in the remainder of the county, some special considerations are given to trip types at the university. In particular, the Home-Based University (HBU) trip purpose is defined as a trip by a university student or visitor between home and any location on the university campus. Trip ends at the University are associated with University faculty and staff, students living on campus, and students and visitors living off campus. Trip-ends occurring at the university are described as follows:

- **HBW, HBS, and HBO Productions:** These production trip ends can occur only for students living on campus.
- **HBW Attractions and WBO Productions:** These trip ends can occur only for University faculty and staff.
- **WBO Attractions and all OBO Trips:** These trip ends can only occur for students and visitors living off campus.
- **HBS and HBO Attractions:** These trip ends cannot occur at the University. All home-based trips to the University by students and visitors are considered HBU trips and all home-based trips to the University by faculty and staff is considered HBW trips.
- **HBU Productions:** Trips within the university campus are not modeled, so HBU productions cannot occur on campus.
- **HBU Attractions:** HBU attractions can occur only for students and visitors living off campus and traveling to the campus.

Special Generator Survey Adaptation

Detailed survey data was not available for HSU, but use of university special generator surveys from outside of the region can be useful in specifying special generator model for HSU. Unfortunately, neither the SLO Citywide Model or the WCOG model included a university special generator survey as part of model development. However, the SLO Citywide Model includes a university special generator model based on surveys at two Northern Colorado universities: Colorado State University (CSU)[5] and the University of Northern Colorado (UNC)[6]. The special generator model was originally developed for the Colorado North Front Range Regional Travel Model (NFR RTM). This model has been borrowed and adapted for application at HSU.

Employment and Enrollment Data

Total employment at HSU is published on the HSU website and is summarized in Table 3.11. Both the UNC and CSU special generator values were developed based on full time equivalent (FTE) University employment, not including employment at third-party vendors. Therefore, special generator adaptation is based on FTE employment data retrieved from the HSU website.

5 1999 Colorado State University Special Generator Study, City of Fort Collins, 2000.
6 2004 University of Northern Colorado Special Generator Study, North Front Range MPO, 2004.

Fall 2010 enrollment data for HSU was obtained from University website. This data is summarized in Table 3.12.

Table 3.11: Humboldt State University at Arcata Employment Data

	FTE Employment
Faculty	322
Staff	451
Total Employment	***773***

Table 3.12: University Enrollment Summary (Fall 2010)

Student Type	HSU Students	% HSU Students
On-Campus	1,962	25%
Off-Campus	5,940	75%
Total Enrollment	***7,902***	***100%***

Special Generator Values

Special generator values from the NFR RTM were adapted for use in the Humboldt County Model by computing a surrogate trip rate for each trip type based on FTE employment, on-campus students, or off-campus students. Where data was available, the CSU special generator values were used because CSU is more similar to HSU. The CSU special generator study grouped WBO and OBO trips into non home-based trips, so UNC values were used to compute WBO and OBO special generator values for HSU. Trip rates and special generator values are shown in Table 3.13.

During data collection, traffic counts were taken to form a cordon around HSU. After initial model runs, model volumes were compared to traffic counts along this cordon. The sum of model volumes crossing the cordon was observed to be very similar to the observed data. Therefore, it was not necessary to adjust special generator values to accurately represent the level of activity at HSU.

Table 3.13: University Special Generator Values

Trip Purpose	Trip Rate	Unit	HSU Special Generator Value
HBW Productions	0.22	On Campus Students	432
HBW Attractions	1.6	FTE Employment	1,236
HBS Productions	0.2	On Campus Students	392
HBS Attractions	n/a	n/a	0
HBU Productions	n/a	n/a	0
HBU Attractions	3.80	Off Campus Students	22,572
HBO Productions	0.3	On Campus Students	981
HBO Attractions	n/a	n/a	0
WBO Production	0.37	FTE Employment	286
WBO Attractions	0.19	Off Campus Student	1,129
OBO Productions	0.25	Off Campus Student	1,485
OBO Attractions	0.25	Off Campus Student	1,485

Note: These values do not include intra-university trips.

University Production Allocation

The production end of each off-campus HBU trip will occur at a household, most likely near the university. The university provided geocoded student address data to assist in development of an HBU production allocation model. These addresses were then aggregated to the model TAZs using a simple area-based overlay. The calibration parameters in Equation (1) were adjusted iteratively until the resulting production allocation model matched the allocation of geocoded student address data. The geocoded trips are shown in Figure 3.2 as a dot density map.

$$[\text{Allocation Factor}] = HH * a*(D^{b})*(e^{D*c}) \quad (1)$$

Where:

HH	= Total households in zone
D	= Right angle distance to university (mi)
a	= Calibration Parameter (70)
b	= Calibration Parameter (-0.787)
c	= Calibration Parameter (-0.063)

FIGURE 3.2: GEOCODED HSU STUDENT ADDRESSES (AGGREGATED TO TAZ)

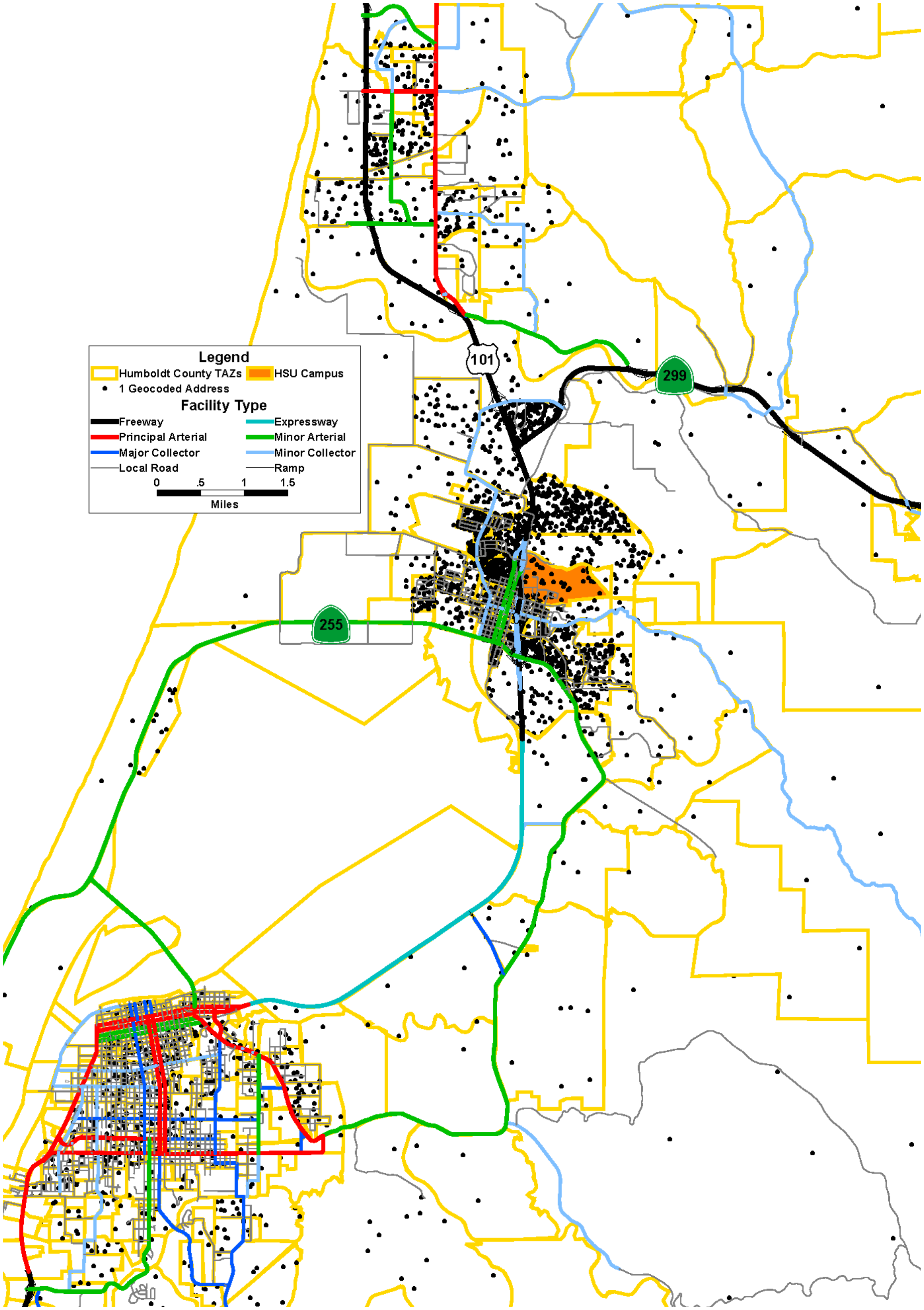
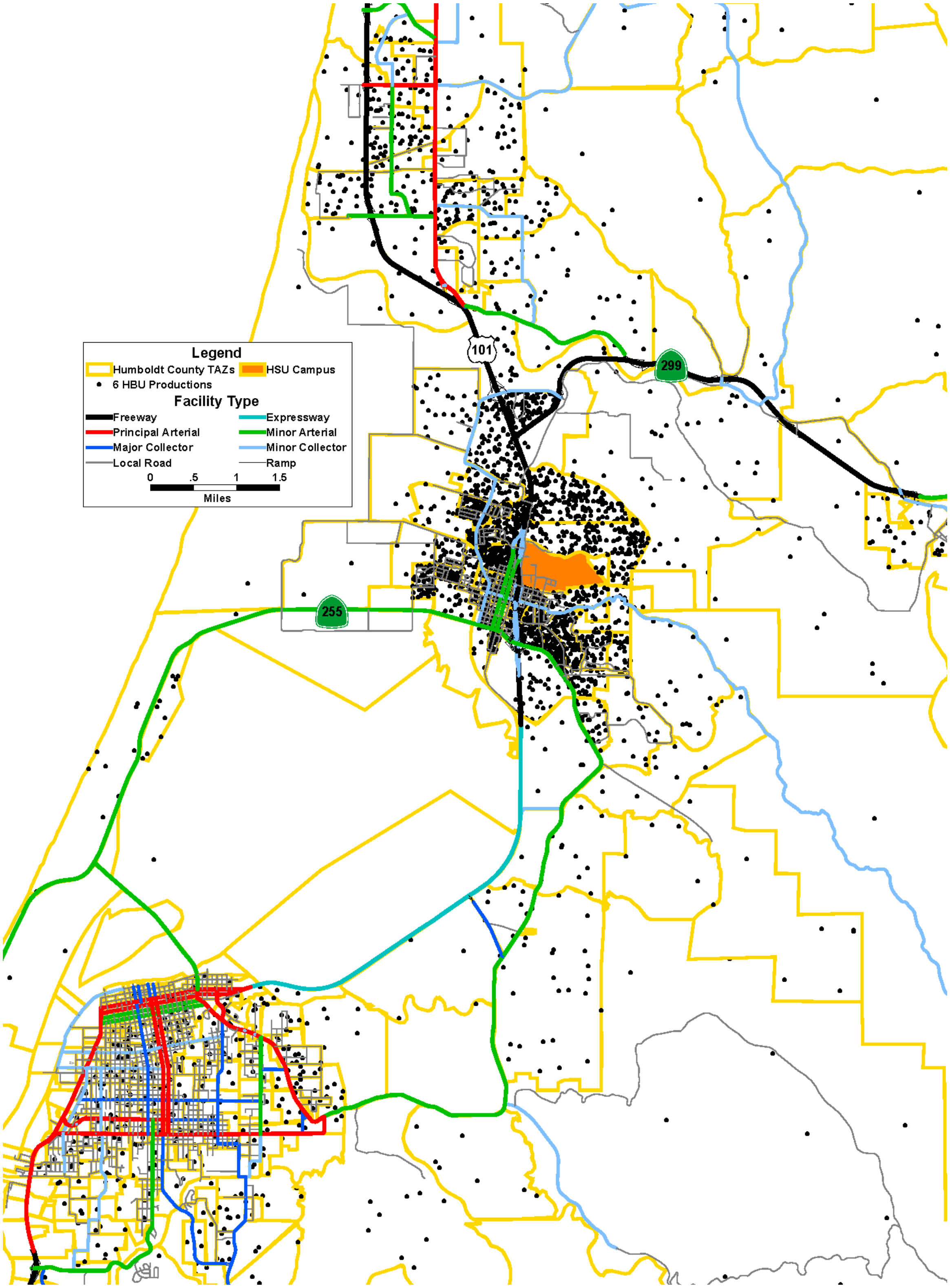


FIGURE 3.3: HSU PRODUCTION ALLOCATION RESULTS



Casino Special Generators

Humboldt County is home to several casinos. These establishments have significant localized traffic impacts and need to be accounted for in the travel model. However, the InfoUSA data used to prepare socioeconomic data does not include casino employment. Casinos are therefore treated as special generators in the Humboldt County Model. Special generator values are based on employment data and trip rates obtained from the previous version of the Humboldt County Travel Model. Employment assumptions and resulting special generator assumptions are shown in Table 3.14.

TABLE 3.14: CASINO SPECIAL GENERATORS

TAZ	Casino Name	Employment (Retail/Service)	Trip Attractions					
			HBW	HBS	HBSc	HBO	WBO	OBO
146	Lucky Bear Casino	0 / 32	50	0	0	93	40	42
159	Cher-Ae Heights Casino	6 / 180	291	35	0	543	232	277
228	Blue Lake Casino	25 / 76	159	146	0	299	116	270
741	Bear River Casino	0 / 85	133	0	0	247	107	111

External Trips

In addition to the internal-internal trips that occur entirely within the modeling area, the model must include external travel from outside of the region. Trips with one end inside the modeling area and the other outside of the area are called Internal-External (IE) and External-Internal (EI) trips. Through trips, or External-External (EE) trips, are those that pass through the modeling area without stopping (or with only short convenience stops).

External travel is modeled explicitly at the external stations where roadways cross the model boundary. The ten (10) external stations in the Humboldt County model are shown in Figure 3.4.

External Station Volumes

The first step in estimating external travel for the model is to determine the average weekday traffic at each location in the base year. Next, it is necessary to determine the split between the EE and IE/EI trips at each external station. This was accomplished using guidance provided in NCHRP Report 365[7] along with a manual review of external station locations, volumes and connections to other regions. The resulting split between EE and IE/EI trips for each external station is shown in Table 3.15. Only a few external stations are assumed to carry a significant number of EE trips. In this model update, external stations have been numbered as zones 1 through 10.

[7] National Cooperative Highway Research Program (NCHRP) Report 365: Travel Estimation Techniques for Urban Planning, Transportation Research Board, 1998.

FIGURE 3.4: EXTERNAL STATION LOCATIONS

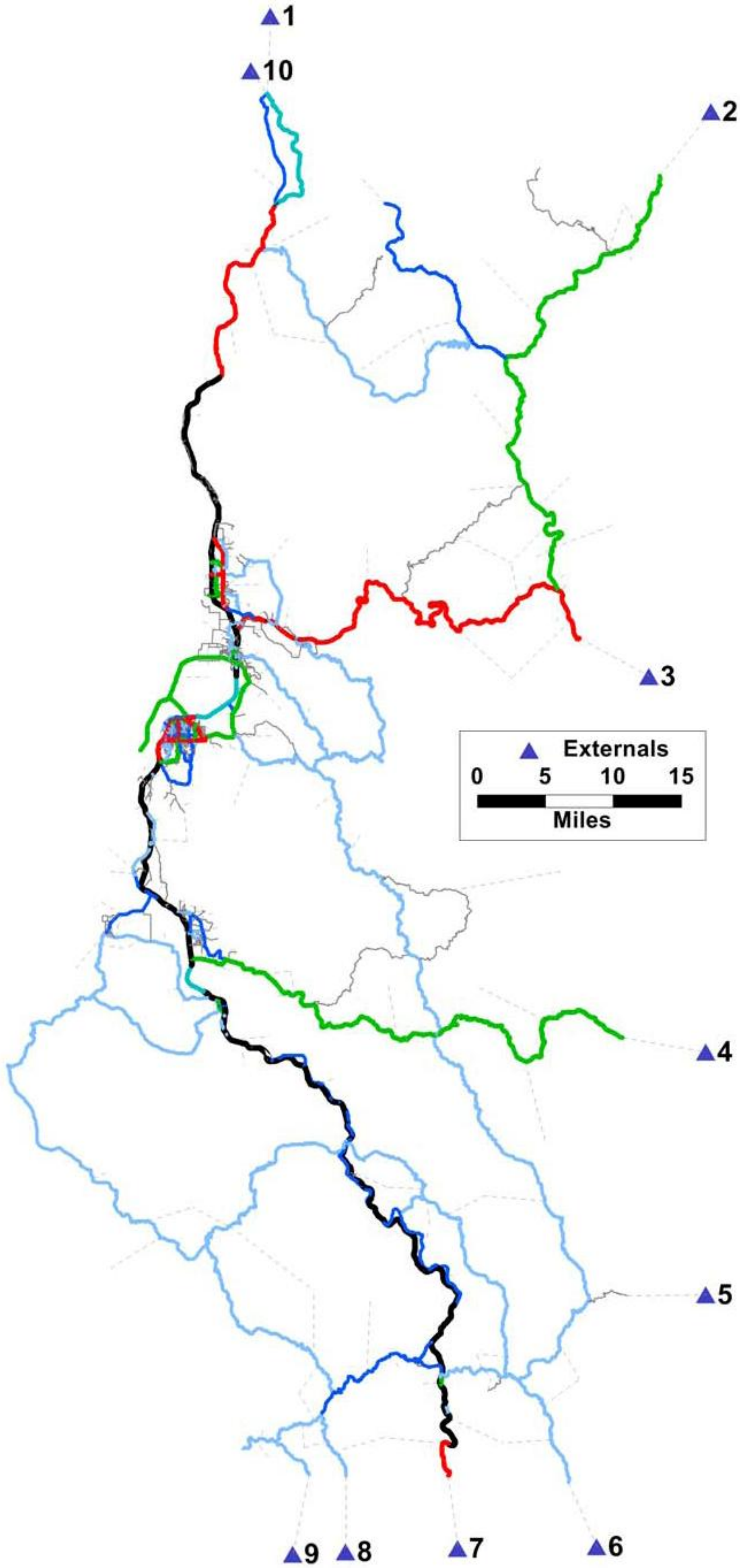


TABLE 3.15: EXTERNAL TRAVEL ASSUMPTIONS

External Station	Location	Total Volume	%EE	%IE/EI	EE Trips	IE/EI Trips
1	US-101	2,942	6%	94%	178	2,764
2	SR-96	752	0%	100%	0	752
3	SR-299	4,533	6%	94%	277	4,256
4	SR-36	1,362	0%	100%	0	1,362
5	Zenia Bluff Rd	244	0%	100%	0	244
6	Bell Springs Rd	349	0%	100%	0	349
7	US-101	6,942	7%	93%	454	6,488
8	Briceland Thorne Rd	595	0%	100%	0	595
9	Chemise Mountain Rd	81	0%	100%	0	81
10	Newton Drury Pkwy	532	0%	100%	0	532

Internal-External and External-Internal Trips

IE/EI trips are processed in the travel model using the internal trip purposes described previously. Trips with a production at the external station are defined as EI trips, while trips with an attraction at the external station are defined as IE trips. IE/EI trips are allocated among the various trip purposes and by direction using the distributions shown in Table 3.16. HBSc and HBU trips are assumed to remain within the county, so these trip purposes are not included in the IE/EI trip table.

TABLE 3.16: IE/EI TRIPS BY TRIP PURPOSE AND DIRECTION

Purpose	P/A	Percent By P/A Purpose	Percent of Total IE Trips
HBW	P	80%	24.0%
	A	20%	6.0%
	Total	***100%***	***30%***
HBS	P	90%	22.5%
	A	10%	2.5%
	Total	***100%***	***25%***
HBO	P	70%	17.5%
	A	30%	7.5%
	Total	***100%***	***25%***
WBO	P	50%	3.0%
	A	50%	3.0%
	Total	***100%***	***6%***
OBO	P	50%	7.0%
	A	50%	7.0%
	Total	***100%***	***14%***

External-External Trips

A significant number of EE trips are only assumed to occur at a subset of external stations. EE trips are further restricted to only occur between a subset of all remaining external station pairs. For example, it would be exceedingly unlikely for trips to occur between the southern US-101 external station and the southern Bell Springs Road external station. Therefore, trips between these external station pairs are not modeled. Conversely, it is expected that a large number of external station trips occur between the north and south US-101 external stations. Each pair of external stations is assigned one of the following values:

- 0 = EE trips are not expected and are therefore not modeled,
- 1 = EE trips are expected, or
- 2 = EE trips are expected to occur more frequently than for other external station pairs.

These values are entered into an EE trip seed table, shown in Table 3.17.

Over the course of a day, the total number of EE trips at each external station is assumed to be equal for both directions (inbound trips = outbound trips). This assumption is used to develop total inbound and outbound trips at each external station. The seed table and total trips are used in an iterative proportional factoring process (also called a Fratar process) to develop an EE trip table for input to the travel model, shown in Table 3.18.

TABLE 3.17: EE TRIP TABLE SEED VALUES

		1	2	3	4	5	6	7	8	9	10
		US-101	SR-96	SR-299	SR-36	Zenia Bluff Rd	Bell Springs Rd	US-101	Briceland Thorne Rd	Chemise Mountain Rd	Newton Drury Pkwy
1	US-101	0	0	1	0	0	0	2	0	0	0
2	SR-96	0	0	0	0	0	0	0	0	0	0
3	SR-299	1	0	0	0	0	0	1	0	0	0
4	SR-36	0	0	0	0	0	0	0	0	0	0
5	Zenia Bluff Rd	0	0	0	0	0	0	0	0	0	0
6	Bell Springs Rd	0	0	0	0	0	0	0	0	0	0
7	US-101	2	0	1	0	0	0	0	0	0	0
8	Briceland Thorne Rd	0	0	0	0	0	0	0	0	0	0
9	Chemise Mountain Rd	0	0	0	0	0	0	0	0	0	0
10	Newton Drury Pkwy	0	0	0	0	0	0	0	0	0	0

TABLE 3.18: 24 HOUR EE TRIP TABLE

		1	2	3	4	5	6	7	8	9	10	
		US-101	SR-96	SR-299	SR-36	Zenia Bluff Rd	Bell Springs Rd	US-101	Briceland Thorne Rd	Chemise Mountain Rd	Newton Drury Pkwy	TOTAL
1	US-101	0	0	0	0	0	0	89	0	0	0	89
2	SR-96	0	0	0	0	0	0	0	0	0	0	0
3	SR-299	0	0	0	0	0	0	138	0	0	0	139
4	SR-36	0	0	0	0	0	0	0	0	0	0	0
5	Zenia Bluff Rd	0	0	0	0	0	0	0	0	0	0	0
6	Bell Springs Rd	0	0	0	0	0	0	0	0	0	0	0
7	US-101	89	0	138	0	0	0	0	0	0	0	227
8	Briceland Thorne Rd	0	0	0	0	0	0	0	0	0	0	0
9	Chemise Mountain Rd	0	0	0	0	0	0	0	0	0	0	0
10	Newton Drury Pkwy	0	0	0	0	0	0	0	0	0	0	0
TOTAL		89	0	139	0	0	0	227	0	0	0	909

Trip Balancing

Trip productions and attractions are estimated separately by purpose using the trip rates and allocation models previously described. While an attempt is made to make the initial estimate of productions equal to the initial estimate of attractions, it is not feasible to make them exactly equal in all scenarios, which is necessary to ensure conservation of trips in the model. The balancing process provides this conservation by making the productions and attractions equal.

Balancing depends on the level of confidence associated with the initial estimate of productions and attractions. Since (borrowed) household survey data was used to estimate trip production rates, the home-based trip purposes are balanced to trip productions. One exception to this is the HBU trip purpose. The special generator studies and cordon counts upon which the HSU estimates are based provided increased reliability for HBU trip attractions to the university campus, so HBU productions are balanced to attractions.

Non-Home-Based trips (WBO and OBO) are also balanced to productions. These trips are balanced to the initial estimate of productions from the basic trip rates in the cross-classified trip production model. Then, the productions are re-allocated using the allocation models previously discussed.

Humboldt County Travel Model

4. Trip Distribution

Context and Background

This chapter describes the process used to develop the Trip Distribution model for the Humboldt County Travel Model. The pathbuilding process, trip distribution process, and gravity model parameters, are defined herein.

Trip distribution is the second phase of the traditional 4-step travel demand modeling process. Trip distribution is the process through which balanced person trip productions and attractions (from the trip generation model) are apportioned among all zone pairs in the modeling domain by trip purpose. The resulting trip table matrix contains both intrazonal (e.g., trips that don't leave the zone) and interzonal trips for each trip purpose. Intrazonal trips are shown on the diagonal, while all other zone interchange cells represent interzonal trips.

The Humboldt County Travel Model uses a standard gravity model equation and applies friction factors to represent the effects of impedance between zones. As the impedance (e.g., travel time, spatial separation) between zones increases, the number of trips between those zones will decrease as represented by a decreasing friction factor. This relationship is similar to the standard gravity model which assumes that the gravitational attraction between two bodies decreases as they become further apart. The gravity model also assumes that the gravitational attraction between the two bodies is directly proportional to their masses. The trip distribution model makes a similar assumption in that the number of trips between two zones is directly proportional to the number of productions and attractions contained in those zones. The gravity model used by trip distribution to estimate the number of trips between each zone pair is defined in Equation (1).

$$T_{ij} = P_i \frac{A_j \cdot F_{ij} \cdot K_{ij}}{\sum_{i=1}^{n} (A_j \cdot F_{ij} \cdot K_{ij})} \qquad (1)$$

Where:

Tij	=	trips from zone i to zone j
Pi	=	productions in zone i
Aj	=	attractions in zone j
Kij	=	K-factor adjustment from i to zone j
i	=	production zone
j	=	attraction zone
n	=	total number of zones
Fij	=	friction factor (a function of impedance between zones i and j)

K-factors are often used in travel demand models to account for nuances in travel behavior and the transportation system that cannot be accurately modeled with simplified aggregate modeling techniques. K-factors are often applied at the district or jurisdictional level to adjust regional distribution patterns and may be applied by trip purpose or for all trips. K-factors were not determined to be necessary in the Humboldt County Travel Model.

Friction factors represent the impedance to travel between each zone pair. Friction factors have been calibrated for the HBW trip purpose based on observed trip length (time) from the 2000 Census Transportation Planning Package (CTPP) data. Friction factors for other trip purposes were developed using a borrowed relationships and an ODME procedure as described later in this chapter.

Peak and Off-Peak Period Definitions

Trips occurring during the AM and PM peak hours are distributed based on peak congested speeds; trips occurring during off-peak times are distributed based on off-peak congested speeds. Trip distribution is performed in Production-Attraction (PA) format rather than Origin-Destination (OD) format because the majority of trips in the AM peak period travel from production to attraction (e.g., to work) and the majority of trips in the PM peak period travel from attraction to production (e.g., from work). The model uses directional AM peak period speeds to compute impedance for both AM and PM peak period trips in the PA format.

To implement trip distribution by time of day, factors representing the portion of trips occurring in the peak (combined AM and PM peak hours) and off-peak (all other times) are necessary. Peak period trips are further separated prior to traffic assignment. As discussed in previous chapters, the San Luis Obispo Citywide Travel Model was selected as a data source for trip generation. Trips are separated into peak and off-peak period trips based on data borrowed from the San Luis Obispo Citywide Travel Model using the factors shown in Table 4.1. These trip proportions are used to separate trip generation results into peak and off-peak trips.

Table 4.1: Peak and Off-Peak Trip Percentages by Purpose

Period	HBW	HBS	HBSc	HBU	HBO	WBO	OBO
Off-Peak	0.814	0.890	0.798	0.770	0.832	0.872	0.814
Peak	0.185	0.110	0.202	0.230	0.168	0.128	0.185

Roadway Network Shortest Path

The impedance portion of the gravity model equation is based on the shortest path between each zone pair. The shortest path is determined through a process called pathbuilding, which identifies the shortest route between two network centroids that minimizes an impedance variable. Shortest paths cannot pass through other centroid connectors. Various data, such as path distance, can be "skimmed" along the shortest impedance route. The set of all zone to zone shortest paths is called a "shortest path matrix" and is sometimes referred to as a "skim matrix" with the understanding that the skimmed variable may differ from the variable(s) used to determine the shortest path. This section describes the process used to generate the shortest path matrices used in trip distribution.

The Humboldt County Travel Model finds the shortest paths between each zone pair based on peak or off-peak congested travel time. Because the individual communities in Humboldt County are relatively small, and because freeflow time is a reasonable measure of trip distance, freeflow travel time is used to distribute both peak and off-peak trips.

Terminal Times

In the model, terminal penalties are applied to the shortest paths, in order to simulate several travel-related variables such as the time to locate a parking space, walking to a final destination, paying for a parking space, etc. Terminal penalties, shown in Table 4.2, are added to both the production and attraction end of each zone pair based on the area type of each zone.

TABLE 4.2: TERMINAL PENALTIES BY AREA TYPE

Area Type		Terminal Time
1	CBD	1.5
2	Urban	1
3	Suburban	1
4	Rural	0.75

Intrazonal Impedance

Impedance, or travel time, for trips within a zone (intrazonal impedance) is not generated in the zone to zone pathbuilding process because the roadway network is not detailed enough for a sub-TAZ level analysis. Instead, the nearest neighbor rule is used to estimate intrazonal impedance. The nearest neighbor rule is applied by taking an average of the nearest TAZs and multiplying that average by a factor. Intrazonal travel time for the Humboldt County model has been calculated by averaging the distance to the three nearest neighbors.

Friction Factors

Friction factors represent the impedance to travel between each zone pair. The Humboldt County Travel Model applies the friction factors in the form of gamma functions for each trip purpose. The gamma function is defined by Equation (2).

$$F_{ij} = \alpha t^{\beta} e^{\gamma t} \quad (2)$$

Where:

F_{ij} *= friction factor between zones i and j*

t *= travel time*

α, β, γ *= calibration parameters*

Work Trip Calibration

The 2000 CTPP Journey to Work data provides a tabulation of home/work pairs at the tract to tract level within Humboldt County. This information can be extrapolated to the TAZ level, resulting in an approximate TAZ-level trip table for HBW trips. This trip table is then processed along with the shortest path matrix to generate a trip length distribution curve. Friction factors for HBW trips are calibrated to match the average trip length and trip length distribution curve generated from CTPP data.

The CTPP data includes a reported work commute time, which was also reviewed. However, the reported commute time is often longer than the observed commute time due to reporting bias such as, large scale rounding and over-estimation of travel time. For Humboldt County, the reported travel time is only slightly longer on average than the travel time generated based on worker flow data. The calibration target, model results for HBW trips, and reported travel time are all shown in Figure 4.1.

Non-Work Trip Calibration

For trip purposes other than HBW trips, trip length distributions are based on a combination of relationships borrowed from the San Luis Obispo Citywide Travel Model and an origin-destination matrix estimation (ODME) process. The borrowed data provides relationships between average trip lengths for HBW and other trip purposes, while the ODME process provides an indication of trip length distribution for all trip purposes.

The first step in preparing trip distribution calibration targets for non-HBW trips is to prepare a count-based origin-destination trip table. This was accomplished using the TransCAD software's ODME module, which uses an OD matrix seed along with traffic count data to estimate an origin-destination trip table. The process works by iteratively assigning traffic to the roadway network and adjusting the trip table until the resulting assignment volumes are similar to traffic count volumes. The ODME process is sensitive to following input assumptions:

- Traffic Count Data,
- Initial "Seed" trip table – both magnitude and distribution of trips, and
- Traffic assignment methodology and congestion delay parameters.

The most important input to the ODME process is the traffic count data. During the data effort, traffic count data was collected in strategic locations to ensure a consistent and complete coverage throughout the county. Traffic count data obtained from Caltrans, Humboldt County, and local jurisdictions was supplemented with additional data collected specifically for use in this project. The resulting count dataset covers 197 individual links within the county.

The initial seed trip table also has an impact on the ODME process, but testing of the process with various seed matrices showed that the effect was minimal. The seed table input to the ODME process was generating by scaling the CTPP-based commute trip table to match trip generation totals by TAZ using an iterative proportional factoring process. This process involves iteratively factoring the seed trip table until row and column totals match production and attraction totals resulting from trip generation. A simple PA to OD conversion was then applied by transposing the trip table, adding the transposed trip table to the original, and then factoring the table by 0.5.

It was also necessary to include external travel in the ODME seed, since the traffic count data includes all travel, including external travel. External to External (EE) travel was entered directly into the seed matrix based on the estimated EE trip table described in Chapter 3. The remaining trips to and from external stations were proportionally distributed based on seed matrix row and column totals.

Traffic assignment settings for ODME were also found to have only minimal impact on the resulting trip table. Traffic assignment for ODME was performed using an approximate daily capacity, computed as the hourly capacity of each link divided by 0.09. Hourly link capacity and freeflow speed values were set as identified in Chapter 1.

The result from the ODME procedure is a synthesized trip table in OD format representing daily trips of all purposes. The purpose of this exercise is to generate a 24-hour trip length distribution representing all trips that are not represented in the CTPP-based trip table. This is accomplished by subtracting the CTPP-based trip table from the ODME results and removing external trips from the ODME results, producing a 24-hour non-work trip table. This trip length distribution of the resulting table is the initial trip distribution calibration target for all non-work trips. Because the ODME process produces a synthesized table, rather than the observed table generated from CTPP data, the non-work trip table is treated as a less stringent calibration target. Calibration of non-work trips is shown in Figure 4.2.

In calibration of non-work trips, separate non-work friction factors were prepared for each trip purpose. Initial non-work friction factors were based on friction factors in the San Luis Obispo Citywide Travel Model. During adjustment of friction factor parameters, friction factor curves were monitored to ensure consistency with patterns from the SLO Citywide Model. Figure 4.3 shows the friction factors from the SLO Citywide Travel Model, while Figure 4.4 shows the Humboldt County Travel Model friction factors for each trip purpose. Table 4.3 contains the calibrated gamma function parameters.

In addition to friction factor adjustments, other model variables and parameters including terminal penalties, intrazonal travel times, volume/delay equations, and K-factors can affect calibration of trip length distribution curves. These parameters were monitored during model validation, but it did not become necessary to modify these parameters.

FIGURE 4.1: HBW TRIP TIME DISTRIBUTION

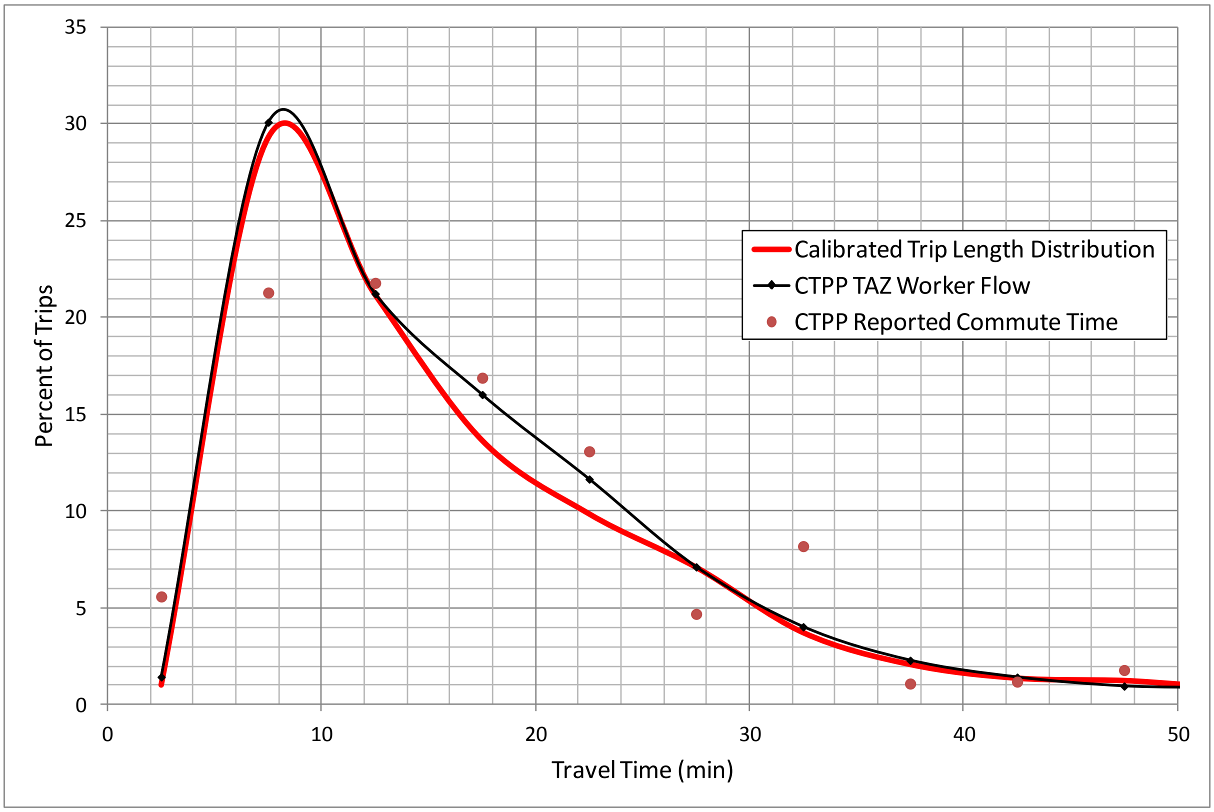


FIGURE 4.2: NON-WORK TRIP TIME DISTRIBUTION

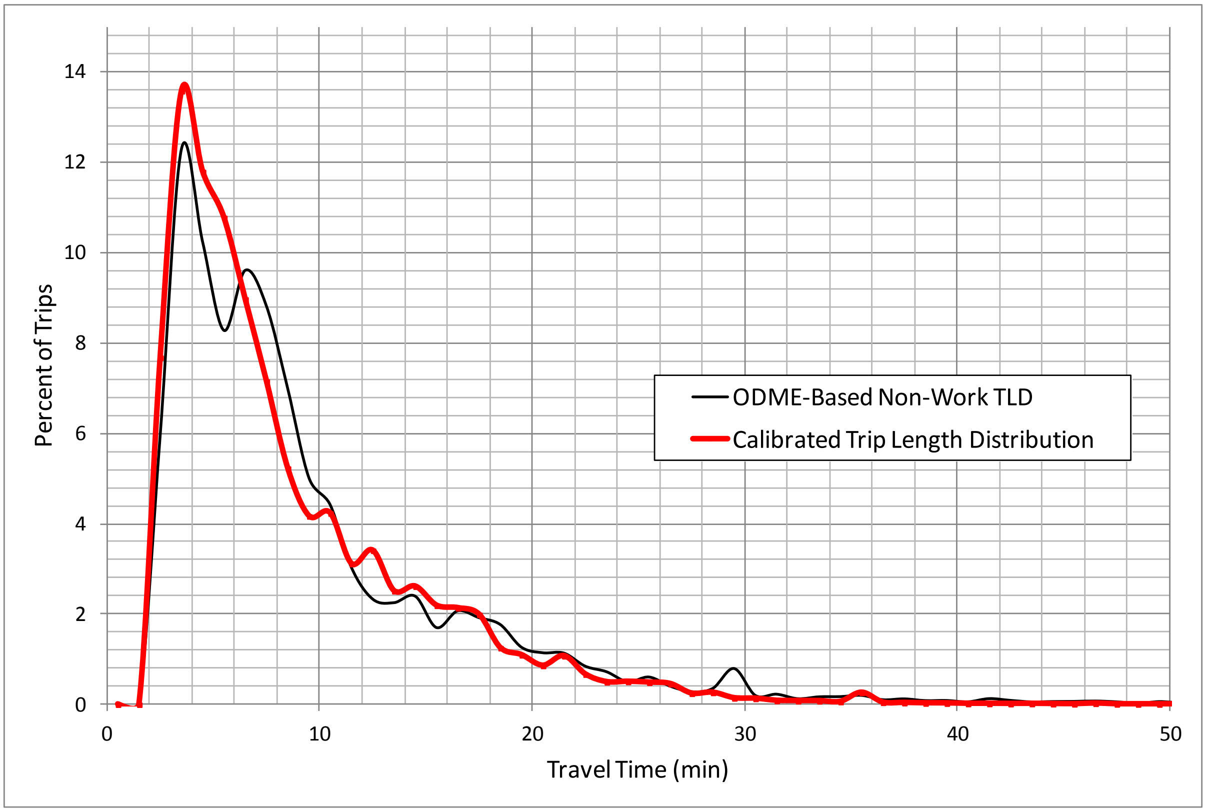


Figure 4.3: Friction Factors (SLO Citywide Model)

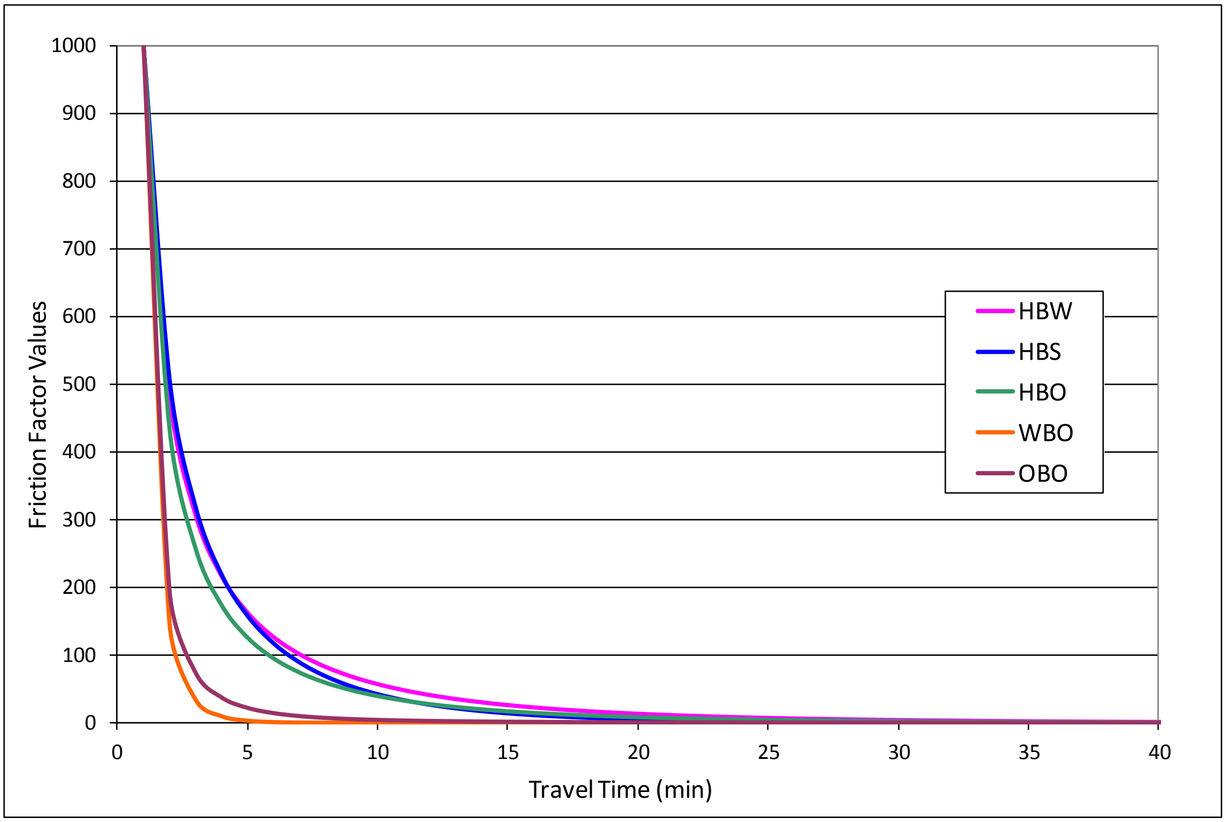


Figure 4.4: Friction Factors (Humboldt County Model)

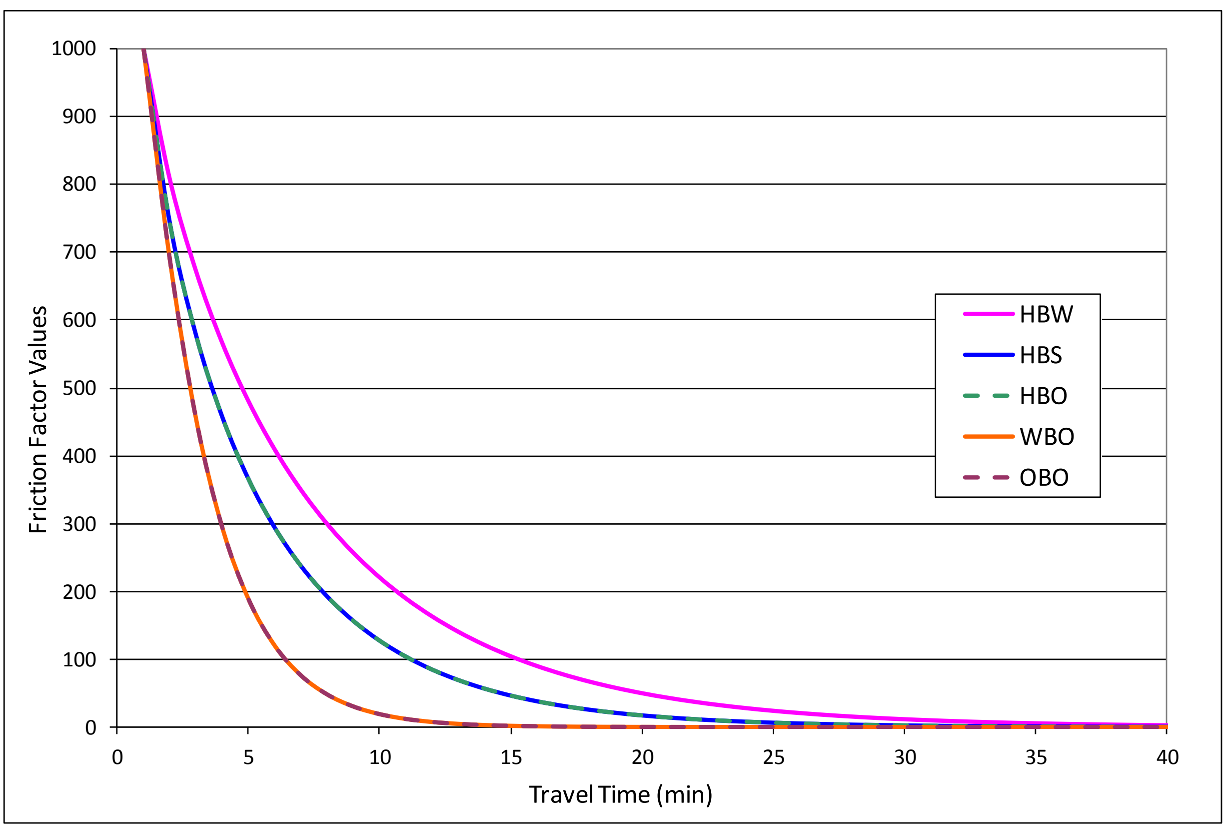


Table 4.3: Friction Factors

Trip Purpose	Alpha (α)	Beta (β)	Gamma (ϒ)
HBW	1000	0.105	0.141
HBS	1000	0.155	0.189
HBSc	1000	0.155	0.189
HBO	1000	0.155	0.189
WBO	1000	-0.156	0.480
OBO	1000	-0.156	0.480

Trip Lengths

In addition to trip length distribution curves, overall average trip lengths are useful in calibration of trip distribution friction factors. It has been frequently observed that commute trips have a longer average trip length than any other trip purpose. Conversely, non-home-based trip lengths are generally expected to be shorter than trip lengths for other purposes. A comparison of average trip lengths resulting from the travel model is included in Table 4.4. As expected, HBW trips are longer than other trip purposes and non-home-based trips generally have the shortest trip lengths. Furthermore, high income commute trips tend to be longer than lower income trip lengths.

Table 4.5 includes a comparison of modeled and observed trip lengths. Trip lengths resulting from model application are reasonably similar to the observed average trip lengths based on CTPP data and trip lengths generated using ODME.

Table 4.4: Modeled Average Trip Lengths

Measure	HBW	HBS	HBU	HBO	WBO	OBO
Distance (Miles)	10.40	8.67	5.60	6.64	4.78	2.43
Time (Minutes)	18.23	15.94	13.31	14.11	10.81	7.13

Note: HBSc trips are combined with HBO trips in this table.

Table 4.5: Average Trip Length Calibration

Measure	CTPP	Model HBW	ODME Non-Work	Model Non-Work
Distance (Miles)	9.75	10.40	7.60	5.44
Time (Minutes)	16.05	18.23	14.25	12.02

Intrazonal Trips

Intrazonal trips are trips that begin and end in the same TAZ. While limited data is available to quantify the total number of intrazonal trips, it is important to ensure that the percentage of trips identified as intrazonal trips is reasonable. Table 4.6 shows the intrazonal trip percentages from the base year Humboldt County Travel Model.

TABLE 4.6: INTRAZONAL TRIP PERCENTAGES

HBW	HBS	HBU	HBO	WBO	OBO
2.81%	2.62%	0.00%	5.63%	12.96%	15.40%

As expected, HBW trips are the least likely to occur within a single zone than other trip purposes. Conversely, non-home-based trips are the most likely trip purpose to remain within a single zone.

District to District Patterns

Trip distribution patterns can also be monitored by comparing travel patterns between different parts of the county. Trip patterns were summarized for the districts shown in Figure 4.5. District to district patterns for work trips are shown in Tables 4.7A and 4.7B, with the difference between model results and CTPP data shown in Table 4.7C. ODME results and model results for all trips are shown in Tables 4.8A and 4.8B, with the difference shown in Table 4.8C.

Resulting HBW trip patterns are reasonably similar to observed patterns. When reviewing overall trip patterns (i.e., including the non-commute trips), it was noted that the model shows fewer trips remaining within Eureka than suggested by the ODME process. Review traffic count data in and around Eureka suggests that modeled trip distribution patterns are reasonable, as the ODME process only produces an estimated trip table.

FIGURE 4.5: TRIP DISTRIBUTION DISTRICTS

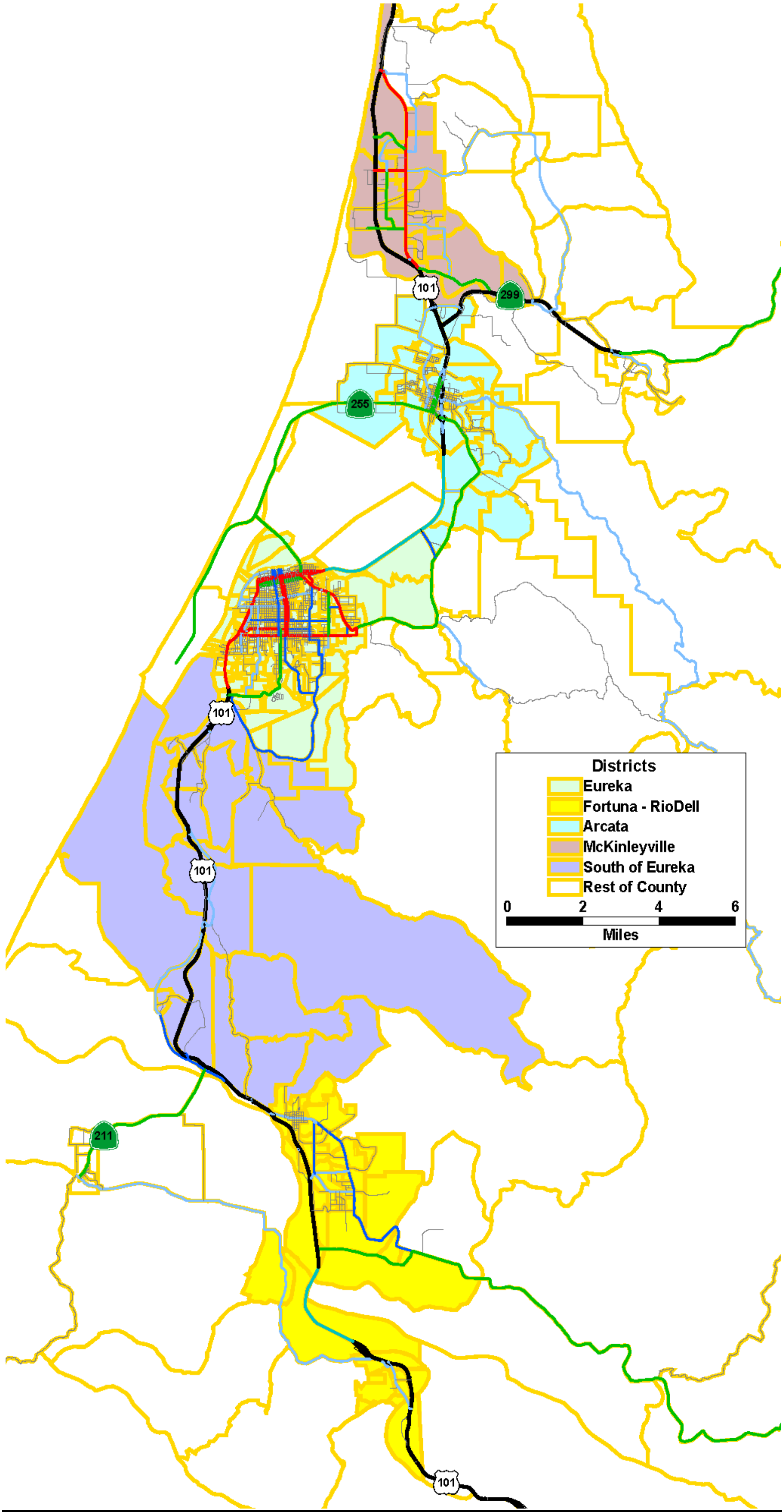


TABLE 4.7A: CTPP TRIP PATTERNS

	1 - Eureka	2 - Fortuna-Rio Dell	3 - Arcata	4 - McKinleyville	5 – South of Eureka	6 - Other	TOTAL
1 - Eureka	27.0%	1.0%	2.9%	0.7%	1.2%	1.1%	**33.9%**
2 - Fortuna-Rio Dell	2.8%	6.1%	0.4%	0.1%	1.4%	1.6%	**12.4%**
3 - Arcata	5.9%	0.2%	7.9%	0.7%	0.3%	1.3%	**16.3%**
4 - McKinleyville	3.6%	0.1%	3.2%	2.6%	0.3%	1.0%	**10.7%**
5 – South of Eureka	3.3%	0.8%	0.4%	0.1%	0.8%	0.3%	**5.7%**
6 - Other	5.9%	1.9%	3.8%	1.1%	0.7%	7.5%	**21.0%**
TOTAL	**48.5%**	**10.1%**	**18.6%**	**5.3%**	**4.8%**	**12.8%**	**100.0%**

TABLE 4.7B: MODELED HBW TRIP PATTERNS

	1 - Eureka	2 - Fortuna-Rio Dell	3 - Arcata	4 - McKinleyville	5 – South of Eureka	6 - Other	TOTAL
1 - Eureka	26.8%	0.2%	2.5%	0.4%	0.6%	0.8%	**31.3%**
2 - Fortuna-Rio Dell	4.3%	6.1%	0.3%	0.1%	0.8%	0.7%	**12.3%**
3 - Arcata	4.4%	0.0%	7.9%	1.3%	0.1%	0.8%	**14.5%**
4 - McKinleyville	2.5%	0.0%	4.7%	3.2%	0.0%	1.1%	**11.5%**
5 – South of Eureka	3.7%	0.4%	0.3%	0.1%	0.7%	0.2%	**5.3%**
6 - Other	6.4%	2.4%	4.0%	1.4%	0.5%	10.4%	**25.2%**
TOTAL	**48.1%**	**9.1%**	**19.8%**	**6.5%**	**2.6%**	**13.9%**	**100.0%**

TABLE 4.7C: DIFFERENCE BETWEEN MODEL AND CTPP

	1 - Eureka	2 - Fortuna-Rio Dell	3 - Arcata	4 - McKinleyville	5 – South of Eureka	6 - Other	TOTAL
1 - Eureka	-0.2%	-0.8%	-0.4%	-0.3%	-0.6%	-0.3%	**-2.6%**
2 - Fortuna-Rio Dell	1.5%	0.0%	-0.1%	0.0%	-0.6%	-0.9%	**-0.1%**
3 - Arcata	-1.5%	-0.2%	0.0%	0.6%	-0.2%	-0.5%	**-1.8%**
4 - McKinleyville	-1.1%	-0.1%	1.5%	0.6%	-0.3%	0.1%	**0.8%**
5 – South of Eureka	0.4%	-0.4%	-0.1%	0.0%	-0.1%	-0.1%	**-0.4%**
6 - Other	0.5%	0.5%	0.2%	0.3%	-0.2%	2.9%	**4.2%**
TOTAL	**-0.4%**	**-1.0%**	**1.2%**	**1.2%**	**-2.2%**	**1.1%**	**0.0%**

Table 4.8a: ODME Trip Patterns

	1 - Eureka	2 - Fortuna-Rio Dell	3 - Arcata	4 - McKinleyville	5 – South of Eureka	6 - Other	TOTAL
1 - Eureka	43.6%	0.8%	3.3%	1.2%	2.0%	1.2%	**52.1%**
2 - Fortuna-Rio Dell	0.7%	7.8%	0.1%	0.0%	0.3%	1.4%	**10.2%**
3 - Arcata	3.2%	0.1%	9.0%	2.4%	0.1%	1.3%	**16.1%**
4 - McKinleyville	1.2%	0.0%	2.2%	1.2%	0.0%	0.5%	**5.2%**
5 – South of Eureka	2.8%	0.4%	0.1%	0.0%	0.8%	0.2%	**4.3%**
6 - Other	1.2%	1.4%	1.4%	0.5%	0.2%	7.6%	**12.2%**
TOTAL	**52.7%**	**10.4%**	**16.0%**	**5.4%**	**3.2%**	**12.2%**	**100.0%**

Table 4.8b: Modeled Trip Patterns for All Purposes

	1 - Eureka	2 - Fortuna-Rio Dell	3 - Arcata	4 - McKinleyville	5 – South of Eureka	6 - Other	TOTAL
1 - Eureka	31.9%	0.3%	1.9%	0.3%	0.6%	0.8%	**35.8%**
2 - Fortuna-Rio Dell	1.7%	9.0%	0.1%	0.0%	0.4%	0.8%	**12.0%**
3 - Arcata	2.1%	0.0%	12.6%	1.5%	0.0%	0.6%	**16.8%**
4 - McKinleyville	1.0%	0.0%	3.3%	4.9%	0.0%	0.8%	**10.0%**
5 – South of Eureka	2.2%	0.4%	0.1%	0.0%	1.0%	0.2%	**3.9%**
6 - Other	3.0%	1.2%	2.8%	1.2%	0.2%	13.1%	**21.4%**
TOTAL	**41.8%**	**10.9%**	**20.9%**	**7.9%**	**2.3%**	**16.3%**	**100.0%**

Table 4.8c: Difference Between Model and ODME

	1 - Eureka	2 - Fortuna-Rio Dell	3 - Arcata	4 - McKinleyville	5 – South of Eureka	6 - Other	TOTAL
1 - Eureka	-11.7%	-0.5%	-1.4%	-0.9%	-1.4%	-0.4%	**-16.3%**
2 - Fortuna-Rio Dell	1.0%	1.2%	0.0%	0.0%	0.1%	-0.6%	**1.8%**
3 - Arcata	-1.1%	-0.1%	3.6%	-0.9%	-0.1%	-0.7%	**0.7%**
4 - McKinleyville	-0.2%	0.0%	1.1%	3.7%	0.0%	0.3%	**4.8%**
5 – South of Eureka	-0.6%	0.0%	0.0%	0.0%	0.2%	0.0%	**-0.4%**
6 - Other	1.8%	-0.2%	1.4%	0.7%	0.0%	5.5%	**9.2%**
TOTAL	**-10.9%**	**0.5%**	**4.9%**	**2.5%**	**-0.9%**	**4.1%**	**0.0%**

Humboldt County Travel Model

5. Mode Analysis

Context and Background

This chapter describes the process used to develop the Mode Split and Auto Occupancy components of the Humboldt County Travel Model. Mode analysis is the third phase of the traditional 4-step travel demand modeling process, converting person trips from the trip generation and distribution models into vehicle trips for assignment to the roadway network. The mode analysis steps identify non-motorized trips and transit trips based on trip distance and proximity to transit service. After the non-motorized and transit trips are split from the person trip table, the remaining auto-driver and auto-passenger trips are converted to vehicle trips. Transit and non-motorized trip tables are retained for further analysis, but are not further processed by the Humboldt County Travel Model.

The Humboldt County Travel Model does not include a more complicated mode choice step, which would estimate transit usage based on a detailed representation of transit service in the county. Because trip generation and distribution include all person trips, a mode choice component could be added at a later time if desired. The algorithms used in this model provide limited information about transit usage in the region, but cannot be used to perform detailed transit forecasts.

Non-Motorized Mode Split

The first step in the mode analysis process is non-motorized mode split. Walk and bicycle trips are identified using a distance-based approach that targets shorter trips. Local data available for this purpose comes from the 2000 CTPP data for Humboldt County. While useful, the CTPP only reports mode use for commute trips, which are defined similar to but not exactly the same as the home-based work trips (HBW) in the Humboldt County Travel Model. Limited local information is available about mode share for the other trip purposes.

Mode share targets for HBW trips in Humboldt County are based on CTPP data for Humboldt County. For the remaining trip purposes, data was borrowed from San Luis Obispo County. Household survey data for San Luis Obispo County was used to develop detailed non-motorized mode shares by trip purpose. Non-motorized shares from San Luis Obispo were adjusted based on the relative differences in non-motorized shares for Humboldt and San Luis Obispo counties. Mode shares from the San Luis Obispo model are shown in Table 5.1. Data adjusted for use in the Humboldt County Travel Model, along with model results, are shown in Table 5.2.

TABLE 5.1: NON-MOTORIZED MODE SHARES – SAN LUIS OBISPO COUNTY

Mode	HBW	HBS	HBU	HBO	WBO	OBO
Bicycle Mode Share Targets	1.6%	2.6%	25.2%	0.9%	1.2%	0.8%
Pedestrian Mode Share Targets	3.7%	2.2%	4.5%	7.7%	7.9%	7.1%

TABLE 5.2: NON-MOTORIZED MODE SHARE– HUMBOLDT COUNTY

Mode	HBW	HBS	HBU	HBO	WBO	OBO
Bicycle Mode Share Targets	2.8%	4.6%	25.3%	1.6%	2.1%	1.4%
Pedestrian Mode Share Targets	5.1%	3.0%	4.5%	10.6%	10.9%	9.8%
Bicycle Mode Share Results	2.8%	4.6%	25.1%	1.6%	2.1%	1.4%
Pedestrian Mode Share Results	5.1%	3.0%	4.5%	10.6%	10.6%	9.8%

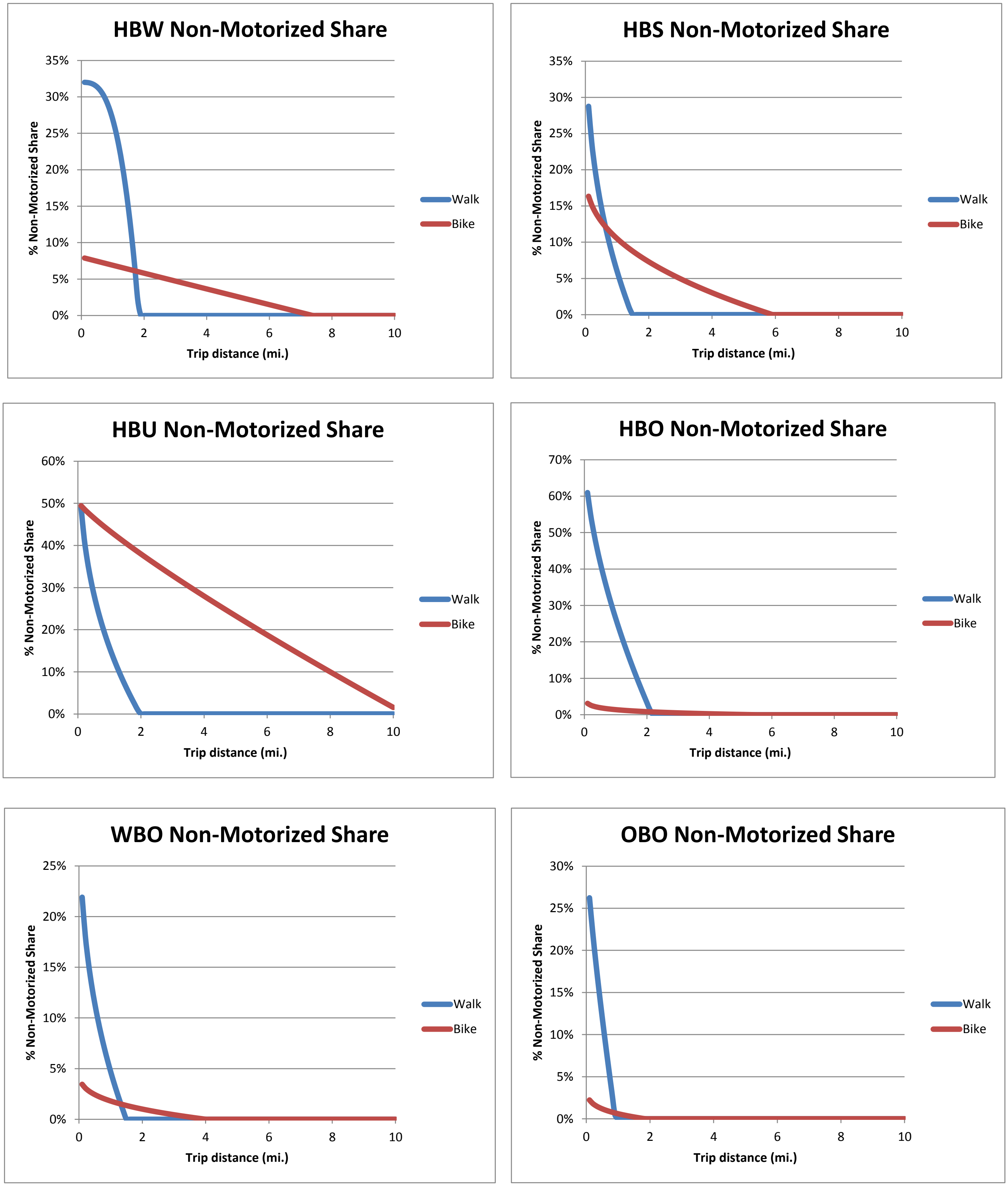
The Humboldt County Travel Model uses a distance-based algorithm to determine non-motorized mode share. This algorithm assumes that shorter trips are more likely to be made using non-motorized means, with the likelihood of a trip being made as a walk or bicycle trip decreasing as trip length increases. Different curves are used for walk and bicycle trips, as bicycle trips tend to occur over longer distances than walk trips. This distance-based approach ensures that the increased walk and bicycle trip activity associated with dense mixed-use developments is accounted for in the travel model.

The distance-based functions were calibrated through an iterative process that involved adjustments to calibration parameters and distance limits by trip purpose. Table 5.3 shows the formulas for each mode by trip purpose, with each function plotted in Figure 5.1. Because non-motorized mode split is distance based, non-motorized mode shares will vary significantly by TAZ. Smaller zones tend to have more short trips as these zones encompass areas with greater land use activity and diversity, leading to higher non-motorized shares. In rural areas where zones tend to be larger and trip lengths tend to be longer, non-motorized trips will be less frequent.

Table 5.3: Non-Motorized Mode Split Models

Trip Purpose	Mode	Model	Valid Range
HBW	Walk	min{max[(0.320 – 0.051 x length$^{3.01}$), 0], [1.0 – (HBW bike shares)]}	0-1.8 miles
	Bike	max[(0.08 – 0.011 x length$^{0.992}$), 0]	0-7.3 miles
HBS	Walk	min{max[(0.464 – 0.404 x length$^{0.36}$), 0], [1.0 – (HBS bike shares)]}	0-1.4 miles
	Bike	max[(0.199 – 0.094 x length$^{0.422}$), 0]	0-5.9 miles
HBU	Walk	min{max[(0.772 – 0.614 x length$^{0.338}$), 0], [1.0 – (HBU bike shares)]}	0-1.9 miles
	Bike	max[(0.505 – 0.069 x length$^{0.85}$), 0]	0-10.3 miles
HBO / HBSc	Walk	min{max[(0. 7333 – 0.468 x length$^{0.58}$), 0], [1.0 – (HBO bike shares)]}	0-2.1 miles
	Bike	max[(0.193 – 0.179 x length$^{0.044}$), 0]	0-5.5 miles
WBO	Walk	min{max[(0.358 – 0.311 x length$^{0.35}$), 0], [1.0 – (WBO bike shares)]}	0-1.4 miles
	Bike	max[(0.049 – 0.031 x length$^{0.33}$), 0]	0-4 miles
OBO	Walk	min{max[(0.319 – 0.341 x length$^{0.78}$), 0], [1.0 – (OBO bike shares)]}	0-0.9 miles
	Bike	max[(0.047 – 0.041 x length$^{0.221}$), 0]	0-1.8 miles

FIGURE 5.1: NON-MOTORIZED SHARES BY DISTANCE



Transit

The Humboldt County Travel Model estimates transit trips using an enhanced mode split procedure. While the predictive capabilities of this transit model are limited, it does provide value in generating relative totals for comparing different transit options. Transit ridership forecasts are based on availability of transit, quality of transit service, and implicitly reflect the effects of land use on transit performance.

Transit availability is represented in the travel model at the TAZ level. Each TAZ is ranked on a scale from 0 to 5 for transit availability, using the scale defined in Table 5.4. Levels 1 and 2 represent existing transit service and are shown in Figure 5.2. Levels 3 and 4 can be added to future scenarios that might include improvements to transit service. Level 5 represents an exceptional level of transit and land use coordination including transit-oriented development.

TABLE 5.4: TRANSIT AVAILABILITY SCORES

Score	Description of Transit Service
0	No transit service available.
1 (Low)	***Minimal transit service:*** This category includes areas that have limited access to transit or low transit frequency.
2 (Medium)	***Basic transit service:*** This category includes areas that have denser land use patterns and transit service, often combined with increased service frequency.
3 (Medium-High)	***Improved transit service:*** This category is applicable in forecast scenarios only and represents a two-fold increase in transit frequency as compared to existing conditions in the CBD.
4 (High)	***Highly refined transit service:*** This category is applicable in forecast scenarios only and can represent: • a four-fold or greater increase in transit frequency, and/or • a two-fold or greater increase in transit frequency combined with transit prioritization measures such as jump lanes or exclusive right-of-way.
5 (Very High)	***Highly refined transit service:*** This category is applicable to areas that have access to transit combined with ***transit-friendly land uses*** such as Transit-Oriented Development (TOD).

To account for transfers, areas with accessibility to transit have been divided into 10 districts. Trips that occur within a single district are not assigned a transfer penalty, while transit trips between districts are reduced by 50% to account for the inconvenience of transferring between routes. However, a transfer reduction is not imposed on trips that begin or end in the central Eureka, represented by district 4. This zone represents areas that can be reached from any other zone without the need to transfer. Transit districts used for the Humboldt County model are shown in Figure 5.3.

FIGURE 5.2: EXISTING FIXED ROUTE TRANSIT LEVEL OF SERVICE

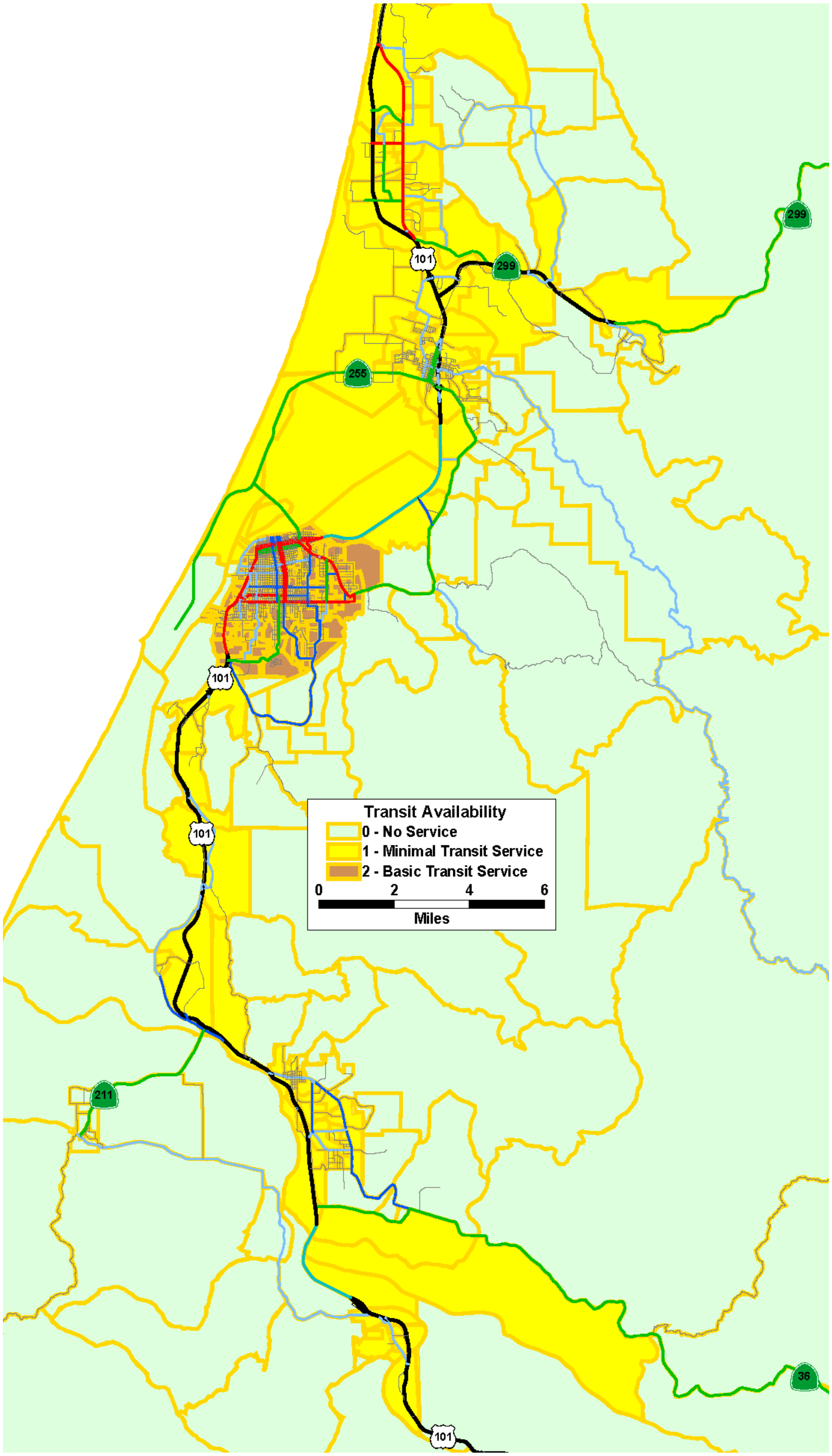
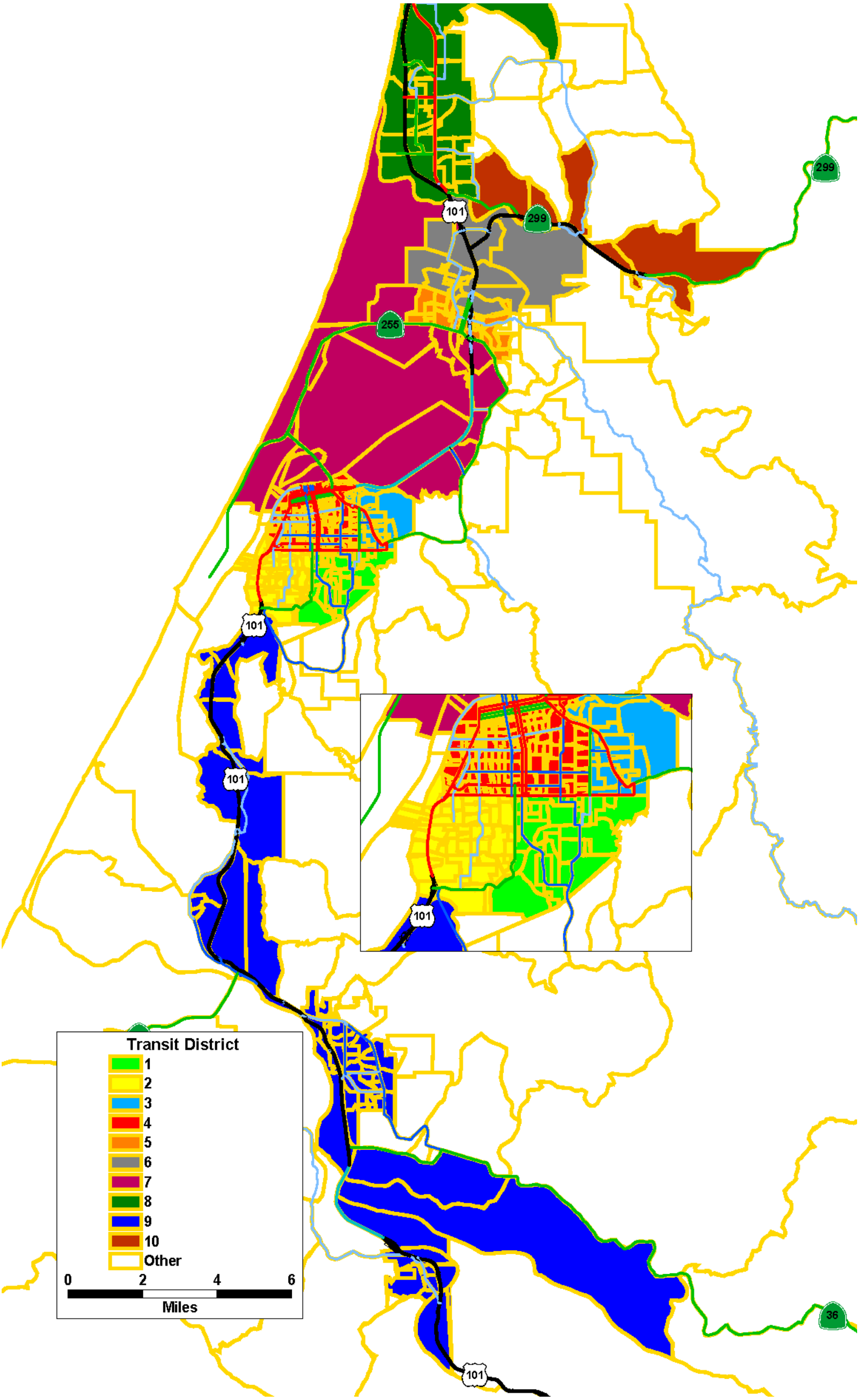


FIGURE 5.3: TRANSIT ZONES/DISTRICTS



The transit model is implemented by factoring trips between each zone pair based on the conditions described above. A set of factors was developed based on census "journey to work" data, and borrowed relationships from San Luis Obispo County. Transit Targets from the San Luis Obispo model are shown in Table 5.5. Data adjusted for use in the Humboldt County Travel Model, along with model results, are shown in Table 5.6. Resulting transit factors are shown in Table 5.7.

Table 5.5: Transit Shares – San Luis Obispo County

	HBW	HBS	HBU	HBO	WBO	OBO
Transit Mode Shares	0.9%	1.3%	5.6%	2.6%	0.7%	3.5%

Table 5.6: Transit Mode Shares – Humboldt County

Mode	HBW	HBS	HBU	HBO	WBO	OBO
Transit Mode Share Targets	2.5%	3.4%	5.6%	6.8%	1.8%	9.2%
Transit Mode Share Results	2.5%	3.4%	5.5%	6.8%	1.8%	9.2%

Table 5.7: Transit Ridership Factors

Trip Purpose	Transit Availability Score				
	1	2	3	4	5
HBW	5.0%	6.2%	7.5%	10.5%	15.8%
HBS	4.5%	8.7%	14.6%	20.2%	30.2%
HBU	11.9%	23.8%	39.2%	54.9%	54.9%
HBO	9.1%	17.7%	29.6%	41.0%	61.6%
WBO	1.5%	3.5%	5.5%	8.0%	12.0%
OBO	7.3%	16.9%	26.6%	38.7%	58.1%

Auto Occupancy

After the non-motorized and transit trips are split from the person trip table, the remaining auto-driver and auto-passenger trips are converted to vehicle trips before time-of-day processing and assignment to the roadway network. The CTPP commute trip (HBW) auto occupancy estimate for Humboldt County, auto occupancy rates from various other areas and the recommended auto occupancy values for the Humboldt County Travel Model are provided in Table 5.8. As the values in Table 5.8 indicate, auto occupancy trends are evident across trip purposes for different regions. Resulting Humboldt County Travel Model auto occupancy rates are based on data from San Luis Obispo, but have been adjusted based on CTPP data for HBW trips.

TABLE 5.8: AUTO OCCUPANCY

Trip Purpose	1997/98 Denver Travel Behavior Inventory	2010 Colorado North Front Range Regional Travel Survey	San Luis Obispo City-Wide Model	CTPP (Humboldt County, 2006 – 2008 ACS)	Humboldt County Model
HBW	1.08	1.06	1.11	1.17	1.17
HBS	1.32	1.37	1.36		1.44
HBO		1.55	1.77		1.88
WBO		1.07	1.08		1.14
OBO		1.46	1.62		1.71

4D Trip Reductions

The HCAOG travel model includes the capability to reduce vehicle trip totals to account for land use characteristics. The model reduces vehicle trips to help represent effects of density, diversity, design (e.g., good sidewalks and a dense street network), and proximity to regional destinations. The 4D model uses an elasticity-based approach that accounts for differences in similar land use scenarios. 4D vehicle trip adjustments are applied to trip tables after mode choice, but prior to application of auto occupancy factors.

Because the model bases trip reductions on *changes* in land use characteristics, it is necessary to consider two scenarios when applying this model: a baseline and alternative scenario. The model will reduce vehicle trips in the alternative scenario based on changes compared to the baseline scenario. Both the baseline and alternative scenarios should represent the same timeframe and similar overall regional conditions.

Because the 4D model is intended for use only in very specific cases, and because it requires two similar model scenarios to run correctly, it is disabled by default. The 4D model can be activated by providing the 4D variables for a baseline and alternate scenario and setting the 4D model to “On” in the model scenario manager. A set of default 4D elasticities is included in the model database.

Humboldt County Travel Model

6. Traffic Assignment

Context and Background

This chapter describes the traffic assignment model for the Humboldt County Travel Model, including the time of day process used to convert trips from production-attraction (PA) format to origin-destination (OD) format and the iterative speed feedback process.

In the time of day model component, the vehicle trip tables by trip purpose from the mode split process are converted from PA to OD format and factored into time periods for roadway network assignment. The time of day process is not considered a separate phase in the 4-step travel modeling process, but is instead grouped with the traffic assignment model.

In the remaining traffic assignment model steps, vehicle trip tables by time of day are assigned to the roadway network. After traffic assignment is completed, resulting travel times are fed back into trip distribution and the model is run iteratively until speeds input to trip distribution are reasonable and relatively consistent with speeds resulting from traffic assignment.

Time of Day

In the early days of travel demand modeling, models were either set up directly as peak hour models or were established as 24-hour models that were post-processed to obtain peak hour directional design year traffic volumes. With the dramatic increase in processing speeds and electronic storage capability, disaggregation of the models occurred at a faster pace with more traffic analysis zones, larger modeling areas, and more detail in the modeling process. Combined with the need for time-specific traffic volumes and congested speed detail to assess air quality conformity, these influences made detailed time of day modeling commonplace.

Based on the analysis of hourly traffic count data, the AM and PM peak hours were defined as shown in Table 6.1. The peak hour definitions are consistent with the traditional morning and evening peak hours observed in many similarly-sized areas.

Table 6.1: Peak Period Definitions

Period Name	Period Definition
AM Peak Hour	7:00 AM – 8:00 AM
PM Peak Hour	4:30 PM – 5:30 PM
Off-Peak Period	All Remaining Time (22 hours)

Directional time of day factors are used to convert trips from PA to OD format and allocate them into peak and off-peak time periods used in the model. This process is based on extensive data indicating that trips are made directionally by time of day. For example, HBW trips generally occur from the production to the attraction (i.e., from home to work) in the AM peak hour and from the attraction to the production (i.e., from work to home) in the PM peak hour. However, some trips are made in the reverse of this pattern and many trips are made outside of the peak periods.

Although traffic count data can be used to identify peak hours and to validate the model for peak hours, it is not particularly useful in defining time of day PA to OD conversion factors. Traffic count data does not include information about trip purpose or trip direction which is necessary for developing model parameters. Therefore, time of day data used in the Humboldt County Travel Model is borrowed from San Luis Obispo.

In the model, time of day factors are applied directly to the purpose-specific vehicle trip tables created by the mode split model. As described in *Chapter 4 - Trip Distribution*, daily trip tables are separated into peak period (combined AM and PM peak periods) and off-peak period trips prior to trip distribution and mode split. The traffic assignment time of day module further separates peak period trips into AM and PM peak hour trips. At the same time, all trip tables are converted from PA to OD format.

Time of day factors shown in Table 6.2 demonstrate the portion of trips by purpose and direction assigned to each time period. These factors are applied in a two stage process: first in a pre-distribution time of day module and second in a pre-assignment time of day module. The pre-distribution time of day parameters are defined in *Chapter 4 - Trip Distribution* and are repeated in Table 6.3 for reference. The pre-assignment time of day parameters are shown in Table 6.4.

Pre-distribution time of day factors are computed based on the 24-hour time of day factors. For the off-peak period, the distribution time of day factor is simply the sum of the PA and AP factors. For the peak period, the distribution time of day factor is the sum of the PA and AP factors for the AM and PM peak periods. Distribution time-of-day factors are applied by simple multiplication of the time of day factors and the trip tables.

Because they are applied to trip tables that have already been separated into peak and off-peak periods, pre-assignment time of day factors are computed by dividing 24-hour factors by the pre-distribution factors for each period and trip purpose. The pre-assignment time of day factors are applied to the peak and off-peak PA tables using Equation (1). Since EE trips are not processed through trip distribution or mode choice, EE time of day is not applied prior to trip distribution. EE time of day is computed by simply multiplying time of day factors by the 24-hour EE trip tables.

$$T_{OD,subper} = \left(\frac{1}{2} \cdot T_{PA,per} \cdot F_{PA}\right) + \left(\frac{1}{2} \cdot T'_{PA,per} \cdot F_{AP}\right) \qquad (1)$$

Where:

$T_{OD,subper}$	= OD trip-table for the AM or PM hour (or for the off-peak period)
$T_{PA,per}$	= PA trip-table for the peak or off-peak period
$T'_{PA,per}$	= Transposed PA trip-table for the peak or off-peak period
F_{PA}	= Pre-assignment time of day factor for the PA direction
F_{AP}	= Pre-assignment time of day factor for the AP direction

Table 6.2: Time of Day Factors (Based on 24 hours)

Period	HBW		HBS		HBU		HBO		WBO		OBO	
	PA	AP	PA	AP	PA	AP	PA	AP	PA	AP	PA	AP
Off-Peak	0.427	0.387	0.351	0.539	0.388	0.410	0.380	0.390	0.537	0.295	0.44	0.44
AM Peak	0.100	0.005	0.009	0.003	0.150	0.000	0.111	0.069	0.010	0.060	0.02	0.02
PM Peak	0.005	0.075	0.046	0.052	0.015	0.037	0.030	0.020	0.096	0.003	0.04	0.04

Table 6.3: Pre-Distribution Time of Day Factors

	HBW	HBS	HBU	HBO	WBO	OBO
Off-Peak	0.814	0.890	0.798	0.770	0.832	0.872
Peak	0.185	0.110	0.202	0.230	0.168	0.128

Table 6.4: Pre-Assignment Time of Day Factors

Period	HBW		HBS		HBU		HBO		WBO		OBO		EE
	PA	AP	PA	AP	PA	AP	PA	AP	PA	AP	PA	AP	
Off-Peak	0.525	0.475	0.395	0.605	0.486	0.514	0.493	0.507	0.646	0.354	0.5	0.5	0.82
AM Peak	0.539	0.027	0.081	0.03	0.742	0	0.483	0.299	0.058	0.355	0.168	0.168	0.06
PM Peak	0.029	0.405	0.416	0.474	0.074	0.183	0.131	0.087	0.571	0.016	0.332	0.332	0.12

Trip Assignment

Assignment Algorithms

The Traffic Assignment module loads the travel demand as represented by the time of day vehicle trip tables onto the roadway network. Several different algorithms have been used in past and present models and there will likely be new algorithms developed in the future. For the purposes of the Humboldt County Travel Model, the selection of assignment algorithms was based on tried and true methods as follows.

- **User Equilibrium -** This method is the most common and assumes all travelers use the fastest possible route between origin and destination, considering the effects of congestion. With this method, the total travel time for all trip makers is minimized. This method tends to work best for short assignment periods for which an equilibrium condition can be defined.

- **Stochastic Equilibrium -** This method considers congestion and assumes that most, but not all, travelers use the fastest possible route between origin and destination. The stochastic component of this method represents imperfect knowledge of the roadway system.

- **Origin-Based User Equilibrium** – This method replicates the user equilibrium method, but can decrease model run times considerably in certain applications. This method tends to converge in fewer iterations than the traditional implementation, but each iteration takes longer to compute. Use of a "warm start" option can further reduce the number of iterations required when running a multiple-period assignment or when running speed feedback. An additional benefit of this method is the ability to save resulting paths, allowing the user to run select link and zone assignment without the need to re-run traffic assignment.

- **All-or-Nothing -** This method does not consider congestion and assigns all trips to the fastest possible route between origin and destination. It is not appropriate for congested networks because it does not consider congestion effects and thus tends to overload some facilities and under-load others. Results from this method can be useful for informational purposes.

- **Stochastic -** This method does not consider congestion and assigns most, but not all, trips to the fastest possible route between origin and destination. For similar reasons as the all-or-nothing assignment, the stochastic assignment method is not appropriate for congested networks.

Because roadways in Humboldt County experience congestion, only the equilibrium-based assignment methods were considered. Based on previous experience, the equilibrium assignment method is preferred over the stochastic equilibrium method except in cases where specific problems are encountered. Therefore, the Humboldt County Travel Model uses the equilibrium traffic assignment method. The origin-based equilibrium produces results that are very similar to the equilibrium method and is included in the model interface as an alternate assignment method.

Closure Criteria

When equilibrium traffic assignment is used, oscillations between equilibrium iterations can sometimes result in unstable assignment results. If closure criteria are not sufficient, two very similar model runs (e.g., with only one small adjustment to the socioeconomic data or roadway network) can produce un-intuitive results. These results generally occur when the equilibrium traffic assignment algorithm converges at a different number of iterations – sometimes only one apart – for each run. Even when equilibrium traffic assignment converges after the same number of iterations, alternating oscillations in traffic volumes can sometimes be observed in traffic assignment results based on slightly different model networks.

While oscillations introduced by the equilibrium traffic assignment procedure can be of concern, they can be managed through introduction of a very tight closure criterion. Traffic assignment is performed with a closure gap of 0.00001 (10^{-5}) and a maximum number of iterations of 500. When running the model for very congested networks, such as a buildout scenario, it is important to review the model report file and ensure that equilibrium has been reached. If equilibrium has not been reached, it may be necessary to modify the maximum number of allowable iterations.

Impedance Calculations

In the Traffic Assignment Model, the impedance used for determining the shortest path can take many forms, but typically it includes one or more of the following – travel time, travel distance, and tolls. If more than one impedance variable is used, a generalized cost function is necessary so that the relevant variables can be added together into a single impedance function expression. Since tolls are not an issue in Humboldt County, they were not seriously considered for the impedance function. Furthermore, experience has shown that distance is less important than travel time; and including distance is problematic because it results in double-counting the emphasis on this variable since distance is also inherent in the travel time calculations.

Therefore, congested travel time, rather than a generalized cost function, was used in traffic assignment calculations as is done in numerous models around the country.

Volume-Delay Functions

A volume-delay function represents the effect of increasing traffic volume on link travel time. While several volume delay functions are available, the most commonly used function is the modified Bureau of Public Roads (BPR) function, which is based on the original BPR equation shown in Equation (2).

$$T_C = T_F \left(1 + \alpha \left(\frac{V}{C}\right)^{\beta}\right) \qquad (2)$$

Where:

T_C = Congested travel time
T_F = Freeflow travel time
V = Traffic volume
C = Highway design (practical) capacity
α = Coefficient alpha (0.15)
β = Exponent beta (4.0)

The modified BPR equation uses the same form, but replaces design capacity with ultimate roadway capacity. Ultimate roadway capacities for links in the Humboldt County model roadway network are defined in *Chapter 1 - Roadway Network*. The modified BPR equation also replaces the coefficient alpha and the exponent beta with calibrated values that vary by facility type and area type. The alpha and beta parameters used in the Humboldt County model were borrowed from the San Luis Obispo Citywide Travel Model and are shown in Table 6.5. Alpha and beta parameters for centroid connectors are specified to ensure that congestion is not represented on centroid connectors.

TABLE 6.5: VOLUME DELAY PARAMETERS ALPHA AND BETA

Functional Classification	CBD		Urban		Suburban		Rural	
	Alpha (α)	Beta (β)	Alpha (α)	Beta (β)	Alpha (α)	Beta (β)	Alpha (α)	Beta (β)
Freeway	0.83	5.5	0.83	5.5	0.83	5.5	0.83	5.5
Expressway	0.71	2.1	0.71	2.1	0.71	2.1	0.71	2.1
Principal Arterial	0.15	10	0.15	10	0.15	10	0.15	10
Minor Arterial	0.15	7	0.15	7	0.15	7	0.15	7
Collector	0.15	7	0.15	7	0.15	7	0.15	7
Ramp	0.83	5.5	0.83	5.5	0.83	5.5	0.83	5.5
Centroid Connector	0.15	7	0.15	7	0.15	7	0.15	7

Note: Parameters are provided for all FT/AT combinations, even though some do not exist (e.g., CBD Freeway).

Traffic Assignment Validation

Roadway volumes resulting from traffic assignment were compared against traffic count data. This process, called traffic assignment validation, ensures that the model is reasonably representing observed traffic patterns. Traffic count data was obtained from various sources and placed on the roadway network. Travel model results were then compared to traffic count data using a variety of techniques, including regional comparisons, screenline comparisons, and visual inspection of individual link data.

Traffic Count Data

The roadway network has been populated with traffic count data provided by Caltrans, Humboldt County, and other local jurisdictions. Additional traffic counts were collected specifically for the purpose of supporting this model update. Due to differences in the way various agencies provide traffic data, some adjustments were made to the original data, which has been retained on the roadway network for reference. For model validation, traffic count data must represent a "typical weekday when school is in session." This condition allows model results to reflect volumes that would be consistent with traffic counts taken during this time period. Due to minimal growth during the last few years, all traffic count data was assumed to represent 2010 conditions for use in model validation.

Overall Activity Level

Overall vehicle trip activity was validated by comparing count data to model results on all links where count data is available using two statistics: the Model Volume as compared to Count Volume and the Model VMT as compared to Count VMT. These statistics were reviewed at the facility type, area type, and regional level and are shown in Table 6.6. In addition, regional daily VMT and VHT are shown in Table 6.7.

TABLE 6.6: REGIONAL ACTIVITY VALIDATION

Link Type	Number of Counts	Model Volume / Count Volume	Model VMT / Count VMT	Target
Freeway	18	9.8%	6.3%	+/- 7%
Expressway	4	-4.7%	-7.9%	+/- 7%
Principal Arterial	47	-3.2%	0.2%	+/- 10%
Minor Arterial	38	-11.3%	-16.4%	+/- 15%
Collectors	59	4.1%	6.6%	+/- 25%
CBD	7	2.3%	3.2%	n/a
Urban	62	0.9%	1.4%	n/a
Suburban	53	-1.0%	-9.2%	n/a
Rural	44	-3.9%	5.8%	n/a
Total	**166**	**-0.80%**	**0%**	**+/- 5%**

TABLE 6.7: 2010 VMT AND VHT TOTALS

Link Type	VMT	VHT
Freeway	1,053,298	16,419
Expressway	258,433	5,174
Principal Arterial	654,439	17,627
Minor Arterial	339,716	9,141
Collectors	635,407	22,020
Ramps	52,326	1,923
Local Streets	93,264	12,624
Centroid Connectors	459,424	18,335
CBD	26,755	1,163
Urban	381,356	15,931
Suburban	974,426	30,874
Rural	2,163,770	55,295
Total	**3,546,307**	**103,263**
Total per Household	**63.29**	**1.84**

Screenlines and Cordons

Another important validation test is the comparison of modeled volumes and observed traffic counts on screenlines and cordons. Screenlines are imaginary lines that extend across a series of roadway links and form a logical basis for evaluating regional travel movements in the model. Screenlines can also be drawn to separate major activity areas, along highways, or natural features. Cordons are similar to screenlines, but are drawn around an activity area. A map of screenlines and cordons used in the Humboldt County Travel Model is shown in Figure 6.1. Results of the screenline analysis are shown in Figure 6.2, along with a recommended maximum acceptable error for each screenline and cordon. The maximum acceptable error is based on guidance contained in the National Cooperative Highway Research Program (NCHRP) report number 255 – Highway Traffic Data for Urbanized Area Project Planning and Design. Screenline and cordon data points are listed in Table 6.8.

FIGURE 6.1: SCREENLINE LOCATIONS

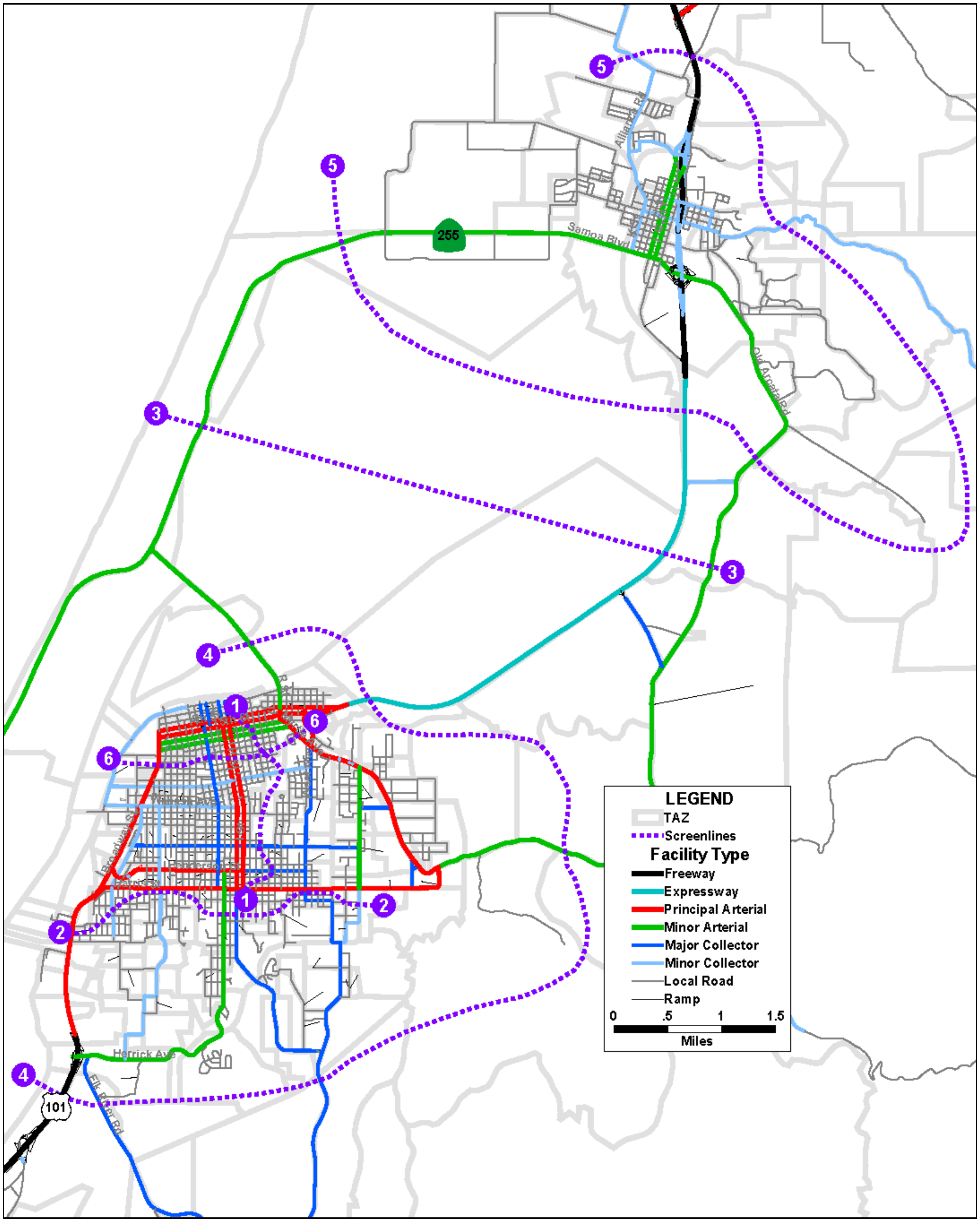


FIGURE 6.2: SCREENLINE ERROR VALUES

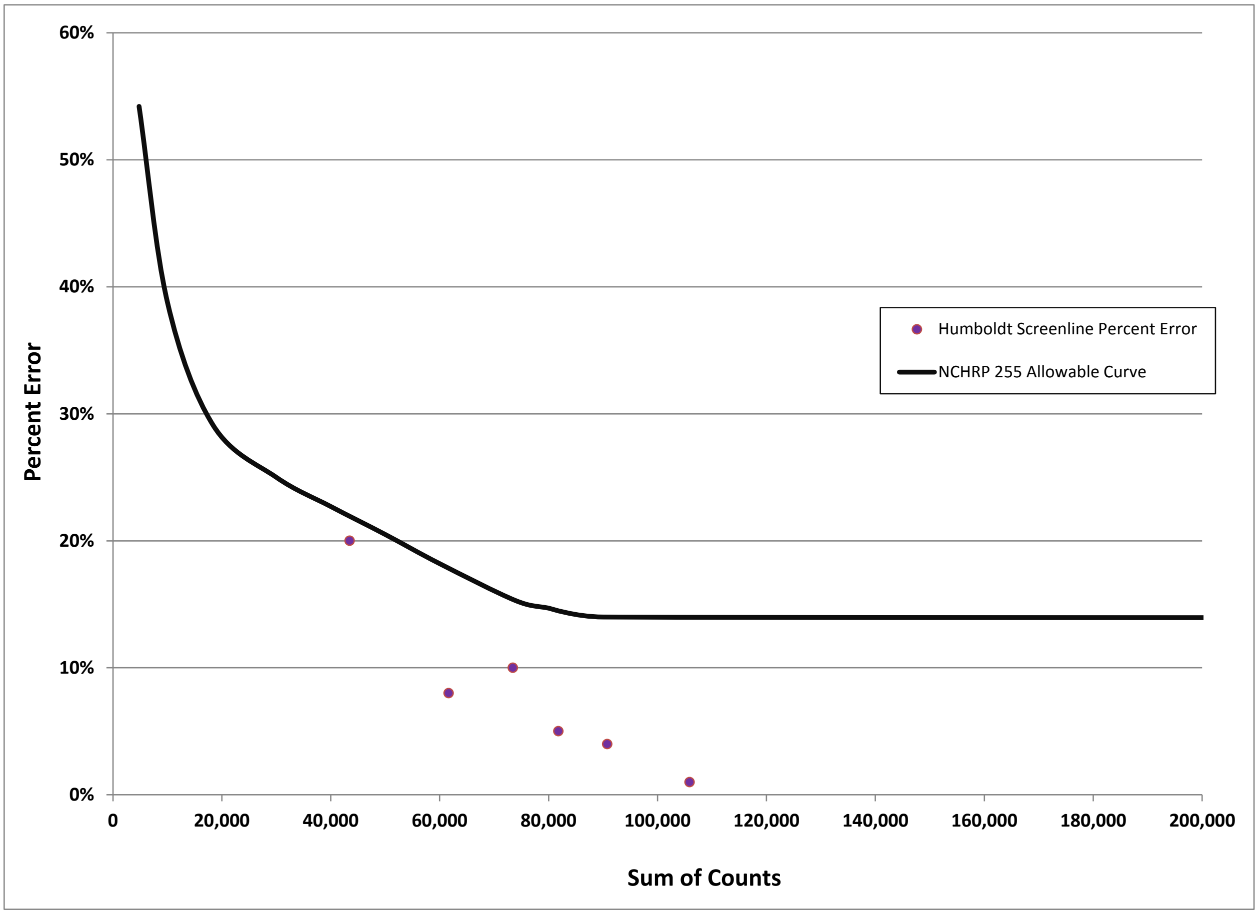


TABLE 6.8: SCREENLINE DATA

Screenline	Mode Volume	Count Volume	% Error
1	73,423	81,864	10.0%
2	61,660	57,337	8.0%
3	43,490	54,118	20.0%
4	90,792	87,187	4.0%
5	105,883	104,694	1.0%
6	81,826	77,653	5.0%

Measures of Error

While the model should accurately represent the overall level of activity, it is also important to verify that the model has an acceptably low level of error on individual links. It is expected that the model will not perfectly reproduce count volumes on every link, but the level of error should be monitored. The plot shown in Figure 6.3 demonstrates the ability of the Humboldt County Model to match individual traffic count data points and notes the resulting R^2 value. Table 6.9 lists % RMSE values and target values for each facility type. General guidelines suggest that % RMSE should be below 40% region-wide, with values below 30% for high volume facility types. The % RMSE measure tends to over-represent errors on low volume facilities, so values on collector and local facilities are not particularly meaningful. Table 6.10 shows % RMSE values by volume group.

FIGURE 6.3: MODEL COUNT/VOLUME COMPARISON

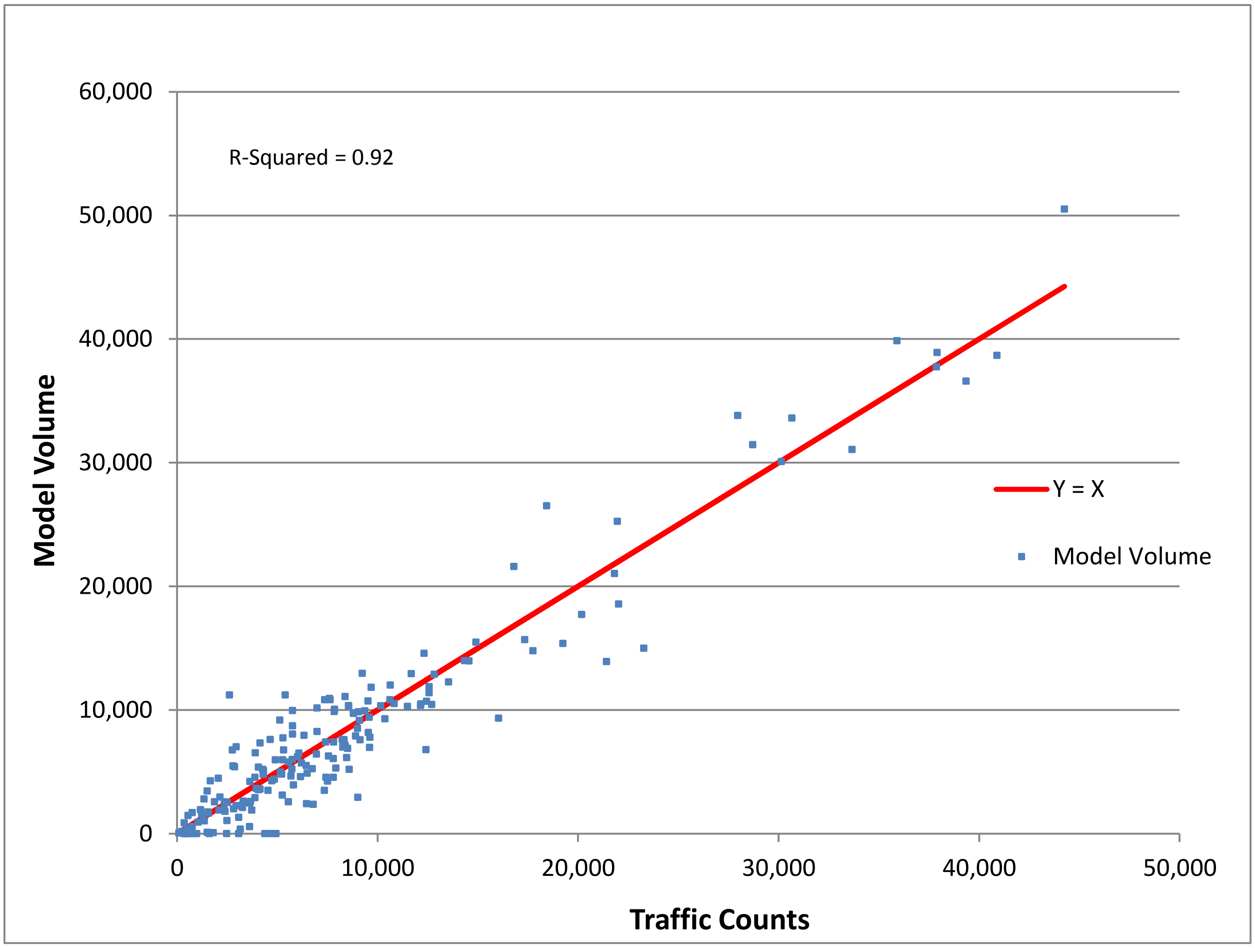


TABLE 6.9: MODEL % ROOT MEAN SQUARE ERROR

Link Type	Number of Counts	RMSE	% RMSE	Validation Target
Freeway	18	3,537	19.8%	30%
Expressway	4	2,068	6.8%	40%
Principal Arterial	47	2,717	22.1%	40%
Minor Arterial	38	2,467	37.5%	40%
Collectors	59	1,925	45.3%	50%
CBD	7	3,036	26.8%	n/a
Urban	62	2,661	29.2%	n/a
Suburban	53	2,863	33.3%	n/a
Rural	44	1,787	26.0%	n/a
Total	**166**	**2,508**	**30.0%**	**40%**

TABLE 6.10: % ROOT MEAN SQUARE ERROR BY VOLUME GROUP

Low	High	Mid-Point	Number of Counts	% RMSE
0	5,000	2,500	75	74%
5,000	10,000	7,500	71	32%
10,000	20,000	15,000	26	22%
20,000	30,000	25,000	8	23%
30,000	40,000	35,000	7	7%
40,000	50,000	45,000	2	16%

Humboldt County Travel Model

7. Sensitivity Tests

Context and Background

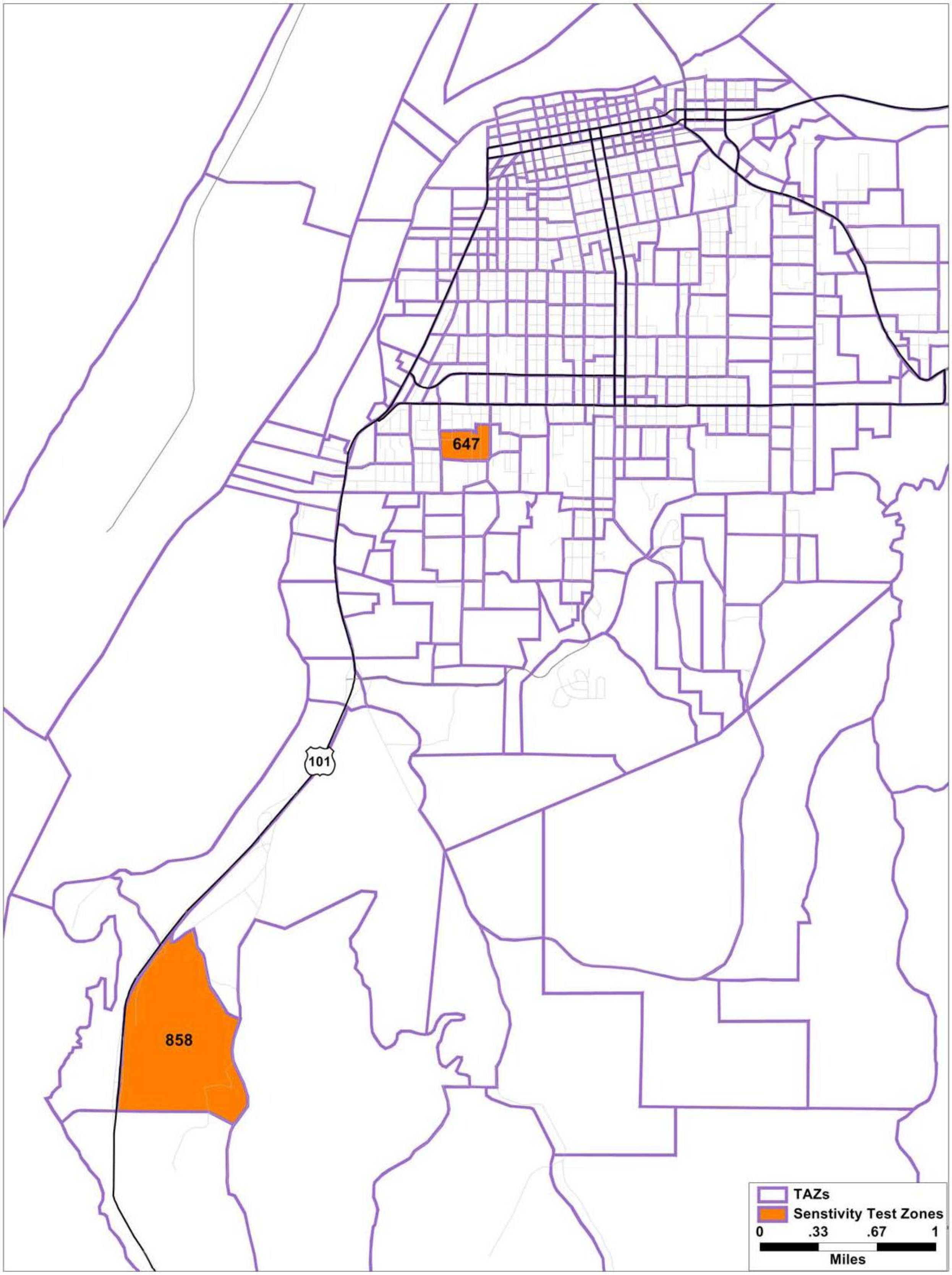
The base year validation measures described in the preceding chapters of this report are critical in ensuring the validity of the HCAOG Travel Model. These measures show that the model adequately reproduces observed trip generation, distribution, mode split, and assignment patterns. However, the base year validation measures are *static* – they do not demonstrate the sensitivity of the model. This chapter describes a dynamic validation process in which the model is run through a series of simple sensitivity tests. These tests show that the model provides appropriate sensitivity to variables that are important in the forecasting and planning process.

Socioeconomic Data Adjustments

The addition of new land use data to a TAZ is expected to affect the total number of trips made, and the regional total VMT and VHT. The type and location of new land use data may impact the type of change seen. For example, addition of new land use data in the fringe areas surrounding the suburban area would be expected to result in higher VMT increases than addition of data in a developed urban area (e.g., infill development).

Land use sensitivity tests were performed in two TAZs – numbered 647 (urban area in Eureka) and 858 (outside of Eureka). These zones are shown in Figure 7.1.

FIGURE 7.1: TRAFFIC ANALYSIS ZONES FOR SENSITIVITY TESTING



Household Changes

Initially, addition of new households to a TAZ was expected to increase regional VMT and VHT, while reducing the total number of households was expected to decrease regional VMT and VHT. The placement of new households in an urban TAZ is expected to produce a smaller increase in VMT than the placement of new households in a developing TAZ (suburban).

After performing these sensitivity tests, it was observed that addition of 10 or 100 households in Eureka reduced in a *reduction* in overall VMT. This was not the expected result. Review of traffic difference maps, however, demonstrate that the model is indeed behaving properly. Addition of households in Eureka allows the model to complete more trips within the Eureka area, reducing the amount of traffic traveling to Eureka from other areas in the county (especially areas to the south). This behavior is a result of the trip balancing process and occurs due to a high job/household ratio in Eureka and a much lower jobs/household ratio in areas south of Eureka.

It is noted that VMT within Eureka does increase as expected with the addition of new households. The results of household sensitivity tests for the region as a whole are shown in Table 7.1, with results for the Eureka subarea shown in Table 7.2.

Table 7.1: Household Sensitivity Test Results (Regional Totals)

TAZ	HH Adjustment	Trips / HH	VMT / HH	Trip Change	VMT Change	VHT Change
n/a	Baseline	15	52			
647 Urban Area	+1	14	1	14	1	0
	+10	14	-18	141	-175	1
	+100	14	-15	1,409	-1,502	11
	-1	-14	-23	-14	-23	1
	-10	-14	-2	-140	-19	-6
	-100	-14	13	-1,408	1,322	-11
858 Outside Eureka	+1	14	2	14	2	0
	+10	14	-6	141	-56	7
	+100	14	1	1,408	97	60
	-1	-14	-34	-14	-34	-1
	-10	-14	-15	-140	-147	-12
	-100	-14	-3	-1,407	-316	-60

Note: Trips and VMT per HH reflect added or subtracted activity per added or subtracted household.

TABLE 7.2: HOUSEHOLD SENSITIVITY TEST RESULTS (EUREKA SUBAREA TOTALS)

TAZ	HH Adjustment	Trips / HH	VMT / HH	Trip Change	VMT Change	VHT Change
n/a	Baseline	17	31			
647 Urban Area	+1	13	19	13	19	4
	+10	12	8	124	81	7
	+100	12	7	1,234	715	40
	-1	-12	6	-12	6	3
	-10	-12	-8	-123	-80	-4
	-100	-12	-7	-1,233	-691	-34
858 Outside Eureka	+1	2	25	2	25	6
	+10	2	20	21	201	12
	+100	2	20	207	1,966	85
	-1	-2	-2	-2	-2	0
	-10	-2	-18	-20	-178	-9
	-100	-2	-19	-206	-1,934	-75

Note: Trips and VMT per HH reflect added or subtracted activity per added or subtracted household.

Employment Changes

Because the HCAOG Travel Model balances trips to total productions, adding new employment will not increase the total number of trips generated. Therefore, adding new employees is expected to increase or decrease total regional VMT and VHT depending on the location of the change. Adding new employment in dense residential neighborhoods may enable residents to make shorter trips, thereby reducing VMT and VHT. Conversely, adding employment to a more rural area may result in a VMT increase, as residents will need to travel farther to reach the new activity. Sensitivity tests based on changes to employment data are shown in Table 7.3 and 7.4.

TABLE 7.3: EMPLOYMENT SENSITIVITY TEST RESULTS (REGIONAL TOTALS)

TAZ	Data Adjustment	VMT / Emp	Trip Change	VMT Change	VHT Change
n/a	Baseline	60	n/a	n/a	n/a
647 Urban Area	+1	67	0	67	2
	+10	16	0	161	7
	+100	21	0	2,074	43
	-1	-161	0	-161	-1
	-10	-24	0	-240	-2
	-100	-22	0	-2,176	-43
858 Outside Eureka	+1	33	0	33	3
	+10	10	0	102	1
	+100	7	0	703	-15
	-1	-20	0	-20	1
	-10	-9	0	-86	2
	-100	-8	0	-810	10

TABLE 7.4: EMPLOYMENT SENSITIVITY TEST RESULTS (EUREKA SUBAREA TOTALS)

TAZ	Data Adjustment	VMT / Emp	Trip Change	VMT Change	VHT Change
n/a	Baseline	12	n/a	n/a	n/a
647 Urban Area	+1	-2	2	-2	2
	+10	5	21	45	5
	+100	5	205	485	23
	-1	12	-2	12	2
	-10	-4	-20	-42	0
	-100	-5	-205	-477	-16
858 Outside Eureka	+1	-1	-1	-1	3
	+10	-7	-17	-71	0
	+100	-7	-177	-727	-32
	-1	12	2	12	2
	-10	7	18	72	5
	-100	7	178	740	33

Wholesale Changes

In addition to verifying the model's ability to represent existing conditions, it is necessary to ensure that the model can produce reasonable forecast volumes. Table 7.5 represents the results of a *preliminary* 2040 forecast year model run using the existing roadway network. While this scenario is based on a preliminary version of the forecast land use data, it can be used to ensure that the model is showing reasonable sensitivity for predicting future conditions. A review of model results shows that trip, VMT, and VHT patterns are reasonable.

TABLE 7.5: FORECAST YEAR MODEL SENSITIVITY TEST RESULTS

Data Point	Base	Forecast	% Change
Total Households	56,031	64,148	14.5%
Trips per Household	14.83	14.87	0.3%
VMT per Household	63.29	70.34	11.1%
Total VMT	**3,546,306**	**4,511,926**	**27.2%**
Total VHT	**103,262**	**131,565**	**27.4%**

Note: Information in this table is based on a preliminary dataset and was used solely for sensitivity testing. These results may or may not be consistent with final forecast year model results.

Roadway Network Changes

Because the travel model will be used to test roadway network alternatives, it is important that the model provide intuitive results when such changes are made. Roadway network sensitivity tests involve making small changes to the roadway network and observing the changes in VMT, VHT, and assigned traffic volume. Results should be consistent with expectations.

Link Removal

This sensitivity test involves removing a link from the roadway network and observing the resulting changes in traffic volumes. Two links were removed independently and the model results were evaluated for reasonableness. One test involved removing a heavily traveled link in the urban area, which was expected to have significant and intuitive impacts on network volumes. A second test involved removing a lightly traveled local street, which was expected to have minimal impact on roadway volumes.

Table 7.6 shows the impacts of these changes on regional statistics, while Figure 7.2 shows the impact of removing an urban link with moderate traffic volume. Removing a lightly traveled local street produced veryminor and intuitive changes to the traffic volumes, as shown in Figure 7.3.

TABLE 7.6: LINK REMOVAL SENSITIVITY TEST RESULTS

Data Adjustment	Trip Change	VMT Change	VHT Change
Baseline	n/a	n/a	n/a
Heavily Traveled	0	8,639	354
Lightly Traveled	0	-2	1

FIGURE 7.2: TRAFFIC ASSIGNMENT CHANGES DUE TO THE REMOVAL OF A HEAVILY TRAVELED LINK

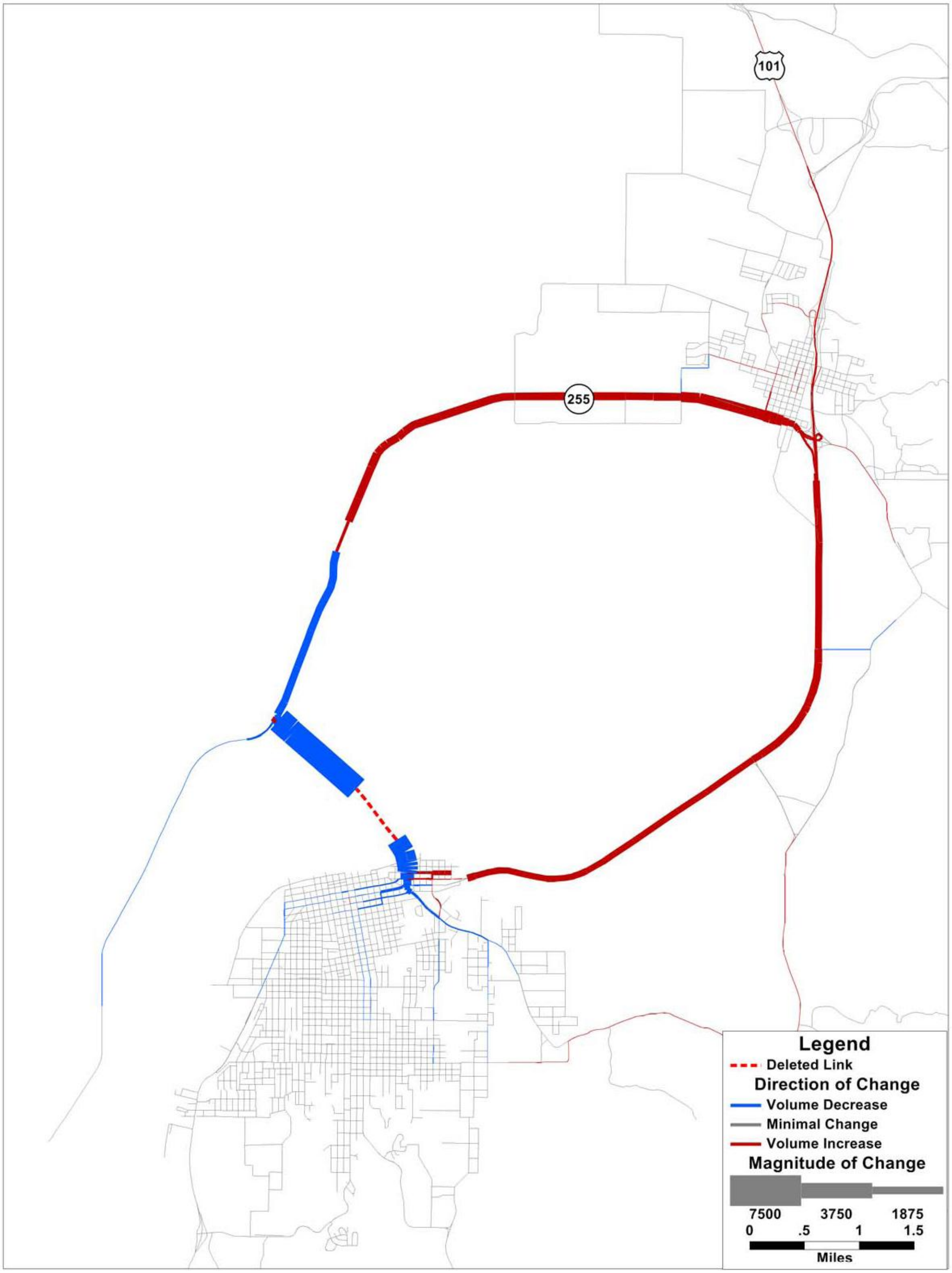


FIGURE 7.3: TRAFFIC ASSIGNMENT CHANGES DUE TO THE REMOVAL OF A LIGHTLY TRAVELED LINK