

Travel Demand Model Development and Validation Report



Prepared by the Bannock Transportation Planning Organization

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Section 1. Introduction

This report aims to document the development and validation of a travel demand model (TDM) for the Bannock Transportation Planning Organization (BTPO). TDM covers the BTPO planning area Figure 1 and has a 2020 base year. The travel demand models try to replicate the traffic conditions in each area based on the road network, population data, employment data, and information on the driving characteristics of that population. Once calibrated and validated, travel demand models can use future road networks, population, and employment data to estimate travel on a specific roadway or the entire network.

TDM data sources include a street layer, socioeconomic data, and information about travel behaviors. TransCAD software is the model used to develop the TDM. The TDM follows a non-traditional four-step travel demand model Figure 2. Jurisdiction

Figure 1 BTPO Planning Area

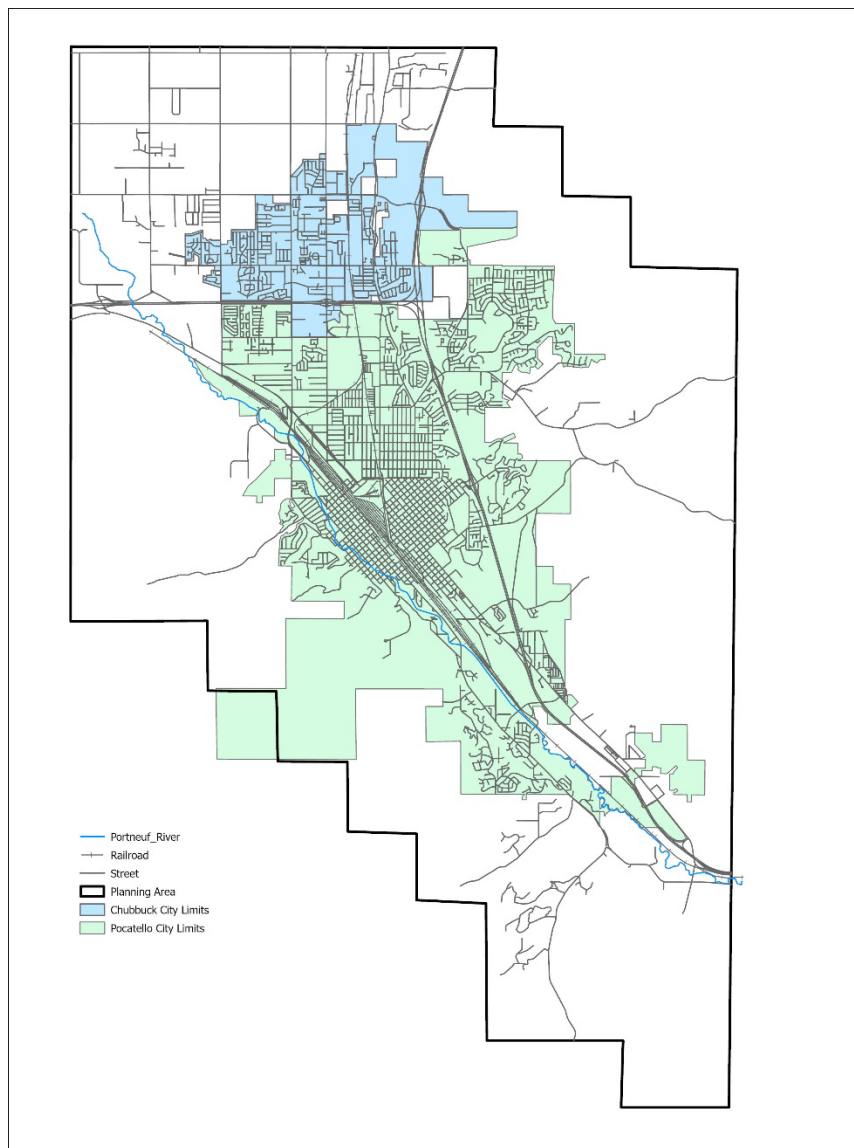
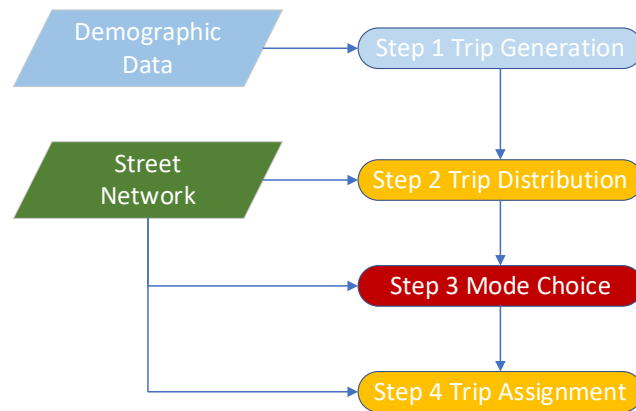


Figure 2 Four-Step Travel Demand Model



Section 2. Traffic Analysis Zone and Socioeconomic Data

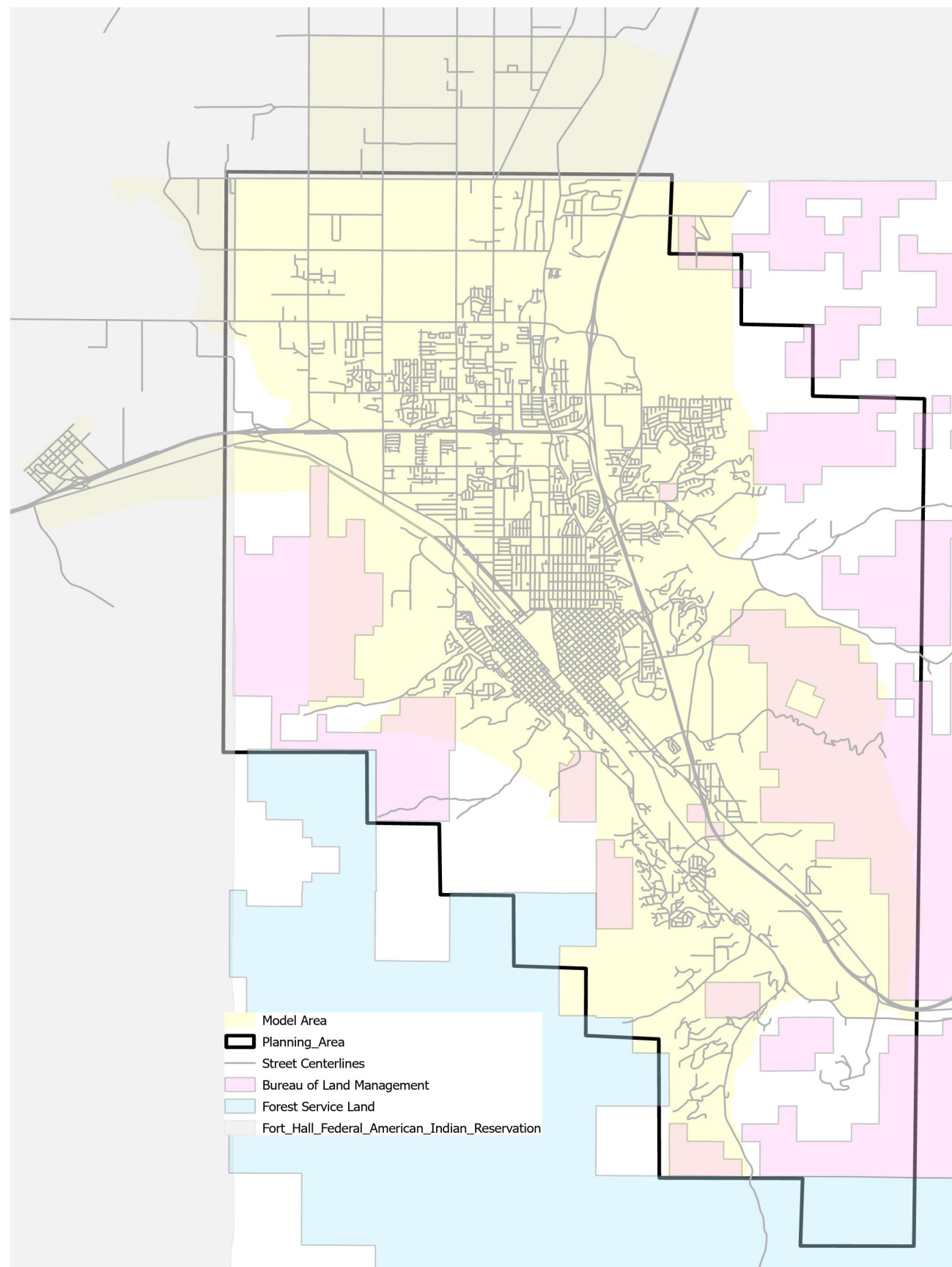
2.1. Planning and Modeling Areas

The BTPO planning area is defined by the Portneuf Valley Non-Attainment Area (PVNAA) boundaries. The Environmental Protection Agency designated the PVNAA as a PM₁₀ Non-Attainment Area, but the original boundary included the Fort Hall Non-Attainment Area. BTPO developed a model to capture motor vehicle travel for both non-attainment areas. The Environmental Protection Agency divided the two non-attainment areas. BTPO kept the modeling domain mostly the same due to the locations of major facilities such as Simplot and Pocatello Regional Airport.

The Modeling area also follows the U.S. Census Urbanized boundary. The location of existing and projected housing units and employment also contributed to the model area boundary. Figure 3 shows the planning and modeling area boundaries and the Forest Service, Bureau of Land Management, and Fort Hall Reservation boundaries.

Although the model area is larger than the planning area, only the planning area is included in the model validation analysis.

Figure 3 Planning and Modeling Area Boundaries



2.2. Socioeconomic Data

The socioeconomic data used in the TDM are population, households, and sector employment. BTPO developed the socioeconomic data for the TDM in the Population, Housing, and Employment Forecast 2050 Report¹. The report outlines the methodology for determining the 2020 and 2050 socioeconomic data. Table 1 provides the total model area population, households, and employment for 2020 and 2050.

Table 1 Model Area Population, Households, and Employment for 2020 and 2050

Traffic Analysis Zone Total			
Year	Population	Households	Employment
2020	77,951	29,189	36,951
2050	89,927	33,804	47,667
Bannock County Traffic Analysis Zones			
2020	77,770	29,116	39,296
2050	89,546	33,651	46,829
Power County Traffic Analysis Zones			
2020	181	73	655
2050	381	154	838

2.3. Traffic Analysis Zones

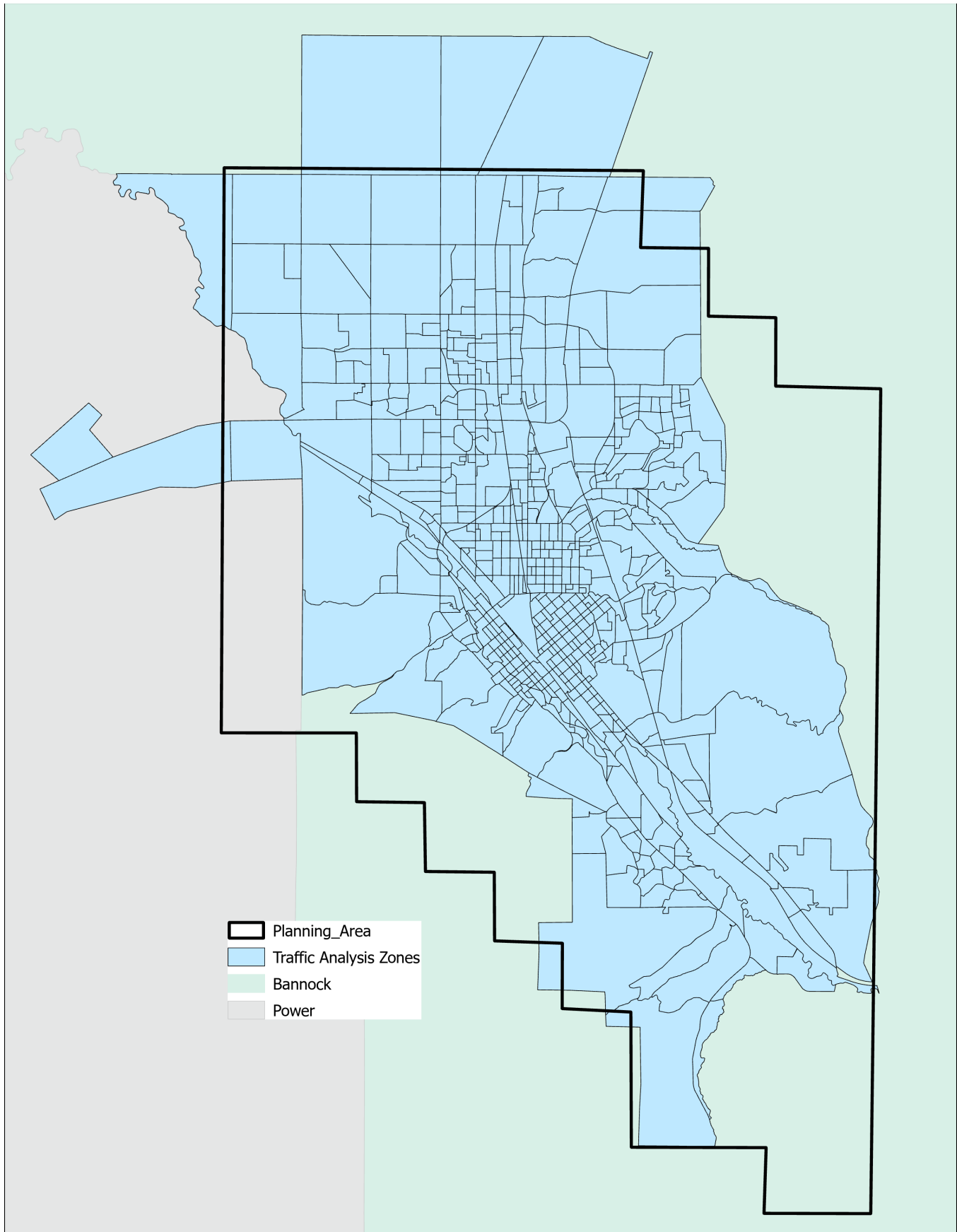
The economic data is divided into small geographic areas called Traffic Analysis Zones (TAZs). TAZs are homogeneous areas and were delineated based on the following:

- Census geography (2020 U.S. Census Blocks),
- Physical separation (Census blocks that included areas separated by a barrier like a ravine, water, and major road were divided)
- Land use,
- Population, and
- Governmental jurisdiction.

The Census block with similar travel patterns and land use were combined into one of the regions of 644 TAZs (Figure 4). The traffic generated or attracted to the specific TAZ is represented by one point called a centroid. The planning area has 638 TAZs, and the modeling area has six additional zones. The model area has three TAZs within Power County, and the remaining are within Bannock County.

¹ BTPO, Population, Housing, and Employment Forecast 2050 Report August 2, 2022. <https://www.bannockplanning.org/wp-content/uploads/2022/11/Population-Housing-and-Employment-Forecasts-reports.pdf>

Figure 4 Traffic Analysis Zones For 2020 Model



Section 3. Street Network

The street network in the model uses all public roads. The street network contains attributes of street design and operations. This chapter provides information on the source of the street network and the attributes used in the travel demand process.

3.1. Street Network Development

The TDM street network will include all the public streets in the planning area in 2020. The street Centerline data was originally built in 1990 using Global Position Satellites (GPS) technology. Since 1990, Bannock County, the City of Chubbuck, the City of Pocatello, and BTPO have worked together to maintain and update the master street network. The street centerline layer uses the Bannock County Geographic Information System (GIS) street layer as the starting point. The Bannock County files are stored using ArcGIS. TransCAD uses a GIS platform in the model to represent the actual position of the street. The ESRI Geodatabase Street file is exported to a TransCAD file and joined to the TDM street layer. Change area made within the TransCAD environment.

3.2. Network Attributes

The attributes listed in Table 2 are those TDM attributes added to or modified from the street centerline. The street centerline attributes, including street name and address range, are maintained but not used in the model.

3.3. Centroid Connectors

Centroid Connectors are special links the model uses to connect socioeconomic data to the street network but are not actual streets. The model used centroid connectors to load trips into the street network. The locations of centroid connectors are determined using aerial imagery and local knowledge of trip patterns.

Table 2 Network Attributes

Display Name	Description
ID	Identification Number
Dir	Direction of Street 0 = two ways street, 1= one-way street in AB direction, -1 = one-way street in BA direction
Length	Length of the feature in Miles
County	The County the link is in
Lanes in the AB Direction	Number of through lanes AB
Lanes in the BA Direction	Number of through lanes BA
Urban Area	1 = Street Segment is located within the Pocatello/Chubbuck Urban Area
Area Type	1 = Rural, 2 = Urban, 3= Central Business District
Facility Type	Centroid Connector = 0, Local=1, Collector = 2, Minor Arterial = 3, Principal Arterial = 4, Ramp = 5, Interstate = 6
Functional Classification	Functional Classification of the street segment
ONEWAY Direction	Direction of one-way road
Posted Speed AB	Used to generate the Free-flow Time - AB Direction
Posted Speed BA	Used to generate the Free-flow Time - AB Direction
PVNAA	1 = link is within the Portneuf Valley Non-Attainment Area (PVNAA)

3.4. Functional Classification (Facility Type)

The street's functional classification reflects its role in the street network, but it does not have the same definition as the Federal Highway Administration version. An additional attribute, Facility Type, is added to the network to define factors affecting speed and capacity. The model includes an additional Facility Type ramp (5) to allow the differences in speed and capacity. Figure 5 shows the 2020 street network by facility type and functional classification.

3.5. Area Type

Area type is an attribute assigned to each link to represent the activity level and character of the adjacent land use. The activity type can change over time. The area type is defined based on the underlying TAZ's employment and household density. The TAZ density is computed as the sum of (households + 2 * total employment) per square mile. The area types are central business district (CBD), urban, and rural. Table 3 provides the densities for each area type. The final density for each bin was decided upon by reviewing the zone map for reasonable results. Figure 6 shows the area type for each link in the 2020 TDM.

Table 3 Area Type Definition

Area Type	Density Per Square Mile
Rural	Below 1,000
Urban	1,000- 7,000
Central Business District (CBD)	Above 7,000

3.6. Link Speeds

Link speeds are assigned to each link based on the posted speed limits. The link speeds of arterials were adjusted up by five (5) miles per hour to reflect the free-flow speed and account for the interstate speeds.

Figure 5 2020 Facility Type

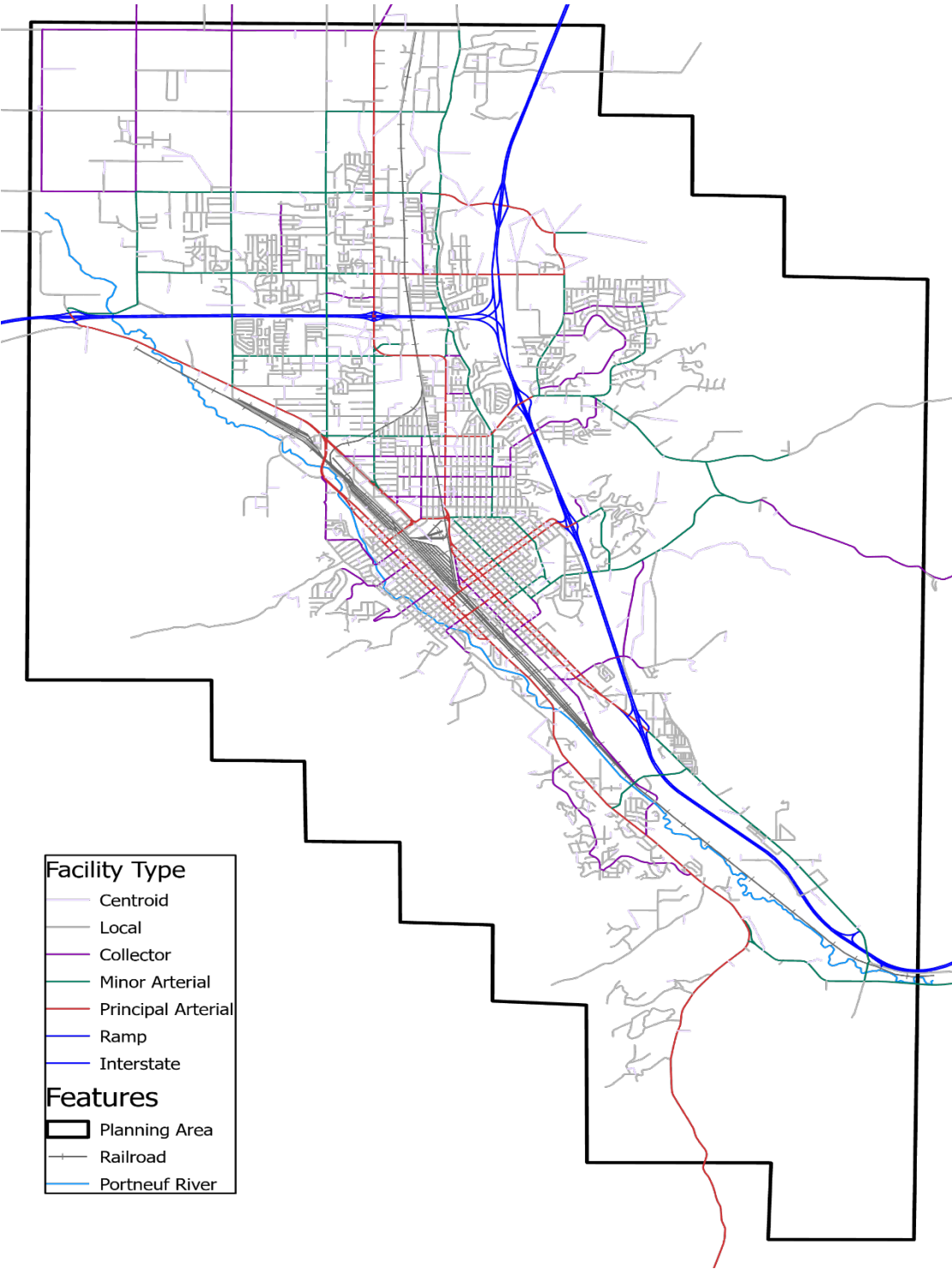
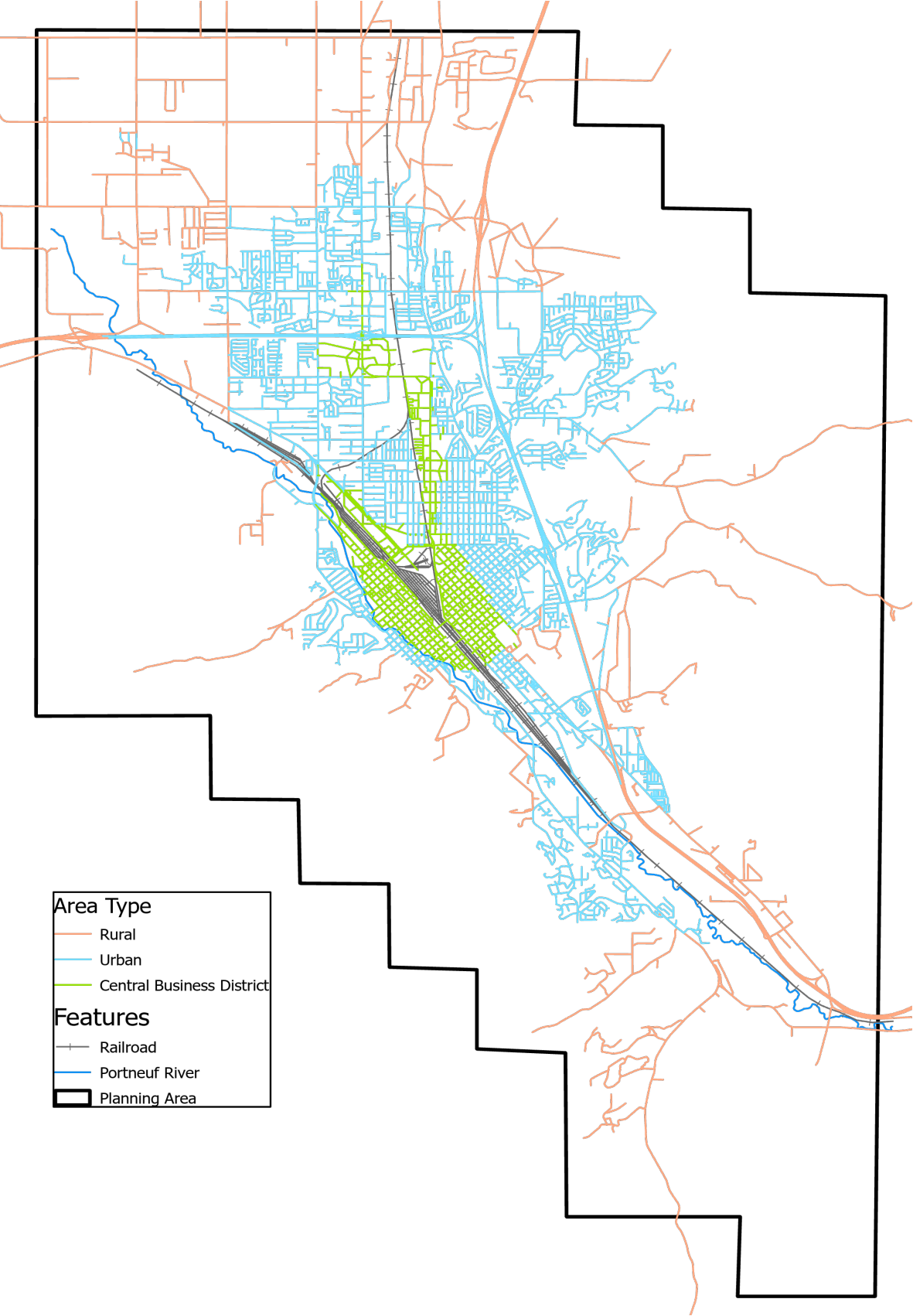


Figure 6 Area Type



3.7. Link Capacities

The link capacities are based on service volume, not the actual capacity of the street. The values in the TDM are set at a level of service D. Level of service measures how the driver experiences the roadway. The regional standard is LOS D. The initial values are from NCHRP Report 599 Default Values for Highway Capacity and Level of Service Analyses (2008).

Table 4 provides the link capacity lookup table. The facility and area type determines the link capacity. The capacity of centroids connectors is set a 9999 to ensure that all traffic assigned will be added to the street network.

Table 4 Link Capacity Lookup Table

Lookup	Area Type	Facility Type	Capacity	Link Delay
300	3	0	9999	0
301	3	1	450	0.05
302	3	2	500	0.1
303	3	3	625	0.05
304	3	4	800	0.08
305	3	5	850	0.14
306	3	6	1700	0
200	2	0	9999	0
201	2	1	500	0.05
202	2	2	525	0.05
203	2	3	700	0.08
204	2	4	850	0.07
205	2	5	850	0.09
206	2	6	1750	0
100	1	0	9999	0
101	1	1	625	0.05
102	1	2	650	0.05
103	1	3	760	0.05
104	1	4	950	0.1
105	1	5	850	0.15
106	1	6	1800	0

Capacity is in vehicles per hour per lane

Section 4. Trip Generation

The trip generation is the first step in the modeling process. The step includes network skimming, household disaggregation, and trip generation. The result of trip generation is assigning productions and attractions to the TAZ. Productions are generated at the household level, and attractions are assigned based on employment data. External trips are trips generated outside the planning area or trips leaving the planning area.

Network Skimming

Network skimming takes the street layer and develops a highway network. The TAZ-to-TAZ travel time and distance skims are built in this stage. First, the zone centroid nodes are identified in the highway network node layer, and then the shortest paths between these node pairs are built based on highway link travel times. Free flow link travel times are used for the first iteration, and averaged link travel times are used for the feedback loop iterations. Distance and time skim matrices are generated for each Origin/Destination pair based on the link travel times. In the second step, intrazonal travel times are computed based on the average travel time to the three closest zones. In the third step, the destination zone terminal times are added to the travel times. In the fourth step, internal and external matrix indices are added to identify rows and columns in the matrices.

Household Size

To determine the number of persons per household. The average household size is determined by dividing the households by the population. Table 5 shows the lookup table to determine the size of households based on the TAZ average household size.

Table 5 Households size by the TAZ Average Household Size

Average Size	One Person	Two Person	Three Person	Four Person
0	0	0	0	0
1	1	0	0	0
1.1	0.8975	0.0689	0.0119	0.0216
1.2	0.7944	0.1487	0.0245	0.0325
1.3	0.6942	0.2254	0.037	0.0434
1.4	0.6038	0.2922	0.0496	0.0544
1.5	0.5309	0.3414	0.0621	0.0655
1.6	0.479	0.3695	0.0746	0.0769
1.7	0.445	0.3795	0.0868	0.0887
1.8	0.4217	0.3785	0.0988	0.101
1.9	0.4019	0.3739	0.1103	0.1139
2	0.3813	0.37	0.1211	0.1277
2.1	0.3589	0.3677	0.131	0.1423
2.2	0.3354	0.3666	0.14	0.1581
2.3	0.3118	0.3654	0.1478	0.175
2.4	0.2893	0.3633	0.1543	0.1931
2.5	0.2689	0.3591	0.1594	0.2126
2.6	0.2512	0.3523	0.1631	0.2333
2.7	0.2356	0.3437	0.1654	0.2553
2.8	0.2188	0.3365	0.1663	0.2784
2.9	0.1976	0.3342	0.1659	0.3024
3	0.1753	0.3335	0.1642	0.327
3.1	0.1553	0.3315	0.1613	0.3519
3.2	0.1384	0.3277	0.1573	0.3766
3.3	0.124	0.3229	0.1523	0.4008
3.4	0.1113	0.3181	0.1465	0.4242

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Average Size	One Person	Two Person	Three Person	Four Person
3.5	0.1637	0.3559	0.1246	0.3559
3.6	0.0888	0.31	0.1338	0.4673
3.7	0.0791	0.3066	0.2838	0.3305
3.8	0.0703	0.3035	0.2349	0.3913
3.9	0.0626	0.3005	0.229	0.4079
4	0.056	0.2975	0.2233	0.4232
4.1	0.0503	0.2945	0.1043	0.5509
4.2	0.0455	0.2913	0.099	0.3311
4.3	0.0416	0.2878	0.1634	0.577
4.4	0.0383	0.284	0.0883	0.5894
4.5	0.0353	0.28	0.083	0.6016

Household Disaggregation

The total number of housing units in that zone was assigned for each TAZ. In 2012 BTPO conducted a household survey to determine the total number of trips generated by various household sizes and the number of workers in each household. The census data verified the data, but that data is no longer available from the Census. The American Community Survey data uses a 5-year average to provide the e detailed information previously provided by the Census. Table 6 provides the percentage of the number of workers by household size.

Table 6 Percent of Workers by household Size

Household Sizes	0 Worker	1 Worker	2 Workers	3 or More Workers
1	0.5449	0.4551		
2	0.3469	0.2992	0.3540	
3	0.1002	0.3537	0.3802	0.1659
4 Plus	0.0677	0.3479	0.3941	0.1903
Source American Community Survey 2020 5-year average table B08202				

The average weekday person trips are generated for each of the six trip purposes:

- HBW – Home-Based Work
- HBC – Home-Based College
- SCH – Home-Based School
- HBS – Home-Based Shopping
- HBO – Home-Based Other
- NHB – Non-Home-Based

The production rates for all purposes are classified by household size and the number of workers per household. Table 7 displays the trip rates by trip purpose. The trip rates were estimated from the BTPO household travel survey and the Travel Demand Forecasting: Parameters and Techniques NCHRP Report 716.

Table 7 Trip Production Rates by Household Size and Trip Purpose

Household Size and Workers	HBW	HBO	HBS	SCH	HBC	NHB
Household Size 1 Workers 0	0.00	2.10	0.81	0	0.30	1.04
Household Size 1 Workers 1	1.25	2.10	0.34	0	0.40	1.60
Household Size 1 Workers 2	0	0	0	0	0	0
Household Size 1 Workers 3+	0	0	0	0	0	0
Household Size 2 Workers 0	0	3.60	1.26	0.14	0.20	1.80
Household Size 2 Workers 1	1.55	3.60	1.1	0.14	0.24	2.40
Household Size 2 Workers 2	2.74	3.60	1.2	0.14	0.24	3.20
Household Size 2 Workers 3+	0	0	0	0	0	0
Household Size 3 Workers 0	0	6.00	1.61	1.70	0.26	2.70
Household Size 3 Workers 1	1.60	6.70	1.75	1.70	0.40	3.30
Household Size 3 Workers 2	2.74	6.70	1.75	1.70	0.40	4.50
Household Size 3 Workers 3+	5.00	6.70	1.10	1.70	0.40	4.80
Household Size 4 Workers 0	0	8.10	1.10	1.50	0.82	3.95
Household Size 4 Workers 1	1.55	8.70	1.83	1.60	0.29	4.88
Household Size 4 Workers 2	2.74	10.10	1.83	1.70	0.29	5.90
Household Size 4 Workers 3+	5.00	11.20	1.83	1.80	0.29	7.08

4.1. External Trips

The region has two interstate highways that run through the region. Through trips do not stop in the planning area; instead, they remain on the interstate. Figure 7 shows the locations of the external stations. The model distributed these external to external (EE) trips from the origins to productions based on the Streetlight data from the fall of 2020. Streetlight Data uses mobile phone and fleet data to track vehicle movements within the region (Table 8). The distribution patterns to/from the other external stations were assigned based on local knowledge (Table 9).

Table 8 External to External Trip Information

Origin	Destination			
	I-15 North (904)	I-15 South (911)	I-86 West (902)	Internal
I-15 North (904)	0.0%	23.3%	12.3%	64.4%
I-15 South (911)	31.2%	0.0%	4.7%	64.1%
I-86 West (902)	23.7%	7.6%	0.0%	68.7%
Internal	44.9%	35.7%	21.2%	0.0%

Figure 7 External Stations

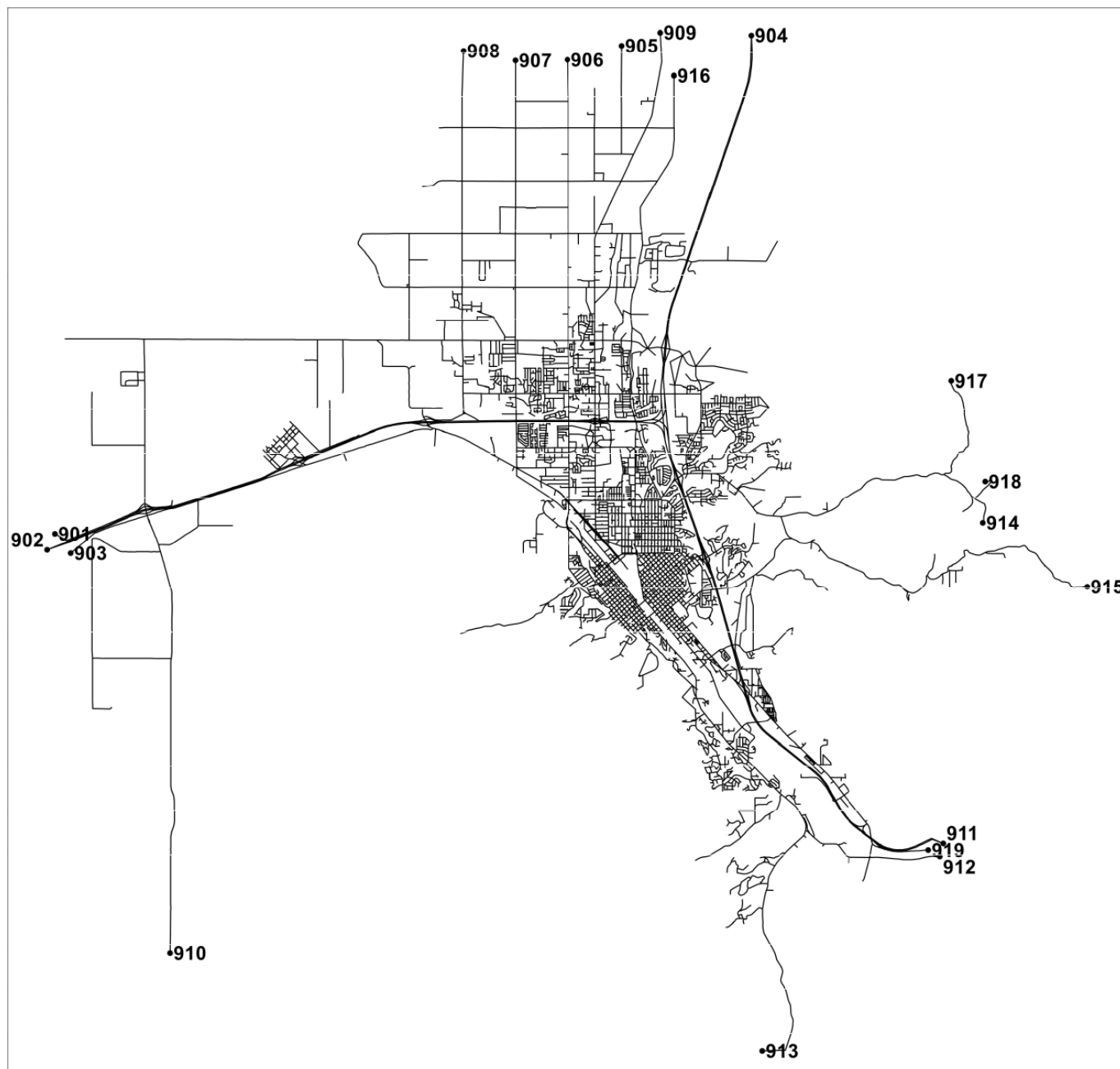


Table 9 External Stations

Station	Annual Average Weekday Traffic	Percent External to External	EE_IN	EE_OUT	EI	IE
901	0	0.06	0.5	0.5	0.5	0.5
902	13,243	0.31	0.47	0.53	0.54	0.46
903	0	0.06	0.5	0.5	0.5	0.5
904	26,865	0.36	0.54	0.46	0.5	0.5
905	200	0.06	0.5	0.5	0.5	0.5
906	317	0.06	0.5	0.5	0.5	0.5
907	395	0.06	0.5	0.5	0.5	0.5
908	0	0.06	0.5	0.5	0.5	0.5
909	4,678	0.06	0.5	0.5	0.62	0.38
910	0	0.06	0.5	0.5	0.5	0.5
911	16,988	0.36	0.46	0.54	0.35	0.65
912	341	0.06	0.5	0.5	0.5	0.5
913	860	0.06	0.5	0.5	0.5	0.5
914	412	0.06	0.5	0.5	0.5	0.5
915	336	0.06	0.5	0.5	0.5	0.5
916	400	0.06	0.5	0.5	0.5	0.5
917	412	0.06	0.5	0.5	0.5	0.5
918	0	0.06	0.5	0.5	0.5	0.5
919	1,583	0.06	0.5	0.5	0.5	0.5

Section 5. Trip Distribution

The destination choice trip distribution model was developed in 2012 from the household travel survey data using a multinomial logit estimation procedure. The model coefficients were evaluated against the Caliper Corporation's model estimation work for the Central Coast CA MPOs of Monterey, San Luis Obispo, and Santa Barbara. The review allowed a better understanding of the model specifications and appropriate coefficients. The structure of the destination choice model did not change. Still, some of the coefficients did change as part of the update to get a better handle on the attractions, improve the trip distribution, and increase the model's sensitivity.

In a destination choice model, trip productions are distributed to destination zones by calculating the utility of each destination, which is a function of the impedance (travel time) and size of the destination (employment at the location). The model uses the following variables:

- A. Auto travel time - Autott = auto travel time matrix
- B. Employment in attraction zones:
 - a. RetEmp = retail trade employees
 - b. SvcEmp = service employees
 - c. EduEmp = education employees
 - d. ISUEmp = Idaho State University employees

- e. OthEmp = all other employees
- C. Households = Households

Table 10 shows the destination choice model utility expressions for the six trip purposes. The Non-Home-Based Production Model was included to address delivery vehicles

Table 10 Destination Choice Model Utility by Trip Purpose

Purpose	Utility Expressions
Home-Based Work	$U = \exp (-0.2975 * \text{autott} + 0.0139 * (\text{autott}^2) - 0.0002 * (\text{autott}^3) + \ln (1.0 * \text{RetEmp} + 2.1441 * \text{SvcEmp} + 3.5078 * \text{EduEmp} + 0.2789 * \text{ISUEmp} + 0.3736 * \text{OthEmp} + 0.4027 * \text{Households}))$
Home-Based Other	$U = \exp (-0.8897 * \text{autott} + 0.0584 * (\text{autott}^2) - 0.0015 * (\text{autott}^3) + \ln (4.475 * \text{RetEmp} + 6.0 * \text{SvcEmp} + 1.252 * \text{EduEmp} + 3.0 * \text{OthEmp} + .1124 * \text{ISUEmp} + 2.5577 * \text{Households}))$
Home-Based Shopping	$U = \exp (-1.0320 * \text{autott} + 0.0719 * (\text{autott}^2) - 0.0018 * (\text{autott}^3) + \ln (2.162 * \text{RetEmp} + 0.1175 * \text{SvcEmp} + 2 * \text{OthEmp} + 0.0103 * \text{Households}))$
Home-Based School	$U = \exp (-1.2490 * \text{autott} + 0.0902 * (\text{autott}^2) - 0.0024 * (\text{autott}^3) + \ln (1.0 * \text{EduEmp} + 0.0616 * \text{SvcEmp} + 0.0239 * \text{OthEmp}))$
Home-Based College	$U = \exp (\ln (1.0 * \text{ISUEmp}))$
Non-Home-Based	$U = \exp (-0.6339 * \text{autott} + 0.0355 * (\text{autott}^2) - 0.0008 * (\text{autott}^3) + \ln (6.702 * \text{RetEmp} + 1.482 * \text{SvcEmp} + 0.7446 * \text{EduEmp} + 0.0624 * \text{ISUEmp} + 0.15 * \text{OthEmp} + 0.5 * \text{Households}))$
Non-Home-Based Production Model	$U = \exp (\ln (6.702 * \text{RetEmp} + 1.482 * \text{SvcEmp} + 0.7446 * \text{EduEmp} + 0.15 * \text{OthEmp} + 0.261 * \text{Households}))$

Section 6. Mode Split

The mode split model is based on a simple lookup table of auto mode shares by district production-attraction pair as calculated from the 2012 household survey. The model defines two modes of travel: auto (which includes driving alone, driving with a passenger, and being a passenger) and non-auto (which includes transit, school bus, walking, and biking). The mode distribution factors vary by trip purpose, production, and attraction district. Table 11 shows the auto-share by production and attraction district for each trip purpose. See Figure 8 for the district boundaries.

Table 11 Model Split by Auto Share and Trip Purpose

From District	To District	HBW auto	HBO auto	HBS auto	SCH auto	HBC auto	NHB auto
1	1	0.98	0.82	0.98	0.6	1	0.88
1	2	0.99	0.99	0.99	0.6	1	1
1	3	1	0.99	0.99	0.6	1	1
1	4	0.95	0.99	0.99	0.6	1	1
1	5	1	1	1	0.6	1	1

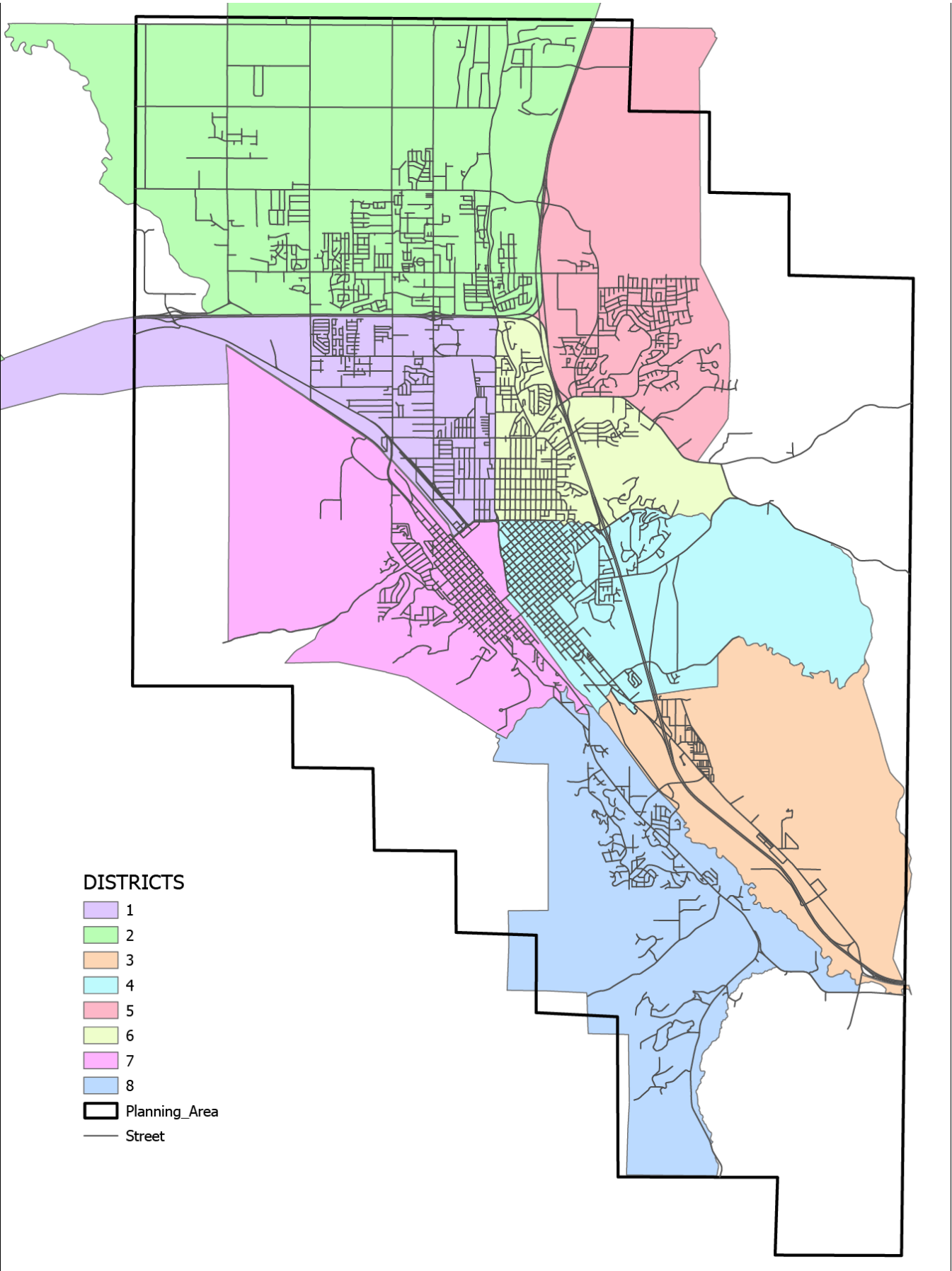
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1	6	1	0.98	0.98	0.6	1	1
1	7	0.99	0.99	0.99	0.6	1	1
1	8	1	1	1	0.6	1	1
2	1	1	0.99	0.99	0.6	1	1
2	2	0.99	0.82	0.98	0.6	1	0.88
2	3	1	0.99	0.99	0.6	1	1
2	4	0.99	0.99	0.99	0.6	1	1
2	5	1	1	1	0.6	1	1
2	6	0.99	0.99	0.99	0.6	1	1
2	7	1	0.99	0.99	0.6	1	1
2	8	1	1	1	0.6	1	1
3	1	0.99	0.99	0.99	0.6	1	1
3	2	1	0.99	0.99	0.6	1	1
3	3	0.99	0.82	0.98	0.6	1	0.88
3	4	0.98	0.99	0.99	0.6	1	1
3	5	1	1	1	0.6	1	1
3	6	0.98	0.99	0.99	0.6	1	1
3	7	0.99	0.99	0.99	0.6	1	1
3	8	1	1	1	0.6	1	1
4	1	0.99	0.99	0.99	0.6	1	1
4	2	1	0.99	0.99	0.6	1	1
4	3	0.99	0.99	0.99	0.6	1	1
4	4	0.9	0.8	0.95	0.6	0.5	0.88
4	5	1	1	1	0.6	1	1
4	6	0.98	0.98	0.98	0.6	1	1
4	7	0.94	0.98	0.98	0.6	0.95	1
4	8	1	1	1	0.6	1	1
5	1	1	1	1	0.6	1	1
5	2	1	1	1	0.6	1	1
5	3	1	1	1	0.6	1	1
5	4	1	1	1	0.6	1	1
5	5	1	0.82	0.99	0.6	1	0.88
5	6	1	1	1	0.6	1	1
5	7	1	1	1	0.6	1	1
5	8	1	1	1	0.6	1	1
6	1	0.99	0.98	0.98	0.6	1	1
6	2	0.99	0.99	0.99	0.6	1	1
6	3	0.99	0.99	0.99	0.6	1	1
6	4	0.95	0.98	0.98	0.6	1	1
6	5	1	1	1	0.6	1	1
6	6	0.99	0.82	0.98	0.6	1	0.88
6	7	0.99	1	1	0.6	1	1
6	8	1	1	1	0.6	1	1
7	1	0.99	0.99	0.99	0.6	1	1

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7	2	1	0.99	0.99	0.6	1	1
7	3	0.99	0.99	0.99	0.6	1	1
7	4	0.94	0.98	0.98	0.6	0.95	1
7	5	1	1	1	0.6	1	1
7	6	0.99	1	1	0.6	1	1
7	7	0.98	0.82	0.98	0.6	1	0.88
7	8	1	1	1	0.6	1	1
8	1	1	1	1	0.6	1	1
8	2	1	1	1	0.6	1	1
8	3	1	1	1	0.6	1	1
8	4	1	1	1	0.6	1	1
8	5	1	1	1	0.6	1	1
8	6	1	1	1	0.6	1	1
8	7	1	1	1	0.6	1	1
8	8	1	0.82	1	0.6	1	0.88

Figure 8 Planning Districts



Section 7. Trip Assignment

7.1. Time of Day Factors

Travel by time of day is estimated for auto trips, and the factors are direction-specific (production to attraction or attraction to production direction). The time-of-day factors were estimated by the hour using the trip start and end time data from the household travel survey and are similar to national defaults. Table 12 provides the factors used to convert the daily trip tables to hourly.

Table 12 Time of Day Factors

Purpose	Am pa	Am ap	Md pa	Md ap	Pm pa	Pm ap
HBW	0.1736	0.0328	0.053	0.0347	0.013	0.1557
HBO	0.085	0.2467	0.08	0.0444	0.062	0.0758
HBS	0.015	0.1824	0.165	0.0799	0.028	0.063
SCH	0.346	0	0.019	0.0127	0.007	0.0545
HBC	0.264	0	0.124	0.0461	0.0097	0.0255
NHB	0.045	0.0165	0.97	0.0646	0.0175	0.02825
pa = Production to Attraction ap = Attraction to Production						

7.2. Volume Delay Function

The volume-delay function affects the travel speed on links as the volume of that link increases. The model used the Bureau of Public Roads function. Table 13 provides the alpha and beta by facility and area type.

$$t_i \cdot \left[1 + \alpha_i \left(\frac{x_i}{C_i} \right)^{\beta_i} \right]$$

Where:

- t_i = Free flow travel time on link i
- C_i = Capacity of link i
- x_i = Flow on link i
- α = Constant
- β = Constant

Table 13 Volume Delay Parameters Alpha and Beta

Area Type	Facility Type	alpha	beta
3	0	0.00001	2
3	1	1.601	6.7774
3	2	1.5472	6.8996
3	3	1.4906	7.0338
3	4	1.4299	7.185
3	5	1.3205	7.4798
3	6	1.3205	7.4798
2	0	0.00001	2
2	1	1.601	6.7774
2	2	1.5472	6.8996
2	3	1.4906	7.0338
2	4	1.4299	7.185
2	5	1.3205	7.4798
2	6	1.3205	7.4798
1	0	0.00001	2
1	1	1.601	6.7774
1	2	1.5472	6.8996
1	3	1.4906	7.0338
1	4	1.4299	7.185
1	5	1.3205	7.4798
1	6	1.3205	7.4798

7.3. Auto Occupancy Rates

The trip rates identified in Table 7 are person trips. The model uses auto occupancy by trip purpose to convert the person trips to vehicle trips (Table 14).

Table 14 Auto Occupancy Factors

Trip Purpose	Auto Occupancy Factor
Home-Based Work	1.0050
Home-Based Other	1.2800
Home-Based Shopping	1.1400
Home-Based School	1.1400
Home-Based College	1.0900
Non-Home-Based	1.2000

7.4. Turn Penalties Restrictions

In the TDM, the connection of two or more street segments is completed using a node. The node is a GIS representation of an intersection. Intersections allow left, right, and through movements to occur. There are intersections like South 2nd Avenue and East Benton Street where specific movements are not allowed. A turn penalty table identifies the movements that are not allowed and prohibits trips from routing through that node.

7.5. Assignment Algorithms

There is usually more than one route from an origin to a destination. Traffic assignment is the procedure used to determine each trip's route. The BTPO model uses the equilibrium assignment algorithm. Equilibrium assumes that travelers have perfect knowledge and they select the route with the fastest travel time. The volume delay function changes the travel time for each model run, and the resulting travel times can change the selected routes. Equilibrium assignment tries to minimize travel time for all users. The changing travel time can cause the model to switch from one route to another on each model iteration. The BTPO model runs a maximum of 50 iterations, and traffic assignment has a closure gap of $0.0001(10^{-5})$.

Section 8. Model Validation

8.1. Trips

Validating the model involves comparing the observed (traffic counts) against the assigned (model volumes). BTPO and the Idaho Transportation Department take traffic counts throughout the region annually. The observed data comes from the fall of 2020 or 2021. The 2021 data is used when the count is similar to the historic counts on that link. COVID-19 affected spring and summer counts in the BTPO Planning Area.

Table 15 provides a comparison of model volumes to count volumes. The model performs well, with the model volumes within the validation targets. The Interstate ramp is the only facility type over the validation targets.

Table 15 Daily Observed Versus Model Volumes by Facility Type

	Number of Segment	Model Volume	Count Volume	Percent Difference	Validation Target ²
Local	54	54,952	73,701	-25.4%	N/A
Collector	106	119,007	140,839	-15.5%	+/- 25%
Minor Arterial	213	772,572	770,713	.24%	+/- 15%
Principal Arterial	146	982,457	954,053	3.0%	+/- 15%
Ramp	4	15,854	14,240	11.3%	+/- 7%
Interstate	11	142,246	137,763	4.0%	+/- 7%
Total	534	2,087,088	2,091,309	0.2%	+/- 2%

The overall difference between assigned and observed is less than one percent. The overall percentage does not mean every street segment is within one percent. Some links perform very well, but others underestimate or overestimate the traffic volumes. The percent Root Mean Square Error (RMSE) for each facility type is shown in Table 16. Figure 9 shows the model estimation for all facility types. The validation targets were taken from the Virginia Department of Transportation, but several other states, including Utah and Tennessee, have similar validation targets.

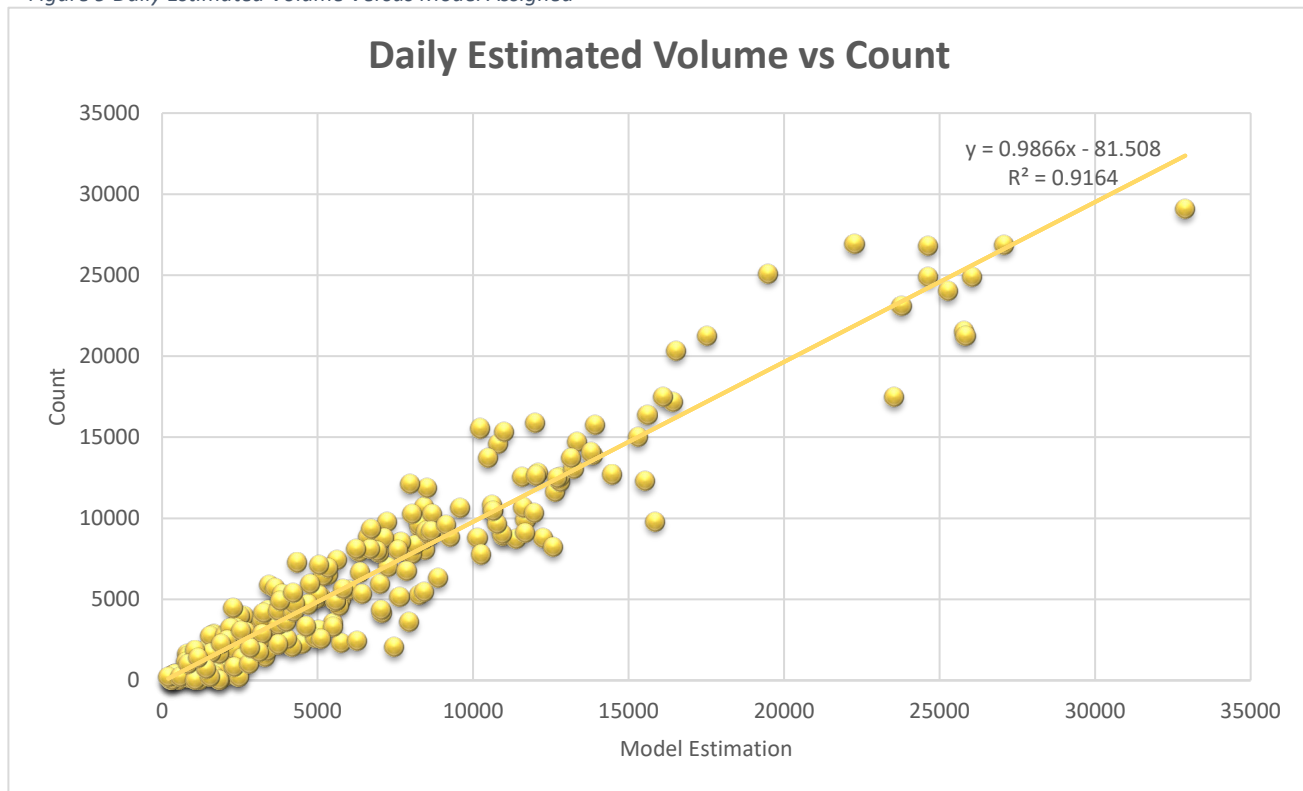
² TMIP “Travel Model Validation and Reasonability Checking Manual – Second Edition” Cambridge Systematics Inc. Sept. 2010)

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Table 16 Model Percent Root Mean Square Error

	Number of Segment	Percent RMSE	Validation Target ³⁴
Local	54	58.89%	N/A
Collector	106	46.56%	70%
Minor Arterial	213	24.35%	40%
Principal Arterial	146	22.62%	30%
Ramp	4	22.84%	20%
Interstate	11	23.34%	20%
Total	534	11.91%	40%

Figure 9 Daily Estimated Volume Versus Model Assigned



8.2. Trip Length Distribution

The 2012 household survey provided information on the length of trips for the trip purpose. Streetlight Data uses mobile phone and fleet data to look at the trip characteristics within the region. The data does not include the trip purpose. Figure 10 shows the trip length data for the Travel Demand Model, Household Survey, and Streetlight data for all trip purposes. The trip length for each trip purpose was summed to get a trip length distribution for all trips. The Streetlight data set does not include trip purposes.

The trip length distribution curve for the six trip purposes is shown in Figures 12 through 16.

³ NCHRP Report 716 “Travel Demand Forecasting Parameters and Techniques” Transportation Research Board, 2012

⁴ Virginia Department of Transportation Travel Demand Model Policies and Procedures version 2, 2014

Figure 10 Trip Length Distribution

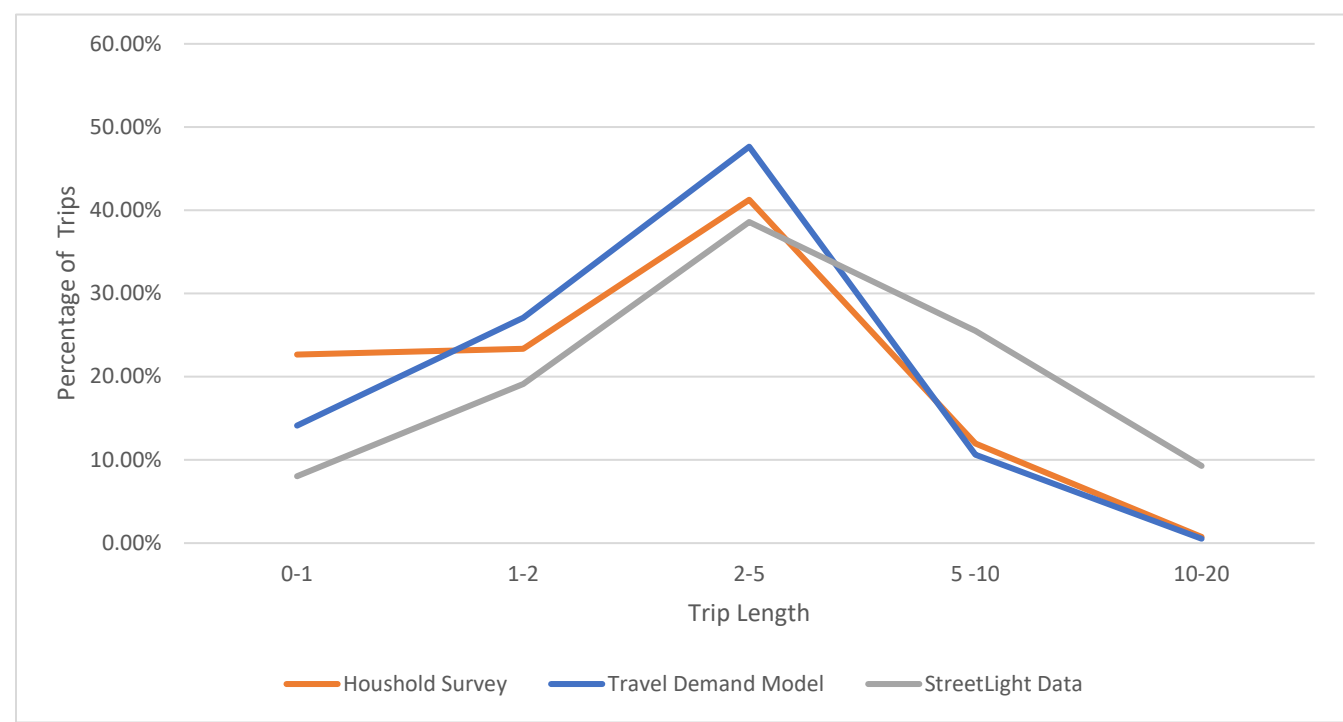


Figure 11 Work Trip Length Distribution

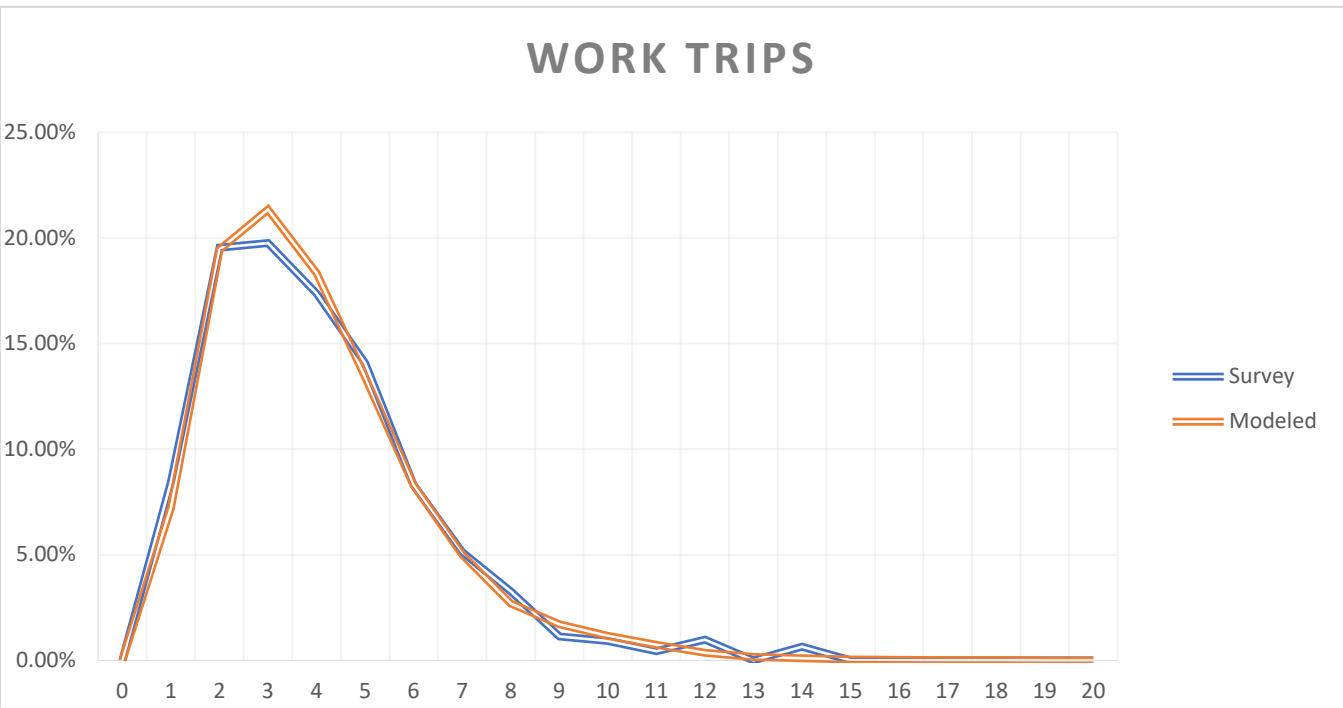


Figure 12 Home Based Other Trip Length Distribution

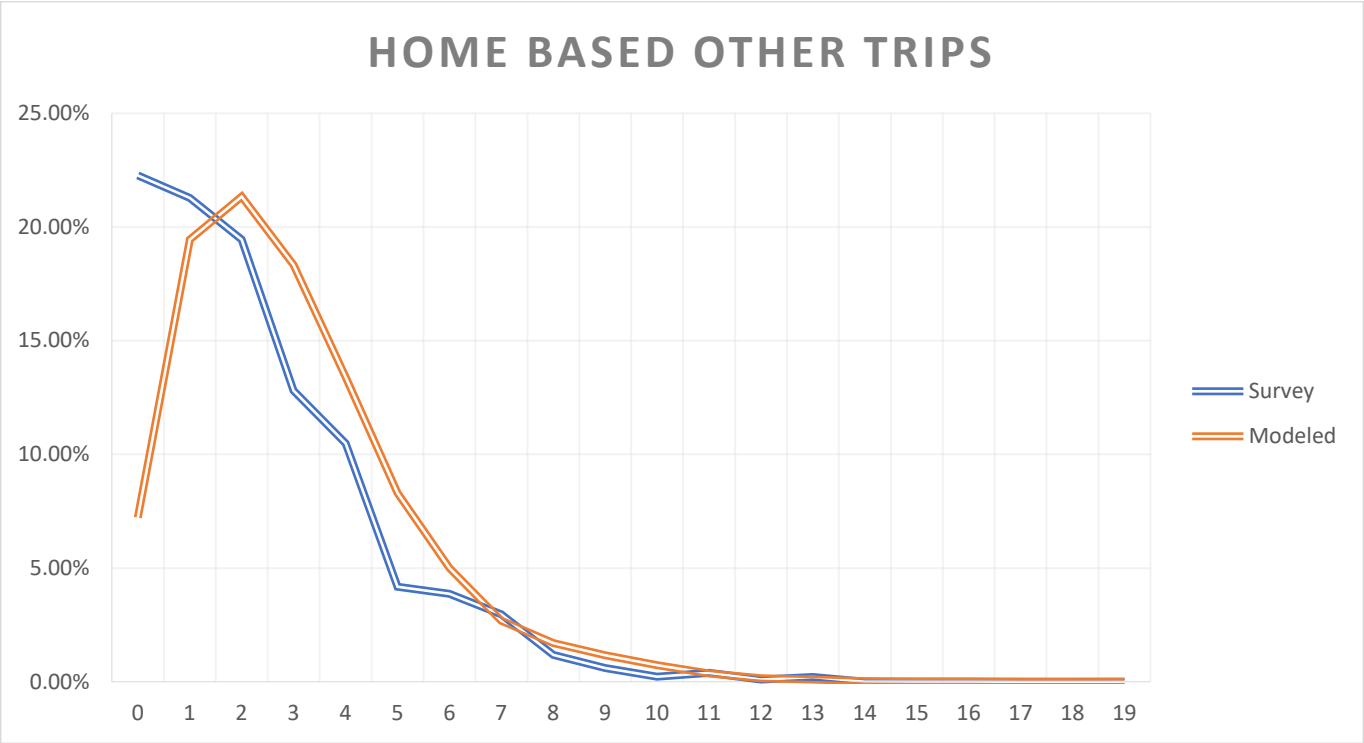


Figure 13 Shopping Trip Length Distribution

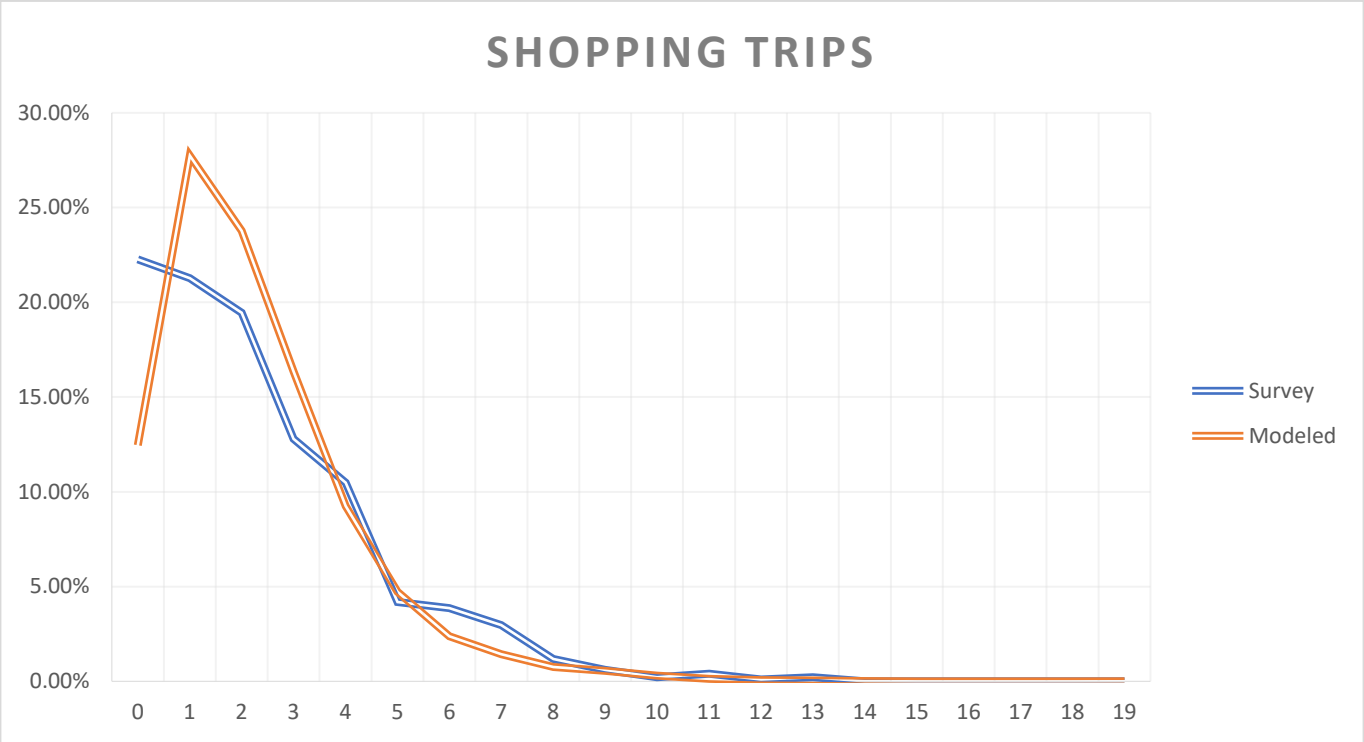


Figure 14 Not Home-Based Trip Length Distribution

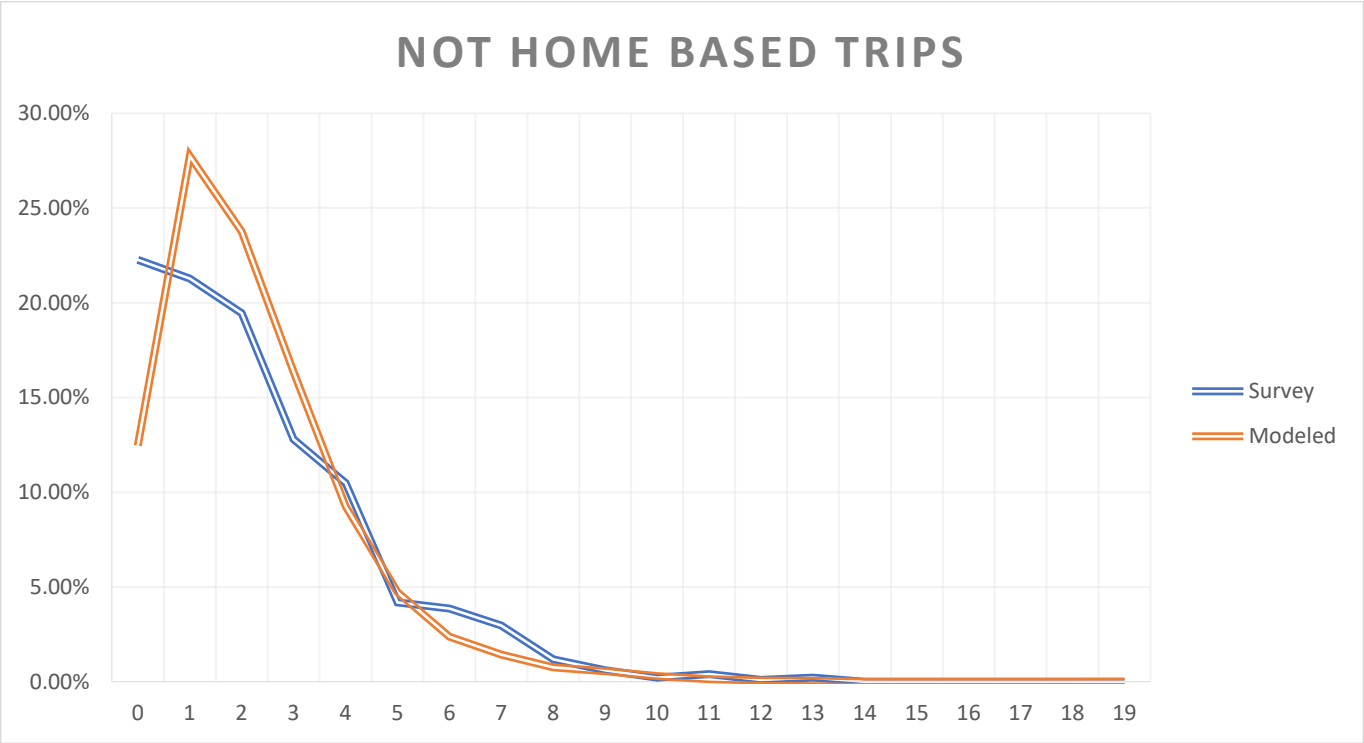


Figure 15 Home Based College Trip Length Distribution

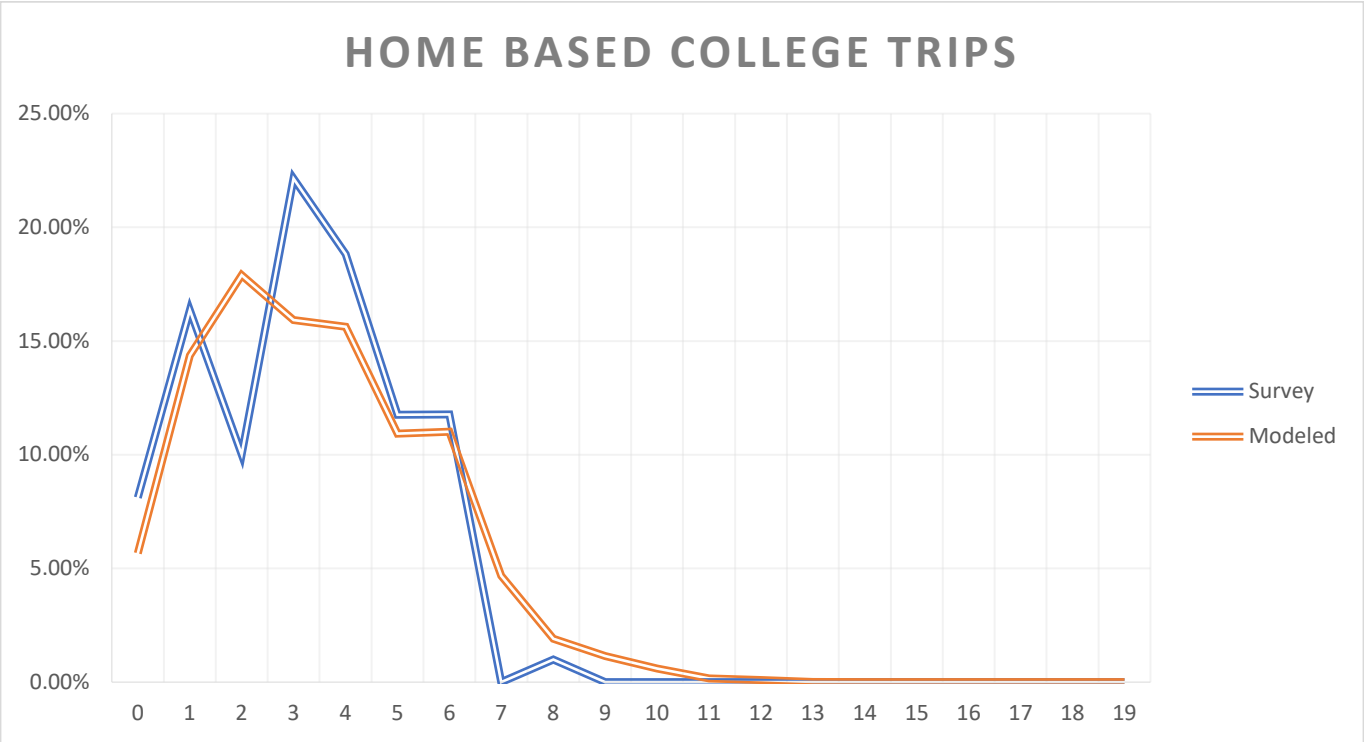
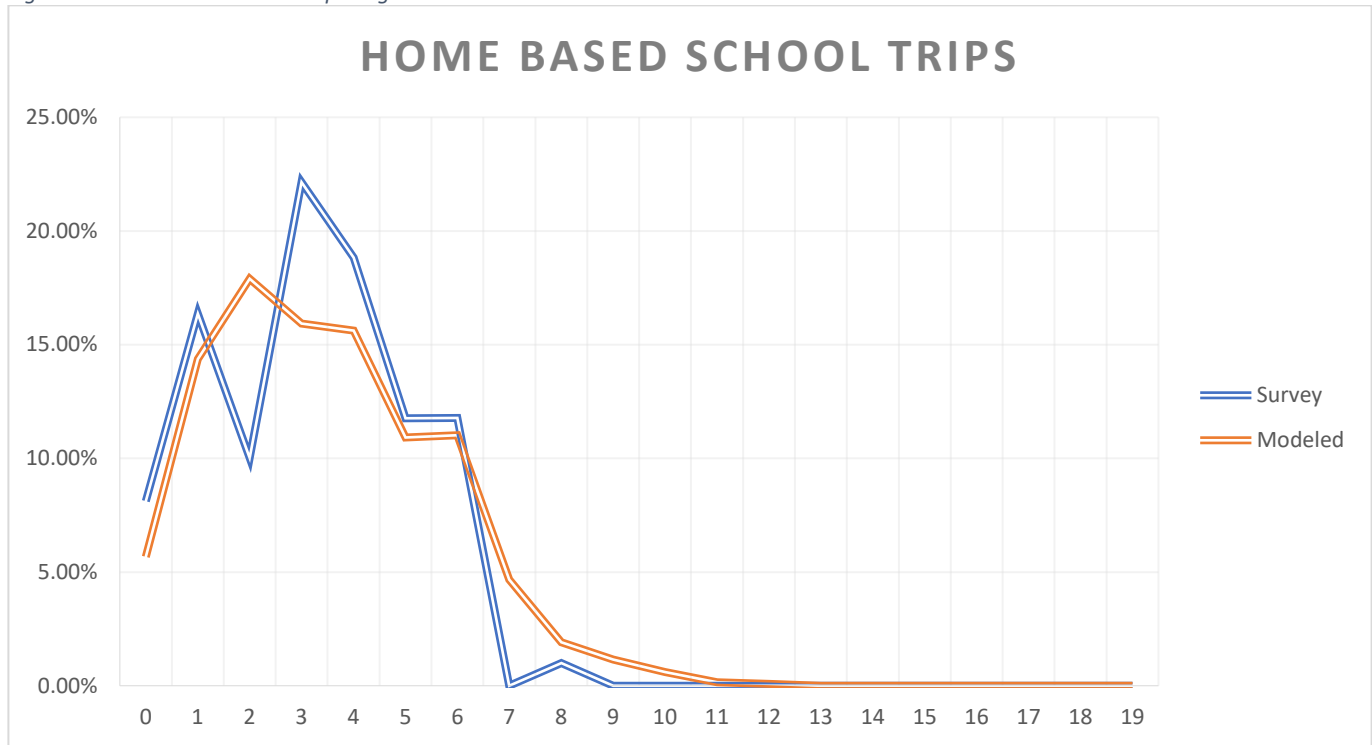


Figure 16 Home Based School Trip Length Distribution



Section 9. Future Year Model Development

The validation of the base 2020 model allows the TDM to be used to project future years and changes to the street network. Future year models require socioeconomic data, external travel, and changes to the street network.

9.1. Future Year Socioeconomic Data

Woods and Poole Economics 2020 data was used to determine the county-level control total for the population. The projected gain in population from 2020 to 2050, divided by the 2020 Census average persons per household, determined the additional housing units needed in the region. The number of households was determined by applying the 2020 regional vacancy rate of 4.5%. Table 17 provides the housing unit and household data for 2020 – 2050 in five-year intervals.

The absence of a mandatory employment census makes employment projections more challenging than housing units. The Bureau of Economic Analysis (BEA) employment data is the best estimate of county employment data. BEA counts the jobs in the County using the U.S. Bureau of Labor Statistics and the Internal Revenue Service data. BEA also uses additional not disclosed data sources to make other adjustments to account for jobs not captured in those data. Table 18 provides the employment data for 2020 – 2050 in five-year intervals.

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Table 17 2020 -2050 Housing Units and Households based on Woods and Poole Population Projection

Housing Units		Planning Area		
Year	Bannock County	Bannock County	Power County	Total
2020	34,903	31,068	79	31,147
2025	36,399	32,268	89	32,358
2030	37,366	33,129	101	33,231
2035	38,239	33,907	115	34,021
2040	38,989	34,574	130	34,704
2045	39,678	35,187	147	35,334
2050	40,385	35,816	166	35,983
Change 2020 -2050	5,482	4,748	87	4,836
Percent Change 2020 -2050	13.57%	13.26%	52.50%	13.44%
Households		Planning Area		
Year	Bannock County	Bannock County	Power County	Total
2020	31,068	29,116	73	29,189
2025	32,268	30,262	83	30,345
2030	33,129	31,085	94	31,178
2035	33,907	31,827	106	31,933
2040	34,574	32,464	120	32,584
2045	35,187	33,049	136	33,185
2050	35,816	33,651	154	33,804
Change 2020 -2050	4,748	4,535	81	4,615
Percent Change 2020 -2050	13.26%	13.48%	52.50%	13.65%
Source is the 2020 Census data used for Bannock County, Power County, and the BTPO Planning Area. Woods and Poole is the source of future housing data. The percentage of Bannock County Housing Units in the BTPO Planning area is 89%. The 2020 percentage is used to calculate BTPO Housing Units for 2025 -2050. The estimated household size is 2.62 people per household. The vacancy rate is .955 percent. Power County housing information is only for the BTPO modeling area.				

Table 18 Employment Projections from 2020 -2050

Year	Bannock County	Planning Area		
		Bannock County	Power County	Total
2020	39,366	36,296	655	36,951
2025	41,270	38,051	686	38,737
2030	43,174	39,807	715	40,522
2035	45,078	41,562	746	42,308
2040	46,983	43,318	777	44,095
2045	48,887	45,073	807	45,881
2050	50,791	46,829	838	47,667
Change 2020 -2050	11,424	10,533	183	10,716
Percent Change 2020 -2050	22.49%	22.49%	21.85%	22.48%
Note: the BTPO Planning Area employment is calculated as 92.2% of the Bannock County employment. The percentage is consistent over the forecast period. Power County employment was increased by a similar percentage as Bannock County				

Figure 17 Housing Unit Allocation 2050 by TAZ

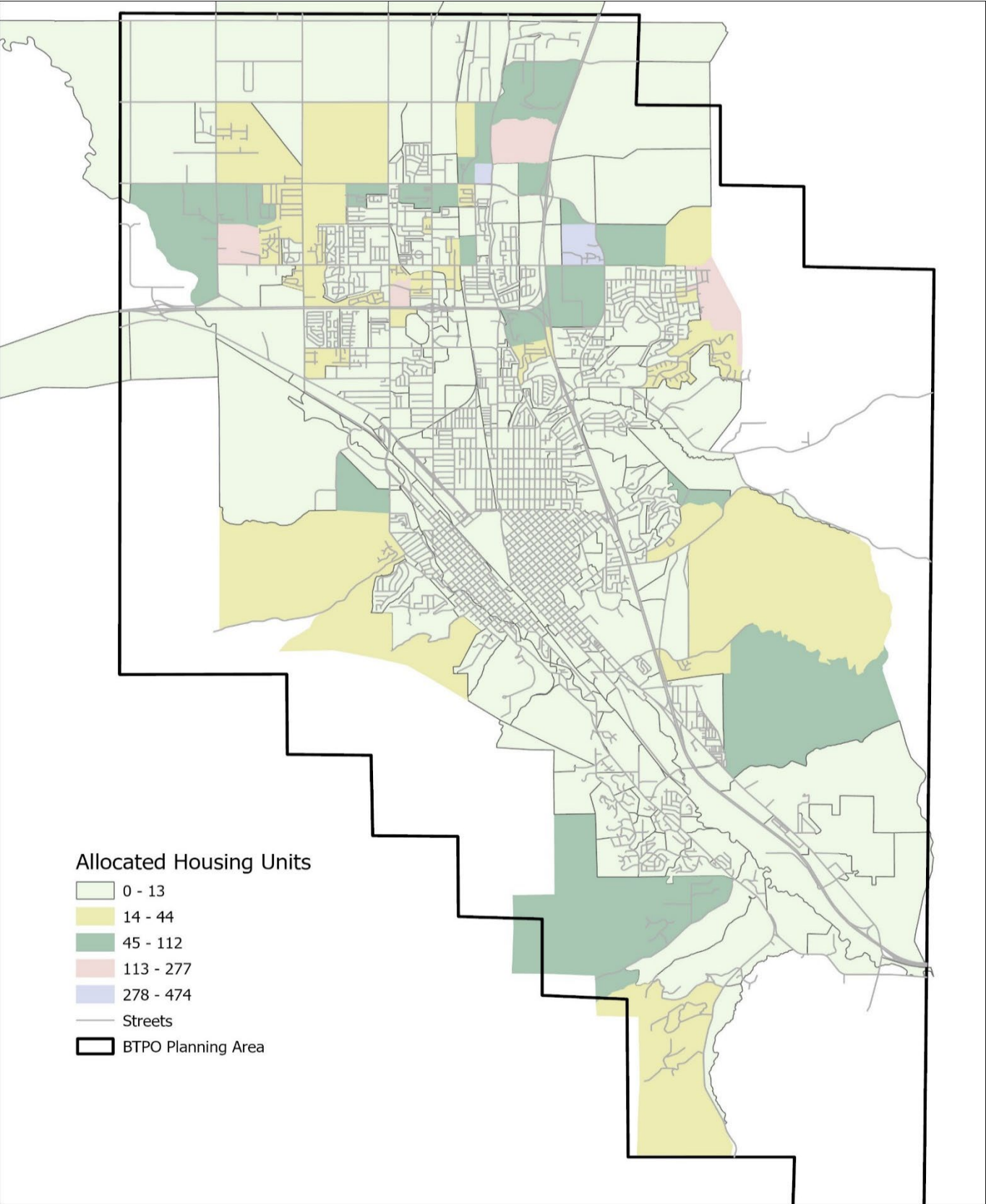


Figure 18 Employment Allocated 2050

