Butte County Association of Governments 2012 Metropolitan Transportation Plan Sustainable Communities Strategy

Technical Methodology for Estimating Greenhouse Gas Emissions

The work upon which this publication is based was funded in whole or in part through a grant awarded by the Strategic Growth Council

Purpose

As required by the Sustainable Communities and Climate Protection Act of 2008, BCAG has prepared this document describing the technical methodology it has used in estimating greenhouse gas emissions from its 2012 Metropolitan Transportation Plan /Sustainable Communities Strategy (MTP/SCS). An initial report, prepared by BCAG in 2011, was reviewed by the California Air Resources Board (ARB) in order to insure that the methods would yield accurate measures of greenhouse gas emissions.

SB 375 Background

In September 2008, Senate Bill 375 (SB 375), also known as the Sustainable Communities and Climate Protection Act of 2008, was enacted by the state of California. SB 375 prompts regions to reduce greenhouse gas (GHG) emissions from passenger vehicles through the coordinated planning of long range transportation plans. The new legislation requires all Metropolitan Planning Organizations (MPO) in California to develop a Sustainable Communities Strategy, which meets regional passenger vehicle GHG emissions targets, as an additional element of their regional transportation plans. BCAG's 2012 MTP/SCS update is to be completed by December 2012.

As described in SB 375, the SCS will be an integrated transportation and land use plan which is intended to meet the regional GHG target for the years 2020 and 2035 while also accommodating the region's forecasted growth. If the SCS is unable to meet the regional GHG target within the required state and federal constraints for RTP development, then an Alternative Planning Strategy (APS) must be prepared. The APS will identify how GHG targets would be achieved through alternative development patterns, infrastructure, or additional transportation measures or policies.

In February 2011, ARB approved regional passenger vehicle GHG targets for all of California's 18 MPOs, including the Butte County Association of Governments (BCAG). The Butte County region's targets for the years 2020 and 2035, for this first round of the MTP/SCS development, are to achieve no greater than a 1% increase in per capita CO_2 emissions from passenger vehicles, from 2005 levels. The metric used for preparing the reductions will be GHG emissions per capita.

Model Development

BCAG was awarded both a Caltrans 5304 Planning Grant and Strategic Growth Council Model Improvement Plan Grant for the purpose of enhancing BCAG's regional modeling capabilities to assist in preparing and quantifying the region's 2012 MTP/SCS. The enhancements from each of these grants are included in the descriptions for each model within the section below and included in Attachments 1 & 2. The improvements from these grants were implemented by BCAG and used in preparing the MTP/SCS.

Modeling the 2012 MTP/SCS

BCAG utilized 3 models to prepare the 2012 MTP/SCS and estimate the GHG emissions: (1) BCAG Regional Land Use Allocation Model, (2) BCAG Regional Travel Demand Model (a three-step transportation forecasting model), and (3) the 2007 emission factors (EMFAC) model from ARB.

Land Use Allocation Model

The BCAG Land Use Allocation Model was developed by a team of project consultants from the University of California Davis – Information Center for the Environment (ICE), California State University, Chico – Geographical Information Center (GIC), and Fehr & Peers. The model utilizes the UPlan software platform, which has been implemented broadly across the state for various Blueprint planning efforts. UPlan is a rule based model which allocates future residential and employment growth while considering the region's existing land use plans, growth forecasts, and development attractions (e.g. transportation and infrastructure) and discouragements (e.g. resource areas, farmland, and floodplains).

The land use allocation model uses the base year of 2010, to coincide with the latest available validated travel model and existing land use datasets. Land use scenarios were developed for the GHG target years of 2020 and 2035. After completion of the scenarios, the model outputs were summarized by traffic analysis zone (TAZ) and used as inputs for the regional travel demand model.

Attachment #1 contains the documentation for the BCAG Land Use Allocation Model.

Travel Demand Model

The BCAG Travel Demand Model uses the TransCAD software package to forecast travel activity. The transportation model requires two major inputs. The first input is the forecasted allocation of housing and non-residential land uses from the land use allocation model. The other input is the regional road network. Inputs are prepared for the emissions analysis year of 2005, the model base year (2010), and the GHG target years of 2020 and 2035.

The first version of this model was developed in 2007 and validated to the 2006 base year. The model is a three step travel demand forecasting model consisting of Trip Generation, Trip Distribution, and Trip Assignment. In 2012, the model was updated to include the following components.

- Validating the base year to 2010 consistent with the 2010 California Regional Transportation Guidelines
- Increasing sensitivities for age of head of household, number of workers, income household size, and cost of travel.

- Adding multiple time periods (daily, AM peak period, AM peak hour, PM peak period, PM peak hour, mid-day period, and evening period conditions)
- Implementing the 4D's (density, diversity, design, and destination accessibility)
- Adding a new transit forecasting component.

These new updates were utilized in preparing and quantifying the 2012 MTP/SCS.

The travel model outputs vehicle trips (VT), vehicle miles traveled (VMT), vehicle hours of travel (VHT), delay, and congestion, for both on and off peak travel periods and for various trip end types (e.g. II, XX, and IX-XI) for the years 2005, 2010 and GHG target years (2020 and 2035). A post-processor is used to prepare the data for the vehicle emissions model (EMFAC). The post-processor divides the VMT into 13 separate speed bins set at 5 mile per hour intervals.

Attachment #2 contains the documentation for the BCAG Regional Travel Demand Model.

<u>EMFAC</u>

ARB's 2007 emissions factor model (EMFAC) has been used to calculate the greenhouse gas, carbon dioxide (CO2), emissions output based on the provided VMT and speed bin classification from the travel model and post-processor. BCAG utilized the annual option for CO2 output as suggested by the RTAC report.

Once all trips were ran in EMFAC, BCAG extracted the total VMT and carbon dioxide (CO2) emissions for LDA, LDT1, LDT2, and MDV vehicle types. This ensured that only passenger vehicle (cars and light trucks) types were included in the emissions analysis.

In 2010, ARB released the Pavley 1 + LCFS post processor for EMFAC. This post processor was <u>not</u> used by BCAG.

<u>Modeling Interregional Trips</u>

For the purpose of preparing the GHG emissions analysis for 2012 MTP/SCS, BCAG subtracted all emissions from through trips (X-X trips). In addition, the portion of VMT from trips that either begin or end within the region but travel to/from neighboring regions (X-I, I-X trips) has been included for all portions of the trip within the BCAG region, this is consistent with the method used in preparing the targets.

The percentage of VMT by through trip type (X-X) was calculated for the years 2005, 2020, and 2035.

Table 1 contains the percent of VMT associated with through trips for the years 2005, 2020, and 2035.

Table 1.

2012 BCAG MTP/SCS – Through Trips			
	2005 Base Yr	**2020 Interim Yr**	**2035 Horizon Yr**
% of Through (X-X) Trips	3.4%	4.1%	5.3%

Source: Fehr & Peers, 2012 – BCAG Travel Demand Forecasting Model, 2035 Cumulative Year.

GHG Emissions in the 2012 MTP/SCS

As prescribed by the final ARB-RTAC report, BCAG staff quantified the outputs from the modeling methods described in this document using the target metric in terms of a percent reduction in per capita greenhouse gas emissions (CO2) from base year levels.

The baseline year for the BCAG GHG forecasts is 2005, as requested by ARB in its November 17, 2011 letter to BCAG (Attachment #3) and as stated in ARB's approved Resolution 10-31. BCAG has prepared the 2005 base year data utilizing the updated travel demand model and performing a "backcast" from the validated year of 2010. During the target setting process, the base year of 2006 was utilized by BCAG since it was the closest available model year from BCAG's 2008 MTP. Attachment # 4 contains a table illustrating the modeling parameters for the years 2005, 2006, 2010, 2020, and 2035.

Table 2 contains the per capita GHG emissions and calculations for the years 2005, 2020, and 2035 for BCAG's 2012 MTP/SCS.

Table 2.

2012 BCAG MTP/SCS – GHG Emission Calculations			
	2005 Base Yr	**2020 Interim Yr**	**2035 Horizon Yr**
Passenger Vehicle Weekday VMT	3,668	4,397	5,681
Population	214,582	257,266	332,459
Weekday CO2 (tons)	1,770	2,080	2,690
Per Capita CO2 (lbs)	16.50	16.17	16.18
% Reduction VMT Per Capita from '05		0.01%	0.03%
% Reduction CO2 Per Capita from '05		1.98%	1.91%

Notes:

VMT and CO2 from passenger vehicles (LDA, LDT1, LDT2, and MDV);

Trips based on intra-regional and inter-regional travel (no through trips);

Growth based on BCAG Regional Growth Forecasts 2010-2035 medium scenario.

Butte County Association of Governments

Land Use Allocation Model

Technical Methodology for Preparing 2012 Metropolitan Transportation Plan / Sustainable Communities Strategy Land Use Allocation

November 2012

The work upon which this publication is based was funded in whole or in part through a grant awarded by the Strategic Growth Council

INTRODUCTION

BCAG, in coordination with local agency members, California State University-Chico, and the University of California at Davis, developed the Butte County region's first land use allocation model for the purpose of assisting in preparing the forecasted development pattern for BCAG's 2012 Metropolitan Transportation Plan (MTP) and Sustainable Communities Strategy (SCS). The model was used by BCAG in developing three distinctive land use allocation scenarios to be analyzed as part of the 2012 MTP/SCS. The following describes the process used in preparing the allocations utilizing the model.

DATA PREPARATION

Three scenarios were developed to model future planned growth in the Butte County region. In preparing an individual scenario, growth was modeled separately for each of the Butte County Association of Government's (BCAG) member jurisdictions and combined into one county-wide growth projection for each scenario. BCAG member jurisdiction's boundaries included Chico, Paradise, Oroville, Gridley, Biggs, and the remaining unincorporated area of Butte County.

General Plan

A standard list of general plan classification code values were developed for use in the model. Each of the jurisdiction's general plan classifications was cross-walked into one of twenty standard modeling classifications (See Appendix A). This addressed any variations in general plans across the county, and allowed for the implementation of a single countywide general plan classification system. The purpose of the general plan modeling classifications is to restrict the type and location of new growth to designated areas when preparing the allocations.

Planning Areas

Planning area boundaries were created to define the extent of each jurisdiction, for planning purposes. The extents determine the areas in which a jurisdictions future growth allocation is accounted for. The Oroville planning area was further divided into an Oroville-City and Oroville-County due to the overlap in anticipated growth planned by both the City and County. Planning areas were adapted from a combination of jurisdiction city limits, Local Agency Formation Commission (LAFCo) spheres of influence, general plan and special planning area considerations. Planning areas do not overlap one another and together they encompass the entirety of Butte County (See Appendix B).

Land Use Assumptions

Land Use (LU) assumptions for regional and jurisdiction specific employment and housing characteristics were developed for each of the modeling classifications where new growth was assigned (See Appendix C). These assumptions included metrics for the following:

- Dwelling units per acre (DU/AC): Density of homes for a specific residential or mixed use land classification.
- Average square footage per employee (Avg. SF/E): Density of employees working in a business (Retail, Office, Industrial, or Mixed Use).
- Floor Area Ratio (FAR): Described as the relationship between the total useable floor space inside of a building(s) and the total area of the lot where building(s) are located.
- Mixed use ratio: Mixed use LU classifications receive a percentage of two or more different LU types (Residential, Retail, Office, and Industrial).

Attractors, Discouragements, and Masks

Attractors, discouragements, and masks, are used in the model to assist in determining where specific types of new growth may be desirable, unfavorable, or not allowed. Attractors (Table 1.) are defined as features that promote or make new growth more suitable. An example of which would be existing bike routes. Residents of a new housing development next to an established bike route will have better and safer alternative transportation options. Discouragements (Table 2.) are defined as features that deter or make new growth less desired in an area. An example is prime farmland. New development on land with ideal conditions for farming would not be considered desirable, based on local planning policies. Masks (Table 3.) are areas where new growth is not permitted or reasonably foreseeable to occur. Areas such as existing development, public parks, and protected lands are all examples of areas where growth is not permitted. Below is a list of attractors, discouragements, and masks used in the development of the Butte County urban growth model.

Table 1. Attraction Layers
Butte Regional Conservation Plan – Urban Permit Areas
City Spheres of Influence
City Limits
Butte Regional Transit Bus Routes
Bike Routes
Regional Road Network
Service Districts (LAFCo)
Oroville Enterprise Zone

Table 2. Discouragement Layers
Federal Flood Zones
California Land Conservation Act Lands
Prime Farmlands
Butte Regional Conservation Plan – Ecological Baseline Areas
Areas of Slope 15 to 25%

Table 3. Mask Layers
Public Park Lands
Existing Protected Lands
Existing Developed Lands
Butte Regional Conservation Plan – Draft Preserve Hardline Area
Lakes
Rivers
Existing Right of Ways
Areas of Slope > 25%
Public Lands
Federal Lands
Utility Lands
State Lands
Union Pacific Lands
Proposed/Approved Development Areas

Layer Weighting

In addition, each attraction and discouragement has associated weights at specified buffer distances, specific to each particular modeled land use classification (See Appendix D). The further away new growth is from an attracting feature; the less desirable the location is for development. Discouragement weighting works just the opposite; the further from a discouraging feature, the more desirable the location is for development within the model. Appendix E-1 through E-3 includes three “heat maps” developed using the weighting and referenced by planners when preparing the scenarios.

Available Lands

For each jurisdiction, an “available lands” (See Appendix F) layer was created by overlaying the General Plan with each jurisdiction’s plan area and the mask layers. First the land use layer was overlaid with a chosen jurisdiction’s plan area. All modeled land use classifications not inside the plan area were removed, leaving only model land uses specific to the plan area. The remaining area was then overlaid with all applicable mask layers. All modeled areas that intersected with a mask, were then removed. The final remaining area consists of all the “available lands” for new growth within the plan area. This process was repeated for each jurisdiction. Appendix G is included and illustrates the areas masked in preparing the “available lands”.

ALLOCATING FUTURE LAND USES

Once data and inputs were prepared, allocation of new growth began. First the “available lands” layers attribute tables were imported into a spreadsheet based allocation model for each jurisdiction, which included specific tables for allocating growth for planned development, mixed use (employment and housing), and redevelopment.

Growth Areas

Each jurisdiction was further broken down into Growth Areas. Jurisdiction plan areas were split into five Growth Areas; center, established, new, rural, and agricultural growth areas. Center growth areas are downtown and central business areas where higher densities of commercial LU’s were present. Established growth areas are within the currently built environment. They represented areas where infill and redevelopment opportunities are present. New growth areas are where new development could occur outside of the currently established built environment. Rural and agricultural growth areas are only present in the unincorporated county jurisdiction and represented areas for new growth that are separated from any incorporated area in the county. Appendix H is included illustrating the locations of Growth Areas.

Allocation Process

Allocation of forecasted development for each Growth Area was based on the considerations of regional guiding principles and growth forecasts, current and proposed land use plans, modeled attractions and discouragements, and input from local jurisdiction planners and public outreach. Allocations were prepared for the region using the process of combining available lands growth, planned development, and redevelopment at the parcel group and TAZ levels in GIS format.

Available Lands Allocation

The allocation spreadsheets prepared for the “available lands” were translated back to a GIS based model for each growth area. Conversion was performed at the traffic analysis zone (TAZ) and parcel group level for analysis and input to the travel demand model and 4Ds post processor. Allocation spreadsheets outlined how much growth was to occur in each modeled land use classification per growth area. The growth was then distributed between all parcels of the particular land use classification based on the total percentage of development for that particular class. For example, if the High Density Residential (HDR) land use class was to receive a 40% allocation, all HDR areas received equal portions of that allocation based on parcel size.

Planned Projects Allocation

In the case of planned projects, or projects which have been or are likely to be approved by local agencies and can reasonably be assumed to develop within the 2012 MTP/SCS planning period, details on the location and development is pre-determined. For these situations growth was allocated into specified parcels, split by TAZ. Appendix I-1 contains the locations of planned projects allocated in the model. In addition, Appendix I-2 contains the detailed listing of planned projects by plan area.

Redevelopment Allocation

Redevelopment was allocated into designated parcels where redevelopment opportunities existed, based on input from local jurisdiction planning staff. The same techniques for allocating the available lands were applied. In most cases a percentage of the existing land uses were subtracted from the redevelopment allocation to account for displaced existing uses. In other cases redevelopment was accomplished by reclaiming underutilized space such as removing portions of an existing parking lot. For these cases, no existing uses were displaced. Appendix J illustrates the general location of areas receiving redevelopment allocations.

Final Allocation Files

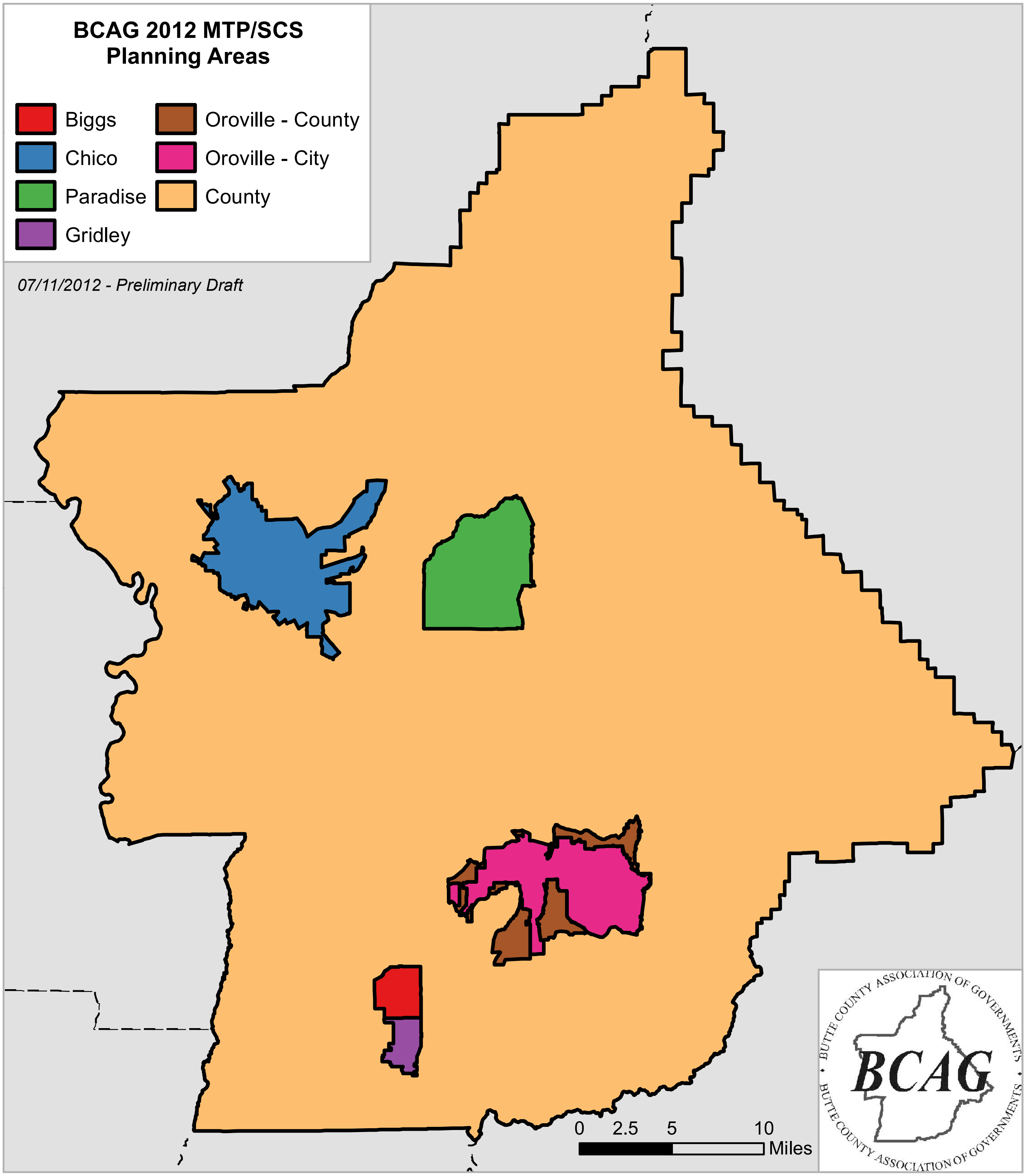
The results were shapefiles with attributes containing the allocated growth for each sub area. These were then merged together into a single county-wide shapefile. Growth types were then cross-walked into travel demand model (TransCAD) classifications. The final Butte County Allocation shapefile was then delivered to the travel modeling team for incorporation in the travel demand model. Appendix K illustrates the areas receiving final allocations by modeled land use classification for land use scenario #1.

APPENDIX A.

General Plan Class to Model Class Crosswalk

Model Code	Model Classification	TransCAD Classification	City of Chico 2030 GP (Final)	Town of Paradise 1994 GP	City of Gridley GP 2030 (Final)	City of Biggs GP 2030 (Pending)	City of Oroville GP 2030 (Final)	Butte County GP 2030 (Final)
0	Unclassified	N/A			Right of Way (ROW), Right of Way Railroad (ROWR), Right of Way Water (ROWW)	Right of Way (ROW), Railroad ROW (RR)	Right of Way (ROW)	Right of Way (ROW), Sports and Entertainment (SE)
1	Agriculture	N/A			Agriculture (AG)	Agriculture (A)		Agriculture (AG)
2	Industry	IND_KSF	Manufactoring and Warehouse (MW)			Agriculture Industrial (AI), Heavy Industrial (HI)	Industrial (IND)	Industrial (I)
4	Agriculture	N/A				Agriculture Commercial (AC)		
5	Office Commercial	OFF_KSF					Office (OFC)	
6.1	Mixed Use Retail	RET_KSF & OFF_KSF	Neighborhood Commercial (NC)	Neighborhood Commercial (NC)	Downtown Mixed Use (DMU)	Commercial (C)	Mixed Use Commercial (MUC)	Mixed Use (MU)
6.2	Mixed Use Retail	RET_KSF & OFF_KSF & MF_DU	Commercial Mixed Use (CMU)	Central Commercial (CC)	Neighborhood Center Mixed Use (MU)	Downtown Mixed Use (DMU)	Retail and Business Services (RBS)	Retail and Office (RTL)
6.3	Mixed Use Retail	RET_KSF & OFF_KSF & MF_DU	Commercial Mixed Use (CMU) with Downtown or Corridor Overlays (OS-3, 7, 9, 13, 14, 15)	Town Commercial (TC)	Commercial (C)	Mixed Use (MU)	Airport Business Park (ABP)	Industrial (I) and Rural Residential (RR) with Retail Overlay (Retail)
6.4	Mixed Use Retail	RET_KSF & OFF_KSF & IND_KSF	Commercial Services (CS)	Business Park (BP)				Recreation Commercial (REC)
6.5	Mixed Use Retail	RET_KSF & OFF_KSF & MF_DU	Regional Commercial (RC)	Community Service (CS)				Research and Business (RBP)
6.6	Mixed Use Office	RET_KSF & OFF_KSF & MF_DU	Office Mixed Use (OMU)					
6.7	Mixed Use Office	RET_KSF & OFF_KSF & MF_DU	Office Mixed Use (CMU) with Downtown or Corridor Overlays (OS-3, 7, 9, 13, 14, 15)					
7	Mixed Use Industrial	IND_KSF & OFF_KSF	Industrial Office Mixed Use (IOMU)	Light Industrial (LI)	Industrial (M), Agriculture Industrial (AI)	Light Industrial (LI)		Agriculture Services (AS)
8.1	Mixed Use Residential	MF_DU & RET_KSF & OFF_KSF	Residential Mixed Use (RMU)					
8.2	Mixed Use Residential	MF_DU & RET_KSF & OFF_KSF	Residential Mixed Use (RMU) with Downtown and Corridor Overlays (OS-3, 7, 9, 13, 14, 15)					
9	High Density Residential	MF_DU	High Density Residential (HDR)		Residential High Density 2 (RHD 2)	High Density Residential (HDR)	High Density Residential (HDR)	High Density Residential (HDR)
10	Medium-High Density Residential	MF_DU	Medium-High Density Residential (MHDR)	Multi-Family Residential (MR)			Medium High Density Residential (MHDR)	
11	Medium Density Residential	SF_DU	Medium Density Residential (MDR)		Residential High Density 1 (RHD 1)	Medium Residential (MDR)	Medium Density Residential (MDR)	Medium High Density Residential (MHDR)
12	Low Density Residential	SF_DU	Low Density Residential (LDR)	Rural Residential (RR) and Town Residential (TR)	Residential Medium Density (RMD), Residential Low Denisty (RLD)	Low Density Residential (LDR)	Medium Low Density Residential (MLDR)	Medium Density Residential (MDR)
13	Very Low Density Residential	SF_DU	Very Low Density Residential (VLDR)	Agricultural Residential (AR)	Residential Very Low Density (RS)		Low Density Residential (LDR)	Very Low Density Residential (VLDR), Low Density Residential (LDR)
14	Rural Residential	SF_DU						Foothill Residential (FR), Rural Residential (RR)
15	Planned Development	N/A	Special Mixed Use (SMU)					Planned Unit Development (PUD)
16	Public Lands & Open Space	N/A	Primary Open Space (POS), Secondary Open Space (SOS)	Recreational (R), Open Space/Agricultural (OS/AG)	Park (PARK), Open Space (OS)		Park (PARK), Environmental Conservation/Safety (ECS), Resource Management (RM)	Resource Conservation (RC)
17	Water Bodies	N/A					State Water Project (SWP)	
18	Urban Reserve	N/A			Urban Reserve (UR)			
19	Timber	N/A		Timber Production (TP)				Timber Mountain (TM)
20	Public Facilities	N/A	Public Facilities and Services (PFS)	Public Institutional (PI)	School (S), Public (PUB)	Public (P)	Public (PUB)	Public (P)

APPEDNIX B.


BCAG 2012 MTP/SCS
Planning Areas
Biggs
Chico
Paradise
Gridley
Oroville - County
Oroville - City
County
07/11/2012 - Preliminary Draft
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX C.

Modeling Assumptions

		CHICO				PARADISE				GRIDLEY				BIGGS			
Model Code	Model Classification	DU / AC	AVG SF / E	FAR	Mixed Use Ratio RES / RET / OFF / IND	DU / AC	AVG SF / E	FAR	Mixed Use Ratio RES / RET / OFF / IND	DU / AC	AVG SF / E	FAR	Mixed Use Ratio RES / RET / OFF / IND	DU / AC	AVG SF / E	FAR	Mixed Use Ratio RES / RET / OFF / IND
2	Industry		900	0.35			900	0.35			900	0.35			900	0.35	
5	Office Commercial		300	0.35			300	0.35			300	0.35			300	0.35	
6.1	Mixed Use Retail		500	0.3	0 / 85 / 15 / 0	0	416.7	0.5	0 / 70 / 30 / 0	20	454.5	1	10 / 60 / 30 / 0		428.6	0.3	0 / 70 / 30 / 0
6.2	Mixed Use Retail	13	545.5	0.3	10 / 75 / 15 / 0	13	555.6	1	30 / 40 / 30 / 0		428.6	0.3	0 / 70 / 30 / 0	20	454.5	1	10 / 60 / 30 / 0
6.3	Mixed Use Retail	33	537.6	1.7	15 / 73 / 12 / 0	6.5	555.6	0.5	30 / 40 / 30 / 0		428.6	0.3	0 / 70 / 30 / 0	13	461.5	0.3	10 / 60 / 30 / 0
6.4	Mixed Use Retail		534.7	0.3	0 / 85 / 10 / 5		403	0.3	0 / 40 / 40 / 20								
6.5	Mixed Use Retail	15.5	531	0.3	3 / 85 / 12 / 0		545.5	0.3	30 / 40 / 30 / 0								
6.6	Mixed Use Office	13	305.1	0.3	10 / 10 / 80 / 0	0											
6.7	Mixed Use Office	30	365	1.7	13 / 12 / 75 / 0	13											
7	Mixed Use Industrial	10.5	562.5	0.35	0 / 0 / 30 / 70		750	0.35	0 / 0 / 10 / 90		642.9	0.35	0 / 0 / 20 / 80		642.9	0.35	0 / 0 / 20 / 80
8.1	Mixed Use Residential	16.2	400	0.3	95 / 2 / 3 / 0												
8.2	Mixed Use Residential	50	400	1.7	90 / 5 / 5 / 0												
9	High Density Residential	40								22.5				20			
10	Medium-High Density	18.5				13											
11	Medium Density Residential	12								12				10			
12	Low Density Residential	5.1								5				4			
13	Very Low Density Residential	1.1				1.5				1							
14	Rural Residential																

		OROVILLE				OROVILLE - COUNTY PORTION				COUNTY			
Model Code	Model Classification	DU / AC	AVG SF / E	FAR	Mixed Use Ratio RES / RET / OFF / IND	DU / AC	AVG SF / E	FAR	Mixed Use Ratio RES / RET / OFF / IND	DU / AC	AVG SF / E	FAR	Mixed Use Ratio RES / RET / OFF / IND
1	Agriculture									0.05			
2	Industry		900	0.35			900	0.35			900	0.35	
5	Office Commercial		300	0.35			300	0.35			300	0.35	
6.1	Mixed Use Retail	20	507	0.3	15 / 60 / 25 / 0	13	514.3	0.3	10 / 70 / 20 / 0	13	461.5	0.3	10 / 60 / 30 / 0
6.2	Mixed Use Retail		428.6	0.3	0 / 70 / 30 / 0		473.7	0.3	0 / 80 / 20 / 0		409.1	0.3	0 / 65 / 35 / 0
6.3	Mixed Use Retail		337.5	0.3	0 / 30 / 60 / 10		428.6	0.3	0 / 70 / 30 / 0		409.1	0.3	0 / 65 / 35 / 0
6.4	Mixed Use Retail						473.7	0.3	0 / 80 / 20 / 0		409.1	0.3	0 / 65 / 35 / 0
6.5	Mixed Use Retail						275.5	0.3	0 / 0 / 90 / 10		275.5	0.3	0 / 0 / 90 / 10
6.6	Mixed Use Office												
6.7	Mixed Use Office												
7	Mixed Use Industrial						818.2	0.35	0 / 10 / 10 / 80		732.6	0.35	0 / 10 / 10 / 80
8.1	Mixed Use Residential												
8.2	Mixed Use Residential												
9	High Density Residential		25			20				20			
10	Medium-High Density		18.5										
11	Medium Density Residential		13			13				13			
12	Low Density Residential		5.5			4.5				4.5			
13	Very Low Density Residential		1			1				1			
14	Rural Residential		0.1			0.1125				0.1125			
19	Timber									0.00625			

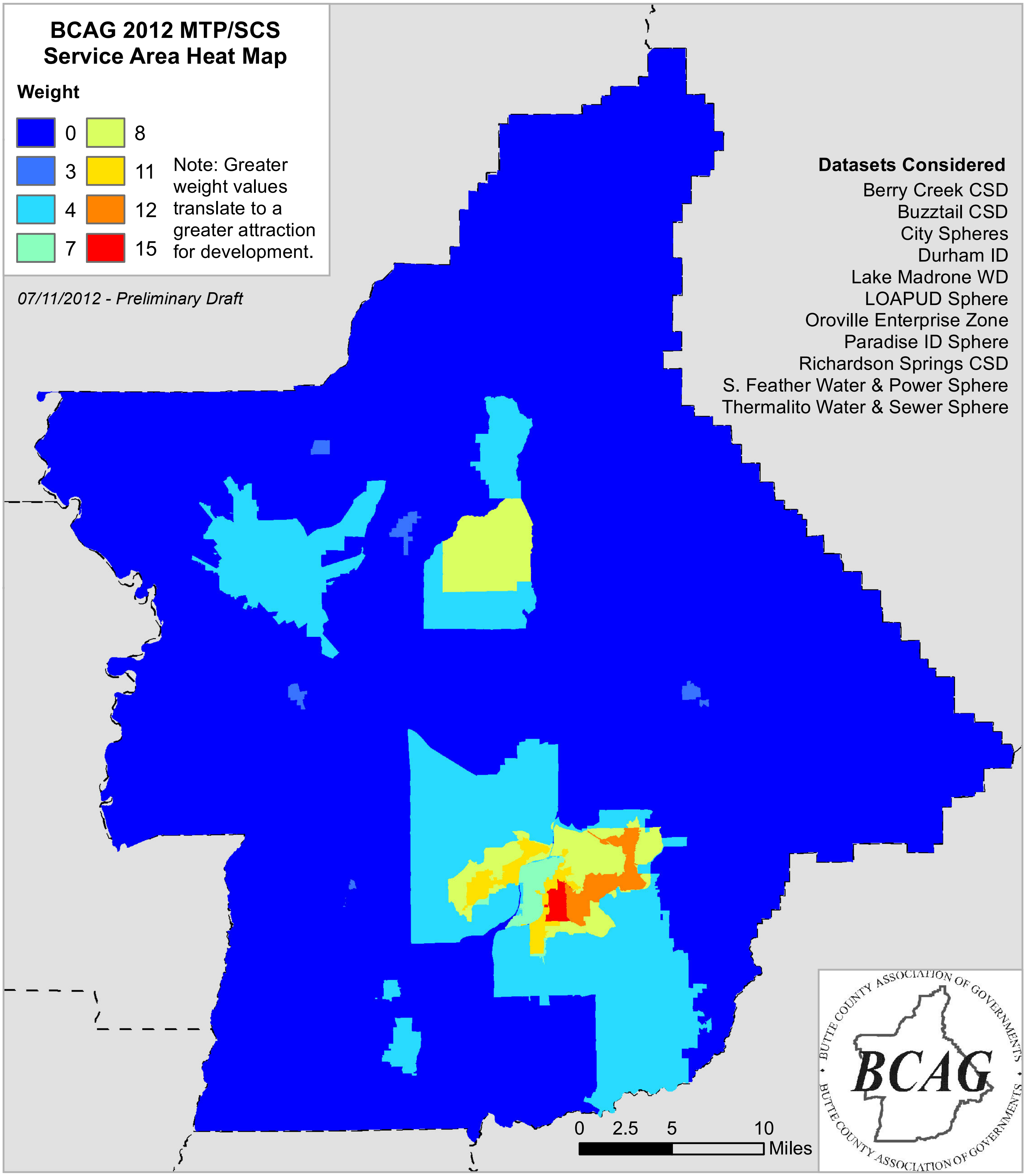
APPENDIX D.

BCAG Weighting Classification Scheme

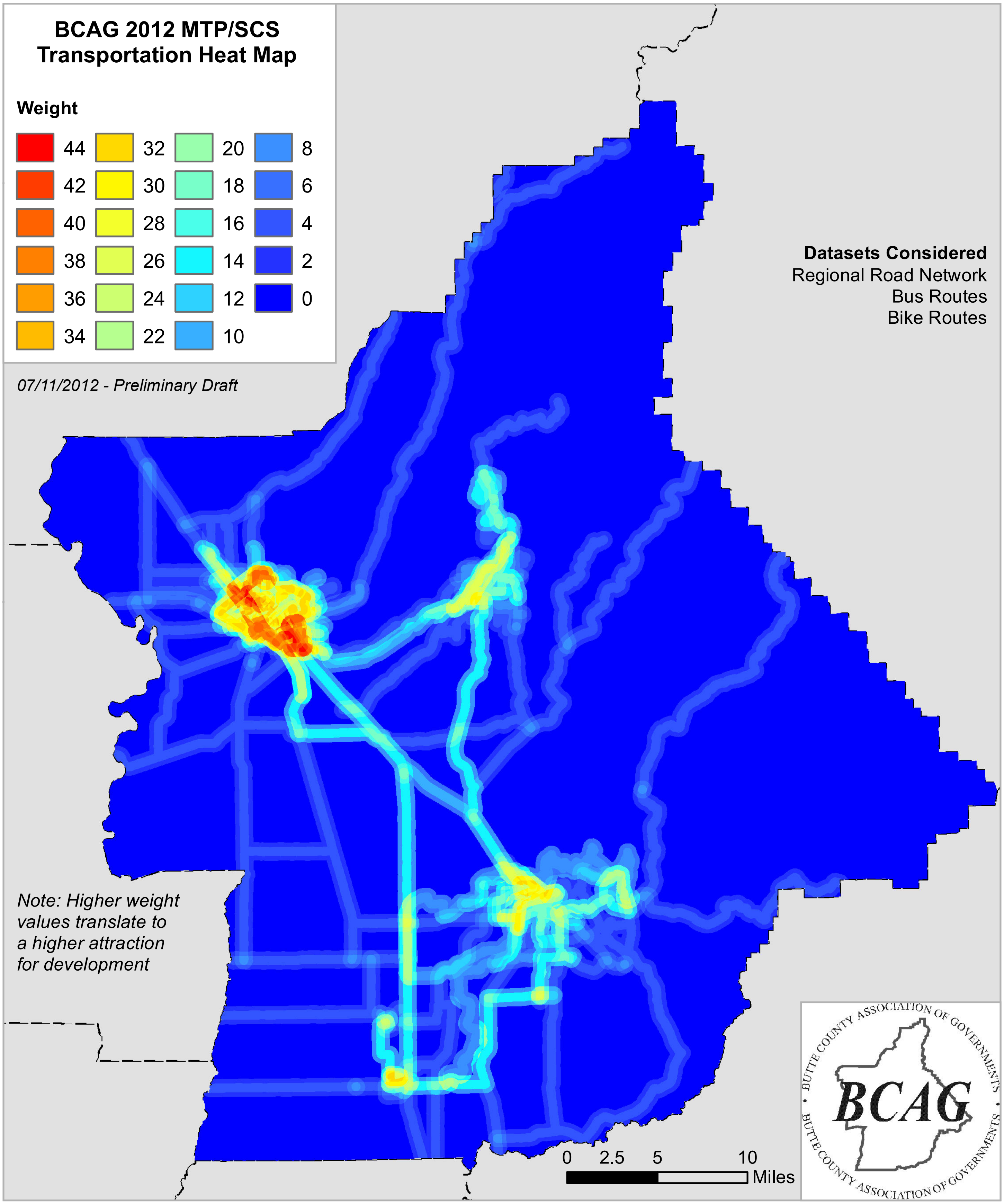
Discouragement Layer	Class	Buffer (mi)	Weight (0 to 10)
FEMA Flood Zones	A, AE, AH, AO	-	6
	0.2 PCT Chance	-	2
	All others	-	-
CLCA Williamson Act	Ongoing	-	8
	Non Renewal	-	4
		-	
DOC Farmland	P and U	-	8
HCP Constraint	Very High	-	8
	High	-	6
	Moderate	-	2
Slope	15-25%	-	10

Attraction Layer	Class	Buffer (mi)	Weight (0 to 10)
HCP UPAs	All	-	8
City Spheres	All	-	4
City Limits	All	-	3
		1/4 mile	2
		1/2 mile	1
Bus Routes	15	1/2 mile	8
	All others	1/4 mile	6
		1/2 mile	4
Bike Routes	Class 1 & Multi Use	1/4 mile	8
		1/2 mile	6
	Class 2	1/4 mile	6
		1/2 mile	4
	Class 3	1/4 mile	4
		1/2 mile	2
Road Network	Freeway	1/4 mile	4
		1/2 mile	2
	Arterial	1/8 mile	4
		1/4 mile	4
		1/2 mile	2
	Collector	1/8 mile	8
		1/4 mile	8
		1/2 mile	4
Utility Districts (LAFCO)	All	-	3
Oroville Enterprise Zone	All	-	3

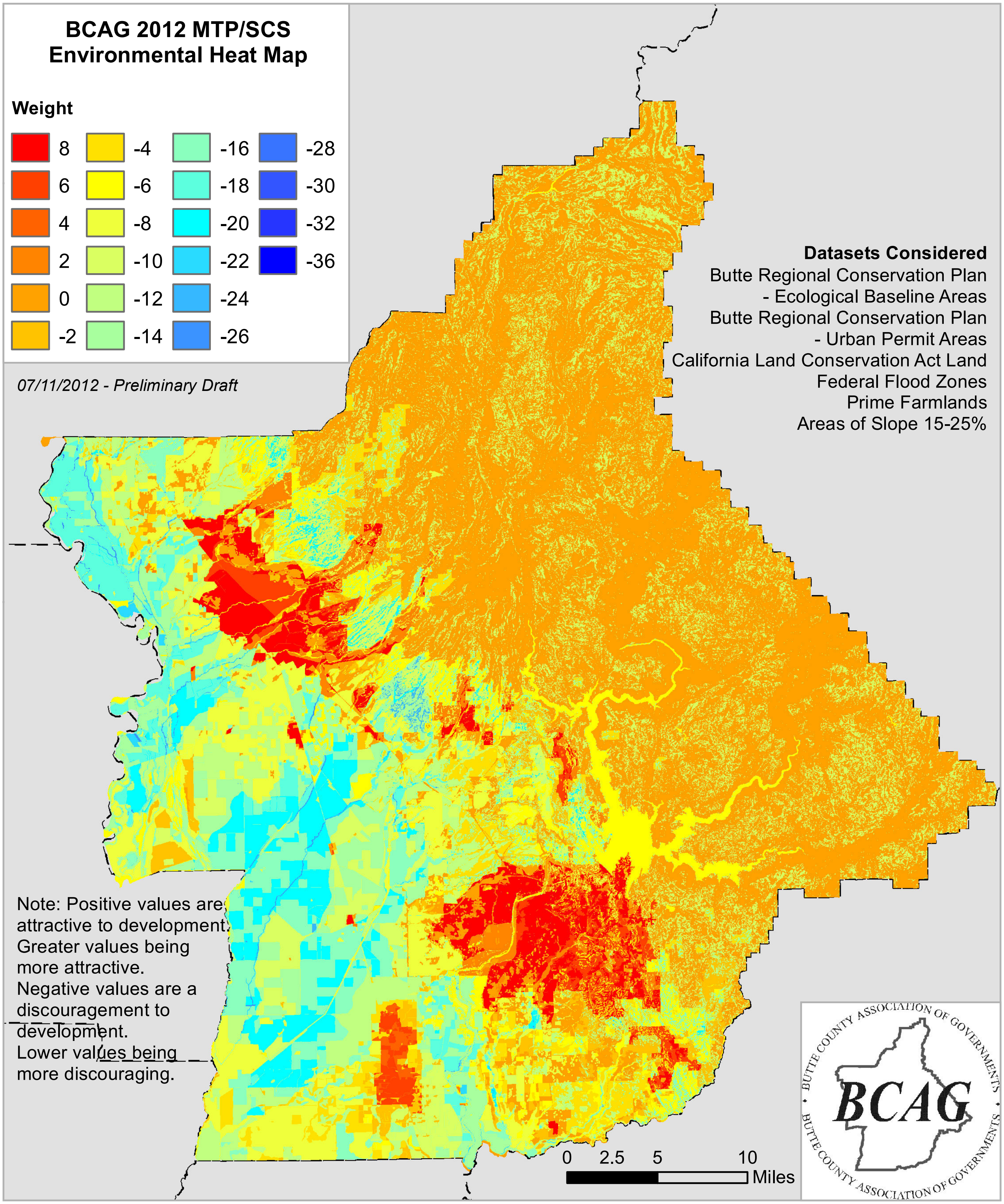
APPENDIX E-1.


BCAG 2012 MTP/SCS
Service Area Heat Map
Weight
0
3
4
7
8
11
12
15
Note: Greater weight values translate to a greater attraction for development.
07/11/2012 - Preliminary Draft
Datasets Considered
Berry Creek CSD
Buzztail CSD
City Spheres
Durham ID
Lake Madrone WD
LOAPUD Sphere
Oroville Enterprise Zone
Paradise ID Sphere
Richardson Springs CSD
S. Feather Water & Power Sphere
Thermalito Water & Sewer Sphere
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX E-2.


BCAG 2012 MTP/SCS
Transportation Heat Map
Weight
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
07/11/2012 - Preliminary Draft
Datasets Considered
Regional Road Network
Bus Routes
Bike Routes
Note: Higher weight values translate to a higher attraction for development
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX E-3.


BCAG 2012 MTP/SCS
Environmental Heat Map
Weight
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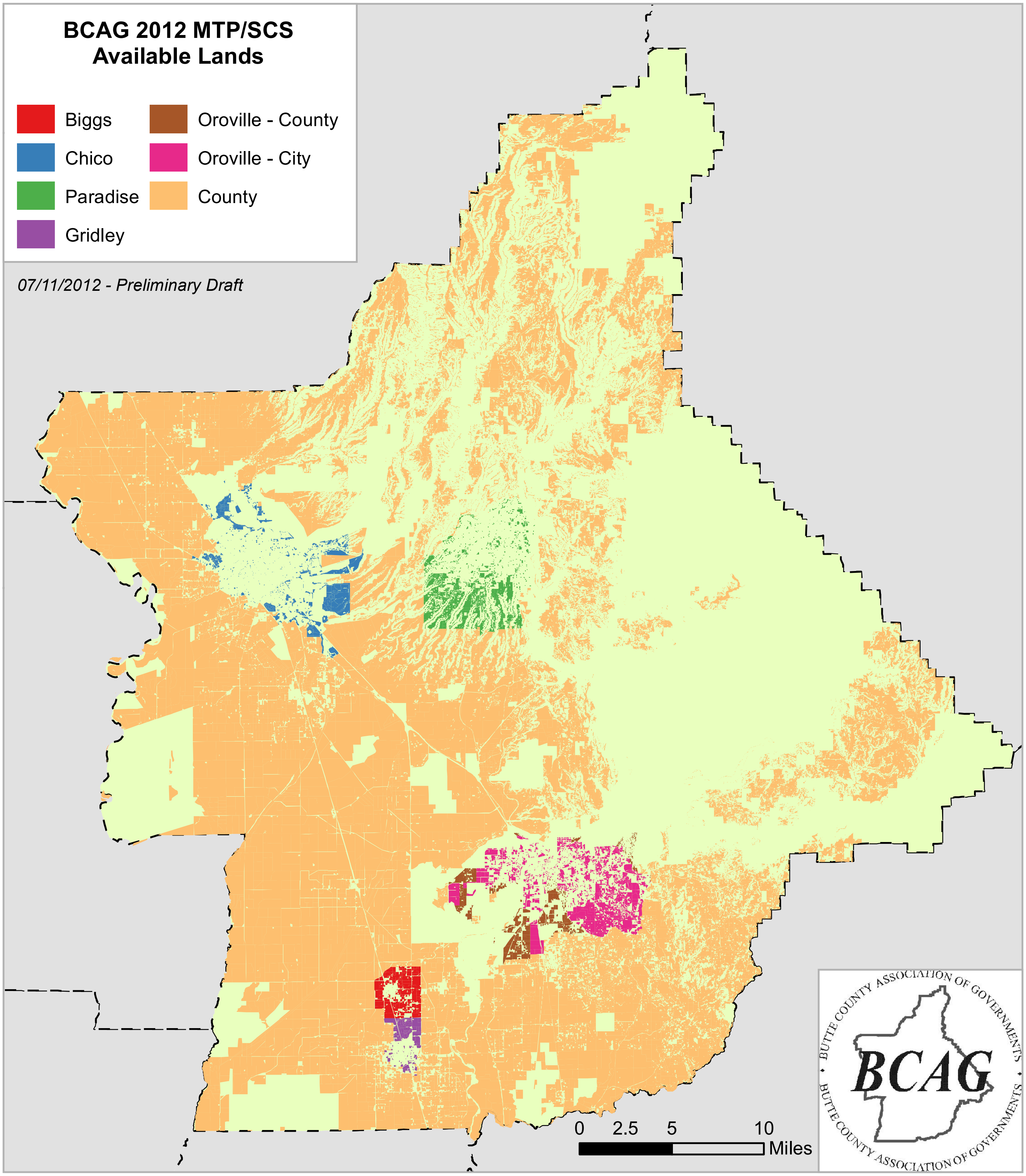
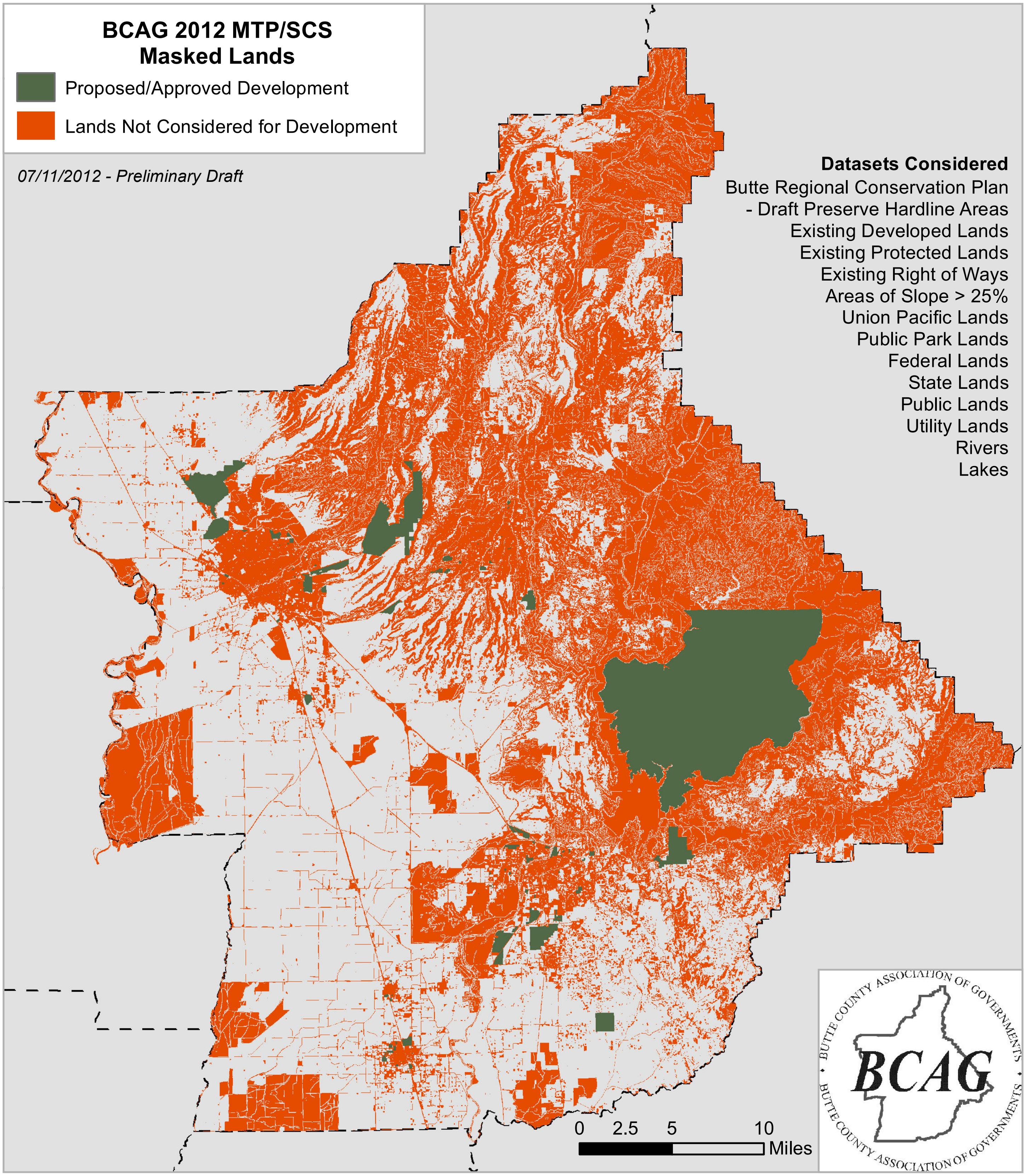
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
-36
07/11/2012 - Preliminary Draft
Datasets Considered
Butte Regional Conservation Plan
- Ecological Baseline Areas
Butte Regional Conservation Plan
- Urban Permit Areas
California Land Conservation Act Land
Federal Flood Zones
Prime Farmlands
Areas of Slope 15-25%
Note: Positive values are attractive to development. Greater values being more attractive.
Negative values are a discouragement to development.
Lower values being more discouraging.
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

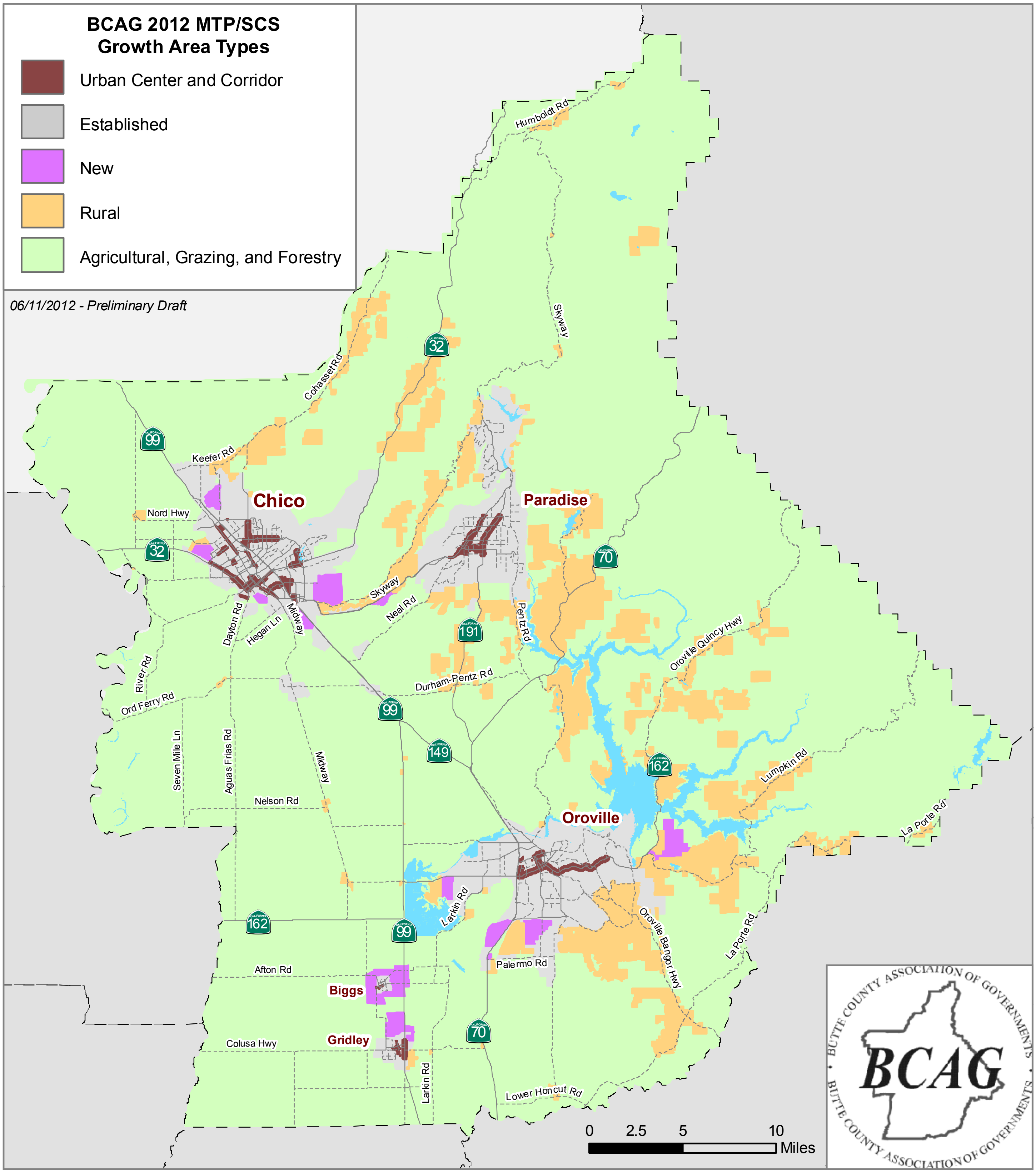
APPENDIX F.


BCAG 2012 MTP/SCS
Available Lands
Biggs
Chico
Paradise
Gridley
Oroville - County
Oroville - City
County
07/11/2012 - Preliminary Draft
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX G.


BCAG 2012 MTP/SCS
Masked Lands
Proposed/Approved Development
Lands Not Considered for Development
07/11/2012 - Preliminary Draft
Datasets Considered
Butte Regional Conservation Plan
- Draft Preserve Hardline Areas
Existing Developed Lands
Existing Protected Lands
Existing Right of Ways
Areas of Slope > 25%
Union Pacific Lands
Public Park Lands
Federal Lands
State Lands
Public Lands
Utility Lands
Rivers
Lakes
0 2.5 5 10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX H.


BCAG 2012 MTP/SCS
Growth Area Types
Urban Center and Corridor
Established
New
Rural
Agricultural, Grazing, and Forestry
06/11/2012 - Preliminary Draft
Humboldt Rd
Skyway
Cohasset Rd
32
99
Keefer Rd
Chico
Paradise
Nord Hwy
70
Skyway
Neal Rd
Dayton Rd
Hegan Ln
Midway
191
Pentz Rd
Oroville Quincy Hwy
River Rd
Ord Ferry Rd
Durham-Pentz Rd
149
162
Lumpkin Rd
Seven Mile Ln
Aguas Frias Rd
Nelson Rd
Oroville
La Porte Rd
Larkin Rd
Oroville Bangor Hwy
La Porte Rd
Palermo Rd
Afton Rd
Biggs
Gridley
Colusa Hwy
Larkin Rd
Lower Honcut Rd
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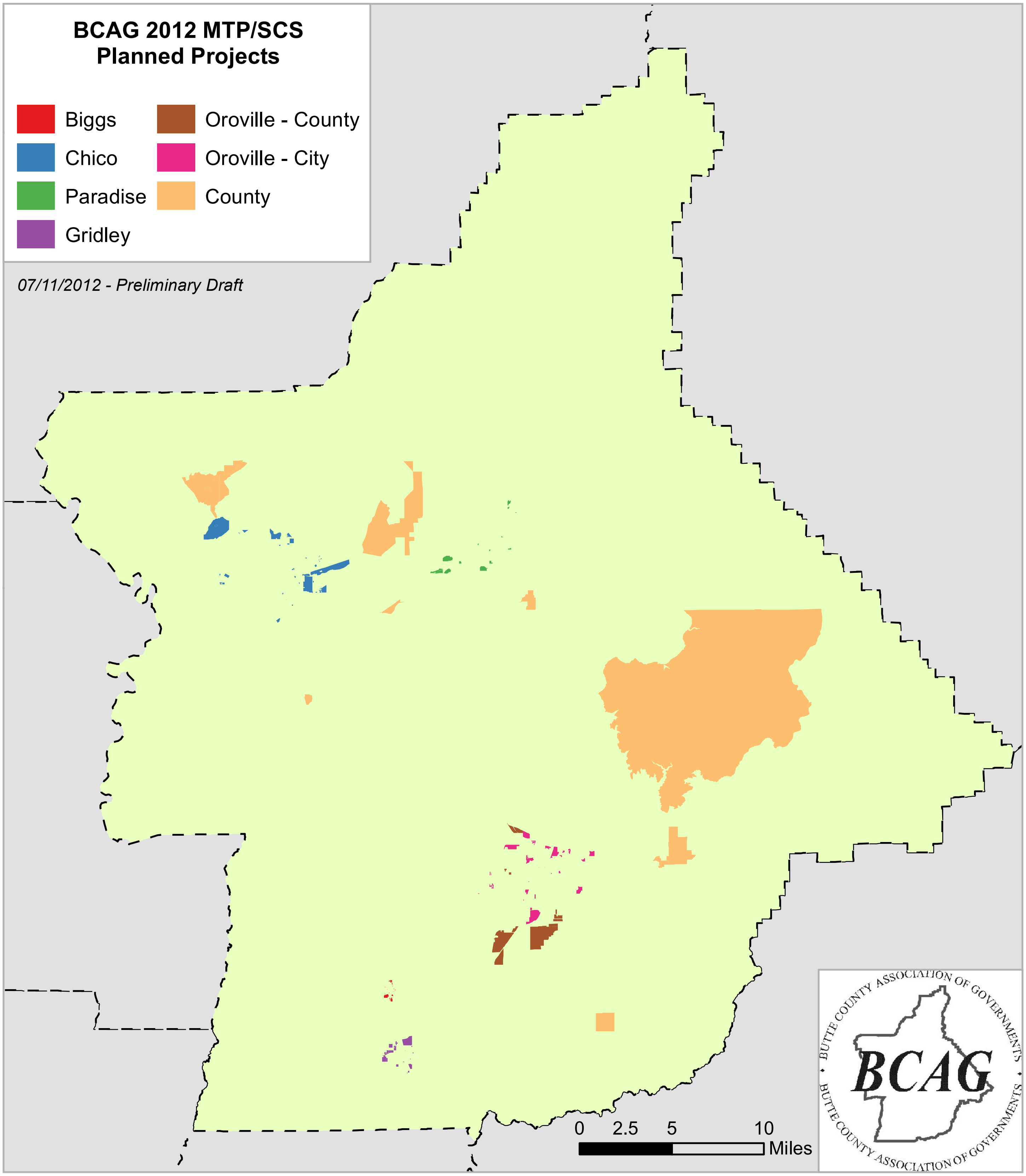
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX I-1.



BCAG 2012 MTP/SCS
Planned Projects
Biggs
Chico
Paradise
Gridley
Oroville - County
Oroville - City
County
07/11/2012 - Preliminary Draft
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX I-2.

Planned Projects

CHICO		Housing Units			Non-Residential (KSF)			
Development Name	**Growth Area**	**Single Fam**	**Multi Fam**		**Retail**	**Office**	**Medical Office**	**Industrial**
Sycamore Glen/Mountain Vista	Established	479	200		25			
NW Chico Specific Plan Phase 1	Established	600	500		50			
Oak Valley Phase 1	Established	160						
Meriam Park Phase 1	Established	150	700		200	150		
Belvedere Heights	Established	192						
Tuscan Village	Established	155						
Foothill Park East 7	Established	65						
Wildwood Estates	Established	175						
Various Other Single Family	Established	176						
Various Other Multi Family	Established		18					
Villa Risa Apartments	Established		292					
Hartford Square	Established		58					
Valley Oak Vet Center	Established						13	
CVS	Established				14			
Sierra Nevada Brewery Security Building	Established					1		
NW Chico Specific Plan Phase 2	Established	180	200		250			
Oak Valley Phase 2	Established	1164			109			
Sierra Gardens Townhouses	Established		72					
Shastan @ Glenwood 2	Established	26						
Meriam Park Phase 2	Established	650	1000		300	250		
BCAG Transit Facility	Established					15		60
Mission Vista Ranch 2	Center	17						
Various Other Single Family	Center	22						
Westside Place	Center	140						
PARADISE								
Paradise Community Village PD Subdivision	Established	32	96					
Skyway Land Project PD Condominiums	Established		35					
Blackberry Knolls PD Subdivision	Established	44						
Valley Vista PD Subdivision	Established	14						
Baume Subdivision	Established	10						
Redbud Estates PD Subdivision	Established	16						
Nielson Estates Subdivision	Established	9						
Pheasant Ridge Commons	Established	2	24					
Walmart PD Subdivision, annexation, etc.	Established				200			
Northwest Assisted Living	Established						5	
Paradise Land Project PD Subdivision	Center	66						
Skyway Meadows PD Subdivision	Center	13			3			
Wendy's restaurant	Center				3			

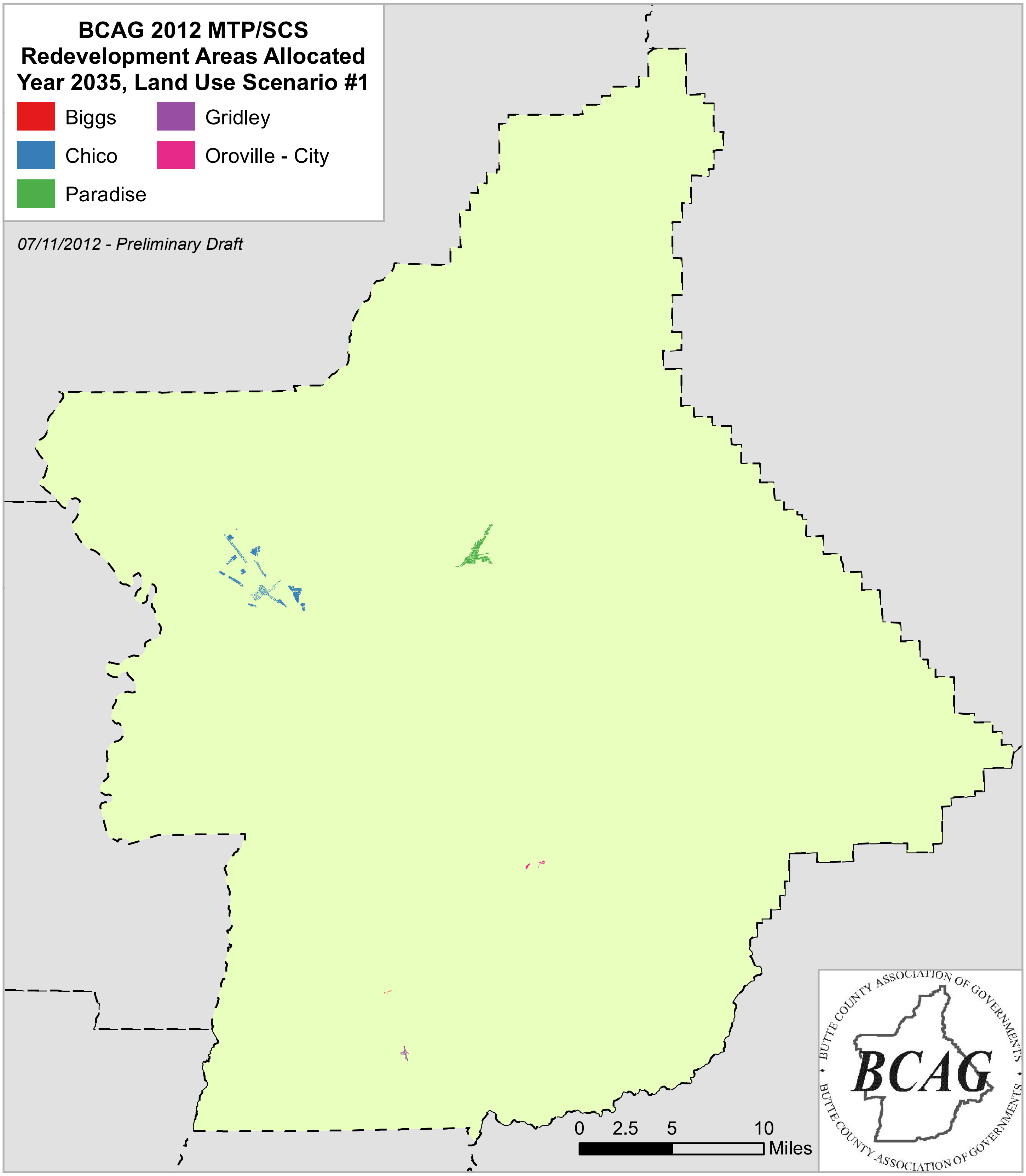
APPENDIX I-2. Continued

GRIDLEY	Growth Area	Single Fam	Multi Fam		Retail	Office	Medical Office	Industrial
Deniz Ranch	Established	465	196					
Little Property	Established	71						
Smith	Established	22						
West Biggs Gridley Road Property	Established	58						
Smith Parcel Map	Established	4						
Valley Oak Estates	Established	18						
North Valley Estates	Established	17						
Steffan Estates	Established	28						
Edler Estates	Established	25						
Butte Country Homes Unit 2	Established	70						
Huffman	Established	3						
Butte Country Homes Unit 1	Established	43						
Moss Parcel Map	Established	0			9	14		72
Gridley Industrial Park 1	Established	0						60
Gridley Industrial Park 2	Established	0						20
Various other Single Family	Established	123						
Qumar Estates	Center	19						
AutoZone	Center	0			47			
Ford and 99 Property	Center	0			6			
Spruce and Washington Property	Center	0			10			
BIGGS								
Sunwest Rice Mill Warehouse Expansion (Ind.)	Established	0						29
North Biggs Estates Project	Established	56	26					
Infill Development (various)	Established	15						
Summit Estates	New	53						
Eagle Meadows of Biggs	Established	17						
OROVILLE								
Oro Industrial Park	Established					10		400
Martin Ranch	Established	237						
Oak Park	Established	222						
Heritage Oaks	Established	79						
Ford Drive	Established	46						
Deer Creek	Established	79						
River View	Established	93						
Rivers Edge	Established	123						
Nelson 56	Established	197						
PEP Housing Project	Established		50					
Mission Olive Ranch	Established	19						
Super Walmart	Established				197			
Hillview Ridge Phase 2	Established		72					
Sierra Silca Sand Plant	Established					2		15
Merle Airport Hanger	Established							3
Community Action Agency	Established					10		20
2875 Feather River - Steel Building	Established							3
Calle Vista Unit 2 Phase 1	Established	43						
Acacia Estates	Established	20						
Highlands Estates	Established	32						
Buttewoods	Established	167						
Canel view Estates	Established	32						
Forebay Estates	Established	122	~~122~~					
Various other Single Family	Established	101						
Steve Horn Building	Center							2
Weichart Building	Center							1
Sonic Burger	Center				2			

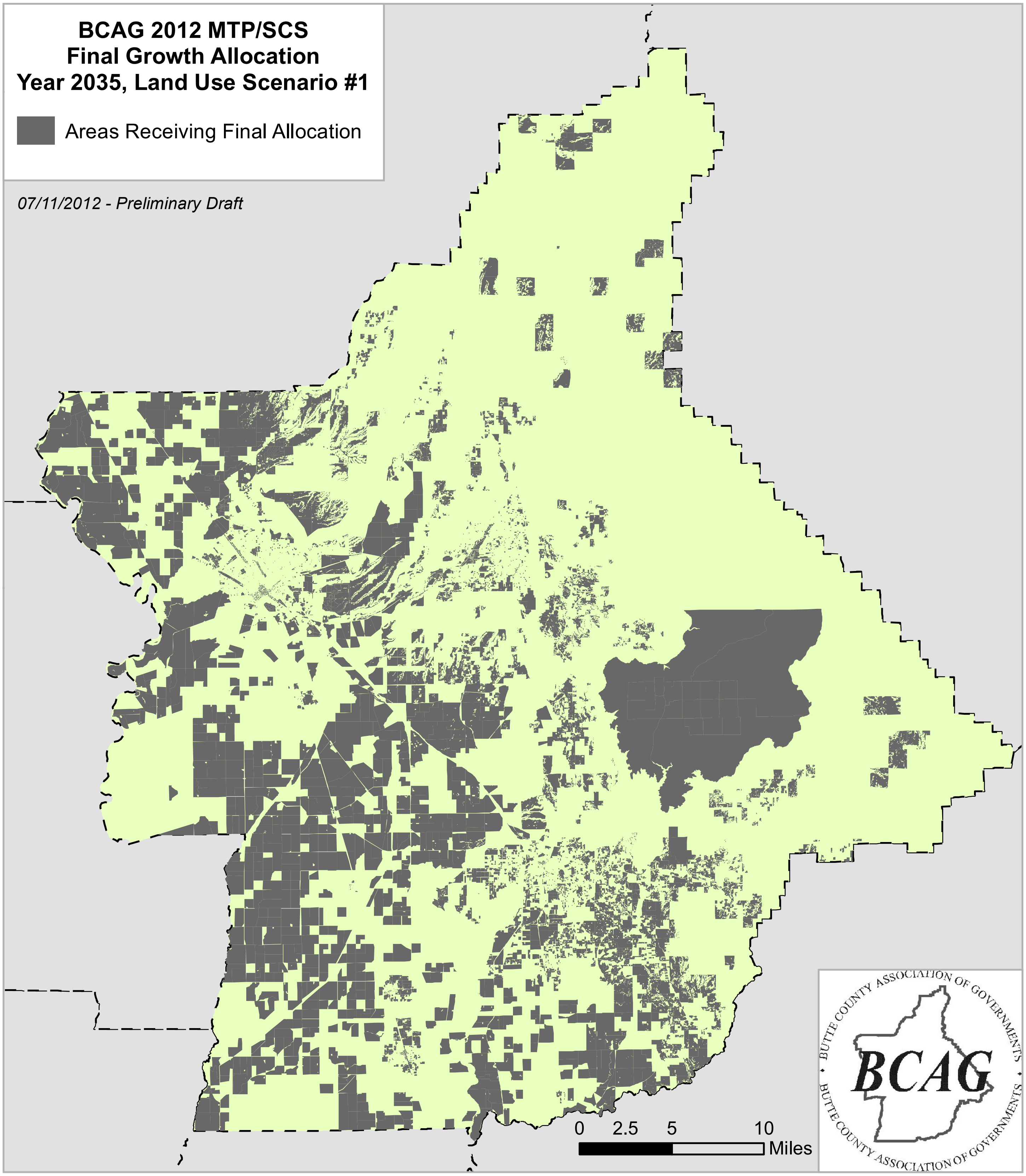
APPENDIX I-2. Continued

OROVILLE - COUNTY PORTION	Growth Area	Single Fam	Multi Fam		Retail	Office	Medical Office	Industrial
Rio d Oro	New	2045	655		248			
South Ophir Specific Plan	New	150	0					
Garden Drive Research & Business Park	Established	0	0			650		
M&T Subdivision	Established	29	0					
Tonriha Subdivision	Established	28	0					
Lincoln and Ophir	Established	65	125		120			
Southlands Subdivision	Established	174	0					
Vista Creek Estates	Established	156	0					
Monte Vista Estates	Established	97	0					
Monte Vista Park	Established	114	0					
COUNTY								
Valencia Estates	Agricultural	28	0					
Tuscan Ridge PUD	New	165	0					
Stringtown Mountain SP - A	New	166	32					
Stringtown Mountain SP - B	New	487	0					
Rancho Sol Tierra	Established	139	0		8			
Sierra Moon	Established	119	0					
Mandville Park	Established	26	0					
TSM 03-02	Established	24	0					
Paradise Summit PUD	Established	335	0					
North Chico SP (Established)	Established	780	0					
Upper Stilson Canyon	Rural	75	0					
Berry Creek Area Plan	Rural	30	0					
Emerald Sea Ranch	Rural	34	0					
Southeast Paradise SP	Rural	0	0					
Paradise Urban Reserve SP	Rural	0	0					
North Chico SP (Rural)	Rural	60	0					

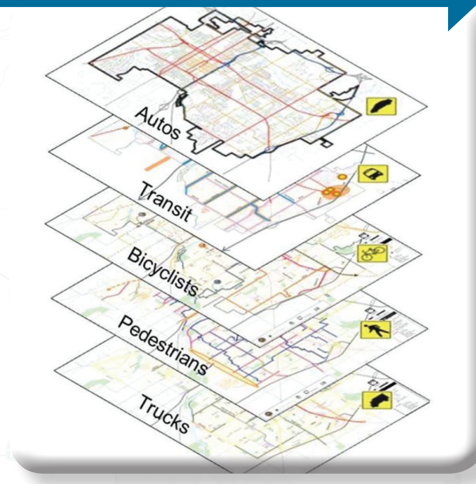
APPENDIX J.


BCAG 2012 MTP/SCS
Redevelopment Areas Allocated
Year 2035, Land Use Scenario #1
Biggs
Gridley
Chico
Oroville - City
Paradise
07/11/2012 - Preliminary Draft
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS

APPENDIX K.


BCAG 2012 MTP/SCS
Final Growth Allocation
Year 2035, Land Use Scenario #1
Areas Receiving Final Allocation
07/11/2012 - Preliminary Draft
0
2.5
5
10
Miles
BUTTE COUNTY ASSOCIATION OF GOVERNMENTS
BCAG

APPENDIX 6 - ATTACHMENT 2



| December 2012

BCAG Travel Demand Forecasting

Final Model Development Report

Prepared For:

Butte County Association of Governments

Prepared By:

FEHR & PEERS
2990 Lava Ridge Court
Suite 200
Roseville, CA 95661

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INTRODUCTION

The purpose of this report is to describe the Butte County Association of Governments' (BCAG) Travel Demand Forecasting (TDF) model update. This report explains the general model development process from data collection through calibration and final validation. Detailed information about key model update refinements can be found in Appendices A-D.

BACKGROUND

BCAG has maintained a TDF model to support long-range transportation planning efforts and to provide a mechanism for evaluating the potential effects of future land development and transportation improvement projects. The last update of the BCAG model occurred in 2008 at which time the model was converted to the TransCAD modeling software package and was calibrated to year 2006 conditions. This latest model update focused on improving the accuracy and sensitivity of the trip generation sub-model, operationalizing the 4D built environment trip adjustments, adding a direct ridership model for transit forecasting, and re-validating the model to year 2010 conditions.

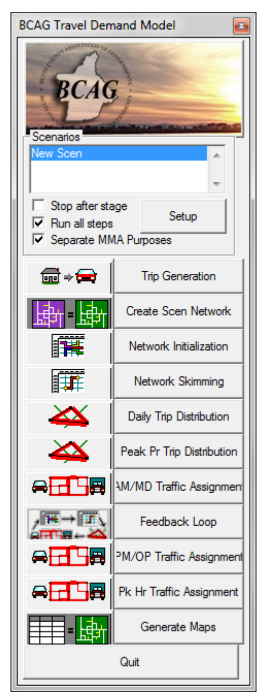
MODEL OVERVIEW

Like the previous version of the BCAG TDF Model, this version is a three-step model consisting of Trip Generation, Trip Distribution, and Trip Assignment. A Mode Choice component was not included in the model process. However, as part of this update, an off-model direct ridership forecasting tool was developed to allow BCAG and member agencies to test the effects of changes to the existing transit system. The model was updated to run in TransCAD version 5.0 Build 1695.

MODEL INTERFACE

The Graphical User Interface (GUI) developed for the BCAG TDF Model was built to conveniently allow the user to run the model with the click of a button, without going into detailed menus or components of the TransCAD program. The GUI closely follows the stages in the model and gives the user the ability to run one stage of the model at a time or run the entire model system by the click of a button.

The figure shows the TransCAD based GUI, programmed with TransCAD's GISDK scripting language.



STUDY AREA

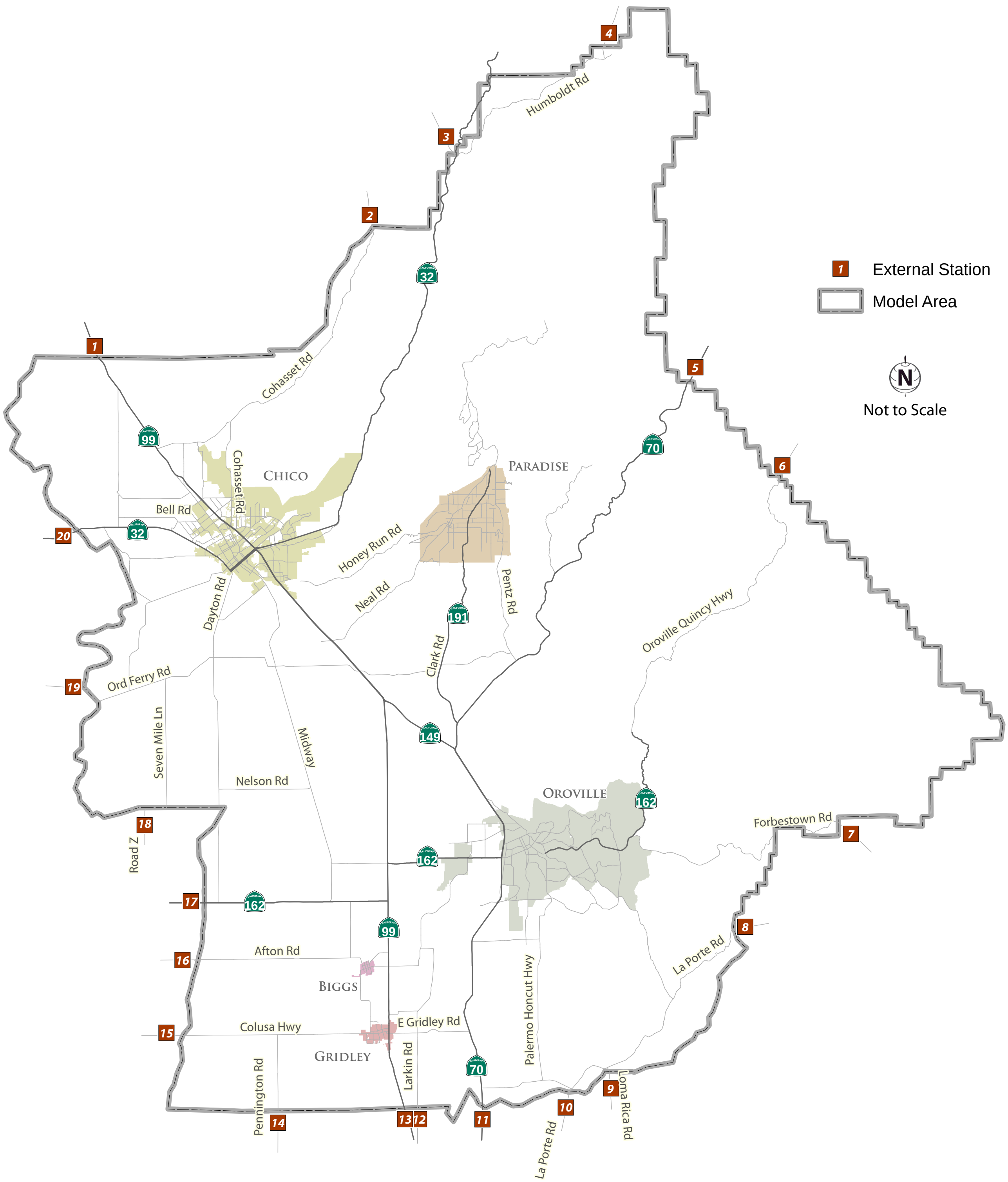
The model area for the BCAG TDF Model encompasses Butte County, which includes the cities of Chico, Paradise, Oroville, Biggs, and Gridley. Figure 1 shows the BCAG TDF model area. To represent travel into and out of Butte County, the model also includes 20 "external gateways" at major roads that cross the county line.

NEW ENHANCEMENTS & UPDATES

Several enhancements have been made to the BCAG TDF Model.

- New 2010 socioeconomic data inputs (e.g., households and employment)
- Updated roadway classifications to be consistent with the 2008 RTP
- New 2010 traffic counts
- Updated TransCAD user interface and additional automated functions;
- Enhanced trip generation sub-model to add sensitivity for age of head of household, number of workers, income, household size, and cost of travel
- Addition of multiple time periods – Daily, AM peak period, AM peak hour, PM peak period, PM peak hour, mid-day period, and evening period
- Implementation of the 4D's – Density, Diversity, Design, and Destination
- New transit direct ridership forecasting tool
- Updated EMFAC post-processor
- Updated 2020 and 2035 forecast years

These updates are described in detail within the document.



Fehr & Peers

MODEL AREA

FIGURE 1

\\fpse2\data2\2010Projects\RS_Projects\RS10_2809_BCAG_Model_Update\mxd\Model_Area_2.mxd

SUMMARY OF THE INPUT DATA

DATA COLLECTION

All of the model's input data was updated to 2010 conditions. In some cases, this effort was limited to modifying existing data to reflect changes since 2006 such as the addition of new lanes to an existing roadway. In other cases, new data had to be developed for the enhanced trip generation sub-model and the direct ridership forecasting model. Specific data and associated sources are listed below.

- Vehicle volume, classification, and speeds were collected for over 200 roadway segments from data compiled by Caltrans and purchased from a private vendor
- Department of Finance (DOF) housing estimates
- Employment Development Department (EDD) employment estimates
- California Statewide Household Travel Survey, 2001
- 2000 Census Bureau data
- Butte Regional Transit ridership data
- BCAG parcel and building footprint land use data
- 2010 Info USA employment data

LAND USE DATA

Land use data is one of the primary inputs to the BCAG model, and this data is instrumental in estimating trip generation. The model's primary source of land use data is BCAGs residential, school, and commercial parcel and footprint datasets (maintained in a GIS format). Each database provides information on the existing level of development within the county and is aggregated to the model's traffic analysis zones (TAZs). A detailed explanation of the TAZ system is provided below.

The land use data in the model is divided into a variety of residential and non-residential categories. The BCAG model employs 17 land use data categories, as shown in Table 1.

TABLE 1 – BCAG MODEL LAND USE CATEGORIES		
Model Land Use	**Land Use Description**	**Units**
SF_DU	Single-Family Residential	Dwelling Units
MF_DU	Multi-Family Residential	Dwelling Units
MH_DU	Mobile Home Residential	Dwelling Units
RET_KSF	Neighborhood-Serving Retail	1,000 Square Feet
RRET_KSF	Region-Serving Retail	1,000 Square Feet
IND_KSF	Industrial	1,000 Square Feet
OFF_KSF	Office	1,000 Square Feet
MED_KSF	Medical Office	1,000 Square Feet
HOSP_KSF	Hospital	1,000 Square Feet
PQP_KSF	Public-Quasi Public	1,000 Square Feet
HOTEL_RMS	Hotels	Rooms
UNIV_STU	University	Students
CC_STU	Community College	Students
K12_STU	K-12 Schools	Students
PARK_AC	Park	Acres
CASINO_SLT	Special Generator for Casino	Slots
CASINO_PRD	External Trip Distribution for Casino (Trips from outside Butte County that go to local Casinos)	Vehicle Trips
Source: 2010 BCAG TDF Model		

TRAFFIC ANALYSIS ZONE SYSTEM

Travel demand models use TAZs to subdivide the study area for the purpose of connecting land uses to the street network. TAZs represent physical areas containing land uses that produce or attract vehicle-trip ends. The TAZ structure and detail from the previous model was deemed sufficient for this update. Therefore, the 2010 model TAZ system maintains 962 zones in the model area, of which 912 zones cover Butte County and the remaining 50 are extra zones available for use in more detailed project analyses. Also included in the TAZ structure are external stations or gateways, which are points where major roadways provide access into the model area (see Figure 1 for specific locations). The external gateways represent all major routes by which traffic can enter or exit the study area and capture the traffic entering, exiting, or passing through the model area.

STREET NETWORK

The street network for the base year condition was originally developed in the 2008 TDF model update from a Butte County GIS centerline file provided by BCAG. The model street network includes all freeways, state highways, arterials, collectors, and local roads within the study area (see Figure 1). The functional classifications were updated for approximately 280 roadways throughout the County to be consistent with the 2008 RTP. The major street categories are described below.

Freeways

Freeways are high-capacity facilities that primarily serve longer distance travel. Access is limited to interchanges typically spaced at least one mile apart. State Route (SR) 70 and SR 99 are the major freeways in the Butte County. Portions of SR 149 that connects SR 70 and SR 99 are also designed to freeway standards.

Expressways

Expressways are high-capacity facilities that primarily serve intermediate distance travel between intercity destinations. Access is limited, but not to the extent of freeways and travel lanes may or may not be divided. Portions of SR 70, SR 99, and SR 149 are classified as expressways in Butte County.

Arterials

Roadway segments classified as Arterials are major roads that provide connections within cities, between cities and neighboring areas, and through the cities (cut-through traffic) of Butte County. Arterials in Butte County typically have one or two lanes in each direction, with travel speeds of 30-40 miles per hour (mph). Examples of these arterials are East Avenue in Chico, Clark Road in Paradise, and Olive Highway in Oroville.

Collectors

Collectors are facilities that connect local streets to the arterial and highway system, and may also provide direct access to local land uses. Collectors typically have one lane in each direction, with speeds of 25-35 mph. Examples of these collectors are Ceres Avenue in Chico, Nunneley Road in Paradise, and Myers Street in Oroville.

Local Streets

Local Streets primarily feed collector roads and are typically one lane in each direction, with speeds of 20-25 mph. These streets provide more realistic loadings to larger roadways in the TDF model network, and may not accurately represent the actual volumes experience on an average day. Examples of these collectors are Chestnut Street in Chico, Roe Road in Paradise, and Hilldale Avenue in Oroville.

For each record, the street network database includes a street name, distance, functional class, speed, capacity, and number of lanes. These attributes were checked using maps, aerial photographs, and other data provided by Butte County. Where necessary, these values were adjusted at specific locations to reflect current conditions as part of the model validation. Table 2 shows the initial roadway capacities used for each roadway functional class in the model.

TABLE 2 – ROAD CAPACITY BY FUNCTIONAL CLASSIFICATION

Roadway Classification	Capacity (vehicles per hour per lane)
Freeway Mainline	1,600 - 1,800
Freeway Ramp	1,700
Expressway (4 Lanes)	1,500
Expressway (2 Lanes)	1,400
Arterial	800
Collector	700
Local	600
Centroid Connector[1]	10,000

[1] Centroid connectors are abstract representations of the starting and ending point of each trip. Capacity is set significantly higher than other model links to prevent travel times from being affected by capacity on these abstract links.

Both existing roadways and future roadway improvements are coded into one master network. The master network concept helps manage the model network files. Users will not need to perform the same edits in different network scenarios. The future road improvements can be turned on and off by changing the construction year field in the master network.

MODEL ESTIMATION AND CALIBRATION PROCESS

Model estimation involves specifying the mathematical formulations and calculations such that the model's output matches or fits observed travel data. Most of the BCAG model was already specified. New estimation effort though was required for the enhanced trip generation sub-model and the transit direct ridership model. These components were calibrated through an iterative process of model testing and refining of model parameters to achieve appropriate matches between model estimates and measured travel demand. This section provides a general description of the estimation and calibration steps and the adjustments made during the process.

TRIP GENERATION

Residential Trip Generation

This update to the BCAG model enhanced the residential trip generation sub-model from one that relied exclusively on land use as the independent variable to one that now considers land use, demographic, and socioeconomic factors in a cross-classified formulation. For this model update, the trip generation rates for single family and multi-family homes have been expanded to represent the different trip making characteristics of a variety of households within Butte County based on the following characteristics.

- Household size
- Number of workers
- Household income

Table 3 displays the cross-classified residential vehicle trip rates for single family homes. Table 4 displays the vehicle trip generation rate for multifamily homes.

TABLE 3 – SINGLE FAMILY DAILY VEHICLE TRIP GENERATION RATES

Household Size	Number of Workers	Income					
		<$10K	$10K - $25K	$25K - $45K	$45K - $75K	$75K - $125K	>$125K
1	0	2.82	2.89	2.97	3.28	3.34	3.37
	1	3.61	3.70	3.80	4.20	4.28	4.32
	2	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A
	4+	N/A	N/A	N/A	N/A	N/A	N/A
2	0	5.62	5.66	5.78	5.82	5.88	5.92
	1	6.15	6.19	6.32	6.36	6.43	6.47
	2	6.53	6.69	6.88	7.60	7.74	7.81
	3	N/A	N/A	N/A	N/A	N/A	N/A
	4+	N/A	N/A	N/A	N/A	N/A	N/A
3	0	8.67	8.73	8.91	8.97	9.06	9.12
	1	9.31	9.38	9.58	9.65	9.75	9.82
	2	10.30	10.37	10.59	10.66	10.77	10.84
	3	10.58	10.66	10.89	10.97	11.08	11.16
	4+	N/A	N/A	N/A	N/A	N/A	N/A
4+	0	13.17	13.26	13.54	13.63	13.77	13.86
	1	15.85	15.87	15.88	15.90	15.92	15.92
	2	15.93	16.04	16.21	16.27	16.44	16.50
	3	16.63	16.75	17.10	17.22	17.40	17.52
	4+	17.57	17.69	18.06	18.18	18.37	18.50

Source: Fehr & Peers, 2011

TABLE 4 – MULTIFAMILY DAILY VEHICLE TRIP GENERATION RATES

Household Size	Number of Workers	Income					
		<$10K	**$10K - $25K**	**$25K - $45K**	**$45K - $75K**	**$75K - $125K**	**>$125K**
1	0	2.23	2.29	2.35	2.59	2.64	2.66
	1	2.85	2.93	3.00	3.32	3.38	3.42
	2	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A
	4+	N/A	N/A	N/A	N/A	N/A	N/A
2	0	4.44	4.48	4.57	4.60	4.65	4.68
	1	4.86	4.89	5.00	5.03	5.08	5.12
	2	5.16	5.29	5.44	6.01	6.12	6.18
	3	N/A	N/A	N/A	N/A	N/A	N/A
	4+	N/A	N/A	N/A	N/A	N/A	N/A
3	0	6.86	6.90	7.05	7.09	7.16	7.21
	1	7.36	7.42	7.58	7.63	7.71	7.77
	2	8.15	8.20	8.37	8.43	8.52	8.57
	3	8.37	8.43	8.61	8.67	8.76	8.83
	4+	N/A	N/A	N/A	N/A	N/A	N/A
4+	0	10.41	10.49	10.71	10.78	10.89	10.96
	1	12.53	12.55	12.56	12.57	12.59	12.59
	2	12.60	12.68	12.82	12.87	13.00	13.05
	3	13.15	13.25	13.52	13.62	13.76	13.85
	4+	13.89	13.99	14.28	14.38	14.53	14.63

Source: Fehr & Peers, 2011

These cross-classified trip generation rates help to explain the differences in trip generation that are observed in different parts of the BCAG region. The mobile home category was not expanded because there is not sufficient data on how mobile home characteristics (household size, number of workers, and income) vary. In general, the trip generation rates presented in Tables 4 and 5 were developed from base vehicle trip generation rates developed by the Sacramento Area Council of Governments (SACOG). The SACOG rates were then calibrated to BCAG conditions using observed trip generation data collected in a variety of locations across Butte County. This was accomplished by cordoning off select residential areas and measuring the vehicle trips entering and leaving. The measured vehicle trips were then divided by the number of occupied residential units to develop an aggregate vehicle trip rate. Details on the development and application of the cross-classified trip generation rates can be found in Appendix A.

Non-Residential Trip Generation

Only limited changes were made to the non-residential trip generation component of the previous BCAG TDF model. The primary source for non-residential trip generation rates in the BCAG TDF model was *Trip Generation, 8th Edition* (Institute of transportation Engineers [ITE], 2008). This reference document contains national averages of vehicle trip generation rates for a variety of land uses in what are generally suburban locations. These rates were calibrated for major non-residential land uses such as prominent retail centers and institutions within Butte County using a methodology similar to that explained above for residential uses. Table 5 displays the final non-residential trip rates.

TABLE 5 – NON-RESIDENTIAL USE DAILY TRIP GENERATION RATES

Land Use Category	Unit	Daily Vehicle Trip Generation Rate
Neighborhood-Serving Retail	1,000 Square Feet	42.94
Region-Serving Retail	1,000 Square Feet	47.63
Industrial	1,000 Square Feet	3.70
Office	1,000 Square Feet	11.69
Medical Office	1,000 Square Feet	33.76
Hospital	1,000 Square Feet	16.50
Public-Quasi Public	1,000 Square Feet	8.00
Hotels	Rooms	6.23
University	Students	2.38
Community College	Students	1.16
K-12 Schools	Students	1.54
Park	Acres	1.59
Special Generator for Casino	Slots	5.18

Source: Fehr & Peers 2011

Trip Purposes

Trip generation rates are initially defined for total trips and later split by trip purpose. Each trip has two ends, a "production" and an "attraction." By convention, trips with one end at a residence are defined as being "produced" by the residence and "attracted" to the other use (workplace, school, retail store, etc.), and are called "Home-Based" trips. Trips that do not have one end at a residence are called "Non-Home-Based" trips.

There are five trip purposes used in the BCAG model:

1. Home-Based Work (HBW): trips between a residence and a workplace.
2. Home-Based Other (HBO): trips between a residence and any other destination.
3. Non-Home-Based (NHB): trips that do not begin or end at a residence, such as traveling from a workplace to a restaurant, or from a retail store to a bank.
4. School (SCHOOL): trips to and from a school.
5. Casino (CASINO): trips to and from a casino.

To determine the appropriate proportion of trips that fall into each purpose, the California Household Travel Survey was used. This survey was conducted statewide and provides a complete summary of daily household trip making, which can be used to determine the specific trip purpose proportions. More details are provided below in the discussion of trip production and attraction balancing since this is also related to each trip purpose.

Production and Attraction Balancing

Local trips (internal-to-internal, or I-I) are trips that both start and end in the study area. One of the basic assumptions of any travel model is that the total number of local trips produced is equal to the total number of local trips attracted. It is logically assumed that if a journey is started, it must also have an end. If the total productions and attractions are not equal, the model will typically adjust the attractions to match the productions, thus ensuring that each departing traveler finds a destination. While it is never possible to achieve a perfect match between productions and attractions prior to the automatic balancing procedure, the existence of a substantial mismatch in one or more trip purposes indicates that either land use inputs or trip generation factors may be in error. Therefore, in developing the trip productions and attractions for the BCAG TDF Model, a careful pre-balancing was conducted outside the model stream to minimize possible errors.

Table 6 summarizes the local trip productions and attractions from the BCAG TDF model for each trip purpose, prior to the application of the automatic balancing procedure. Guidelines published by Federal Highway Administration's Transportation Model Improvement Program (TMIP) and National Highway Cooperative Research Program (NCHRP) suggest that, prior to balancing, the number of productions and attractions should match to within plus or minus 10% (i.e., the production-to-attraction ratio should be within the range of 0.90 to 1.10). The results shown in Table 6 indicate that the model meets the published guidelines for all trip purposes.

TABLE 6 – TRIP PRODUCTION TO ATTRACTION RATIOS BY PURPOSE

Trip Purpose	Production/Attraction Ratio	Percent of Total Daily Vehicle Trips	
		BCAG TDF Model[1]	California[2]
Home-Based Work (HBW)	0.98	20%	21%
Home-Based Other (HBO)	0.99	50%	48%
Non-Home-Based (NHB)	1.00	30%	31%
Total		100%	100%

1. Centroid connectors are abstract representations of the starting and ending point of each trip.
2. 2001 California Statewide Household Travel Survey Final Report, June 2002.

Trip Generation Sensitivity

In addition to the trip generation components described above, certain enhancements were added to the BCAG TDF model to better capture local trip making characteristics and provide the ability to test certain policy options for future development scenarios. These enhancements include adjustments for residential and non-residential vacancy rates and adding sensitivity for the cost of travel, smart growth development, and changes to the transit system.

<u>Vacancy Rates</u>

An important new feature of the trip generation sub-model is the ability to reflect varying levels of occupancy for residential and non-residential buildings. Occupancy levels of existing buildings have declined due to the 2008/09 recession and had not yet recovered in 2010. Occupancy levels were established as part of the production and attraction balancing step described above supplemented with observed conditions from BCAG staff at a handful of commercial sites in Oroville and Chico.

In general, it was necessary to set non-residential occupancy levels at 80 percent countywide such that the observed traffic counts matched model output (see more on matching traffic counts in the Model Validation section of this document). However, several areas, including locations in Paradise, Eastern Butte County, and Oroville, had lower occupancy rates (between 30 and 70 percent) based on BCAG staff observations and local traffic counts. Two TAZs in Paradise had an occupancy rate of 100 percent to match observed traffic counts. Residential occupancy rates were set at 0.80 in the eastern portion of Butte County to match observed traffic volumes. There were also a handful of TAZs in southeast Butte County and south of Durham that had lower occupancy rates – typically of 65 percent. The residential occupancy rate in the remainder of the County was set at 100 percent. This reduction in occupancy assumed to reflect the higher levels of vacation/seasonal homes in the eastern portion of the county. Figures 2 and 3 show the non-residential and residential occupancy rates by TAZ.

This new factor can be adjusted by the user to test different future scenarios where occupancy levels can be maintained at 2010 levels or adjusted to higher levels commensurate with conditions prior to the recession.

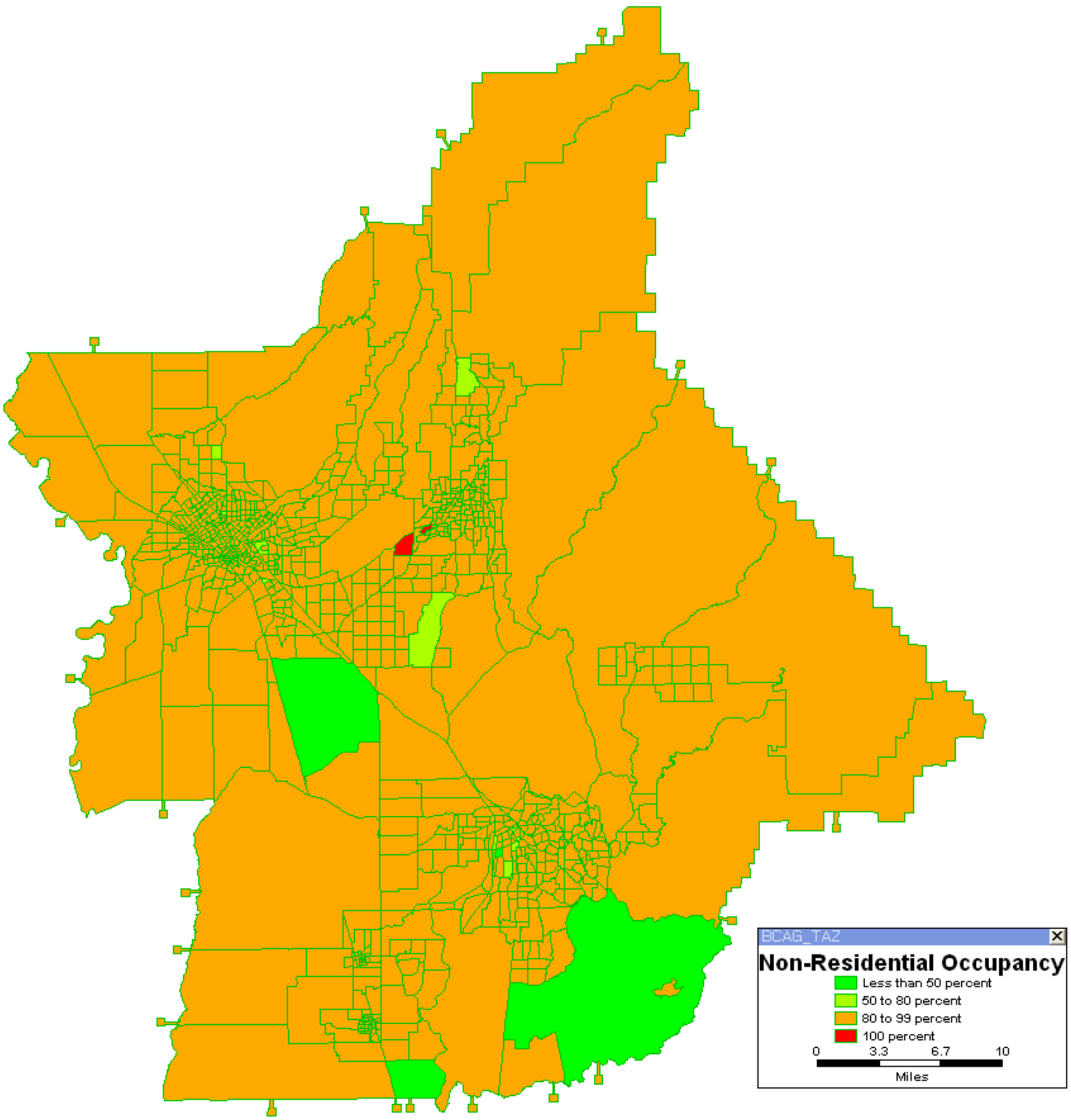


Figure 2 – BCAG Model Base Year Non-Residential Occupancy Rates

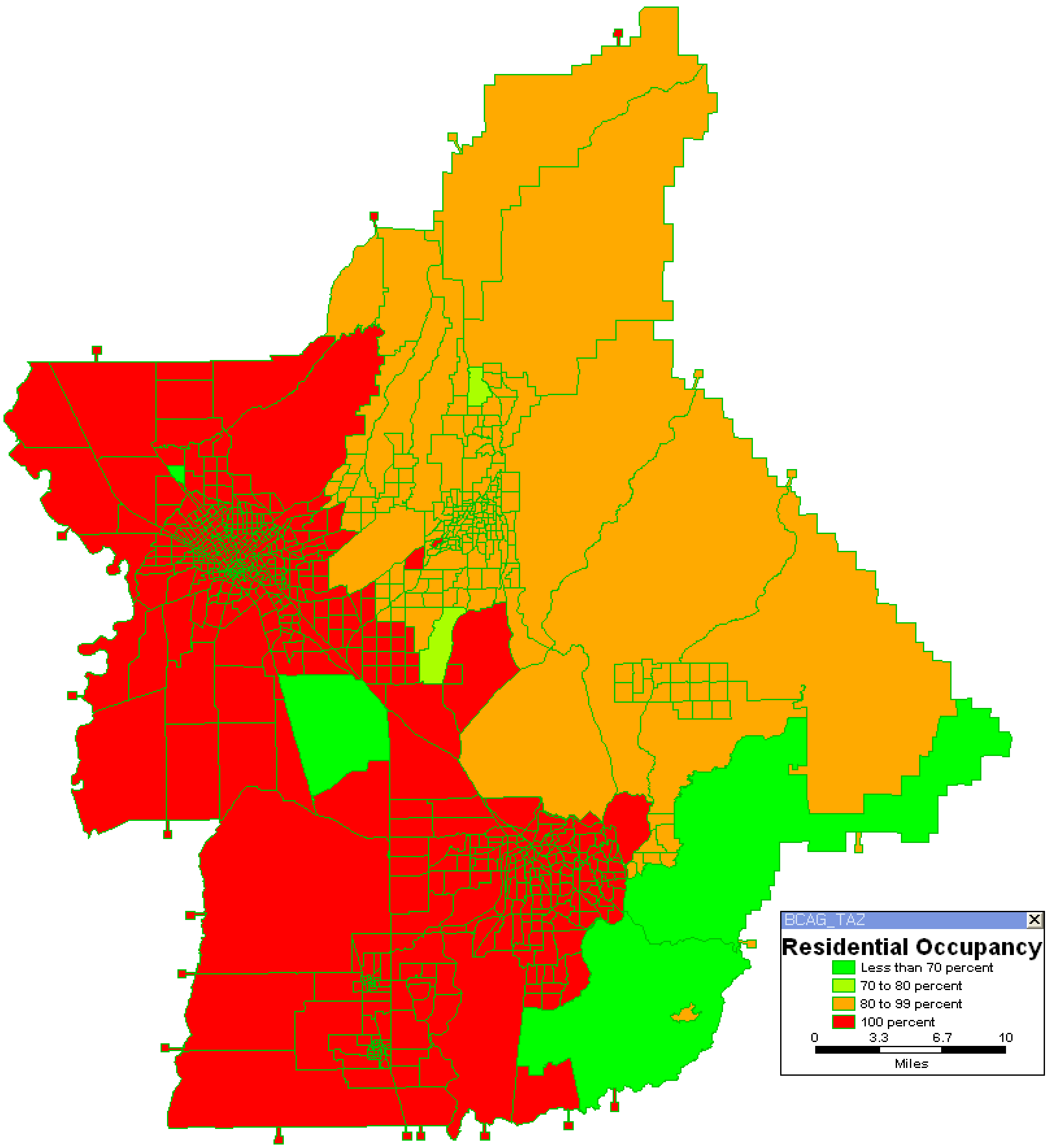


Figure 3 – BCAG Model Base Year Residential Occupancy Rates

<u>Cost of Travel</u>

Fuel prices are a major influence on travel since the price of gasoline or diesel is a substantial component to the overall cost of travel. It is the one cost most recognizable to drivers compared to infrequent costs like tire wear or oil changes. When determining the effects of fuel cost on travel, economists typically use the idea of price elasticity. In the case of fuel price elasticity, this represents the change in VMT with respect to the price of fuel. For example, a VMT/fuel price elasticity of -0.05 indicates that an increase in fuel prices of 10 percent would result in a 0.5 percent decline in VMT.

A fuel price sensitivity component was included in the BCAG TDF model during the trip generation process. However, this component is turned off for default model runs. Planners can turn on the component to test fuel price scenarios and evaluate how fuel prices impact travel outcomes. Details on the research and how to enable fuel price elasticity in the BCAG TDF model can be found in Appendix B.

<u>Built Environment Sensitivity</u>

The BCAG TDF model's ability to capture relationships between "sustainable" land use characteristics and transportation effects was enhanced to improve the VMT forecasts. Since future land use alternatives may be developed to follow sustainable planning principles, enhancing the model for smart growth sensitivity improves the model's ability to capture the potential effects these alternatives would have on vehicle travel. The model has been equipped with the 4Ds (Design, Diversity, Destinations, and Density), which are key built environment variables that have a proven influence on vehicle travel.

As part of the documentation associated with the future model development, Fehr & Peers will be fully describing the 4D component development process, however, the component generally works as follows:

- Step 1 – Calculate D Variables: The first step of the 4D adjustment process is to calculate the D variables across the entire BCAG model area. This task is handled in ArcGIS using detailed parcel-level[1] data from BCAG. Variables such as residential population density, employment population density, street network density, and job-housing diversity are all calculated. Destination accessibility is not calculated in ArcGIS since the BCAG model already considers this affect. The calculations are performed on relatively small grid cells that represent a walkable distance from homes and businesses in the model area. The grid cell data are then averaged to the TAZs within the model structure.

- Step 2 – Calculate Change in 4D Characteristics: The Step 1 calculations are performed for a baseline and alternative scenario. In this step, the change in 4D variables per TAZ between the baseline and alternative scenarios is determined using a spreadsheet. This change in 4D characteristics forms the basis of the trip generation adjustment performed in Step 3.

[1] The existing conditions D calculations were performed using parcel data. Future year D calculations relied on grid cell data from the BCAG Uplan model.

- Step 3 – Calculate and Apply the Trip Generation Adjustment: There is a wide array of literature describing how the 4Ds affect vehicle trip generation. One of the most widely cited sources of the relationship between trip making and the 4Ds is a paper written by Cervero and Ewing, *Travel and the Built Environment: A Meta-Analysis* (Journal of the American Planning Association, Summer 2010). Cervero and Ewing's paper summarized vehicle trip generation/built environment elasticities that were incorporated into the BCAG 4D component. The BCAG TDF model calculates the trip generation adjustment by multiplying the change in 4D characteristics per TAZ (calculated in Step 2) with the elasticities described above. The end result is a modified trip table which is then assigned to the roadway network.

TRIP DISTRIBUTION (GRAVITY MODEL)

Once the trip generation step has estimated the number of trips that begin and end in each zone, the trip distribution process determines the specific destination of each originating trip. The destination may be within the zone itself, resulting in an intra-zonal trip. If the destination is outside of the zone of origin, it is an inter-zonal trip. Inter-zonal trips consist of three types.

- Internal-internal (I-I) trips originate and terminate within the model area.
- Internal-external (I-X) trips originate within but terminate outside of the model area.
- External-internal (X-I) trips originate outside and terminate inside of the model area.

Trips passing completely through the model area are external-external (X-X).

The trip distribution model uses a gravity model equation to distribute trips to all zones. This equation estimates an accessibility index for each zone based on the number of attractions in each zone and a friction factor, which is a function of travel time between zones. Each attraction zone is given its share of productions based on its share of the accessibility index. This process applies to the I-I, I-X, and X-I trips. The X-X trips are added to the trip matrix prior to final assignment.

Friction Factors

Friction factors, also known as travel time factors, are used in calculating the relative attractiveness of each destination zone based on the travel time between TAZs and the number of potential origins and destinations in each TAZ. These factors are used in the trip distribution stage of the model. The BCAG TDF model friction factors are based on data reported in national modeling reference documents such as National Cooperative Highway Research Program (NCHRP) 365. See Appendix D for friction factor curves.

Trips between the Model Area and External Areas

One of the important inputs to a travel model is an estimate of the amount of travel between the study area and neighboring areas outside the model. These are typically called internal-external, or I-X/X-I, trips. Table 7 illustrates the distribution of work locations for Butte County residents and the distribution of residential locations for Butte County employees based on US Census Bureau results.

TABLE 7 – BUTTE COUNTY COMMUTING PATTERNS		
WORK LOCATIONS FOR BUTTE COUNTY RESIDENTS		
Year	**% Working Inside Butte County**	**% Working Outside Butte County**
2010	91%	9%
RESIDENTIAL LOCATIONS FOR BUTTE COUNTY EMPLOYEES		
Year	**% Living Inside Butte County**	**% Living Outside Butte County**
2010	95%	5%
Source: U.S. Census Bureau		

Based on this data, the proportion of HBW trips entering and leaving the study area was estimated. For non-work trip purposes, information from the 2001 California Household Travel Survey (CHTS)[2] was used to develop initial estimates of the percent of HBO and NHB trips that travel between Butte County and to other regions. The CHTS results used in the model are summarized in Table 8.

TABLE 8 – BUTTE COUNTY NON-COMMUTE TRAVEL PATTERNS			
Year	**% of Trips Remaining Inside Butte County**	**% of Trips to Butte County from Other Counties**	**% of Trips from Butte County to Other Counties**
2001	91%	4%	5%
Source: California Household Travel Survey, Caltrans 2001			

After the number of I-X/X-I trips was estimated, these trips were distributed to the external gateways around the perimeter of the model area using external station weights. External station weights were

[2] Note that this is the most recent version of the CHTS.

based on counts collected at each external station (these are roadway segments at the border of the model area). The number of through trips at each station was subtracted from the count and the remainder was filled in by I-X/X-I trips estimates.

Through Trips

Through trips (also called external-external, or XX trips) are trips that pass through the study area without stopping inside the study area. The major flows of through traffic in Butte County use SR 32, SR 70, and SR 99 with lower volumes of through traffic using other county roads. The size of these flows was estimated based on the previous version of the model, adjusted for any growth in traffic between 2006 and 2010.

TRANSIT DIRECT RIDERSHIP FORECASTING

While the BCAG TDF Model does not have a mode choice sub-model, a separate off-model process was developed to forecast transit ridership. The model uses transportation and land use data along bus lines to predict ridership. BCAG developed extensive data on the bus system and the land uses surrounding each bus line and bus stop. A series of direct ridership forecasting (DRF) models were developed and tested, using these data, to best fit the existing ridership levels based on land use and transit system information. Given the geographic and demographic diversity in the County, three separate DRF models were developed. The models can be used, not only to forecast future B-Line ridership, but to estimate the effect of rerouting existing lines, adjusting headways, or developing new bus lines in the County. Descriptions of these models, along with detailed information on their development, can be found in Appendix C.

TRIP ASSIGNMENT

The trip assignment process determines the route that each vehicle trip takes from a particular origin to particular destination. The model selects these routes in a manner that is sensitive to congestion and the desire of drivers to minimize overall travel time. It uses an iterative, capacity-restrained assignment, and volume adjustments are made that progress towards equilibrium. This technique finds a travel path for each trip that minimizes travel time, while taking into account congestion delays caused by the other simulated trips in the model. The trip assignment produces volumes for each roadway segment in the model for the following time periods.

- AM peak period
- AM peak hour
- PM peak period
- PM peak hour
- mid-day period
- evening period

Daily volumes are also produced but not through an assignment routine. Instead, daily volumes are created by summing the AM peak period, PM peak period, mid-day, and evening periods.

Turn Penalties

Turn penalties are used to prohibit or add delay to certain turning movements. The BCAG TDF model prohibits traffic from getting off a freeway ramp and then immediately getting back on. The model also prohibits traffic from making turns across impassable medians. In addition, the model does not allow U-turns to avoid counter-intuitive traffic routing.

MODEL VALIDATION

Model validation describes a model's performance in terms of how closely the model's output matches existing travel data in the base year. During the model development process, these outputs are used to further calibrate model inputs. The extent to which model outputs match existing travel data validates the assumptions of the inputs.

Traditionally, most model validation guidelines have focused on the performance of the trip assignment function in accurately assigning trips to the street network. This metric is called static validation, and it remains the most common means of measuring model accuracy.

However, models are seldom used for static applications. The most common use of models is to forecast how a change in inputs would result in a change in traffic conditions. Therefore, another test of a model's accuracy focuses on the model's ability to predict realistic differences in outputs as inputs are changed. This method is referred to as dynamic validation. This section describes the highest-level validation checks that have been performed for the BCAG TDF model.

STATIC VALIDATION

An important static measurement of the accuracy of any travel model is the degree to which it can approximate actual traffic counts in the base year. The *2010 California Regional Transportation Plan Guidelines*, California Transportation Commission, contains the following specific static validation criteria and thresholds that have been used to evaluate the BCAG TDF model performance.

- *At least 75 percent of the roadway links for which counts are available should be within the maximum desirable deviation*, which ranges from approximately 15 to 60 percent depending on total volume (the larger the volume, the less deviation is permitted).
- *A correlation coefficient of at least 0.88* - The correlation coefficient estimates the overall level of accuracy between observed traffic counts and the estimated traffic volumes from the model. This coefficient ranges from 0 to 1.0, where 1.0 indicates that the model perfectly fits the data.
- *The percent root mean square error (RMSE) below 40%* - The RMSE is the square root of the model volume minus the actual count squared, divided by the number of counts. It is a measure similar to standard deviation in that it assesses the accuracy of the entire model.

In addition to these criteria, the model-wide volume-to-count ratio was checked against a desired maximum threshold of no more than a 10 percent deviation. The validity of the BCAG TDF model was tested for 218 individual roadway segments under daily, AM peak hour, and PM peak hour conditions. The results are shown in Tables 9, 10, and 11.

TABLE 9 – RESULTS OF DAILY MODEL VALIDATION		
Validation Item	**Criterion of Acceptance**	**Model Results**
Model Wide Volume-to-Count Ratio	Within ± 10%	- 5%
% of Links Within Deviation Allowance	At Least 75%	81%
Correlation Coefficient	At Least 88%	93%
RMSE	40% or less	31%
Source: Fehr & Peers, 2011.		

TABLE 10 – RESULTS OF AM PEAK HOUR MODEL VALIDATION		
Validation Item	**Criterion of Acceptance**	**Model Results**
Model Wide Volume-to-Count Ratio	Within ± 10%	+1%
% of Links Within Deviation Allowance	At Least 75%	78%
Correlation Coefficient	At Least 88%	88%
RMSE	40% or less	40%
Source: Fehr & Peers, 2011.		

TABLE 11 – RESULTS OF PM PEAK HOUR MODEL VALIDATION		
Validation Item	**Criterion of Acceptance**	**Model Results**
Model Wide Volume-to-Count Ratio	Within ± 10%	+1%
% of Links Within Deviation Allowance	At Least 75%	75%
Correlation Coefficient	At Least 88%	91%
RMSE	40% or less	37%
Source: Fehr & Peers, 2011.		

In addition to these static tests, the BCAG TDF model's estimate of daily vehicle miles of travel (VMT) for Butte County was compared to independent estimates from the Highway Performance Monitoring System (HPMS). VMT values from HPMS are also a model estimate based on a limited set of existing traffic counts. The purpose of comparing these two estimates is to determine whether there is any significant difference that would require further investigation of either estimate. Table 12 contains the comparison results and shows that the BCAG TDF model estimates a daily VMT that is approximately one percent lower than the slightly older HPMS data. Given the economic recession and its impact on travel, the relatively small difference shown in Table 12 is not a concern.

TABLE 12 – DAILY VMT VALIDATION

Validation Item	HPMS (2009)	Model Results (2010)
Daily Model VMT	4,527,240	4,469,500
Source: Fehr & Peers, 2011.		

DYNAMIC VALIDATION

In addition to testing the BCAG TDF model for its ability to replicate existing traffic volumes, the model was dynamically tested. While reproducing existing conditions is important, it is also important to know that the model will produce stable and reasonable results when various inputs such as land use are changed. The following section presents a summary of the dynamic validation results.

Land Use and Network Changes

A basic form of dynamic validation is to vary the amounts of a particular land use type or make changes to the roadway network and compare the magnitude and direction of change from the original forecast. The specific dynamic validation tests completed for this model update are listed below.

- Add lanes to a roadway segment
- Remove lanes from a roadway segment
- Add a new roadway segment
- Delete a roadway segment
- Add 10, 100, and 1,000 households to a TAZ
- Remove 10 and 1,000 households from a TAZ
- Add and remove 100,000, and 500,000 square feet of retail to a TAZ

In addition to the test outlined above, Fehr & Peers also intends to test the BCAG TDF model's sensitivity to changes in the cost of travel. For these tests, the cost of travel will be varied by -10, 10, and 50 percent. These travel cost dynamic tests will be performed on the future year version of the BCAG TDF model.

The key model output variables involved in the dynamic validation tests are vehicle trips (VT) generated and vehicle miles of travel (VMT). The tests are intended to reveal whether the model output changes in the correct direction and magnitude. The dynamic validation results for the roadway network changes are summarized in Table 13 and the results for the land use changes are summarized in Table 14.

TABLE 13 – DYNAMIC VALIDATION: CHANGE IN ROADWAY NETWORK (DAILY DEMAND)

Roadway Change	Before Change		After Change	
	Changed Link	Screenline[1]	Changed Link	Screenline
Add one Lane to SR 32 (Yosemite Ave & SR 99)	16,643	20,133	17,537	20,714
Remove one Lane from Oro Dam Road (between Feather River Blvd and Olive Hwy)	22,634	41,351	20,670	40,752
New Road (New Bridge over Feather River, between SR 70 and Washington Ave Bridge)	0	38,232	10,128	39,719
Remove Road (Washington Ave Bridge Removed)	16,949	38,232	0	34,790

Note:
[1] Screenlines are as follows for each of the dynamic validation tests:
- Add Lanes: Esplanade to SR 99 N. of W. 3rd Ave
- Remove Lanes: Esplanade to SR 99 N. of W. 3rd Ave
- New Road: SR 70 & Washington Ave Bridges, across Feather River
- Remove Road: SR 70 & Washington Ave Bridges, across Feather River

Source: Fehr & Peers, 2011.

As shown in Table 13, the model behaves as would be expected in response to changes in the roadway network. For example, the addition of a lane on SR 32 between Yosemite Avenue and SR 99 leads to a slight increase in traffic on the link as well as across a screenline between Bidwell Park and Humboldt Road. Similarly, removing a lane from Oroville Dam Road between Feather River Boulevard and Olive Highway leads to an approximate 10 percent decrease in traffic along Oroville Dam Road but a smaller decrease across a screenline between the Feather River and Oroville Dam Road.

In the tests were new bridges were added over the Feather River in Oroville, the model also responded logically. When a new bridge crossing the Feather River was modeled, the overall screenline volumes increased; however, the new bridge experienced more growth the screenline as a whole. This result makes sense since it shows that the new bridge would provide congestion relief to other routes while inducing more overall traffic flow across the river.

TABLE 14 – DYNAMIC VALIDATION: CHANGE IN LAND USES					
Land Use Change	**Change in TAZ Trip Generation**	**Model-wide Changes**			
		Vehicle Trips	**Vehicle Trips/DU or KSF**	**VMT**	**VMT/DU or KSF**
Add 10 Households	+69	737,855	7.82	4,397,868	46.6
Add 100 Households	+685	738,461	7.82	4,398,738	46.6
Add 1,000 Households	+6,854	744,523	7.81	4,408,933	46.2
Remove 10 Households	-70	737,717	7.81	4,397,701	46.6
Remove 1,000 Households	-6,870	729,137	7.80	4,390,904	47.0
Add 100 KSF of Retail	5,811	737,030	17.55	4,414,662	105.1
Add 500 KSF of Retail	18,125	742,171	17.60	4,486,657	105.8
Remove 100 KSF of Retail	-2,398	736,910	17.58	4,381,504	104.8
Remove 500 KSF of Retail	-12,045	733,403	17.49	4,323,897	104.4
Source: Fehr & Peers, 2011.					

Table 14 shows the results of the dynamic land use validation tests. Similar to the roadway network tests, the model responds reasonably to changes in land uses. For example, when changing residential uses, the change in overall model vehicle trip generation and VMT is stable across the entire range and producing results that are reasonable (i.e., 7.8 vehicle trips per household and 46 VMT per household). In addition, the change in trip generation at the TAZ level is as expected with the increase/decrease in TAZ trip generation corresponding to the change in households (add versus remove households). The magnitude of vehicle trip generation at the TAZ level (approximately 6.9 vehicle trips per household) is reasonable given the socioeconomic characteristics of the test area in northeast Chico. The results of the retail dynamic tests were also reasonable.

FUTURE YEAR MODELS

FUTURE YEAR LAND USE GROWTH

BCAG prepared three land use growth scenarios to represent three distinct visions of regional development patterns in designated future years. All three scenarios were created using the same regional transit network and generally contain the same regional employment, population, and housing growth projections for their respective years – only with different geographical distributions. These scenarios are summarized in the following sections.

Scenario 1 - Balanced

- Prepared for future years 2020 and 2035
- Balanced share of new housing within the center, established and new growth areas
- Contains reasonable levels of infill and redevelopment
- Consistent with local land use plans and draft conservation plan
- Consistent with BCAG long-term regional growth forecasts by jurisdiction

Scenario 2 - Dispersed

- Prepared for future years 2035
- Largest share or single-family housing with a greater amount of growth directed to the new, rural, and agricultural growth areas
- Minimize the amount of infill and redevelopment
- Exceeds the unincorporated areas local land use plans reasonable capacities for growth

Scenario 3 - Compact

- Prepared for future years 2035
- Greatest share of infill and redevelopment within the established and center growth areas
- Highest share of multi-family housing
- Exceeds the incorporated areas local land use plans reasonable capacities for growth

PROCESSING THE FUTURE YEAR SCENARIOS

For each future year scenario, BCAG provided an ESRI shapefile containing land use growth (occurring after base model year 2010) by TAZ. Land use growth categories were identical to those included in the

2010 model and described in Table 1. It should be noted that mobile home growth was assumed to be zero for all future year scenarios.

Fehr & Peers extracted the land use growth data from the shapefiles and developed land use inputs for the future year model scenarios. First, single family and multifamily land use growth data were stratified by the same cross-classified independent variables categories described for the 2010 model and shown in Tables 3 and 4. It was assumed that the percent representation of each single family and multifamily category would not change from 2010 conditions. Then, all land use growth categories (including the residential stratifications) were added to the 2010 land use to determine future year land use totals.

Future year land use totals for each scenario are summarized in Table 15 with residential land use re-aggregated for display purposes. Table 16 summarizes the VMT generated by each of the scenarios. Note that the VMT results for the balanced and compact growth scenarios reflect Ds adjustments to account for the effect of built environment variables on vehicle travel.

TABLE 15 – FUTURE YEAR MODEL LAND USE SUMMARY

Model Land Use	Base Year	Scenario 1		Scenario 2	Scenario 3
	2010	2020	2035	2035	2035
SF_DU	56,648	67,843	90,690	95,174	87,662
MF_DU	24,682	28,677	38,150	33,690	41,114
MH_DU	13,019	13,019	13,019	13,019	13,019
RET_KSF	10,059	15,884	19,697	19,663	20,079
RRET_KSF	1,074	1,404	1,404	1,404	1,404
IND_KSF	10,550	16,330	19,799	20,475	19,093
OFF_KSF	6,342	9,353	11,820	11,641	11,828
MED_KSF	1,889	2,594	3,121	3,069	3,087
HOSP_KSF	842	1,221	1,578	1,578	1,578
PQP_KSF	1,679	2,409	3,119	3,119	3,119
HOTEL_RMS	1,972	2,340	2,961	2,961	2,961
UNIV_STU	17,000	18,110	20,000	20,000	20,000
CC_STU	12,200	14,453	18,288	18,288	18,288
K12_STU	31,010	36,006	49,409	49,871	49,409
PARK_AC	476	515	548	548	548
CASINO_SLT	1,900	2,322	3,040	3,040	3,040

Source: 2010 BCAG TDF Model

TABLE 16 – FUTURE YEAR MODEL VMT SUMMARY		
Model Scenario	**Year**	**Total VMT**
Base Year	2010	4,469,500
Scenario 1 – Balanced Growth	2020	5,318,700
	2035	6,932,100
Scenario 2 – Dispersed Growth	2035	7,449,800
Scenario 3 – Compact Growth	2035	6,588,500
Source: Fehr & Peers, 2011.		

MODEL LIMITATIONS

The BCAG TDF Model has been developed for regional planning purposes within a trip-based model framework. The model conforms to the recommendations outlined in the 2010 California Regional Transportation Guidelines for a Type B metropolitan planning organization (MPO), but does have limitations.

- The current structure has limited sensitivity to factors that may affect trip generation rates such as significant declines in economic activity. However, since the model has a land use occupancy component, economic cycles can be reflected in the assumed intensity of land uses within the model.
- Although the model network includes all local roadways, not all local roadways are assigned vehicle trips. Use of the model for local applications will require sub-area refinements and validation to ensure the model is appropriately sensitive to changes at this scale.
- Model parameters relying on household travel survey data are based on a small sample size. Future model updates would benefit from a larger sample of households in Butte County.
- The trip-based model structure does not allow for estimates of forecasts of vehicle trips (VT) or VMT generated by residential households or individual persons. Vehicle trips are assigned at the TAZ level and any connection to individual land uses that originally generated the trips are lost. VT and VMT can be expressed as ratios such as VMT per capita or VMT per household. But these ratios are based only on dividing total VMT by the number of people or households in the model area. It does not indicate the level of VT or VMT being generated.

APPENDIX A:
BCAG TDF MODEL TRIP GENERATION MEMORANDUM

FEHR & PEERS

MEMORANDUM

Date: July 27, 2011

To: Brian Lasagna, BCAG

From: Chris Breiland, Kwasi Donkor, and Ronald T. Milam, Fehr & Peers

Subject: Trip Generation Cross-Classification

RS10-2809

This memorandum describes the development of the cross-classified residential trip generation model for the BCAG regional travel demand forecasting (TDF) model. The previous version of the BCAG TDF model predicted vehicle trips based on simple single-class trip generation rates that vary for each residential unit type (single family, multi-family, mobile home). Single-class trip generation rates are common for smaller regional travel models used in California and elsewhere and have the advantage that they are simple to develop and apply. However, the simplicity of the single-class trip generation rates also limits a model's sensitivity to important household characteristics like the number of residents and income. For this model update, the trip generation rates for single family and multi-family homes have been expanded to represent the different trip making characteristics of a variety of households within Butte County based on the following characteristics.

- Household size
- Number of workers
- Household income

These so-called cross-classified trip generation rates are common for large MPO TDF models and help to explain the differences in trip generation that are observed in different parts of a region.

The mobile home category was not expanded because there is not sufficient data on how mobile home characteristics (household size, number of workers, and income) vary. Moreover, there are relatively few mobile homes in Butte County and we do not feel that the trip generation benefits would be worth the additional complexity associated with the cross-classified trip generation rates. This remainder of this memorandum explains how the trip generation rates were developed and how they will be applied in the BCAG TDF model.

Demographic Data Collection

The first step in developing the enhanced residential trip generation submodel was to obtain data from the US Census Bureau on the household characteristics listed above. The data were derived from block-group datasets and then aggregated to the model's traffic analysis zones (TAZs). A description of each variable is as follows:

Household Size (4 Categories):

- One-person households
- Two-person households
- Three-person households
- Four or more person households

Household Workers (4 Categories):

- One-worker households
- Two-worker households
- Three-worker households
- Four or more worker households

Household Income (6 Categories):

- < $10K
- $10K - $25K
- $25K - $45K
- $45K - $75K
- $75K - $125K
- >$125K

Each household in a block group was classified into a combination of the three demographic variables using the 2000 Census Transportation Planning Package (CTPP) Access Tool[1]. Multiple block groups within a TAZ were then aggregated to develop a "household distribution" for each TAZ. For example, a TAZ with 1,175 single family households may have been stratified by the various household characteristics shown in Table 1.

[1] The 2010 Census Bureau data was not available at the time this model was developed.

TABLE 1: LAND USE CROSS-CLASSIFICATION EXAMPLE							
Household Size	Number of Workers	Income					
		<$10K	$10K - $25K	$25K - $45K	$45K - $75K	$75K - $125K	>$125K
1	0	100	80	50	30	10	0
	1	0	55	50	10	10	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4+	0	0	0	0	0	0
2	0	15	65	20	0	0	0
	1	4	54	40	50	0	0
	2	0	14	45	24	20	0
	3	0	0	0	0	0	0
	4+	0	0	0	0	0	0
3	0	4	10	0	0	0	0
	1	0	25	19	4	0	0
	2	0	25	24	35	10	0
	3	0	0	0	0	0	10
	4+	0	0	0	0	0	0
4+	0	10	35	0	0	0	0
	1	0	35	25	15	4	10
	2	0	0	25	45	0	10
	3	0	10	25	10	0	4
	4+	0	0	0	0	0	0
	Subtotal	133	408	323	223	54	34
						Grand Total	1,175
Source: Fehr & Peers, 2011							

Trip Generation

With the household data stratified across the three 'classifications' of size, workers, and income, the next step was to develop corresponding trip generation rates. Initial person-trip rates were based on the residential cross-classification trip generation submodel contained in the SACMET TDF model developed by the Sacramento Area Council of Governments (SACOG). To convert to vehicle trip rates, the rates were adjusted based on a comparison to the previous model's overall vehicle trip generation. Table 2 shows an example of the BCAG model's residential cross-classified vehicle-trip generation rates. Please note that the vehicle trip generation rates will be adjusted and finalized during the calibration and validation stage of the model development effort.

FEHR PEERS

TABLE 2: SINGLE FAMILY VEHICLE TRIP GENERATION CROSS-CLASSIFICATION EXAMPLE							
Household Size	**Number of Workers**	**Income**					
		<$10K	**$10K - $25K**	**$25K - $45K**	**$45K - $75K**	**$75K - $125K**	**>$125K**
1	0	2.82	2.89	2.97	3.28	3.34	3.37
	1	3.61	3.70	3.80	4.20	4.28	4.32
	2	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A
	4+	N/A	N/A	N/A	N/A	N/A	N/A
2	0	5.62	5.66	5.78	5.82	5.88	5.92
	1	6.15	6.19	6.32	6.36	6.43	6.47
	2	6.53	6.69	6.88	7.60	7.74	7.81
	3	N/A	N/A	N/A	N/A	N/A	N/A
	4+	N/A	N/A	N/A	N/A	N/A	N/A
3	0	8.67	8.73	8.91	8.97	9.06	9.12
	1	9.31	9.38	9.58	9.65	9.75	9.82
	2	10.30	10.37	10.59	10.66	10.77	10.84
	3	10.58	10.66	10.89	10.97	11.08	11.16
	4+	N/A	N/A	N/A	N/A	N/A	N/A
4+	0	13.17	13.26	13.54	13.63	13.77	13.86
	1	15.85	15.87	15.88	15.90	15.92	15.92
	2	15.93	16.04	16.21	16.27	16.44	16.50
	3	16.63	16.75	17.10	17.22	17.40	17.52
	4+	17.57	17.69	18.06	18.18	18.37	18.50
Source: Fehr & Peers, 2011							

Next Steps

As part of the model validation stage we will verify that the vehicle trip generation resulting from the household distribution and cross-classified trip rates are reasonable when compared to the trip generation counts collected earlier this year within Butte County.

We hope this information was helpful. Please do not hesitate to contact us if you have any questions or comments.

APPENDIX B:
BCAG TDF MODEL FUEL PRICE MEMORANDUM

MEMORANDUM

Date: June 27, 2011

To: Brian Lasagna, BCAG

From: Chris Breiland, Kwasi Donkor, and Ronald T. Milam, Fehr & Peers

Subject: Fuel Price Elasticity Information

RS10-2809

As part of the BCAG TDF model update, we are including an option that will allow the TDF model to be sensitive to the expected increases in the cost of travel (specifically fuel prices) between 2010 and 2035. The following discussion summarizes the latest research on the effect of fuel prices in particular on vehicle miles of travel (VMT), with some discussion of other fuel price effects.

How Fuel Prices Affect Travel

Fuel prices are a major influence on travel since the price of gasoline or diesel is a substantial component to the overall cost of travel and the one cost most recognizable to drivers compared to infrequent costs like tire wear or oil changes. When determining the effects of fuel cost on travel, economists typically use the idea of price elasticity. In the case of fuel price elasticity, this represents the change in VMT with respect to fuel prices price. For example, a VMT/fuel price elasticity of -0.05 indicates that an increase in fuel prices of 10 percent would result in a 0.5 percent decline in VMT.

VMT/Fuel Price Elasticities Relevant for California

Two studies of VMT/fuel price elasticity are particularly relevant for travel modeling in California.

- The Congressional Budget Office (http://www.cbo.gov/ftpdocs/88xx/doc8893/01-14-GasolinePrices.pdf) examines highway vehicle flow data from 13 locations around California, intended to represent traffic conditions in California's major metropolitan areas, from 2003 to 2006. The CBO finds a VMT/fuel price elasticity of -0.02 for all weekday VMT and an elasticity of -0.035 for weekday VMT at study locations that specifically had a parallel rail transit option. Weekend VMT effects are not significant.

- Gillingham (2010, http://www.stanford.edu/~kgilling/Gillingham_JMP.pdf) analyzes data from California odometer readings taken at smog checks from 2005 to 2008. He finds medium-run ("roughly two years") VMT/fuel price elasticities ranging between -0.15 and -0.2.

Other VMT/Fuel Price Elasticities

Several other studies address VMT/fuel price elasticities, but are less appropriate for use with current California travel models due to different time periods, different geographic contexts, or methodological issues.

- Hanly et al. (2002, http://www2.cege.ucl.ac.uk/cts/tsu/papers/transprev243.pdf) find a short-run elasticity of -0.1 and a long-run elasticity of -0.3, comparable to the results of other United Kingdom-based studies.
    - Goodwin (1992, http://www.bath.ac.uk/e-journals/jtep/pdf/Volume_XXV1_No_2_155-169.pdf) finds short- and long-run elasticities of -0.16 and -0.33, respectively.
    - Graham and Glaister (2002, http://www.cts.cv.ic.ac.uk/documents/publications/iccts00007.pdf) find similar elasticities of -0.15 and -0.3. However, these results are based on U.K. and U.K.-comparable studies that might not be applicable in California.
- In the United States, Small and Van Dender (2006, http://www.economics.uci.edu /files/economics/docs/workingpapers/2005-06/Small-03.pdf) consider U.S. State-level data from 1966 to 2001, finding a short-run elasticity of -0.056 and a long-run elasticity of -0.296. The inclusion of older data in this study could over-estimate the magnitude of the fuel price effect, because fuel consumption has become more inelastic over time, possibly due to increased consumer dependence on automobiles, suburbanization, the rise of multiple-income households, or decreased availability of public transit (Hughes et al., 2006, http://www.econ.ucdavis.edu/faculty/knittel/papers/gas_demand_final.pdf).
- The Department of Energy (DOE, 1996) also reviews literature from the 1980s and 1990s, finding short-run elasticities in the range of -0.05 to -0.2 and long-run elasticities from -0.09 to -0.26. The DOE also notes the trend toward lower elasticities over time, so these results are consistent with the more recent short- and long-term elasticities from CBO (2008) and Gillingham (2010).
- Brand (2006, http://www.fhwa.dot.gov/policy/otps/innovation/issue1/impacts.htm) considers aggregate, U.S. VMT and fuel price data to calculate short-run elasticities of -0.21 to -0.30. Rather than an econometric analysis, Brand uses a simple “but-for” methodology that uses only 4 data points, adjusted for what he considers to be the long-term, secular trend in VMT growth.

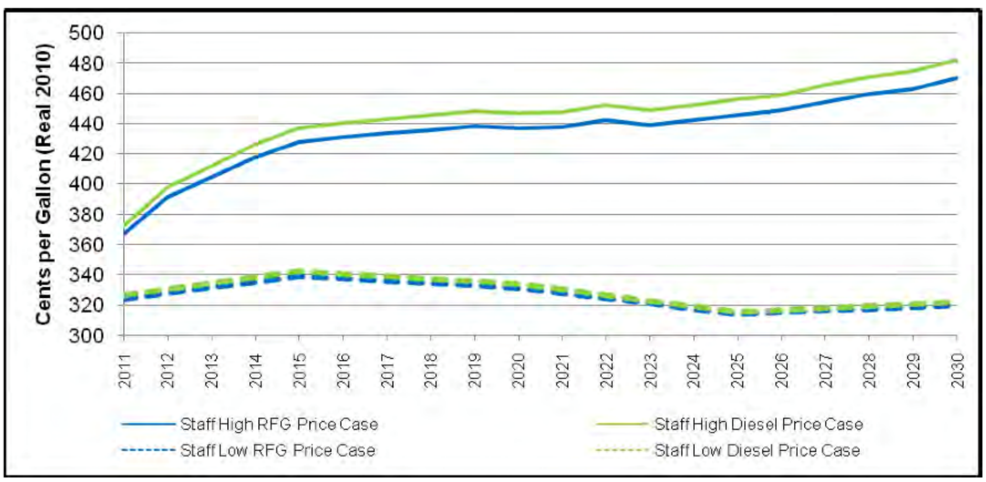
Summary

As described above, there has been a wide range of study related to the effect of fuel price on vehicle travel. The studies listed above employ a variety of methodologies and sample sizes and cover a variety of time spans and geographic locations. However, despite these differences, most of the studies conclude that the long-term elasticity of VMT relative to fuel price is between -0.2 and -0.3. For application in the BCAG TDF model, Fehr & Peers recommends that a mid-range elasticity of -0.25 be used.

To estimate the impact of fuel prices on future travel, the BCAG TDF model will have an option to multiply the elasticity described above against a user-defined estimate of fuel prices. The fuel prices will need to be specified in constant 2010 dollar terms to avoid double-counting the effects of overall price inflation. There are a variety of data sources available that forecast fuel prices 10, 20, and 30 years into the future. All future fuel price forecasts cover a wide range of prices because of the volatile nature of this commodity. Therefore it can be difficult to determine the “right” estimate of future year fuel prices.

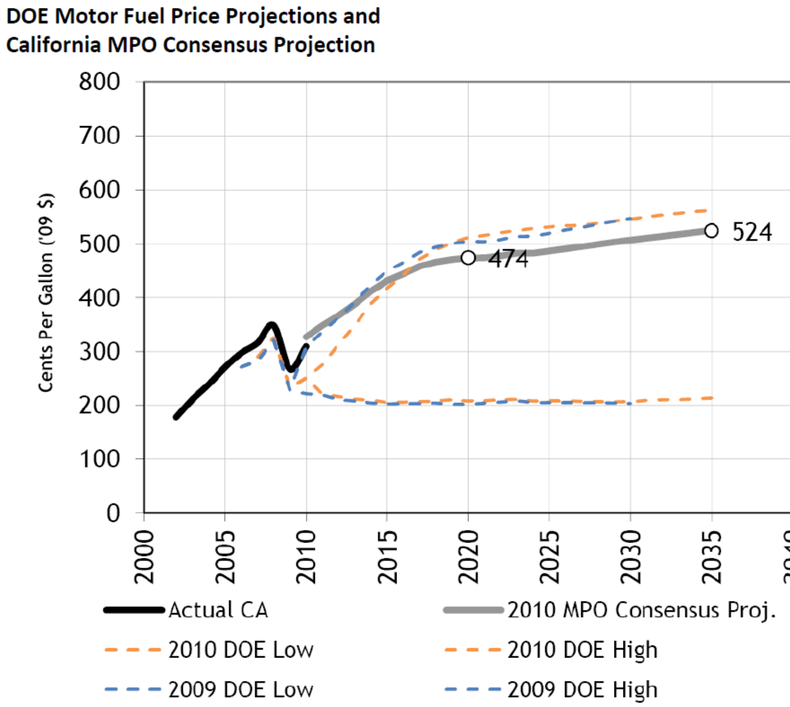
The chart below shows the California Energy Commission’s estimate of gasoline and diesel costs, which range between \$3.20 and \$4.80 per gallon. As of summer 2011, the average gas price in Butte County was \$3.80 per gallon, which is at the high end of the Energy Commission’s 2011 forecast and would be at the median of the 2030 forecast.

Figure 6: California Gasoline and Diesel Price Cases (2010 cents per gallon)

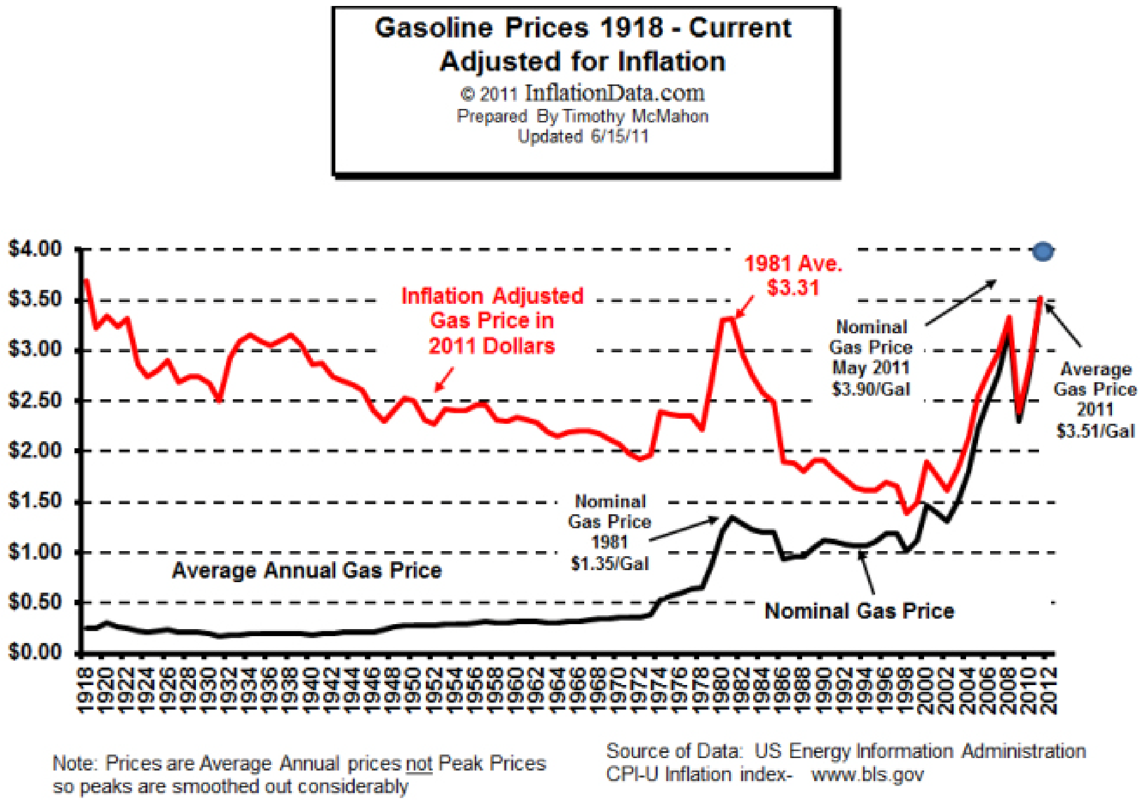


Source: California Energy Commission

The chart below shows the US Department of Energy’s (DOE) estimate of fuel costs, along with the consensus fuel price estimate from California MPOs. The US DOE forecast is more variable than the California Energy Commission’s estimate with a higher upper estimate and lower bottom estimate. The MPO consensus price is near the upper end of the estimate.



The final chart shows the historic average annual gas price in constant 2011 (and nominal) dollars from 1918 to today. The chart shows that there has been considerable variability, including a recent run-up in prices. The current 2011 price is about 40 percent higher than the long-term average of about $2.50 per gallon. While $2.50 per gallon for gasoline may seem unlikely in today's environment, prices were below that level just two years ago amidst the peak of the economic slowdown.



Recommendation

The fuel cost price forecasts and historic average data show that predicting fuel prices 20 years into the future is filled with uncertainty. Many in the industry are preparing for an era of much higher fuel costs; however, this trend, which has been long predicted, has not been borne out in historic data. Further, increased market penetration of hybrid and electric vehicles adds another dimension to future predictions.

If we were to assume the MPO consensus fuel price of $5.00 per gallon in 2030 and the recommended -0.25 VMT/fuel price elasticity, this would result in a 7.9 percent decline in VMT compared to baseline conditions (this assumes 2011 Butte County fuel prices of $3.80 per gallon). However, if we were to assume the midpoint fuel price estimate from the California Energy Commission under 2030 conditions, then baseline VMT would be unchanged since this midpoint fuel price estimate is about the same as today's price. Assuming the low price estimates from either the Energy Commission or DOE forecasts would result in more VMT than the baseline condition.

Based on the information above, we recommend that the fuel price sensitivity component be included in the BCAG TDF model, however, we recommend that this component be turned off for default model runs. Planners can turn on the component to test fuel price scenarios and evaluate how fuel prices impact travel outcomes. In performing these tests, marginal projects that may not provide benefit under a variety of fuel price scenarios can be eliminated during a screening process.

APPENDIX C:
BCAG DIRECT RIDERSHIP FORECASTING MEMORANDUM

FEHR & PEERS

MEMORANDUM

Date: July 13, 2012

To: Brian Lasagna, BCAG

From: Chris Breiland and Jonathan Williams, Fehr & Peers

Subject: Direct Ridership Models to Forecast Bus Line Ridership in Butte County

RS10-2809

This memorandum summarizes the Direct Ridership Forecasting (DRF) models Fehr & Peers prepared for the B-Line system in Butte County, California. DRF is a modeling system that relates transportation and land use data along bus lines to predict ridership. This tool is helpful in predicting future line ridership in the BCAG area and it can also be used to estimate the effect of rerouting existing lines, adjusting headways, or developing new bus lines in the County.

MODEL SUMMARY

BCAG provided extensive data on the bus system and the land uses surrounding each bus line and bus stop. Using these data, Fehr & Peers developed and tested a series of DRF models that best fit the existing ridership levels based on land use and transit system information. Given the geographic and demographic diversity in the County, three separate DRF models were developed. Model A is tailored to conditions in the Chico Area, and focuses only on intracity routes. Model B focuses on the rural routes that serve Paradise/Magalia, Oroville, and Biggs/Gridley area. Model C focuses on intercity routes connecting Chico with the rest of the county.

METHODOLOGY

Linear regression techniques were used to determine the variables and models that better forecast bus ridership in the county's transit system. The statistical software R was used for the calculations.

Butte County provided a complete dataset with land use, population, income distribution and demographic information in the proximity of bus routes. Also, daily ridership information and headways throughout the day were provided.

Several models were tested with ridership as the dependent variable. The selected models are those with the highest adjusted R^2 statistic and with independent variables that are relatively simple to estimate/forecast, have the most intuitive relationships, and have the highest significance levels. A description of the independent and selected independent variables is presented below. The majority of the variables below have a positive impact on ridership (positive sign). However, the headway-related variables have a negative impact on ridership (negative sign) since ridership decreases when headways are longer.

- *Ridership*: average ridership per route per day. BCAG provided ridership for typical weekday (Tuesday, Wednesday, and Thursday) conditions during the spring of 2011.
- *MultiFam*: Total number of multifamily residential units within a quarter-mile of a bus route. This information was provided by BCAG and buffered to the bus route by staff at CSU Chico.
- *Headway_Peak*: approximate peak-period (6:00 AM – 9:00 AM and 3:30 PM – 6:00 PM) headway in minutes. Plots of this variable indicate that ridership decreases faster at the lowest headway values (short headways) and slower at the highest ones (long headways). Therefore, the natural logarithm of the peak headways was used in the regression modeling.
- *Headway_Midday*: approximate midday period (9:00 AM - 3:30 PM) headway in minutes. If a bus does not run during this period a value of 390 was assumed. The natural logarithm conversion is also used with this variable. All headway information was based on the BCAG website.
- *Headway_Avg*: average of the *Headway_Peak* and *Headway_Midday* variables. The natural logarithm conversion is also applied to the resulting averages.
- *Population*: population in the cities and areas served by a route. The 2009 population data was used. If not available, a linear interpolation was performed on 2000 and 2010 population data. This information was obtained from the US Census Bureau.
- *ServPOP*: variable that represents the total population served by the routes. This variable comes from the addition of four variables provided by BCAG:
    - *SingleFam*: Total number of single-family units within a quarter-mile of a bus route. This information was provided by the BCAG and buffered by CSU Chico staff.
    - *Retail KSF*: similar to *SingleFam* but for total retail space, in thousands of square feet (KSF).
    - *Non Retail KSF*: similar to *SingleFam* but for total non-retail space, in thousands of square feet (KSF).
    - *Enroll 2010*: Total number of K-12 students enrolled in public schools within a quarter-mile of a bus route.

RESULTS

The routes serving the BCAG area were grouped in three sets:

A. Bus routes serving only the Chico Area: Chico-serving bus routes tend to have substantially higher ridership than other routes in the county. This effect is likely due to the presence of Chico State University and the higher population densities within Chico.

B. Bus routes serving the areas of Paradise/Magalia, Oroville, and Biggs/Gridley: local and regional buses serving these areas.

C. Regional bus routes connecting Chico with the Paradise/Magalia, Oroville, and Biggs/Gridley Areas. Regional trips serving Chico were grouped in a third set because these routes tended to have somewhat higher ridership than the group B routes.

The selected DRF models for each of these sets are presented below. The adjusted R^2 value for the Group A and B DRF models are presented below each equation. A correlation coefficient is presented for the Group C DRF model since an adjusted R^2 value is not applicable since it is a hybrid model (combining the basic form of the Group B model with an additional parameter describing the regional population of the non-Chico end of the route). Tables summarizing the predicted and actual values are presented as well.

A summary with the significance level of each of the dependent variables and intercepts is presented at the end of this section

A. Bus routes only serving Chico Area

$$Ridership = 0.25 \times \left(2{,}567.11 + 0.11 \times ServPOP + 0.22 \times MultiFam - 733.96 \times \ln\left(Headway_{Midday}\right)\right)$$

$$R^2_{Adjusted} = 0.93$$

The Group A DRF model has three independent variables, which can be interpreted as follows:

- Ridership increases as service population increases
- Ridership increases as the number of multi-family dwelling units increases
- Ridership decreases as headways get longer

The predicted and actual ridership values for this group are presented in Table 1. The actual values range from 71 (Route 7) to 1,298 (Route 15) trips. In general, the model shows good performance across the entire range of ridership. The model over-predicts the low-ridership Route 7, and under-predicts Route 9, which is a relatively short, but high ridership line that is geared toward serving the university population.

TABLE 1. PREDICTED AND ACTUAL WEEKDAY RIDERSHIP FOR ROUTES SERVING THE CHICO AREA

Route	Predicted	Actual	Difference
2	337	334	3
3	452	340	112
4	429	417	12
5	357	271	85
7	14	71	(57)
8	392	411	(18)
9	432	544	(112)
15	1,274	1,298	(24)

Source: Fehr & Peers, 2011.

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B. *Bus routes serving the Paradise/Magalia, Oroville, and Biggs/Gridley Area*

$$Ridership = 0.25 \times (753.82 + 0.05 \times MultiFam - 138.57 \times \ln(Headway\_Avg))$$
$$R^2_{Adjusted} = 0.52$$

The Group B DRF model has only two independent variables, which can be interpreted as follows:

- Ridership increases as the number of multi-family dwelling units increases
- Ridership decreases as headways get longer

The predicted and actual ridership values are presented in Table 2. The actual values vary in a narrower range than the previous case; however, the overall ridership levels are also lower.

TABLE 2. PREDICTED AND ACTUAL WEEKDAY RIDERSHIP FOR ROUTES SERVING THE PARADISE, OROVILLE, AND GRIDLEY/BIGGS AREA

Route	Predicted	Actual	Difference
24	80	99	(20)
25	62	58	4
26	70	65	5
27	53	43	11
30	15	56	(41)
31	32	20	12
46	4	3	1

Source: Fehr & Peers, 2011.

C. *Regional bus routes connecting Chico with the Paradise/Magalia, Oroville, Biggs/Gridley Areas*

$$Ridership = 0.25 \times \left(0.05 \times MultiFam - 138.57 \times \ln\left(Headway_{Avg}\right) + 0.07 \times Population\right)$$
$$Correlation = 0.957$$

The Group C DRF model is an adaptation of the Group B model. Rather than estimating an entirely new model, a similar form was adopted where the intercept is removed and replaced by a third term that accounts for the populations of the areas that are connected to Chico. This approach was taken to simplify the overall model structure so that fewer variables would have to be estimated/forecasted.

Routes 40 and 41 are considered as a single route since they work as complementary services and share the same general alignment (although Route 41 extends further north into Magalia).

Both routes have a common headway and operate in a repeating pattern, essentially leading to a common route with one-hour headways.

The predicted and actual ridership values for this group are presented in Table 3. The actual values cover a wide range, from 8 (Route 32) to 511 (Route 20). The Group C DRF model performs reasonably well for the higher ridership routes, but significantly overestimates (in absolute terms) the ridership on Route 32. However, given the low ridership on this route, the model performance is deemed to be adequate.

TABLE 3. PREDICTED AND ACTUAL WEEKDAY RIDERSHIP FOR ROUTES CONNECTING CHICO WITH PARADISE, OROVILLE, AND GRIDLEY/BIGGS AREA

Route	Predicted	Actual	Difference
20	443	511	(68)
32	81	8	73
40/41	571	494	77

Calculations from software R.

EFFECT OF FUEL PRICES ON RIDERSHIP

Based on data provided by BCAG, transit ridership increased substantially in the summer of 2008 when fuel prices approached $5.00 per gallon. While this one-time increase in fuel price spike is not enough information to develop a model to accurately predict how ridership will change with fuel price, it can provide anecdotal evidence related to transit ridership elasticity with respect to fuel costs. Based on this one data point, the transit/fuel price elasticity is 0.55. In other words, given a doubling in fuel prices, transit ridership increased by 55 percent.

Literature indicates that this is a short-term elasticity and ridership levels will increase over time as people move and switch job locations, in part to have access to transit and reduce travel costs. The literature generally indicates that the long-term transit/fuel price elasticity is 1.5 to 3 times greater than the short-term elasticity, which would suggest that the long-term elasticity in the BCAG area could be as high as 0.83. This value is estimated at the low range, based on the magnitude of the sudden fuel price increase in the summer of 2008 and resulting high short term elasticity.

Based on this limited data, we do not recommend incorporating a fuel price element in the direct ridership model at this time. However, as fuel prices fluctuate and ridership levels are tracked, there may be enough information to add this element to the Direct Ridership model in the future.

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2035 FUTURE CONDITIONS RIDERSHIP FORECASTS

Using the DRF model, 2035 ridership forecasts were developed based on household and non-residential land use information provided by BCAG and processed by CSU Chico. Ridership forecasts were developed for two 2035 land use alternatives: Scenario 1 representing a balanced growth pattern with a mix of infill and new suburban development; and Scenario 2, which represents a more dispersed growth pattern with a greater emphasis on suburban and greenfield development. Both of these scenarios were evaluated as part of BCAG's Sustainable Communities Strategy effort.

Given the uncertainty in transit planning and funding, BCAG did not have any 2035 transit routes identified for evaluation purposes. Therefore the transit ridership forecasts are based on the existing (summer 2012) routing and headways. The 2035 ridership forecasts and growth in transit ridership for each transit line are shown in Tables 4 and 5 for Scenarios 1 and 2, respectively. Note that the ridership estimates developed below reflect application of the "difference method," which adds the DRF model's predicted growth in ridership to the actual ridership counts on each transit line. The difference method is commonly used in all types of travel forecasting to reduce the degree of model error.

TABLE 4. 2035 WEEKDAY RIDERSHIP BY ROUTE, LAND USE SCENARIO 1

Route	Service Area	2035 Ridership Forecast	Change from Existing Ridership
2	Chico	462	128
3	Chico	496	156
4	Chico	581	164
5	Chico	588	317
7	Chico	347	276
8	Chico	535	124
9	Chico	666	122
15	Chico	1,748	450
24	Rural	109	10
25	Rural	62	4
26	Rural	81	16
27	Rural	43	0
30	Rural	65	9
31	Rural	32	12
46	Rural	4	1
20	Intercity	747	236
32	Intercity	113	105
40/41	Intercity	750	256

Source: Fehr & Peers, 2012.

TABLE 5. 2035 WEEKDAY RIDERSHIP BY ROUTE, LAND USE SCENARIO 2

Route	Service Area	2035 Ridership Forecast	Change from Existing Ridership
2	Chico	441	107
3	Chico	443	103
4	Chico	563	146
5	Chico	561	290
7	Chico	327	256
8	Chico	523	112
9	Chico	652	108
15	Chico	1,719	421
24	Rural	104	5
25	Rural	60	2
26	Rural	74	9
27	Rural	43	0
30	Rural	61	5
31	Rural	24	4
46	Rural	3	0
20	Intercity	619	108
32	Intercity	53	45
40/41	Intercity	588	94

Source: Fehr & Peers, 2012.

As expected, Scenario 1 has greater overall transit ridership growth since it is denser and has a greater level of development along the B-Line routes. Overall ridership growth is 32 percent higher for Scenario 1 compared to Scenario 2. Appendix D summarizes the input variables used for the 2035 transit ridership forecasts. In addition, the raw model transit ridership forecasts (which do not have the difference method applied are provided).

APPENDIX A

Significance level of variables and intercept

The following tables show the parameter and significance level for each independent variable and intercept for each of the models highlighted above.

Group A Model: Bus routes only serving Chico Area

TABLE 6: PARAMETERS AND SIGNIFICANCE LEVEL FOR GROUP A MODEL

Variable	Parameter	Significance Level
ServPOP	0.11	98.1%
MultiFam	0.22	92.7%
Ln(Headway_Midday)	-733.96	98.3%
Intercept	2,567.11	95.1%

Source: Fehr & Peers, 2011.

Group B Model: Bus routes serving the Paradise, Oroville, and Biggs/Gridley Area

TABLE 7: PARAMETERS AND SIGNIFICANCE LEVEL FOR GROUP B MODEL

Variable	Parameter	Significance Level
MultiFam	0.05	71.9%
Ln(Headway_Avg)	-138.57	94.5%
Intercept	753.82	96.2%

Source: Fehr & Peers, 2011.

Group C Model: Regional bus routes connecting Chico with the Paradise, Oroville, Biggs/Gridley Areas

This model is the same as the Group B model detailed in Table 7, but with an additional term estimated to quantify the effect of population on transit trips.

TABLE 8: PARAMETER AND SIGNIFICANCE LEVEL FOR THE GROUP C MODEL

Variable	Parameter	Significance Level
Population	0.07	95.0%

Source: Fehr & Peers, 2011.

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APPENDIX B

Model Data Inputs

Table 9 contains the local transit service and demographic data used to create the ridership model.

TABLE 9. MODEL INPUT DATA

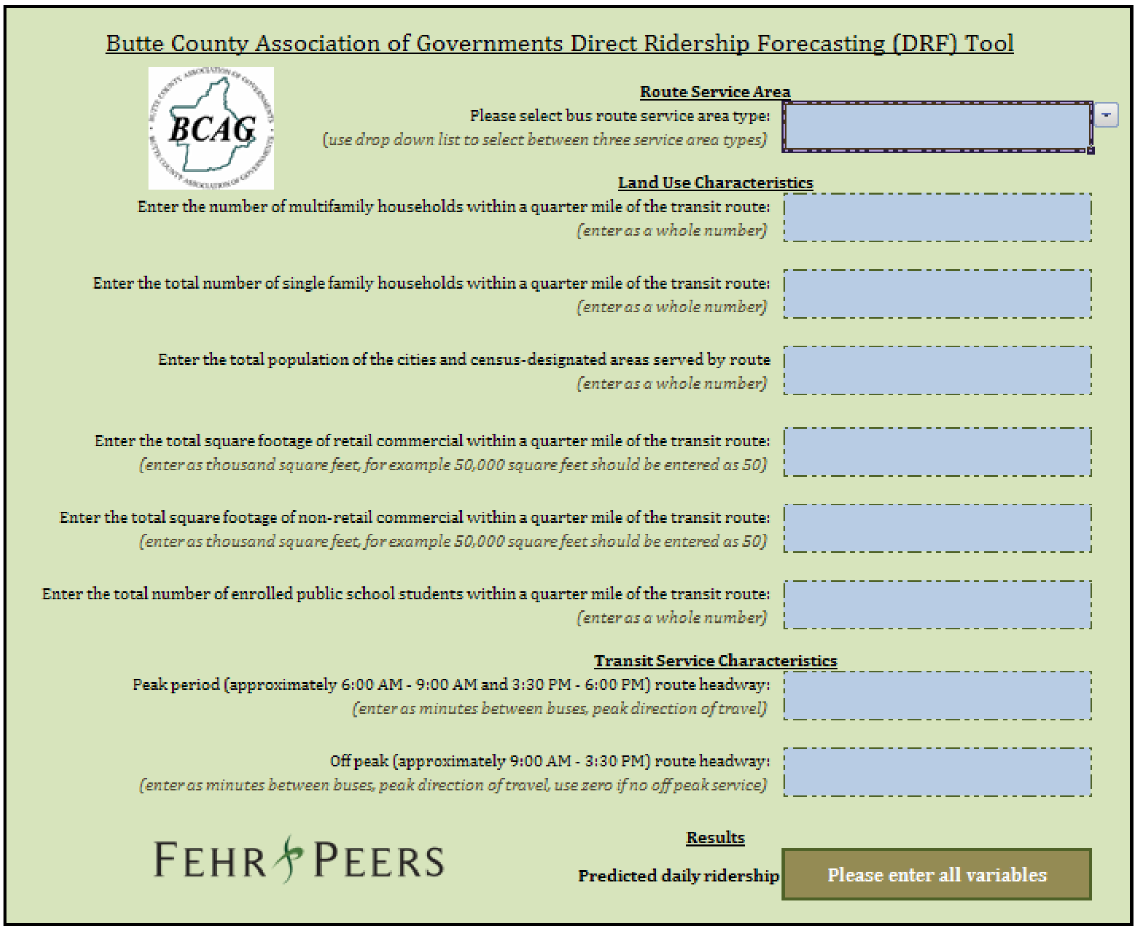
Route	Service Area	Peak Frequency	Off-Peak Frequency	Total Pop.	Quarter Mile Distance from Line				
					MF HH[a]	SF HH[b]	Retail KSF	Non-retail KSF	K-12 Public School Enrollment
2	Chico		60		3,187	2,083	2,230.085	3,612.512	1,758
3	Chico		60		5,765	2,312	2,192.124	2,381.143	1,706
4	Chico		60		2,109	3,256	2,048.806	2,304.908	7,562
5	Chico		60		3,718	2,662	2,864.728	2,424.723	1,350
7	Chico		390[c]		3,463	3,503	1,330.665	1,238.076	3,775
8	Chico		30		3,687	1,058	902.337	918.518	3,185
9	Chico		30		4,493	873	985.536	1,032.680	2,974
15	Chico		30		9,385	5,695	5,427.863	9,664.250	5,576
24	Rural	60	60		2,874				
25	Rural	60	60		1,364				
26	Rural	60	60		2,031				
27	Rural	60	60		584				
30	Rural	180[d]	390[c]		1,814				
31	Rural	180[d]	390[c]		3,209				
46	Rural	180[d]	390[c]		947				
20	Intercity	60	120	31,445	4,258				
32	Intercity	180[d]	390[c]	14,660	1,640				
40/41	Intercity	120	120	38,441	3,484				

[a] Multifamily Households
[b] Single-family Households
[c] No off-peak service, 390 used for model input
[d] Only 1-3 daily trips offered, 180 used for model input

APPENDIX C

Direct Ridership Model

The below is a screen capture of the Butte County Bus Line Ridership Model. This model is created and operates in Microsoft Excel 2007.



Butte County Association of Governments Direct Ridership Forecasting (DRF) Tool

Route Service Area

Please select bus route service area type:
(use drop down list to select between three service area types)

Land Use Characteristics

Enter the number of multifamily households within a quarter mile of the transit route:
(enter as a whole number)

Enter the total number of single family households within a quarter mile of the transit route:
(enter as a whole number)

Enter the total population of the cities and census-designated areas served by route
(enter as a whole number)

Enter the total square footage of retail commercial within a quarter mile of the transit route:
(enter as thousand square feet, for example 50,000 square feet should be entered as 50)

Enter the total square footage of non-retail commercial within a quarter mile of the transit route:
(enter as thousand square feet, for example 50,000 square feet should be entered as 50)

Enter the total number of enrolled public school students within a quarter mile of the transit route:
(enter as a whole number)

Transit Service Characteristics

Peak period (approximately 6:00 AM - 9:00 AM and 3:30 PM - 6:00 PM) route headway:
(enter as minutes between buses, peak direction of travel)

Off peak (approximately 9:00 AM - 3:30 PM) route headway:
(enter as minutes between buses, peak direction of travel, use zero if no off peak service)

Results

Predicted daily ridership Please enter all variables

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APPENDIX D

Tables 10 and 11 summarize the 2035 input variables used for Scenarios 1 and 2, respectively. Tables 12 and 13 summarize the DRF model's raw 2035 ridership forecasts for Scenarios 1 and 2, respectively. These raw ridership forecasts were processed with the difference method to forecast 2035 ridership using the following relationship:

2035 Ridership Forecast = 2011 Observed Ridership + (2035 Raw DRF Forecast – 2011 Raw DRF Forecast)

TABLE 10. SCENARIO 1 2035 INPUT DATA

Route	Service Area	Peak Frequency	Off-Peak Frequency	Total Pop.	Quarter Mile Distance from Line				
					MF HH[a]	SF HH[b]	Retail KSF	Non-retail KSF	K-12 Public School Enrollment
2	Chico		60		3,351	2,091	2,678	3,926	2,158
3	Chico		60		6,300	2,670	2,566	2,748	2,094
4	Chico		60		2,225	3,350	2,347	2,437	9,282
5	Chico		60		5,280	3,415	3,511	2,962	1,657
7	Chico		390[c]		5,893	6,070	2,076	1,882	4,634
8	Chico		30		3,729	1,197	1,177	1,022	3,910
9	Chico		30		4,605	874	1,192	1,139	3,651
15	Chico		30		7,383	11,073	6,637	10,496	6,844
24	Rural	60	60		3,692				
25	Rural	60	60		1,664				
26	Rural	60	60		3,435				
27	Rural	60	60		633				
30	Rural	180[d]	390[c]		2,742				
31	Rural	180[d]	390[c]		4,486				
46	Rural	180[d]	390[c]		1,085				
20	Intercity	60	120	43,782	6,004				
32	Intercity	180[d]	390[c]	20,412	2,183				
40/41	Intercity	120	120	53,523	4,876				

[a] Multifamily Households
[b] Single-family Households
[c] No off-peak service, 390 used for model input
[d] Only 1-3 daily trips offered, 180 used for model input

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TABLE 11. SCENARIO 2 2035 INPUT DATA									
					Quarter Mile Distance from Line				
Route	Service Area	Peak Frequency	Off-Peak Frequency	Total Pop.	MF HH[a]	SF HH[b]	Retail KSF	Non-retail KSF	K-12 Public School Enrollment
2	Chico		60		3,219	2,088	2,257	3,869	2,072
3	Chico		60		5,771	2,520	2,199	2,409	2,011
4	Chico		60		2,114	3,299	2,060	2,353	8,912
5	Chico		60		5,052	3,304	3,273	2,793	1,591
7	Chico		390[c]		5,593	5,949	2,094	1,888	4,449
8	Chico		30		3,690	1,205	902	919	3,754
9	Chico		30		4,497	877	2,257	3,869	3,505
15	Chico		30		7,228	11,067	7,300	10,512	6,572
24	Rural	60	60		3,258				
25	Rural	60	60		1,496				
26	Rural	60	60		2,807				
27	Rural	60	60		614				
30	Rural	180[d]	390[c]		2,373				
31	Rural	180[d]	390[c]		3,775				
46	Rural	180[d]	390[c]		973				
20	Intercity	60	120	36,848	5,385				
32	Intercity	180[d]	390[c]	17,179	1,884				
40/41	Intercity	120	120	45,046	3,725				

[a] Multifamily Households
[b] Single-family Households
[c] No off-peak service, 390 used for model input
[d] Only 1-3 daily trips offered, 180 used for model input

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TABLE 12. RAW 2035 WEEKDAY RIDERSHIP BY ROUTE, LAND USE SCENARIO 1

Route	Service Area	Raw DRF Ridership Forecast
2	Chico	465
3	Chico	608
4	Chico	593
5	Chico	673
7	Chico	290
8	Chico	517
9	Chico	554
15	Chico	1,724
24	Rural	89
25	Rural	66
26	Rural	86
27	Rural	54
30	Rural	24
31	Rural	44
46	Rural	5
20	Intercity	679
32	Intercity	186
40/41	Intercity	827

Source: Fehr & Peers, 2012.

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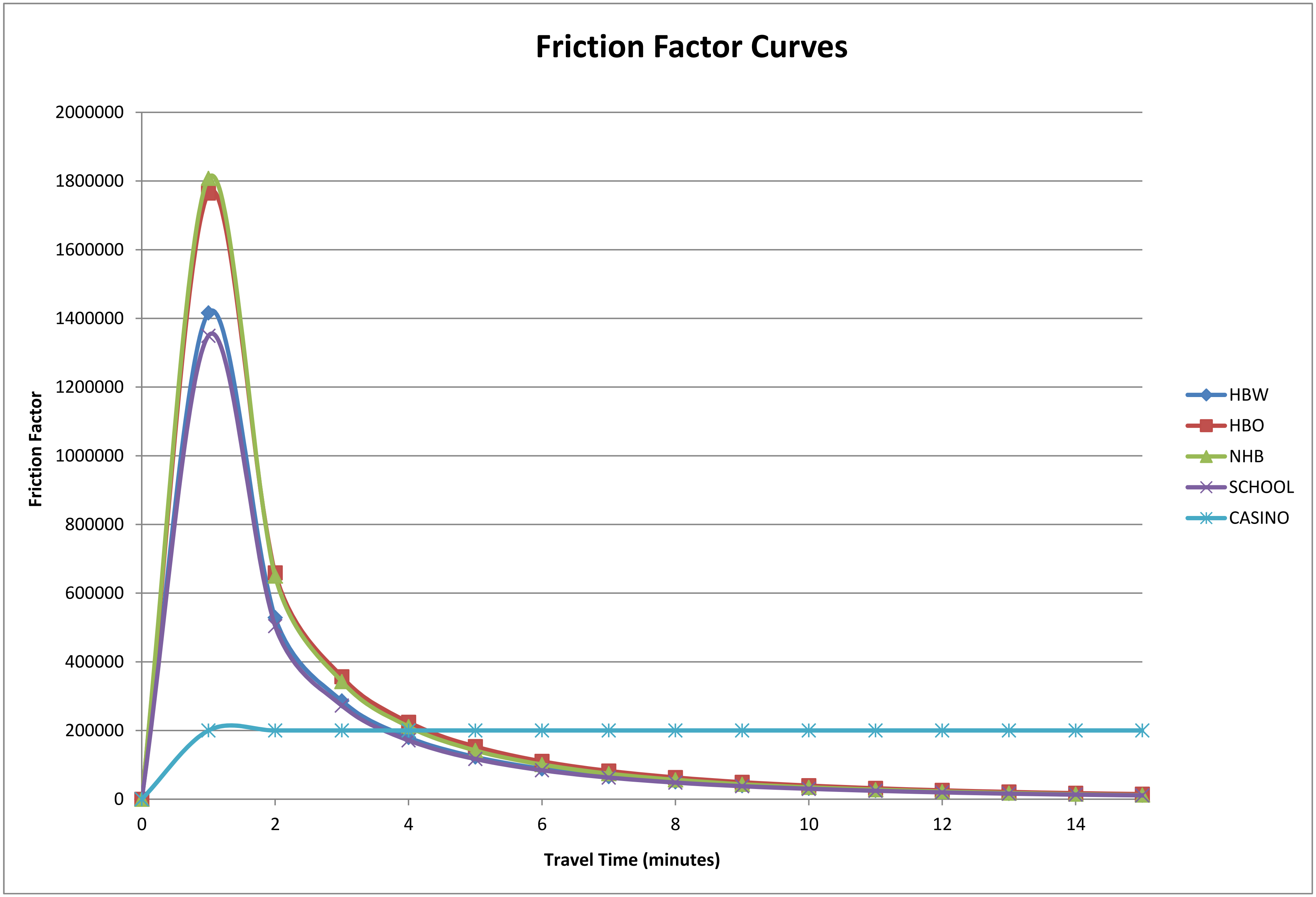
TABLE 13. RAW 2035 WEEKDAY RIDERSHIP BY ROUTE BY ROUTE, LAND USE SCENARIO 2

Route	Service Area	Model Prediction
2	Chico	444
3	Chico	555
4	Chico	575
5	Chico	646
7	Chico	270
8	Chico	505
9	Chico	540
15	Chico	1,695
24	Rural	84
25	Rural	64
26	Rural	79
27	Rural	54
30	Rural	20
31	Rural	36
46	Rural	4
20	Intercity	551
32	Intercity	126
40/41	Intercity	665

Source: Fehr & Peers, 2012.

APPENDIX D:
BCAG TDF MODEL FRICTION FACTOR CURVES

APPENDIX 6 - ATTACHMENT 2



Air Resources Board

Mary D. Nichols, Chairman
1001 I Street • P.O. Box 2815
Sacramento, California 95812 • www.arb.ca.gov

Matthew Rodriquez
Secretary for Environmental Protection

Edmund G. Brown Jr.
Governor

November 17, 2011

Mr. Jon Clark
Executive Director
Butte County Association of Governments
2580 Sierra Sunrise Terrace, Suite 100
Chico, California 95928-8441

Dear Mr. Clark:

Thank you for your letter of August 30, 2011 to Chairman Mary D. Nichols submitting the Butte County Association of Government's (BCAG) proposed technical methodology document to the Air Resources Board (ARB) as required by Senate Bill 375 (SB 375). Your submittal fulfills the requirement under California Government Code section 65080(b)(2)(J)(i) that each metropolitan planning organization (MPO) submit to ARB a description of the technical methodology it will use to estimate greenhouse gas (GHG) emissions from its Sustainable Communities Strategy (SCS).

Under California Government Code section 65080(b)(2)(J)(ii), an MPO must submit its adopted SCS to ARB staff for review, including a quantification of the GHG emissions from its SCS and a determination of whether the SCS meets the region's GHG emission reduction targets established by ARB. ARB is required to review and either accept or reject an MPO's determination that its adopted SCS, if implemented, would meet the GHG emission reduction targets. To facilitate ARB staff's future review of BCAG's adopted SCS, ARB staff will request supporting information regarding your technical methodology during the upcoming development of the draft SCS. The types of supporting information ARB staff will request are identified in ARB's July 2011 "Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies Pursuant to SB 375 (Methodology)." ARB staff's Methodology provides the framework for a transparent evaluation of the GHG emissions from an SCS, and focuses on four technical aspects of transportation modeling that are central to quantifying passenger vehicle-related GHG emissions: use of appropriate modeling tools (including off-model processes), use of appropriate data and assumptions, demonstration of model sensitivity, and demonstration of consistency with related performance indicators.

As you develop your region's draft SCS, ARB staff will work with BCAG to customize our approach to the review of BCAG's SCS, taking into consideration the unique conditions and capabilities in your region. For BCAG, this process is just about to start, and ARB looks forward to working with you to craft a process that is appropriate to BCAG's unique circumstances.

We would also like to clarify that the regional GHG emission reduction targets for the BCAG region established by ARB for 2020 and 2035 are to achieve no greater than a one percent increase in per capita CO_2 emissions from passenger vehicles, from 2005 levels, in either year. This correction should be made to your proposed methodology before proceeding further with development of BCAG's draft SCS.

If you have any questions, please contact me at (916) 322-0285 or have your staff contact Ms. Jennifer Gray, Air Pollution Specialist, at (916) 327-0027, or by email at jgray@arb.ca.gov.

Sincerely,

Douglas Ito, Chief
Air Quality and Transportation Planning Branch

cc: Mary D. Nichols, Chairman
California Air Resources Board

Jennifer Gray
Air Pollution Specialist
Air Quality and Transportation Planning Branch

Modeling Parameters	2005 (GHG Target Base)	2006 [3]	2010 (MTP/SCS Base)	2020	2035
Total Population	214,582 [1]	216,599 [1]	221,768 [1]	257,266	332,459
Total Number of Households	85,478 [1]	87,172 [1]	90,405 [1]	108,095	139,689
Persons Per Household	2.44	2.41	2.38	2.38	2.38
Total Jobs (Non-Farm)	73,400 [2]	75,600 [2]	71,501 [2]	87,214	112,279
Total Housing/Dwelling Units	91,666 [1]	93,381 [1]	96,623 [1]	111,813	143,948

[1] State of California, Department of Finance, E-5 Population and Housing Estimates for Cities, Counties and the State, 2001-2010, with 2000 Benchmark. Sacramento, California, May 2010.

[2] State of California, Employment Development Department, Butte County Industry Employment & Labor Force, March 2009 Benchmark. Sacramento, California, June 18, 2010.

[3] The year 2006 was not modeled within the BCAG travel demand model. 2006 model parameters are included for the purpose of illustrating the difference between the years 2005 and 2006, since the year 2005 was used as the base year for reporting.