WHAT'S NEW

WASATCH FRONT TRAVEL DEMAND MODEL VERSION 9

WFRC / MAG

September 19, 2023

Table of Contents

List of Figures

List of Tables

1 Overview

The vast majority of the changes made to the Wasatch Front Travel Demand Model (WF TDM) in version 9 represent refinements to prepare the model for use in developing MAG and WFRC's 2023 Regional Transportation Plans. These refinements include:

- Updates to the traffic analysis zones
- Updates to the socioeconomic county control totals and TAZ-level forecasts
- Updates to the highway and transit input files to reflect the 2023-2050 Regional Transportation Plan (RTP) and 2023-2028 Transportation Improvement Program (TIP) projects
- Updates to the parameters and input files to reflect the model's new 2019 base year

Other changes made to the WF TDM were to improve the model's capability and to perform regular maintenance of the model's code base and processing.

2 Traffic Analysis Zone Updates

2.1.1 Changes to TAZ Geometry and Attributes

Major changes were made to the version 9 Traffic Analysis Zones (TAZ), including:

- Internal TAZ were split to increase the model's geographic resolution.
- TAZ boundaries were modified to better align with underlying land uses and planning boundaries.
- The geographic coverage area was expanded to encompass the entire county for Davis, Salt Lake, and Utah counties. Weber County was expanded up to the ridgeline of the east canyon/mountain areas of the WFRC planning domain but does not include the Ogden Valley area. Box Elder was expanded to encompass up to the ridgeline of the east canyon/mountain areas of the WFRC planning domain.

Figure 2.1 through Figure 2.6 show the expanded geographic area and the difference in TAZ boundaries between version 9 and version 8.

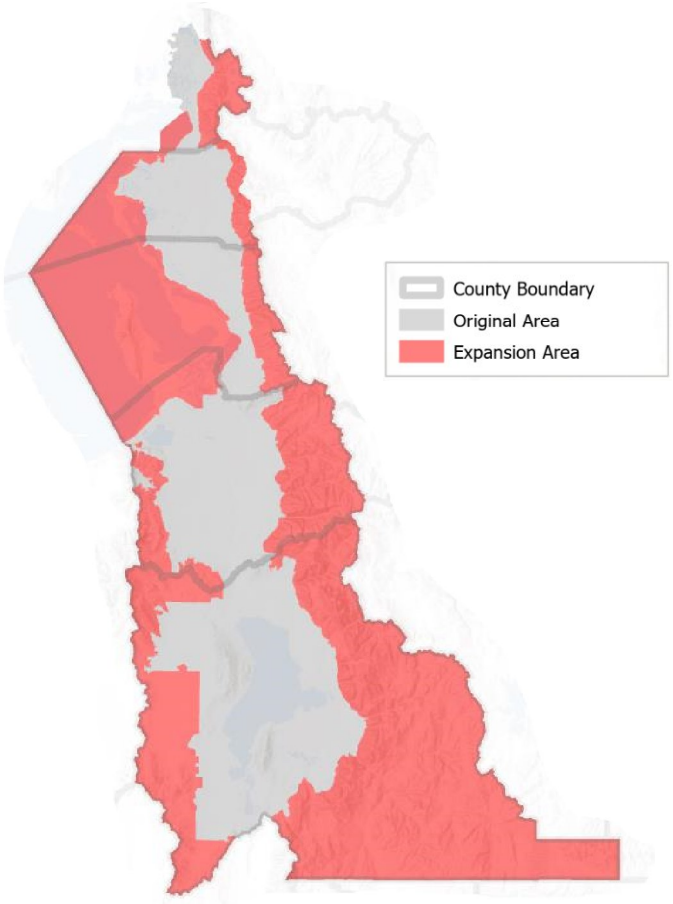


Figure 2.1 Version 9 Expanded Geographic Area

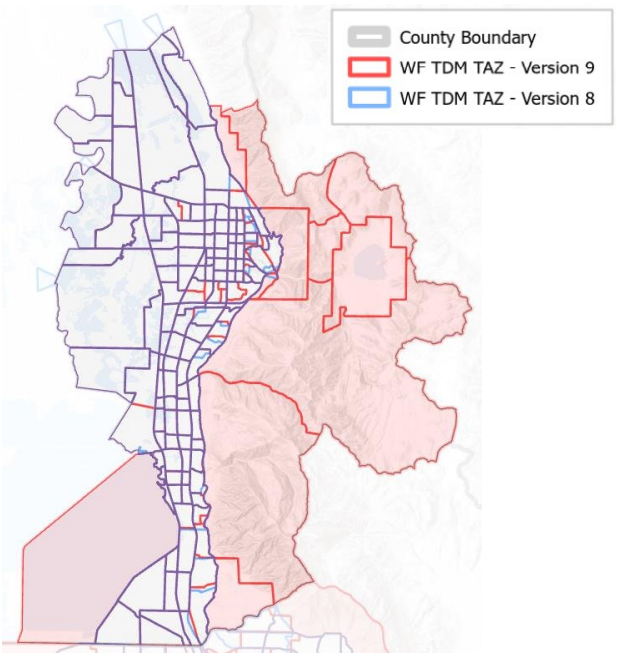


Figure 2.2 TAZ – Box Elder County

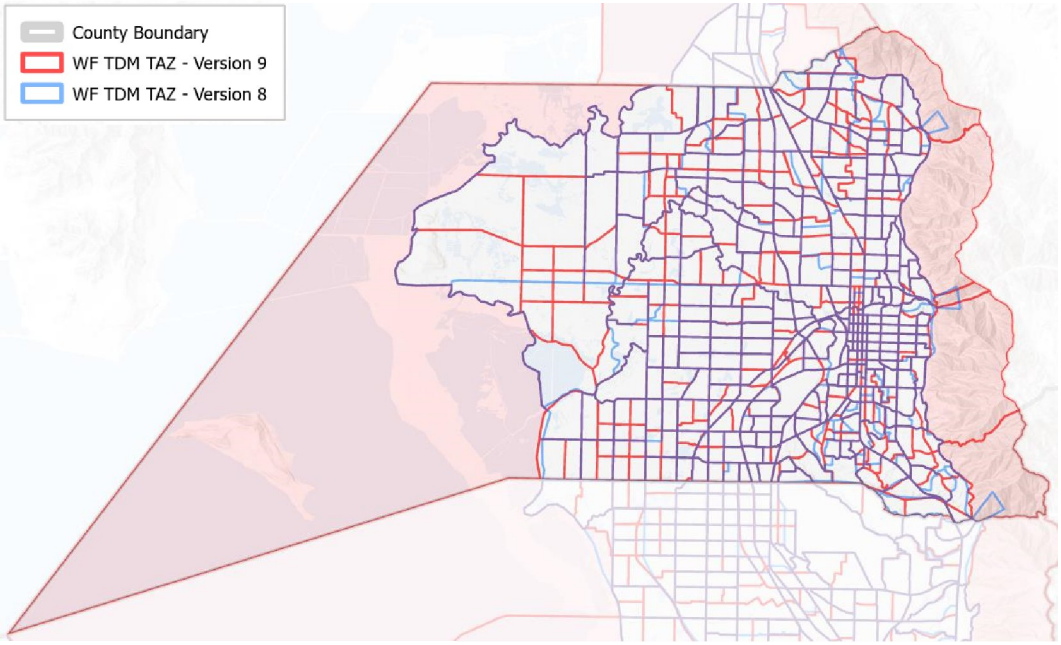


Figure 2.3 TAZ – Weber County

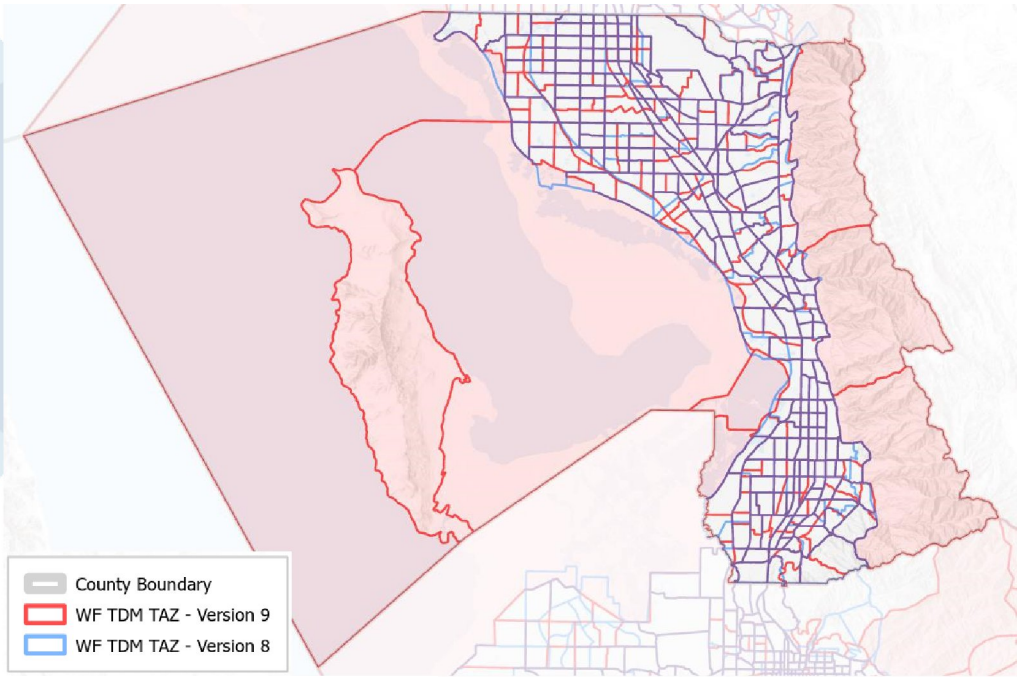


Figure 2.4 TAZ – Davis County

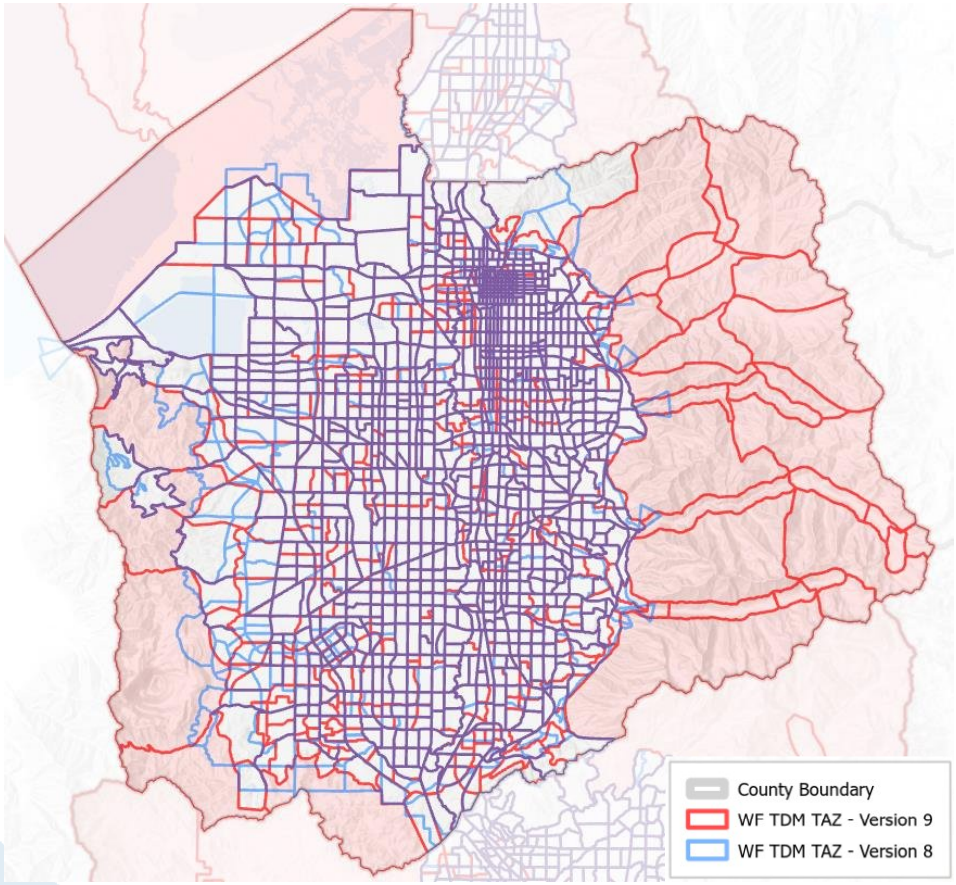


Figure 2.5 TAZ – Salt Lake County

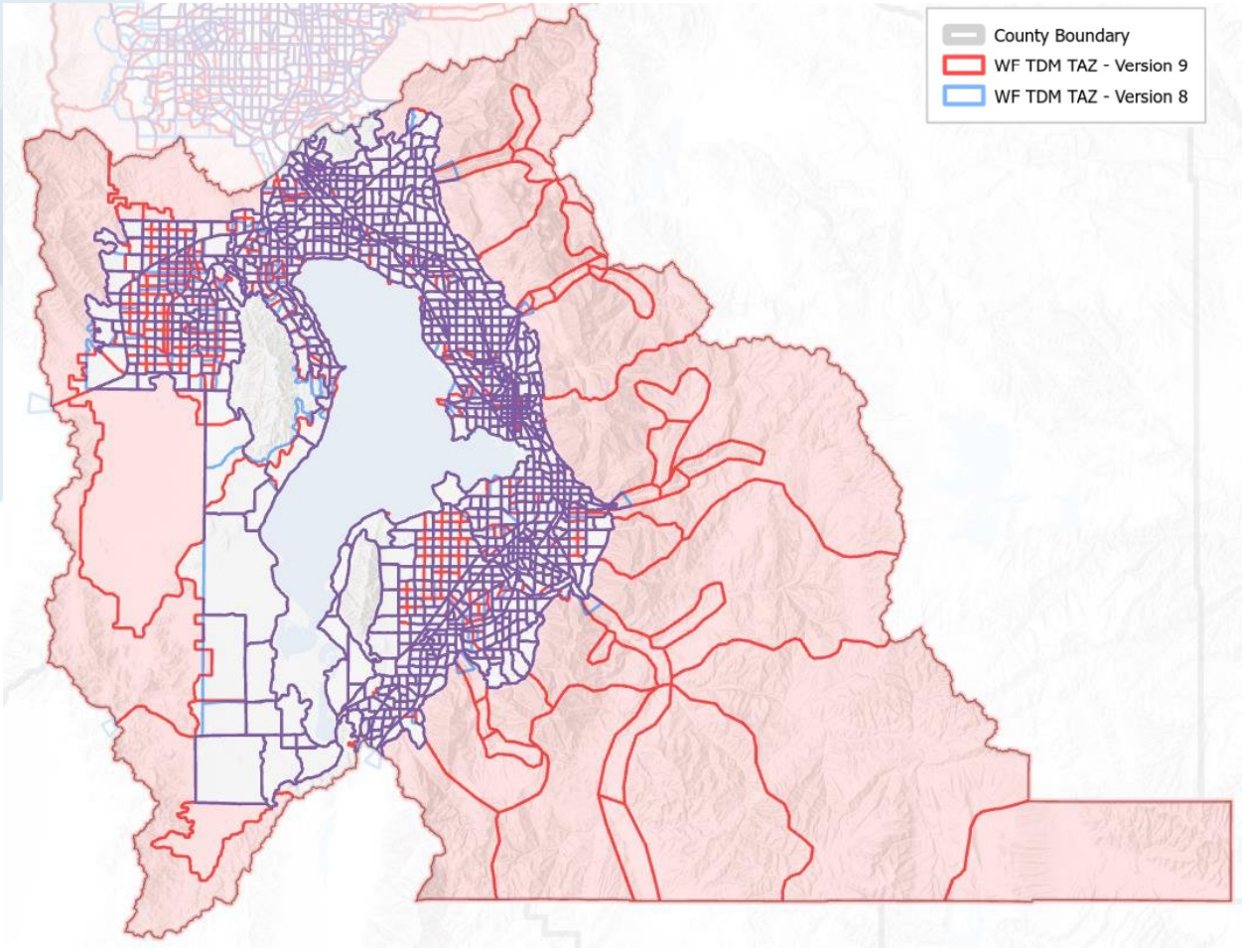


Figure 2.6 TAZ – Utah County

The changes resulted in the addition of 688 internal TAZ. The new internal TAZID range for each county was updated to account for the new zone configuration. A buffer of 54 zones was inserted after the last internal TAZ to allow for future internal TAZ expansion within the max used-zone value.

Table 2.1 Internal TAZ Comparison

County	v9 Count	v8 Count	Change	v9 TAZID Range	v8 TAZID Range
Box Elder	153	135	18	1-153	1-135
Weber	428	280	148	154-581	141-420
Davis	324	231	93	582-905	424-654
Salt Lake	1311	1127	184	906-2216	655-1781
Utah	1330	1085	245	2217-3546	1789-2873
Total	3546	2858	688	1-3546	1-2873
Unused Zones	54	0	54	3547-3600	NA

The locations and numbering of the external TAZ gateways were revised to reflect the changes of the expanded internal TAZ coverage area and new internal numbering. The external TAZ numbering was grouped and placed after the internal TAZ and an unused zone buffer. For reference, version 8 external TAZ were ordered by county and shuffled in the internal TAZ range, (e.g. Box Elder externals TAZ following after the Box Elder internal TAZ, Weber external TAZ following the Weber internal TAZ, etc.). The external TAZ changes resulted in the addition of 6 external TAZ. (See Section 4.1.5 for more information on external zones.)

Table 2.2 External TAZ Comparison

County	v9 Count	v8 Count	Change	v9 TAZID Range	v8 TAZID Range
Box Elder	6	5	1	3601-3606	136-140
Weber	3	3	0	3607-3609	421-423
Davis	0	0	0		
Salt Lake	6	7	-1	3610-3615	1782-1788
Utah	14	8	6	3616-3629	2874-2881
Total	29	23	6	3601-3629	137-140, 421-423, 1782-1788, 2874-2881

In addition, the following changes were made to the TAZ shapefile:

- The TAZ UTM NAD83 projection was fixed to use the standard for Utah rather than the ArcGIS default.
- All TAZ boundaries were realigned to county boundaries from the most recent UGRC county dataset.
- All internal TAZ topology was checked and corrected to exclude slivers, gaps, and overlaps.
- External zone polygons (i.e. the arbitrary polygons representing the external zones) were removed in the TAZ shapefile.
- **PRKCSTPERM** and **PRKCSTTEMP** fields were updated (see Section 5.1.5 for additional information)
- Large, medium, and small district definitions were updated. There are now 26 large districts, 73 medium districts, and 110 small districts. Medium districts still nest within large districts. Small districts were defined based on city area definitions and do not nest within medium districts. All districts were renamed and no longer include commas in the text string.
- **CITY**, **COUNTY**, and **EXTERNAL** fields were removed. All model scripts referencing **CITY** and **COUNTY** were updated to use **CITY_FIPS** and **CO_FIPS**.
- A **REMM** field was added to indicate which TAZs are included in the Real Estate Market Model (REMM), as shown in Figure 2.7. A value of 1 indicates that the TAZ is part of the REMM area.

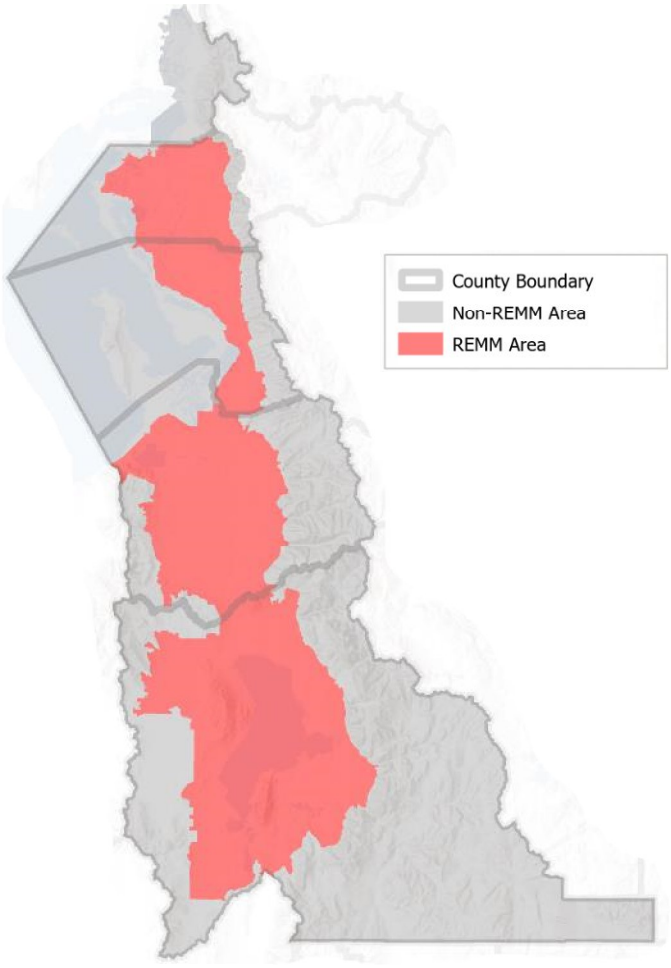


Figure 2.7 TAZ REMM Space

2.1.2 Changes to TAZ Parameters

The following TAZ-related parameters, located in the "0_GeneralParameters.block" file, were changed to reflect the version 9 TAZ updates. For comparison purposes, version 8 parameters are also presented.

Used Zones

Table 2.3: Updated Used Zones

Parameter	v9 Value	v8 Value	Notes
UsedZones	3629	2881	Highest TAZ number used by model

TAZ Ranges

Table 2.4: Renumbered TAZ Ranges

Parameter	v9 Value	v8 Value	Notes
UsedZones	3629	2881	Highest TAZ number used by model
BoxElderRange	1-153	1-140	Box Elder County Range
WeberRange	154-581	141-423	Weber County Range
DavisRange	582-905	424-654	Davis County Range
SLRange	906-2216	655-1788	Salt Lake County Range
UtahRange	2217-3546	1789-2881	Utah County Range
Dummyzones	3547-3600	2882-3400 (note these are outside of UsedZones)	Placeholder for future TAZ splits
Externalzones	3601-3629	136-140, 421-423, 1782-1788, 2874-2881	External zones
NorthBC	3604-3606	138, 139, 140	North Brigham City external zones

College Zones

Where noted, several colleges were effectively removed from the model in version 9. References to these schools are still in the code base but enrollment was set to zero.

Table 2.5 Renumbered College Zones

Area	Parameter	v9 Value	v8 Value	Notes
WFRC Colleges	Ensign (was LDSBC)	1029	950	Ensign College
	Westmin	1263	1150	Westminster College
	UOFU_Main	1051	1075	University of Utah - Main
	UOFU_Med	(removed)	1076	University of Utah - Medical
	WSU_Main (was WSU_OGDEN)	437	383	Weber State University - Main
	WSU_Davis	693	525	Weber State University - Davis
	WSU_West	(removed)	290	Weber State University - West
	SLCC_Main (was SLCC_TL)	1580	897	Salt Lake Community College - Main
	SLCC_SC	1231	1126	Salt Lake Community College - South City
	SLCC_JD	1776	1493	Salt Lake Community College - Jordan
	SLCC_Mead	(removed)	1206	Salt Lake Community College - Meadbrook
	SLCC_ML	1886	1516	Salt Lake Community College - Miller
	SLCC_LB	(removed)	989	Salt Lake Community College - Library
	SLCC_HL	(removed)	1294	Salt Lake Community College - Highland
	SLCC_Airp	(removed)	746	Salt Lake Community College - Airport
	SLCC_West	(removed)	745	Salt Lake Community College - Westpointe
	SLCC_HM	(removed)	1607	Salt Lake Community College - Herriman
MAG Colleges	BYU	2939	2384	Brigham Young University - Main
	UVU_Main	2848	2326	Utah Valley University - Main
	UVU_Geneva	(removed)	2280	Utah Valley University - Geneva
	UVU_Lehi (was UVU_THANKP)	2606	2099	Utah Valley University - Lehi
	UVU_Vine	2809	2259	Utah Valley University - Vineyard
	UVU_Payson	3336	2690	Utah Valley University - Payson

Table 2.6 Updated Colleges (Range)

Parameter	v9 Value	v8 Value
colleges	437, 521, 693, 959, 979, 1007, 1029, 1051, 1085, 1231, 1263, 1491, 1525, 1580, 1776, 1886, 2031, 2606, 2809, 2848, 2882, 2939, 3336	290, 383, 525, 897, 950, 989, 1075, 1076, 1126, 1150, 1294, 1493, 1516, 1607, 2099, 2259, 2280, 2326, 2384, 2690

Zones with Off-line (Exogenous) Trip Tables

Table 2.7 Renumbered Off-line Trip Table Zones

Parameter	v9 Value	v8 Value
Lagoon	781	562
Airport	965	742

Special Generator Zones

Table 2.8 Renumbered Special Generator Zones

Parameter	v9 Value	v8 Value
TempleSquare	1035	966
SLC_Library	1147	1015

Removed Parameters

The following TAZ parameters were removed from the general parameters file as they were not being used in the WF TDM:

- RegionRange
- WFRCRange
- MAGRange

2.1.3 Changes to TAZ Input Folder

The following changes were made in the "1_Inputs\1_TAZ" folder:

- Added "*_Source*" folder which includes the following shapefile datasets:
  - Cities shapefile
  - Counties shapefile
  - Environmental constraints shapefile (just the Wasatch Front model space)
  - Previous version 8.3.2 TAZ
- Added "*_ViewTAZDistricts*" folder containing an ArcGIS Pro project with predefined symbology for viewing TAZ and district shapefiles.
- In the "Districts" folder:
  - Updated the large, medium, and small district shapefiles based on the new TAZ delineations and district definitions.
  - Added new shapefiles representing the Wasatch Front subarea, the REMM area, and super districts.

3 Socioeconomic Data Updates

3.1 Control Totals

3.1.1 Changes to County Socioeconomic Data

The WF TDM version 9's socioeconomic county control totals were updated based on the Gardner Policy Institute (GPI) 2021 release of the state's residential and employment county forecasts. Significant changes were made relative to the 2017 release. A comparison between version 9 and version 8 of the model's socioeconomic control totals can be found in Figure 3.1, Figure 3.2, and Figure 3.3.

Household Population

The 2021 forecasted household population of the combined, 4-county Wasatch Front remained relatively consistent relative to the 2017 projection, with the exception of a slight decrease in forecasted population in the later part of the forecast (-0.7% in 2050). County population, however, is quite different in the 2021 forecast. By 2050:

- Utah County saw a significant decrease (-8.7%) in household population with approximately 120,000 fewer people.
- Salt Lake county saw a moderate increase (2.7%) and Davis County saw a significant increase (7.4%) in population of approximately 40,000 people in each county.
- Weber County showed a modest increase (2.6%) of approximately 9,000 people.

The forecasted age make-up of each county shifted to older populations in the 2021 projections compared to the 2017 projections. By 2050:

- Children aged population (age 0-17) in Salt Lake and Utah counties decreased significantly, with Salt Lake County having 40,000 fewer people and Utah County having 120,000 fewer people.
- Adult aged population (age 18-64) increased in Weber County by 11,000, Davis County by 24,000, and Salt Lake County by 47,000, while Utah County decreased by 50,000.
- Senior aged population (age 65+) increased in all counites with the most significant increase in Salt Lake County of just less than 28,000.
- Overall, the new projection forecasts approximately 113,000 fewer children, 30,000 more adults, and 56,000 more seniors.

Households

The 2021 projections show an initial decrease over the 2017 projections of 43,000 households along the Wasatch Front in 2020, which then transitions to be a net increase of 18,000 households by 2050. Weber, Davis, and Salt Lake counties follow a similar pattern in the 2021 projections where each has a net increase in households between 2035 and 2045 ending with 2,500 more households in Weber County, 15,000 more households in Davis County, and 23,000 more households in Salt Lake County. Utah County shows a further decrease in households beginning in 2030 trending to 23,000 fewer households by 2050.

Population-Housing Balance

The initial population/housing balance, as shown by the average household size, was higher in the 2021 projections relative to the 2017 projections, but quickly trends down to where the average household size is similar to the 2050 projections for Weber, Salt Lake, and Davis counites. The trend in the average household size in Utah County is considerably lower. This may be due to the dramatic drop in child-age population in Utah County which tend to live in households with higher household sizes and the increase in senior population which tend to live in households with lower household sizes.

Employment

The 2021 projections show an initial increase over the 2017 projections of 65,000 jobs along the Wasatch Front after a rebound from Covid. The new projections then transition to a slight decrease of 16,000 jobs by 2050. The differences in employment forecasts are most notable between Utah and Salt Lake counties. By 2050, the 2021 projections show an increase of 37,000 jobs (3.1%) in Salt Lake County and a decrease of 50,000 jobs (-8.5%) in Utah County. By 2050, Weber and Davis counites have little change from the previous forecast. The biggest change in employment was in the “other” employment category.

Employment Ratios

The 2021 projections showed a slight increase in working population per job in Weber and Davis counties compared to the 2017 projections. The working population per jobs ratio in Salt Lake and Utah counties remained fairly constant.

Impact of Control Total Changes on Travel Demand Model Forecasts

The impact on the travel demand model of the socioeconomic control total changes will be most notable in the future volume forecasts in Utah and Salt Lake counties. Utah County has significantly fewer people and jobs in 2050 which translates to fewer trips and less traffic volume than in the previous model. Similarly, Salt Lake County saw an increase in the forecasted people and jobs which translates to more trips and volume. The impact will be more noticeable in Utah County than in Salt Lake County as the socioeconomic difference represents a much higher percent change of the total socioeconomic data. Also, the shift in jobs between Utah and Salt Lake counties is primarily in the “other” employment category, which averages longer commute distances and may cause the commuting pattern between Utah and Salt Lake counties to be different than in the previous model.

In addition, because the average household size control total in Utah County is lower in the later years than the previous socioeconomic projection, it will require more housing units to house a comparable amount of people, implying that the new Utah County socioeconomic forecast could exhibit slightly more sprawl and longer trip lengths per capita than the previous model.

The overall shift to more seniors and less children in the new control totals will have an effect in the future forecasted trip generation. Seniors typically have lower trip rates per household than households with children, with work and school trip purposes being most impacted.

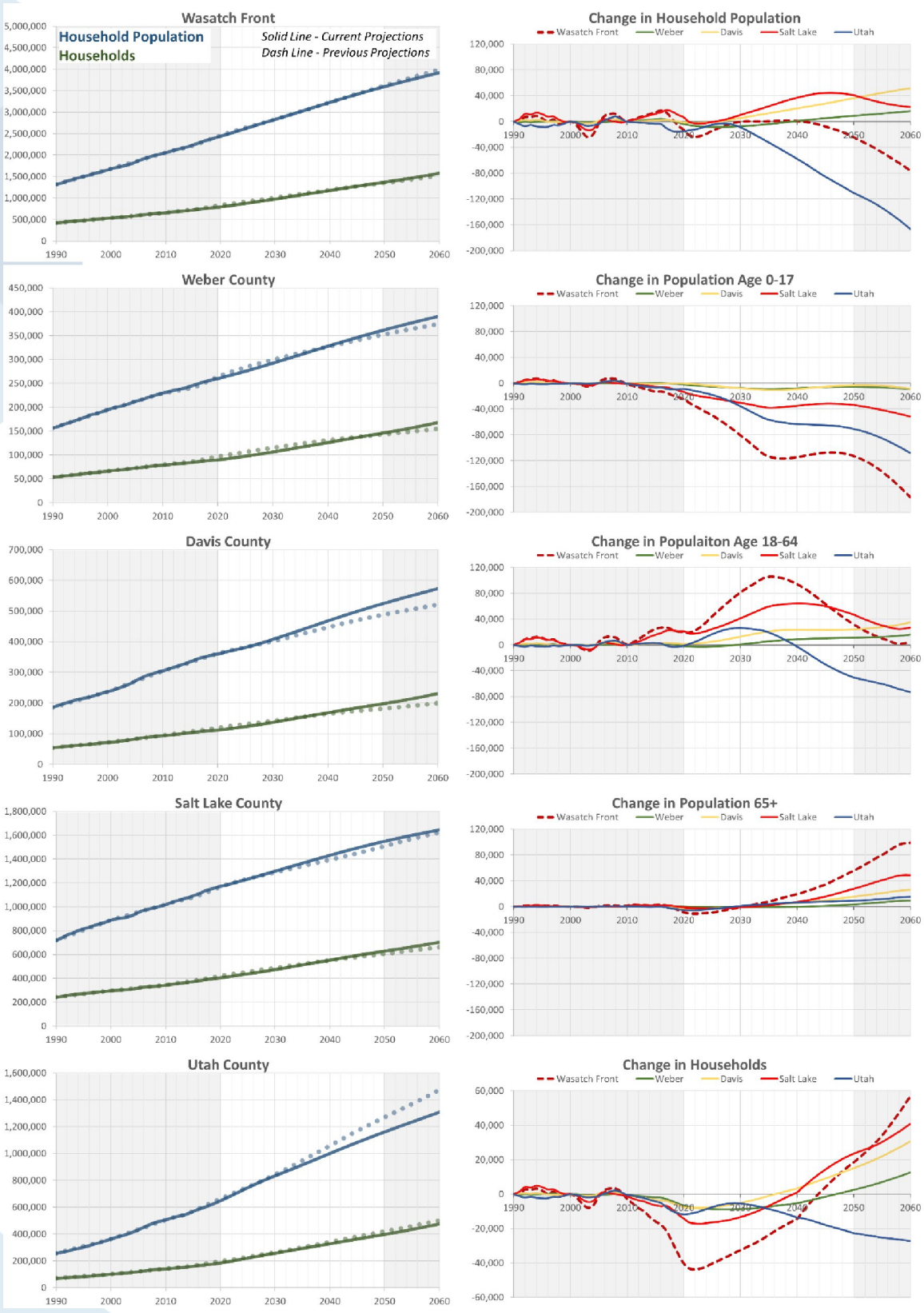


Figure 3.1 Control Total Comparison - Residential

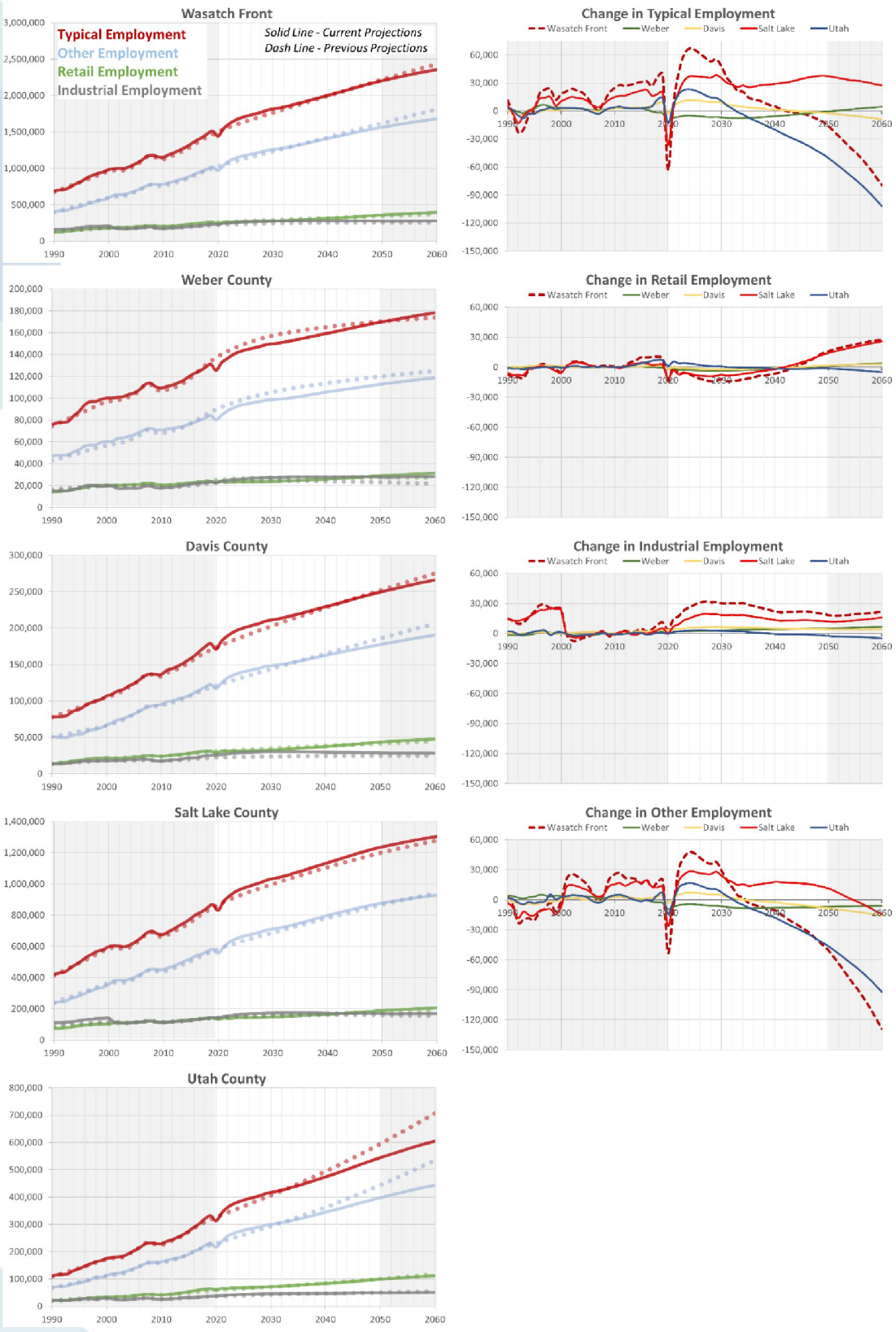


Figure 3.2 Control Total Comparison - Employment

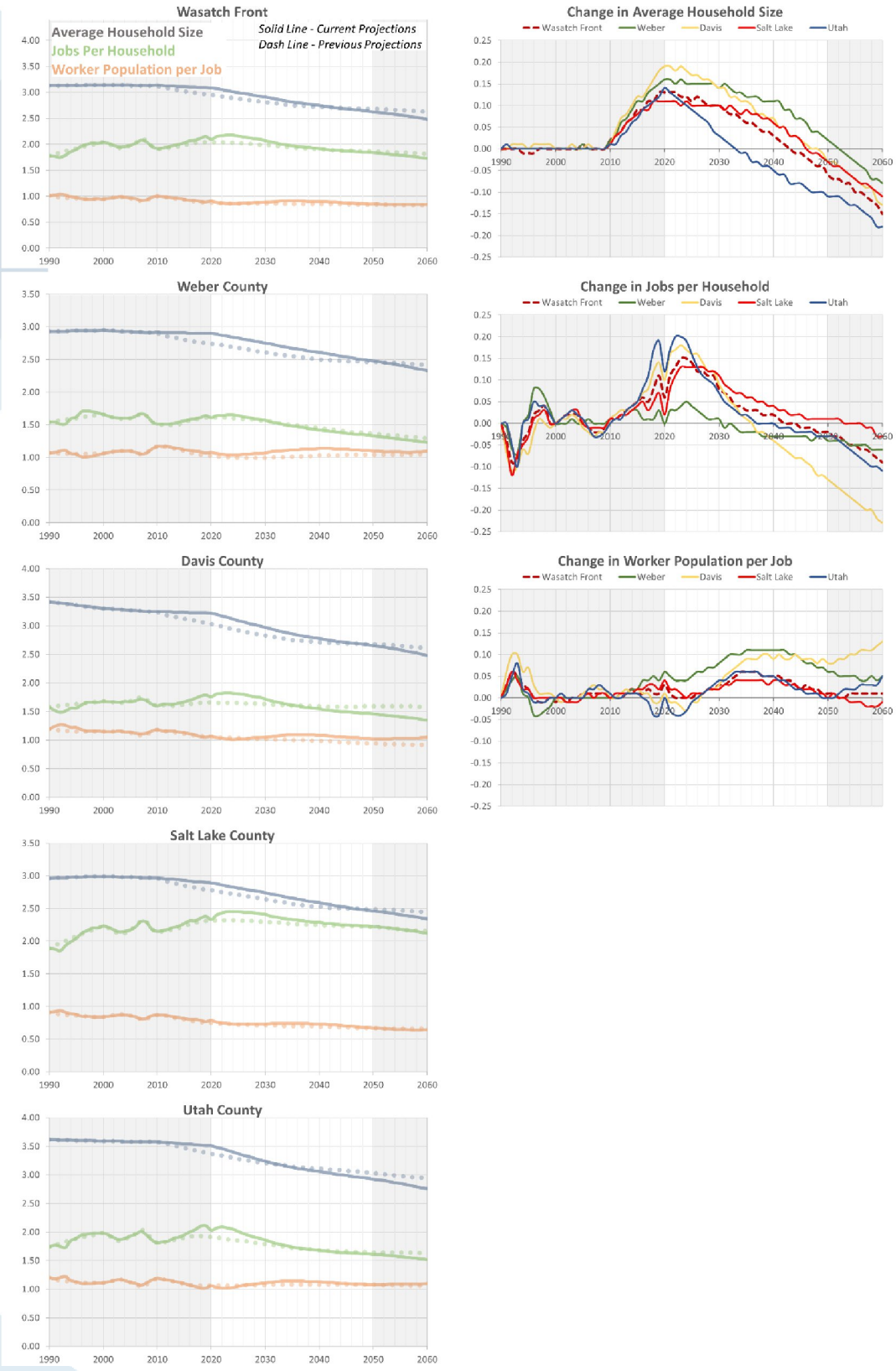


Figure 3.3 Control Total Comparison - Ratios

3.1.2 Changes to Model Control Total Input Files

Many changes were made to the control total source spreadsheet in the "*1_Inputs\2_SEData_ControlTotals*" folder, including:

- The new control total spreadsheet combines several processes that previously were in separate source files or that are needed to create new files required by the models:
    - County SE control totals
    - County Age Group control totals
    - County Work-At-Home control totals
    - County SE by 3-digit NAICS (needed for freight model)
    - Separating Weber County data into Wasatch Front and Ogden Valley datasets
    - Separating Weber, Davis, Salt Lake, and Utah counties into REMM and non-REMM datasets
- The order and number of the output variables were changed in the model input files to make them more consistent with how the socioeconomic data is processed in the current travel and land use models.
- Historical data going back to 1990 was added. The control total source spreadsheet now contains a nice, consistent database that allows a look back 30 years as well as a look ahead 40+ years.
    - Note, some of the historical data had to be estimated to fill in data gaps and convert employment from SIC to NAICS for data prior to 2001.
- Functionality was added to visualize and check the data.
- The Work-At-Home (WAH) control total calculations now include information to siphon off the home-based jobs (HBJ) from each of the 23 GPI employment categories to become the HBJ category in the travel model. With WF TDM version 9, the process now includes county-specific HBJ rates rather than one set of rates for the whole state. HBJ rates were also updated to represent 2019 data.
- Similarly, the Work-At-Home (WAH) control total calculations now include telecommuting information for all travel demand models in the state. The telecommuting rates pivot off of historic data from the 5-year 2019 ACS and the telecommuting forecasting work done for the WF TDM v8.3.2. County-specific telecommuting rates were generated for the following counties:
    - Weber
    - Davis
    - Salt Lake
    - Utah
    - Cache
    - Washington
    - Summit
    - Wasatch
    - Box Elder
    - Tooele
    - Iron

  The remaining rural counties had insufficient data in the ACS to generate unique rates. These counties were grouped together to generate a composite rate to reduce the sampling margin of error.
- Weber County contains two sets of data: one for all of Weber County, the other that separates the Weber County data for the UDOT planning domain (index=9057) and the Wasatch Front planning domain (index=9157).

In addition, the "*ControlTotal_Age.csv*" model input file in the "*1_Inputs\2_SEData_ControlTotals*" folder was combined with "*ControlTotal_SE_WF.csv*" file and renamed "*ControlTotal_SE_AllCounties.csv*". The "1_DemographicsAnalysis.s" script was updated to read "ControlTotal_SE_AllCounties.csv".

3.2 TAZ-Level Forecasts

A new TAZ-level distribution of the updated county socioeconomic control totals was performed for WF TDM version 9. Updates to Weber, Davis, Salt Lake, and Utah counties TAZ-level socioeconomic forecasts were generated by REMM and included the following:

- Base and future year land use capacities based on updated city/county general plans, zoning, and centers (vision) location details.
- Base year residential dwelling units by type (single family, multi-family), household allocation, and population synthesis
- Base year commercial building square foot and employment allocation by employment category

A detailed review of the TAZ-level socioeconomic forecasts was performed by an independent consultant. In addition, knowledgeable parties provided feedback for major development areas, including Falcon Hill, Day Break, Olympia Hills, and Point of the Mountain. A high-level review was also performed by local governments.

Updates to socioeconomic data in Box Elder were provided by UDOT which included similar base year data updates and local review.

The updated TAZ socioeconomic forecasts can be visualized with the Household and Job Forecasts Web App. Changes in the forecasts between versions 8 and 9 can be seen by clicking on *View Advanced Version* in the header and then selecting *New vs. Old.*

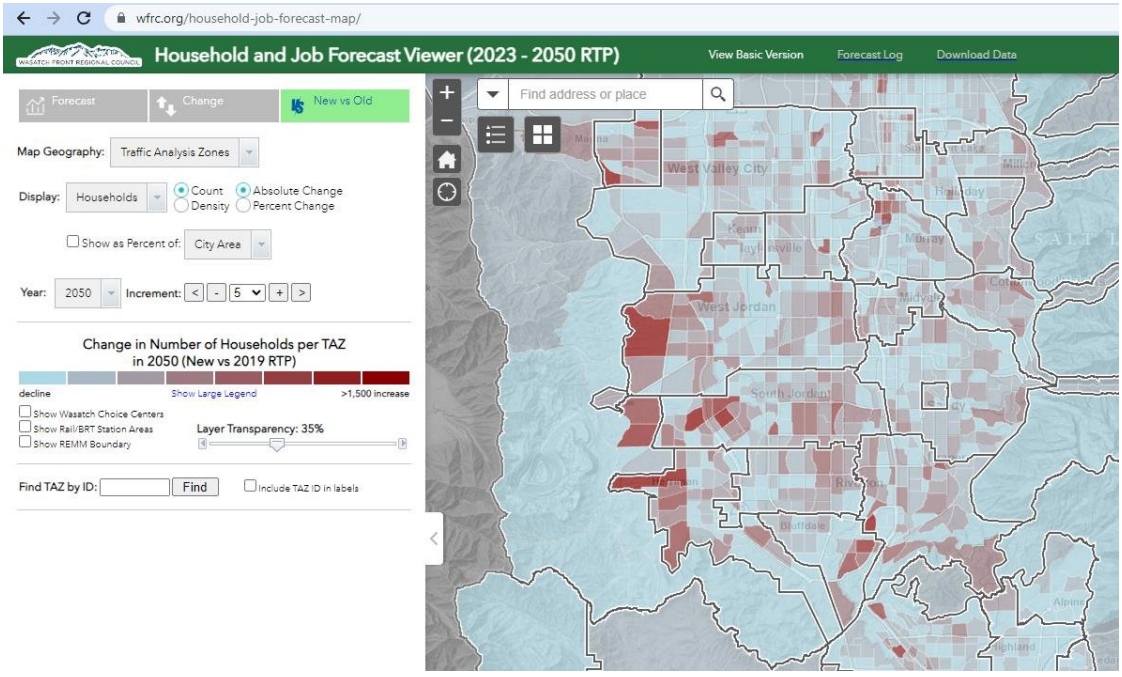


Figure 3.4 Household and Job Forecast WebApp

3.3 Base-Year TAZ Age Percent Lookup File

The TAZ-level age percent parameters were updated using 2020 Census block and 2020 ACS block group data. This update was done statewide by UDOT and provided for use in each travel model area in Utah. The Wasatch Front updated parameters are found in the “1_Inputs\0_GlobalData\1_HHDisag_AutoOwn \Lookup - BYTAZAgePct - AllCo.csv” lookup file.

4 Highway & Transit Networks Updates

4.1 Highway Network

4.1.1 Highway Network Project Coding

The highway network in version 9 was updated to reflect the 2023-2050 RTP and the 2023-2028 TIP. The updated projects were coded into a set of fields in the Master highway network using the same field naming convention[1] as version 8, but field names were updated to reflect the new 2023 RTP:

Attribute Type Identifying Prefix

Link

- **LN** – lane
- **FT** – functional type
- **TSPD** – transit speed (coded on rail links and transit only links)
- **HOT** – marker on general purpose lane indicating presence of adjacent HOV/HOT lane
- **REL** – marker to identify reliability lane project (e.g. managed lanes on arterials or reversible freeway lanes, etc.)
- **OP** – marker to identify operational project (i.e. enhancements to improve the operations of a roadway without adding physical capacity, such as signal timing optimization, access management, ramp metering etc.)
- **GIS** – contains ID or key to link to GIS mapping and project information (currently only includes the "23_32", "23_42", and "23_50" scenarios)

Node

- **PNR** – park-and-ride
- **FARZN** – commuter rail fare zone

Scenario Identifying Suffix

- **_2015**
- **_2019** – model base year
- **_2023** – RTP opening year
- **_2028** – end of 2023-2028 TIP
- **23_32** – 2023 RTP end-of-phase 1 (2032), fiscally-constrained
- **23_42** – 2023 RTP end-of-phase 2 (2042), fiscally-constrained
- **23_50** – 2023 RTP end-of-phase 3 (2050), fiscally-constrained
- **23_32UF** – 2023 RTP end-of-phase 1 (2032), unfunded need

[1] Field names are composed of a prefix and a suffix. The prefix indicates the type of the network attribute (e.g. lane, functional type, etc.). The suffix identifies the scenarios coded into the network. If the scenario is part of a plan phase year, a 2-digit plan-opening-year is included in the suffix name. All field names are limited to 10 characters in length.

- **23_42UF** – 2023 RTP end-of-phase 2 (2042), unfunded need
- **23_50UF** – 2023 RTP end-of-phase 3 (2050), unfunded need
- **23_50UFM** - 2023 RTP end-of-phase 3 (2050), unfunded need MAG alternate (includes different assumption related to Lehi freeway project at the Point of the Mountain), currently only includes "LN" attribute
- Note, TSPD unfunded need scenario fields use "U" instead of "UF" due to the 10-character field width limitation.

Changes to the number of lanes in version 9 can be seen in Figure 4.1.

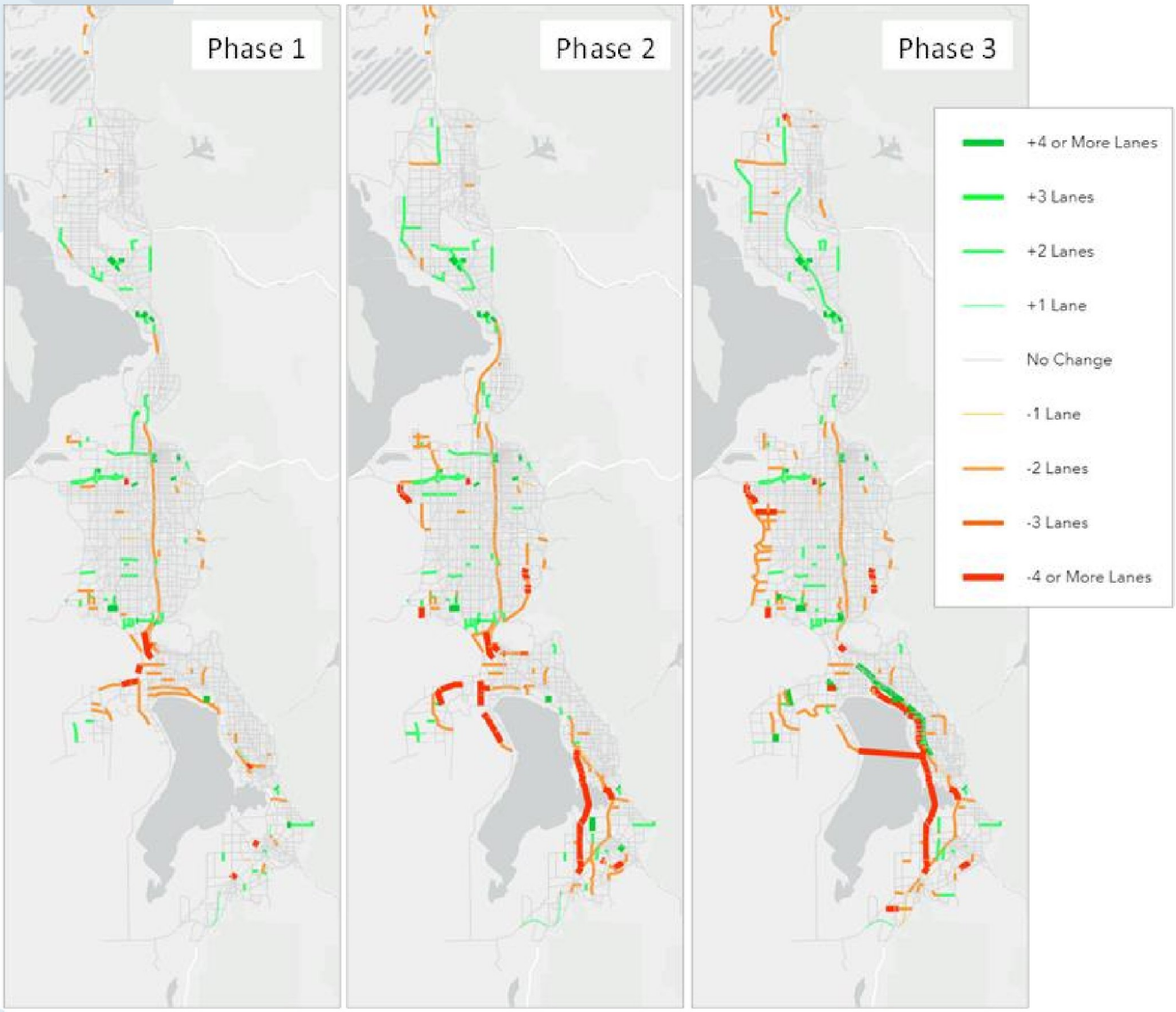


Figure 4.1 Changes to Highway Project List

4.1.2 Other Changes to Network Field Attributes

In addition, the following edits were made to the highway network:

- The distance exception fields (DISTEXCEPT) were set to 0. DISTEXCEPT was used in previous model versions at external links to account for the distance from the external to the county boundary for air quality VMT calculations. Since version 9 model boundaries correspond to county boundaries, this field is no longer needed in the model.
- The "TSP" fields were updated to reflect recent UTA light rail and commuter rail studies.
- The MAG_LINK/MAG_NODE fields identify links and node in the MAG planning area and are used when snapping together changes to the WFRC and MAG master networks. Version 8 included WFRC_LINK/WFRC_NODE fields to identify links/nodes in the WFRC area. These WFRC fields were redundant and dropped from the master network since the MAG and WFRC areas are mutually exclusive.
- The commuter rail Fare Zone for the Vineyard and Orem stations was updated to be the same fare zone, similar to the fare zone for the North Temple and Salt Lake Central stations. There is no additional fare cost for traveling between the new Vineyard and Orem stations.
- SEGID on the highway links was updated and made consistent with the most recent segment shapefile. SEGID exception fields (SEGEX_RTP, SEGEX_NEED) were also created to account for links with future SEGIDs that differ with existing SEGIDs, primarily for the frontage road system in Salt Lake and Utah counties. These new fields are under development and values for these fields will be forthcoming.

4.1.3 Changes to Highway Network Geometry

Version 9 highway network was expanded to incorporate the new model areas (see Section 2.1.1). The expansion to these mountainous areas meant the inclusion of many very curvy roadways. The curvature of these roadways is maintained by the link shapefile in the associated "1_Inputs\3_Highway\GIS" folder. Edits made to the link/node geometry in the highway network in these areas should be done with *True Shape* turned on in Cube Base in order to maintain the link/node association with the underlying shapefile. In addition, *True Shape* will be required when exporting the link shapefile or the shape geometry in the mountain areas will be lost.

4.1.4 Changes to Highway Network Numbering

The version 9 highway network node numbering scheme was updated, as shown in Table 4.1.

Table 4.1 New Master Network Node Numbering

MPO	Transit Nodes	Highway Nodes	v9 Expansion Area Nodes
WFRC	10,000 - 19,999	20,000 - 49,999	90,000 - 94,999
MAG	50,000 - 59,999	60,000 - 89,999	95,000 - 99,999

The "HwyNodes" parameter in the "0_GeneralParameters.block" file was updated to reflect the new highway node numbering.

Table 4.2 Renumbered Master Network Highway Node Range

Parameter	v9 Value	v8 Value	Notes
HwyNodes	10000-99999	3401-999999	Highway and transit node range

Highway node references in the "PT_Parameter \...FAC" files and the "3_TurnPenalty.s" script were updated to reflect the new TAZ and highway node numbering.

Array indices found in the "5_AssignHwy\05_RemoveManagedLanes.s" script were also updated from <=20,000 to 1,000,000 to account for the new highway network numbering scheme.

4.1.5 Changes to External Location and Numbering

Details on the location and numbering of the new external nodes on the master highway network are shown in Figure 4.2 through Figure 4.5 and Table 4.3. (See Sections 2.1.1 and 2.1.2 for more information on external zones.)

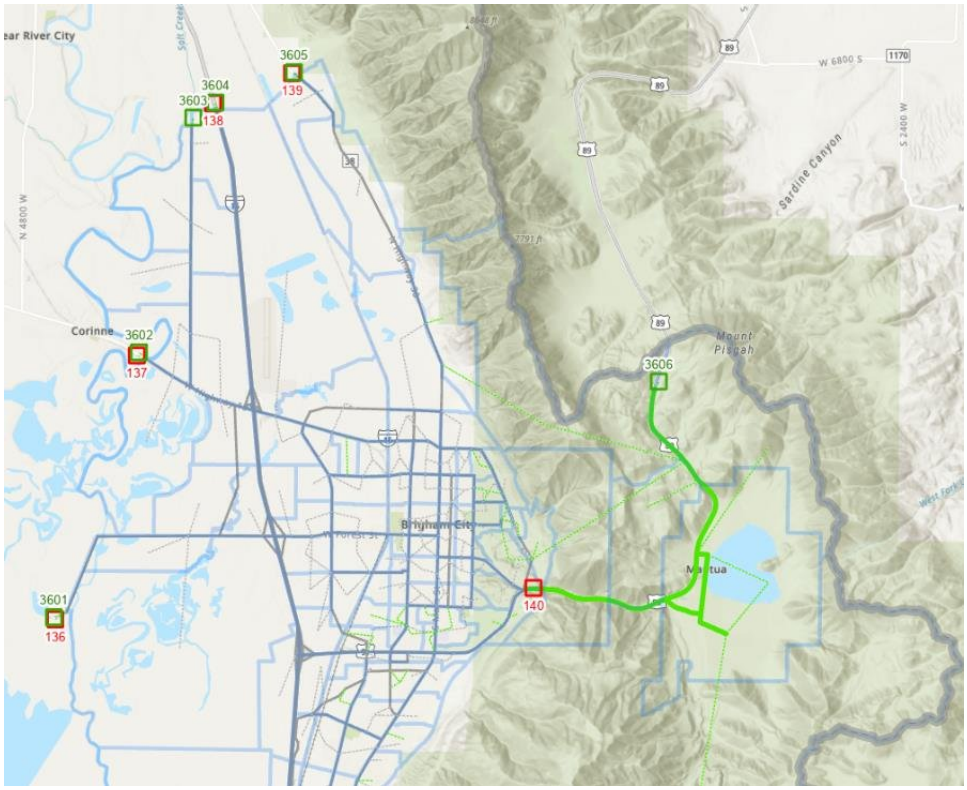


Figure 4.2 Location of External Nodes - Box Elder County

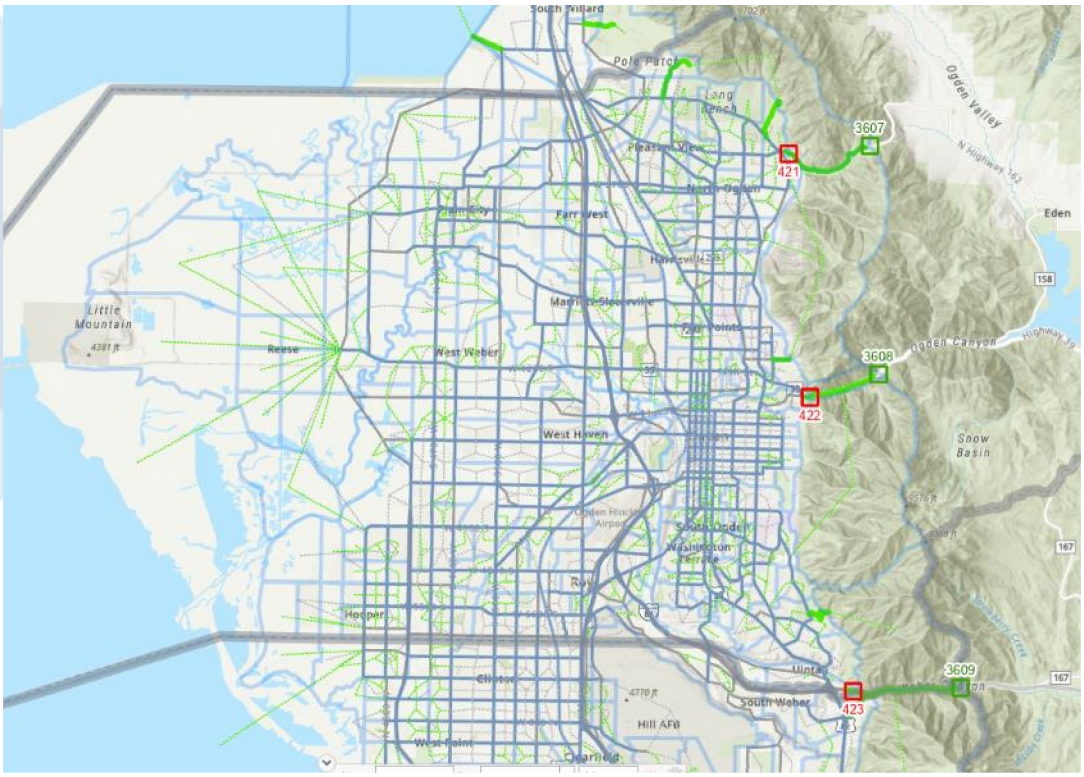


Figure 4.3 Location of External Nodes – Weber County

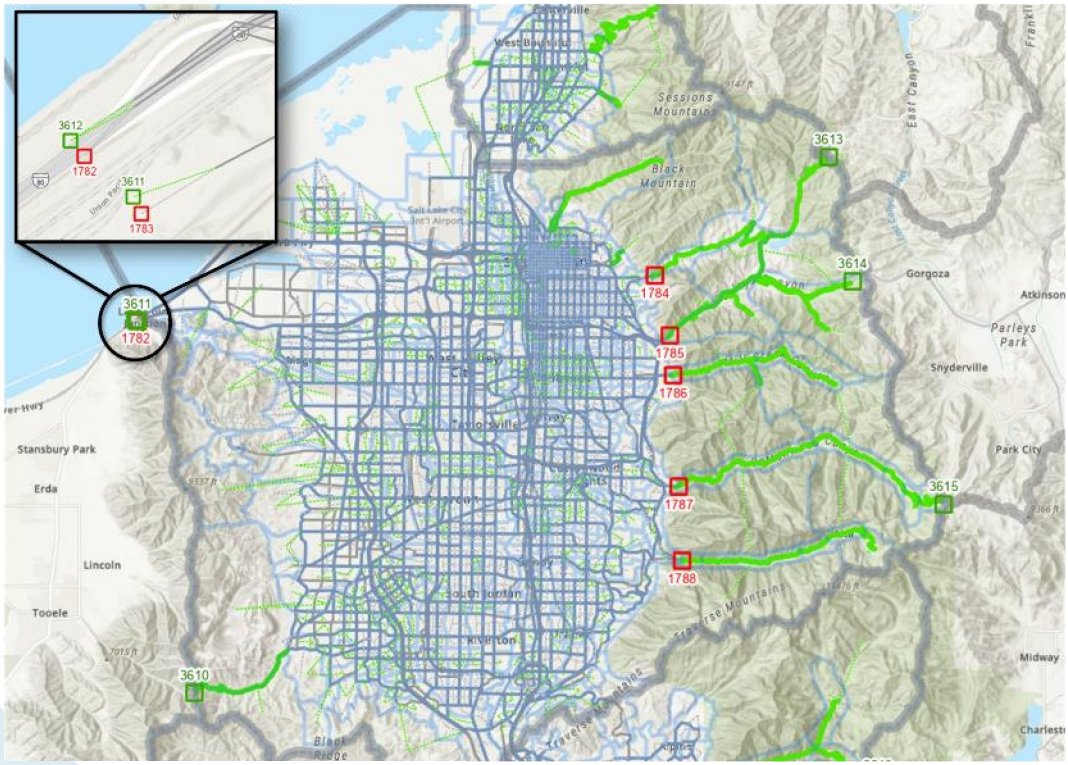


Figure 4.4 Location of External Nodes – Salt Lake County

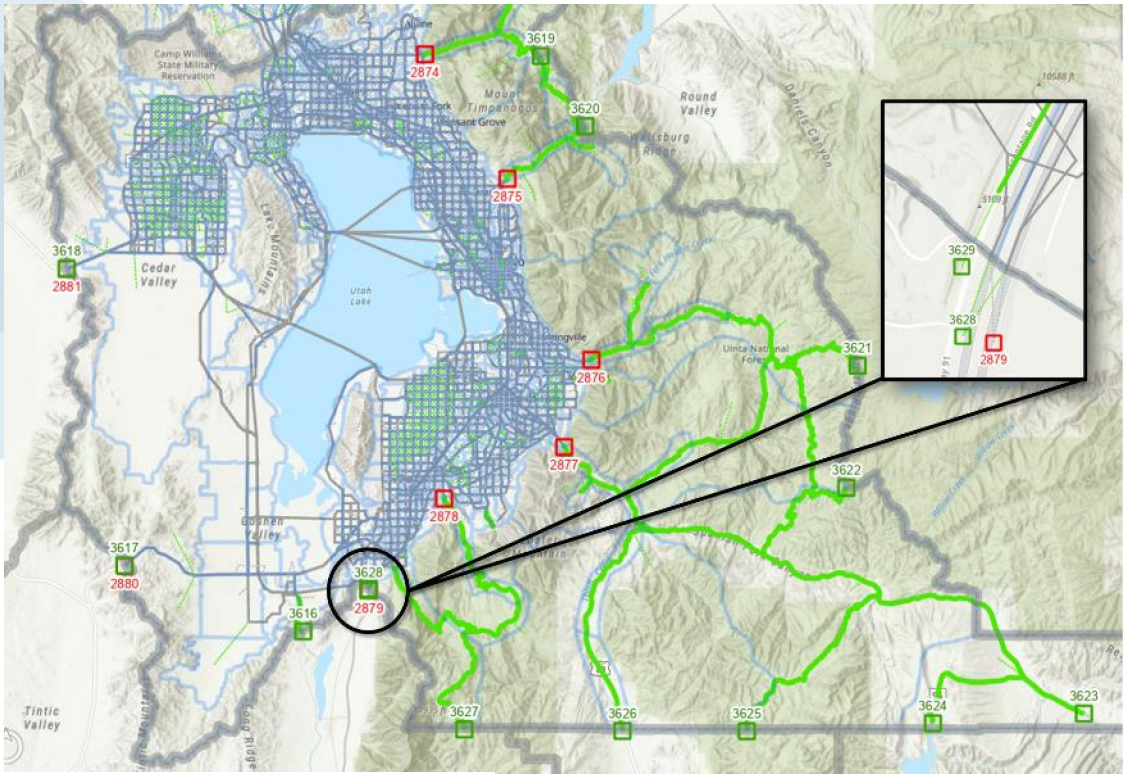


Figure 4.5 Location of External Nodes – Utah County

Table 4.3 External Number & Description

County	v9 Value	v8 Value	Location	Notes
Box Elder	3601	136	FAR-1082 Bird Refuge	
	3602	137	SR-13/83 to Corinne	
	3603		FAR-1112 to Bear River	New External
	3604	138	I-15 to Tremonton	
	3605	139	SR-38 to Riverside	
	3606	140	SR-91 to Logan	Moved for Area Expansion
Weber	3607	421	FAR-3462 N Ogden Pass	Moved for Area Expansion
	3608	422	SR-39 Ogden Canyon	Moved for Area Expansion
	3609	423	I-84 to Summit	Moved for Area Expansion
Salt Lake	3610		FAR-2688 Butterfield Cyn to Tooele	New External
	3611	1783	SR-201 to Tooele	
	3612	1782	I-80 to Tooele	
	3613	1784	SR-65 Mountain Dell Canyon	Moved for Area Expansion
	3614	1785	I-80 East Parley's	Moved for Area Expansion
		1786	FAR-2193 Millcreek Canyon	Removed for Area Expansion
	3615	1787	SR-190 Guardsman Pass	
		1788	SR-210 Little Cottonwood	Removed for Area Expansion
Utah	3616		FAR-1828 Goshen Canyon	New External
	3617	2880	US-6 Eureka	
	3618	2881	SR-73 Rush Valley	
	3619	2874	FAR-3108 Cascade Spring	Moved for Area Expansion
	3620	2875	SR-189 Provo Canyon	Moved for Area Expansion
	3621	2876	FAR-2865 Sixth Water / Horse Creek	Moved for Area Expansion
	3622		FAR-2863 Sheep Creek	New External
	3623	2877	US-6 Price Canyon	Moved for Area Expansion
	3624		SR-96 Scofield	New External
	3625		FAR-2495 Skyline Dr	New External
	3626		US-89 Thistle	New External
	3627	2878	FAR-1822 N Nebo Loop	Moved for Area Expansion
	3628	2879	I-15 to Juab	
	3629		FAR-1826 South Ridge Farms	New External

4.1.6 Additional Network Changes

Additional highway network updates in version 9 include:

- A fix for a small network error in Box Elder where a local road was drawn to the centroid of a TAZ

- A phase change for Managed Motorways in WFRC area
- Significant updates to centroid connectors in the MAG area

4.2 Transit Networks

4.2.1 Changes to Transit Line Files

The transit line files were updated to correspond with the 2023-2050 RTP and the 2023-2028 TIP. Specific changes to these files for each plan year include:

- **Lin_2019** – files were thoroughly vetted to represent Aug 2019 change day.
- **Lin_2023** – route alignment, headways and stops were updated to the August 2022 change day.
- **Lin_2028** – route alignment, headways and stops were updated to the UTA 5-Year Service Plan.
- **Lin_2032**, **Lin_2042**, **Lin_2050** – changes from 2028 were rolled forward into plan phased years and updated based on 2023 fiscally constrained plan.
- **Lin_2032_Needs**, **Lin_2042_Needs**, **Lin_2050_Needs** – changes from 2028 were rolled forward into plan phased years and updated based on 2023 unfunded needs plan.
- **Lin_2032_Needs_MAG**, **Lin_2042_Needs_MAG**, **Lin_2050_Needs_MAG** – these are copies of the "Needs" transit plans and edited to reflect changes in the MAG 2023 unfunded needs plan at the Point of the Mountain.

In addition, route *S902* in Salt Lake County was shortened to exclude the I-80 Parleys Canyon external node and route *LittleCott* which provides access up Little Cottonwood Canyon was added to the model.

4.2.2 Changes to General Hand-Coded Support Links

The "1_Inputs\4_Transit\General_hand_coded_walk_links.NTL" file was updated to be consistent with the new TAZ structure and to ensure all hand coded walk links are realistic.

4.2.3 Added "Transit Route Tester" Folder

A "_chk Transit Compile on Net" folder was added in the "1_Inputs\4_Transit" folder. This folder contains a script to check if the transit line files compile on the related scenario highway network from the Master network. The script helps review transit line edits outside of the model stream. Any transit line compiling issues are reported in the "check - 1 – *{ScenarioName}.*txt" text file created by the script.

4.3 Segment Shapefile

The Wasatch Front segment shapefile (found in "1_Inputs\6_Segment") was updated to reflect the updated highway and transit networks. These changes include:

- Segments were adjusted to reflect new highway projects coded on the master highway network.
- SEGIDs were added to rail links to allow for easier transit result visualization.

5 Model 2019 Base-Year Updates

The following parameters and inputs were updated to bring the WF TDM base year from 2015 to 2019.

5.1 Parameters

5.1.1 Income

Median income parameters for the model were updated using 2019 5-year ACS data and kept in 2019 dollars to reflect 2019 base year. Median income parameters in version 8 were estimated from 2015 ACS data and deflated to 2010 dollars. The regional median income was calculated for each county and for each model space and used to update the following income-related parameters in "0_GeneralParameters.block".

Table 5.1 Regional Median Income

Parameter	v9 Value	v8 Value
Reg_Median_Inc	$74,946	$58,793

Table 5.2 Income Break Points for Airport Exogenous Trip Table Generation

Parameter	v9 Value	v8 Value	Notes
Income_Lo	$45,000	$35,000	breakpoint between Inc1 & Inc2
Income_Md	$75,000	$70,000	breakpoint between Inc2 & Inc3
Income_Hi	$125,000	$100,000	breakpoint between Inc3 & Inc4

The TAZ-level median income was also updated within the socioeconomic input files.

The household disaggregation income lookup curves and seed table were re-estimated based on the 2019 ACS data. The income lookup curves were estimated using data for all of Utah then calibrated specifically for the Wasatch Front model. Figure 5.1 shows a comparison of the version 9 and version 8 income lookup curves for the Wasatch Front.

The version 9 calibrated curves show a slight shift in the proportion of households toward the highest income groups from the middle two income groups relative to version 8. The lowest income group was very similar between versions 8 and 9. As the model currently groups the top three income groups into the "high income" category, the impact to the model is minimal.

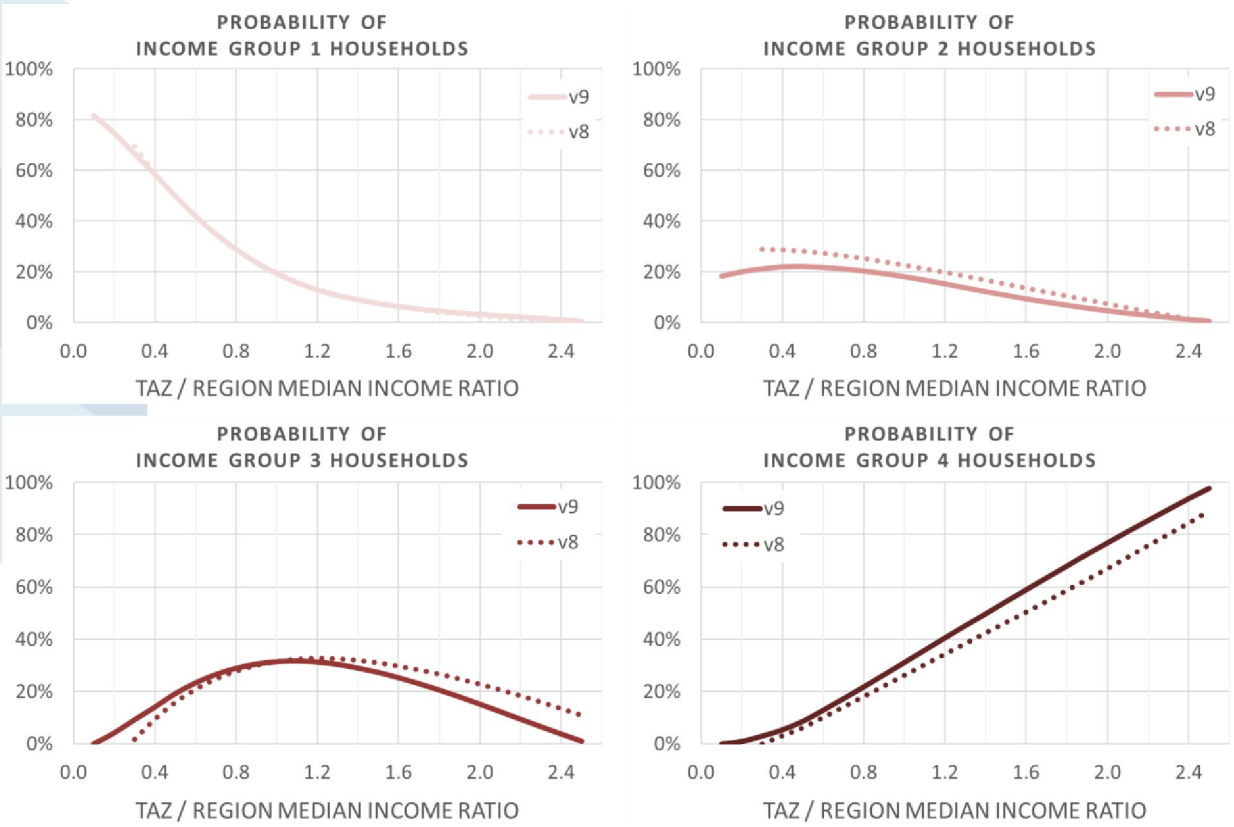


Figure 5.1 Comparison of Wasatch Front Income Lookup Curves

5.1.2 Value of Time

Value of time parameters were updated using 2019 5-year ACS data. The value of time calculation in version 9 used the same assumptions as version 8 (i.e. 39% of median income for work trips, 30% of median income for personal trips, etc.). The value of time parameters in version 9 are in 2019 dollars. Version 8 parameters were calibrated to 2015 ACS data and deflated to 2010 dollars. Values of time are in cents/minute.

Table 5.3 Value of Time Parameters

v9 Parameter	v9 Value	v8 Parameter	v8 Value	Notes
VOT_Auto_Wrk	22	VOT_Auto_Wrk	18	work trips (HBW)
VOT_Auto_Per	17	VOT_Auto_Per	14	non-work trips
VOT_Auto_Ext	20	VOT_Auto_Ext	16	external
VOT_LT	37	VOT_LT	30	light truck
VOT_MD	50	VOT_MD	40	medium truck
VOT_HV	63	VOT_HV	50	heavy truck
VOT_Toll	63	VOT_Toll	50	all vehicles on tollway
VOT_HOT_DA	63	VOT_HOT_DA	50	drive alone on HOT

To better understand the relative change in the value of time parameters, the parameters were normalized by the work-trip parameter and the percent difference in the ratios was compared. The percent differences show that the relative change between the variables in versions 8 and version 9 is very similar, indicating there isn't a strong behavioral change due to the update of this parameter.

Table 5.4 Relative Value of Time Ratios

Category	v9 Value Relative to Work Trips	v8 Value Relative to Work Trips	% Difference
work trips	1.00	1.00	0.0%
non-work trips	0.77	0.78	-0.6%
external	0.91	0.89	2.3%
light truck	1.68	1.67	0.9%
medium truck	2.27	2.22	2.3%
heavy truck	2.86	2.78	3.1%

5.1.3 Auto Operating Costs

Auto operating costs were updated to reflect 2019 fuel cost, average fuel economy, and cost of vehicle maintenance and are in 2019 dollars. Version 8 parameters were calibrated to 2015 data and deflated to 2010 dollars. Costs are in cents/mile.

Table 5.5 Auto Operating Cost Parameters

Parameter	v9 Value	v8 Value	Notes
AOC_Auto	21.7	18.3	auto
AOC_LT	27.3	24.6	light truck
AOC_MD	55.5	47.8	medium truck
AOC_HV	74.3	63.7	heavy truck

The auto operating cost parameters in versions 8 and 9 were normalized by the auto-cost parameter. The percent differences between the version 8 and 9 ratios indicate that the relative cost to operate trucks compared to autos is slightly less in version 9 than in version 8.

Table 5.6 Relative Auto Operating Cost Ratios

Category	v9 Value	v8 Value	% Difference
auto	1.00	1.00	0.0%
light truck	1.26	1.34	-6.4%
medium truck	2.56	2.61	-2.1%
heavy truck	3.42	3.48	-1.6%

The relationship (ratio) between the auto operating costs and the value of time affects the distance term in the best-path functions in the distribution and assignment models. The higher the ratio, the more influence the distance term will exhibit on path choice and the more the model will be sensitive to shortest path vs. shortest time. A comparison of the ratios suggests that, while the overall pattern looks similar, distance will have slightly less influence on path choice for person trips in version 9 than in version 8, meaning person trips will be slightly more sensitive to congestion (i.e. travel time). This slight difference, however, should not be large enough to fundamentally change the behavior in the model. There is a more significant difference in the ratio for truck trips suggesting that truck trips (in particular light trucks) will be a little more sensitive to the influence of congestion in version 9 than in version 8.

Table 5.7 Auto Operating Cost / Value of Time Ratios

Category	v9 Value	v8 Value	% Difference
work trips	0.986	1.017	-3.0%
non-work trips	1.276	1.307	-2.3%
external	1.085	1.144	-5.1%
light truck	0.738	0.820	-10.0%
medium truck	1.110	1.195	-7.1%
heavy truck	1.179	1.274	-7.4%

5.1.4 Managed Lane Costs

Peak and off-peak toll cost parameters for tollways (FT=40) were updated to 48 cents/mile. This equates to approximately $5.00 for work trips (using an average work trip distances of 10.25) and $3.00 for non-work trips (using an average distance of 6.5 miles).

Peak toll cost parameters for HOT lanes (FT=38) and reliability lanes were updated to 34 cents/mile. This equates to approximately $3.50 for work trips and $2.20 for non-work trips (using the same average distances for work and non-work trips). Off-peak toll cost parameters were set as half the peak cost.

Version 9 tolls are in 2019 dollars. Toll costs for version 8 are in 2010 dollars.

Table 5.8 Managed Lane Cost Rates

Parameter	v9 Value	v8 Value	Notes
Cost_Toll_Pk	48	24	Tollways (FT 40) cost - Peak
Cost_Toll_Ok	48	24	Tollways (FT 40) cost - Off-peak
Cost_HOT_Pk	34	10	HOT (FT 38) cost - Peak
Cost_HOT_Ok	17	5	HOT (FT 38) cost - Off-peak
Cost_REL_Pk	34	10	Reliability lane cost - Peak
Cost_REL_Ok	17	5	Reliability lane cost - Off-peak

Relative to HOT toll costs, tollway costs are approximately 40% lower in version 9 than version 8, suggesting tollways would have less sensitivity to cost in version 9 than version 8. However, there are no tollways planned in the 2023 RTP.

5.1.5 Parking Costs

The permanent and temporary cost fields, **PRKCSTPERM** and **PRKCSTTEMP** located in the "1_Inputs\1_TAZ\TAZ.shp" shapefile, were updated to reflect current conditions. Costs for parking in the downtown areas of Salt Lake City, Ogden, and Provo and around the universities were based on 2022 parking rates obtained from the city of Salt Lake City, web searches, and field visits.

The temporary parking cost for the Salt Lake City International Airport was set to $1.25 based on a weighted average of short-term premium and economy rates. This represents a $0.25 (25%) increase from version 8. Permanent parking costs were kept at $0 as workers at the airport do not pay for parking.

The Lagoon temporary parking cost was set to $6 based on the 2022 advertised parking rate of $18 per day by an assumed average occupancy of 3 people per vehicle. This represents a $1 (20%) increase from version 8. Permanent parking costs were kept at $0 as workers at Lagoon do not pay for parking.

Version 9 parking costs are in 2019 dollars, whereas version 8 parking costs are in 2010 dollars.

5.1.6 Transit Fares

Version 9 transit fares in the "PT_Parameter\GENERAL_Fare.FAR" file in the scenario line folder were updated to reflect the 2019 full advertised fares. This represented a two-fold change to the transit fares parameter. Previous models have fares coded as "average discounted fares" which included discounts for monthly passes, education passes, fare-pay, senior discounts, employer paid passes, and other discounts. In order to make updating transit fares in the model easier and more intuitive, the input fares were kept as full advertised fares and the calculation from advertised to discounted fares is now processed in the model stream.

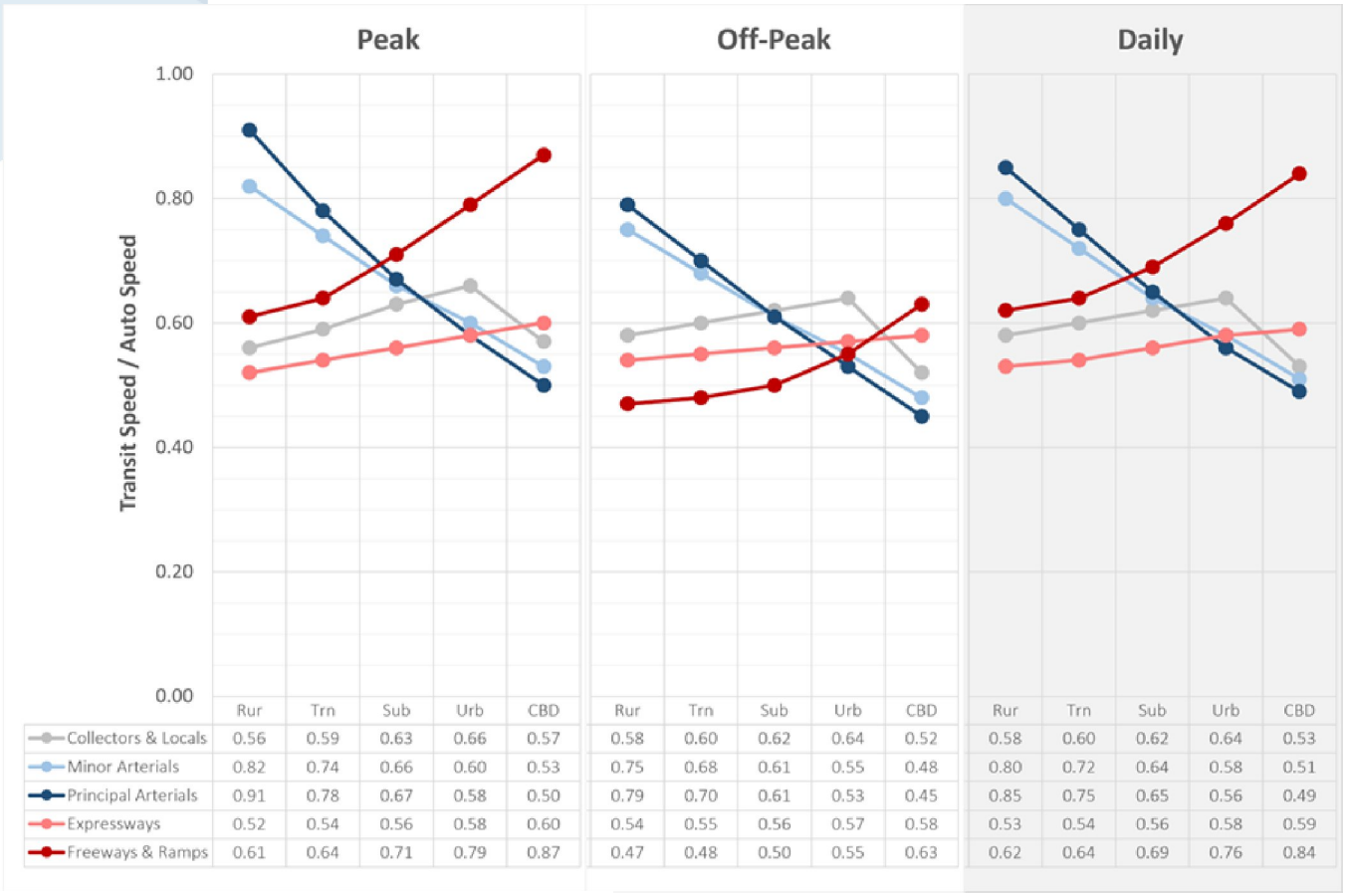
Version 9 uses the same average discount assumptions as version 8. The transit fare discount was calculated in previous models to be 46% off the advertised fare yielding a discounted fare rate of 54% and the following parameter was added to the "0_GeneralParameters.block":

- FARE_DISCOUNT = 0.54

5.1.7 Bus Speed Ratios

An effort was made to refresh the bus speed factors in version 9. General transit feed specification (GTFS) data for 2019 was used to re-evaluate the version 8 bus speed ratio classifications and to estimate new bus speed ratios. The number of bus speed ratios were expanded from 6 in version 8 to 50 in version 9. The new ratios include more area type classifications as well as a classification for peak and off-peak. The bus speed ratios for versions 8 and 9 can be seen in Figure 5.2 and Figure 5.3.

Bus speed ratio parameters were removed from the "0_GeneralParameters.block" file in version 9 and are now read in via an input file ("1_Inputs\0_GlobalData\4_ModeChoice\bus_speed_ratios.csv"). A source spreadsheet ("_source - bus_speed_ratios.xlsx") is also included in the input folder. Modifications to the transit skim script were made to incorporate the new bus speeds input file.



	Peak					Off-Peak					Daily				
	Rur	Trn	Sub	Urb	CBD	Rur	Trn	Sub	Urb	CBD	Rur	Trn	Sub	Urb	CBD
Collectors & Locals	0.56	0.59	0.63	0.66	0.57	0.58	0.60	0.62	0.64	0.52	0.58	0.60	0.62	0.64	0.53
Minor Arterials	0.82	0.74	0.66	0.60	0.53	0.75	0.68	0.61	0.55	0.48	0.80	0.72	0.64	0.58	0.51
Principal Arterials	0.91	0.78	0.67	0.58	0.50	0.79	0.70	0.61	0.53	0.45	0.85	0.75	0.65	0.56	0.49
Expressways	0.52	0.54	0.56	0.58	0.60	0.54	0.55	0.56	0.57	0.58	0.53	0.54	0.56	0.58	0.59
Freeways & Ramps	0.61	0.64	0.71	0.79	0.87	0.47	0.48	0.50	0.55	0.63	0.62	0.64	0.69	0.76	0.84

Figure 5.2 Bus Speeds Plot - Version 9

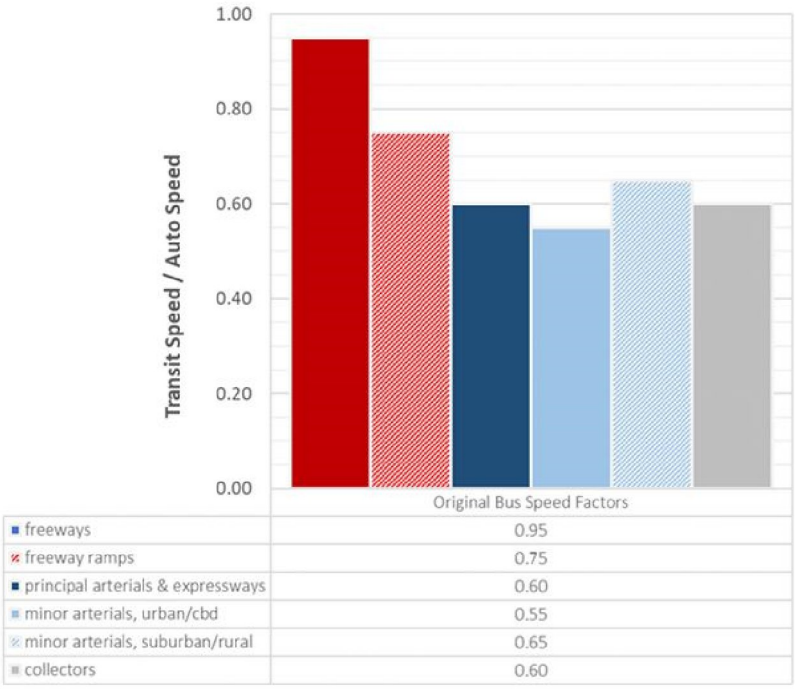


Figure 5.3 Bus Speed Plot - Version 8

5.1.8 Initial Wait Time

The initial wait time curves found in "1_Inputs\4_Transit\Lin_2019\PT_Parameter\GENERAL_System.PTS" were updated in version 9 to make the mode choice model more sensitive to frequency changes. Version 8 initial wait time curves were based on the premise that transit patrons are familiar with the transit schedule and plan their trip to initially board with the minimum amount of delay. To reflect this behavior, a 7.5-minute cap for bus and a 5-minute cap for rail was set on the initial wait time parameter. This cap, however, caused the model to not see much of the benefit/disbenefit a transit user would experience when headways are changed, in particular for longer when moving away/to longer headways.

The version 9 initial wait time parameter was set based on research given to UTA of industry standard-practice initial wait time curves. A range of initial wait time curve values were presented in the research. Version 9 was calibrated to a more conservative curve in that range. The version 9 initial wait time curve can be seen in Figure 5.4.

The new initial wait time curve in version 9 had the effect of increasing transit ridership relative to version 8 in scenarios where an investment in more frequent transit was projected. Early testing showed this increase to be on the order of magnitude of 8-12% based on a comparison of 2019 RTP and draft 2023 RTP transportation investments. However, the actual change in ridership would vary depending on the initial starting point and the magnitude of change in transit frequency.

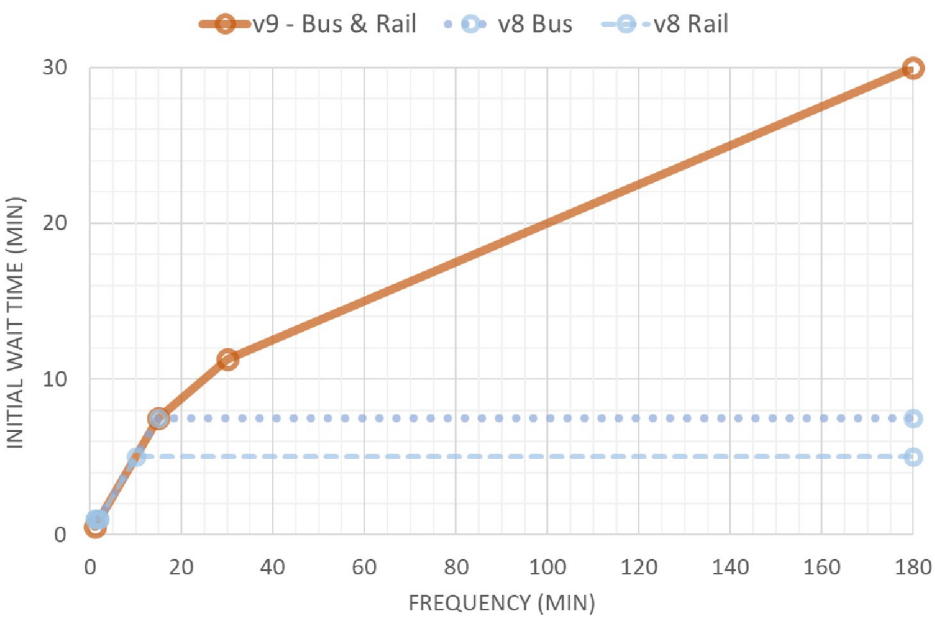


Figure 5.4 Initial Wait Time Curve

5.1.9 Auto Occupancy

Auto occupancy variables were expanded to include additional trips purposes. New auto occupancy rates were calculated based on 2012 Household Travel Survey records for just the Wasatch Front model space. Auto-occupancy rates for external trips are the average of internal-external and external-internal trips. The new version 9 auto occupancy rates can be found in Table 5.9 and

Table 5.10.

Table 5.9 Vehicle Occupancy Rates

v9 Parameter	v9 Value	v8 Parameter	v8 Value	Notes
VehOcc_HBW	1.10	VEH_OCCUPANCY_HBW	1.10	Home-Based Work
VehOcc_HBShp	1.63	VEH_OCCUPANCY_HBSHP	1.58	Home-Based Shopping
VehOcc_HBOth	1.68	VEH_OCCUPANCY_HBOTH	1.66	Home-Based Other
VehOcc_HBSch	1.76	VEH_OCCUPANCY_HBSCH	2.14	Home-Based School
VehOcc_HBC	1.12	VEH_OCCUPANCY_HBC	1.26	Home-Based College
VehOcc_NHBW	1.21	VEH_OCCUPANCY_NHBW	1.20	Non-Home-Based Work
VehOcc_NHBNW	1.76	VEH_OCCUPANCY_NHBNW	1.70	Non-Home-Based Non-Work
VehOcc_Rec	1.68	(Uses HBO)	1.64	Recreation
VehOcc_HBO	1.67	VEH_OCCUPANCY_HBO	1.64	Home-Based Other (HBShp+HBOth)
VehOcc_NHB	1.54	VEH_OCCUPANCY_NHB	1.48	Non-Home-Based (NHBW+NHBNW)
VehOcc_ExtWrk	1.16	(Uses HBW)	1.10	External Work
VehOcc_ExtHBO	1.82	(Uses HBO)	1.64	External Home-Based Other
VehOcc_ExtNHB	1.73	(Uses NHB)	1.48	Non-Home-Based
VehOcc_ExtRec	1.73	(Uses HBO)	1.64	External Recreation

Table 5.10 Vehicle Occupancy 3+ Rates

v9 Parameter	v9 Value	v8 Parameter	v8 Value	Notes
VehOcc_3p_HBW	3.53	VEH_OCC_3P_HBW	3.40	3+ Person Home-Based Work
VehOcc_3p_HBShp	3.49	(Uses HBO)	3.55	3+ Person Home-Based Shopping
VehOcc_3p_HBOth	3.73	(Uses HBO)	3.55	3+ Person Home-Based Other
VehOcc_3p_HBSch	3.88	(Uses HBO)	3.55	3+ Person Home-Based School
VehOcc_3p_HBC	3.24	VEH_OCC_3P_HBC	3.53	3+ Person Home-Based College
VehOcc_3p_NHBW	3.71	(Uses NHB)	3.51	3+ Person Non-Home-Based Work
VehOcc_3p_NHBNW	3.71	(Uses NHB)	3.51	3+ Person Non-Home-Based Non-Work
VehOcc_3p_Rec	3.73	(Uses HBO)	3.55	3+ Person Recreation
VehOcc_3p_HBO	3.68	VEH_OCC_3P_HBO	3.55	3+ Person Home-Based Other (HBShp+HBOth)
VehOcc_3p_NHB	3.71	VEH_OCC_3P_NHB	3.51	3+ Person Non-Home-Based (NHBW+NHBNW)

5.2 Other Input Files

5.2.1 K-12 School Enrollment

The kindergarten through 12th grade (K-12) school enrollment fields, **Enrol_Elem**, **Enrol_Midl**, and **Enrol_High** located in the socioeconomic input files, were updated using the 2019 statewide school enrollment database. This was done at the state-wide level and then applied to the Wasatch Front region.

5.2.2 College Enrollment

Base Distribution

The college student base-year distribution located in "1_Inputs\0_GlobalData\0_TripTables\BaseDistribution.csv" was updated to reflect current conditions. Dormitory populations were assigned to TAZs based on group quarter data from the Census. The remaining enrollment was distributed using StreetLight origin-destination and USHE enrollment data.

Enrollment Forecast

The future-year college enrollment control totals located in "1_Inputs\0_GlobalData\0_TripTables\TripTableControlTotal.csv" were updated to reflect current USHE and other college enrollment data. Colleges that were "removed" in version 9 had the college enrollment control total set to zero. A comparison of the version 9 and version 8 (specifically, version 8.3.2) college enrollment control totals can be seen in the Figure 5.5 through Figure 5.11.

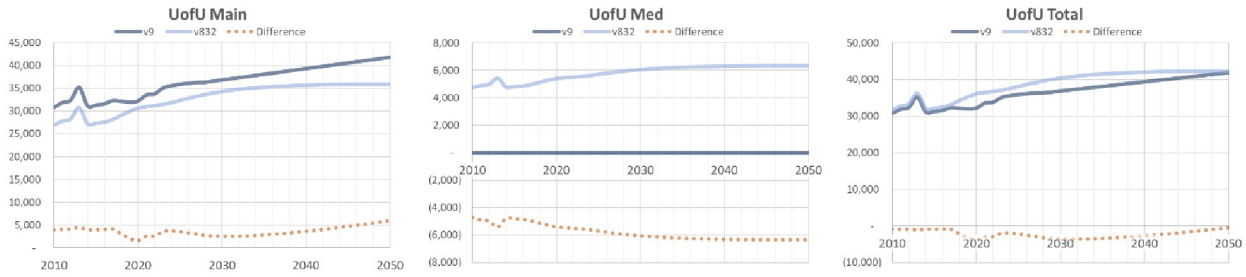


Figure 5.5 College Enrollment Forecast - UofU

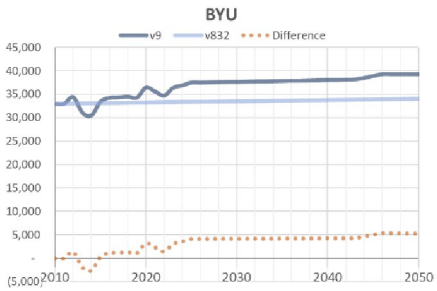


Figure 5.6 College Enrollment Forecast - BYU

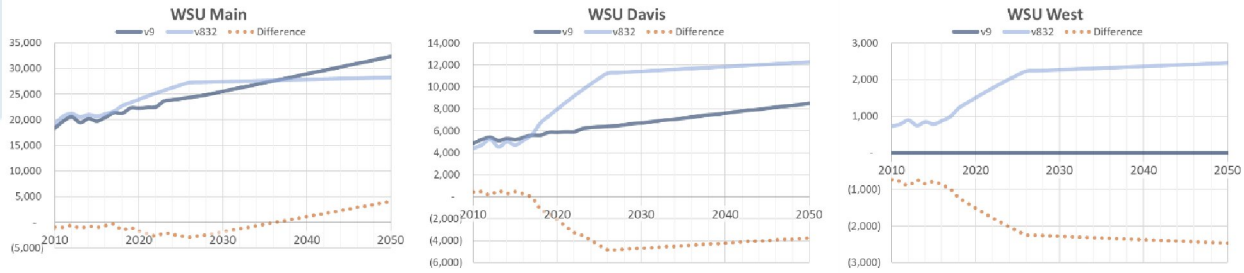


Figure 5.7 College Enrollment Forecast - WSU

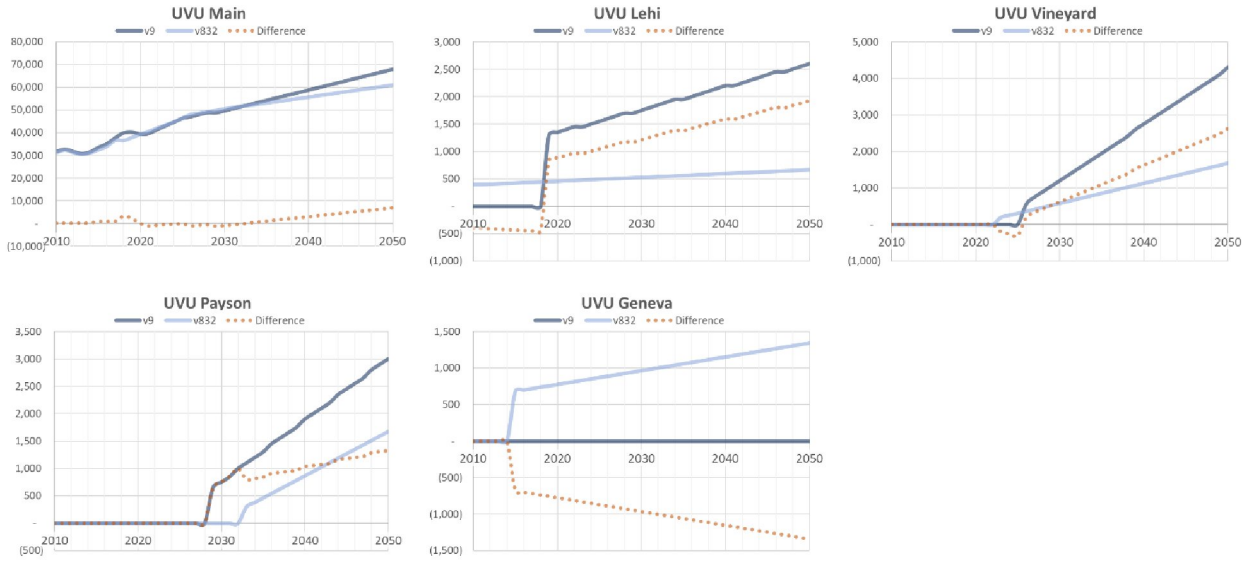


Figure 5.8 College Enrollment Forecast - UVU

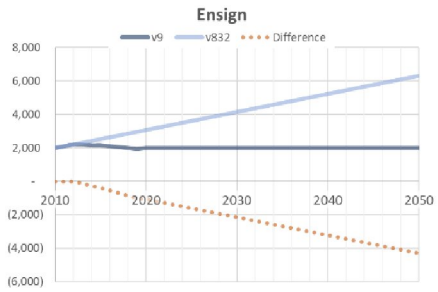


Figure 5.9 College Enrollment Forecast - Ensign

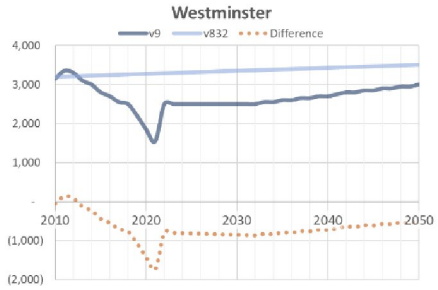


Figure 5.10 College Enrollment Forecast - Westminster

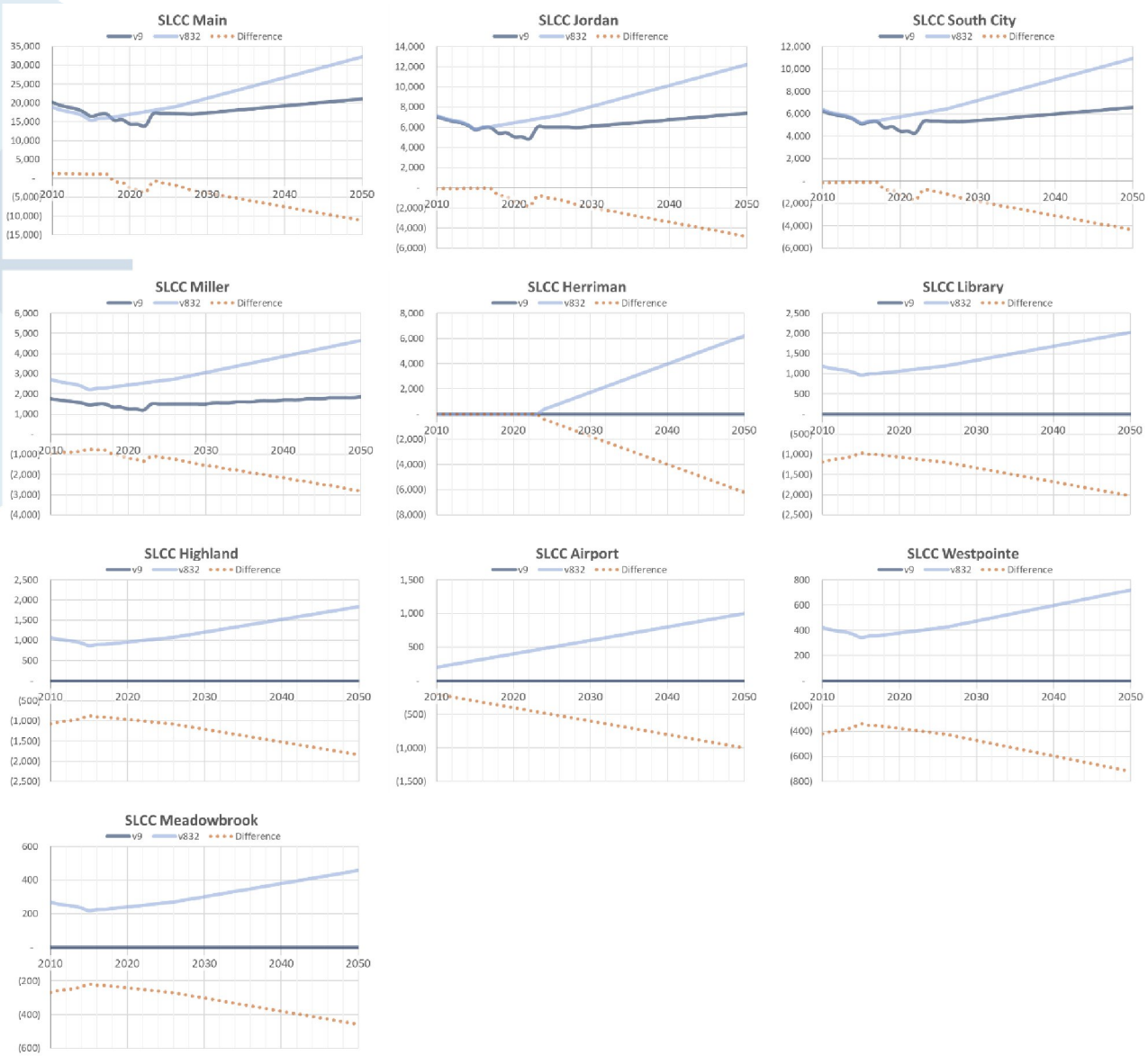


Figure 5.11 College Enrollment Forecast - SLCC

College Enrollment Factors

The college enrollment factors located in "1_Inputs\0_GlobalData\0_TripTables\College_Factors.csv" were updated in association with the college enrollment control totals.

- **% Removed** – For colleges that were removed, the factor was reset to zero.
- **Full-Time Equivalent (FTE)** – the FTE rate was reduced for all colleges. This will have the effect of increasing the number of college students in the HBC college trip table. For colleges that were removed, the factor was reset to one.
- **Home-Based-College (HBC) Trip Rate** – For colleges that were removed, the factor was reset to zero.

A comparison of the version 9 and version 8 (specifically, version 8.3.2) college enrollment control totals can be seen in Table 5.11.

Table 5.11 College Enrollment Factors

Area	Campus	% Removed		FTE Rate		HBC Trip Rate		Notes
		v9 Value	v8 Value	v9 Value	v8 Value	v9 Value	v8 Value	
WFRC Colleges	Ensign	0.101	0.101	1.179	1.179	0.930	0.930	
	Westminster	0.012	0.012	1.098	1.098	0.930	0.930	
	UofU Main	0.026	0.026	1.025	1.210	0.930	0.930	
	UofU Med	0	0.026	1	1.210	0	0.930	(removed)
	WSU Main	0.215	0.215	1.038	1.588	0.830	0.830	
	WSU Davis	0.309	0.309	1.038	1.588	0.677	0.677	
	WSU West	0	0.309	1	1.588	0	0.677	(removed)
	SLCC Main	0.341	0.341	1.208	2.005	0.622	0.622	
	SLCC South City	0.341	0.341	1.208	2.005	0.642	0.642	
	SLCC Jordan	0.341	0.341	1.208	2.005	0.569	0.569	
	SLCC Meadowbrook	0	0.341	1	2.005	0	0.569	(removed)
	SLCC Miller	0.341	0.341	1.208	2.005	0.616	0.616	
	SLCC Library	0	0.341	1	2.005	0	0.616	(removed)
	SLCC Highland	0	0.341	1	2.005	0	0.616	(removed)
	SLCC Airport	0	0.341	1	2.005	0	0.616	(removed)
	SLCC Westpointe	0	0.341	1	2.005	0	0.616	(removed)
	SLCC Herriman	0	0.341	1	2.005	0	0.616	(removed)
MAG Colleges	BYU	0.026	0.026	1.025	1.210	0.930	0.930	
	UVU Main	0.270	0.270	1.097	1.400	0.945	0.945	
	UVU Geneva	0	0.270	1	1.400	0	0.945	(removed)
	UVU Lehi	0.270	0.270	1.097	1.400	0.945	0.945	
	UVU Vineyard	0.270	0.270	1.097	1.400	0.945	0.945	
	UVU Payson	0.270	0.270	1.097	1.400	0.945	0.945	

5.2.3 External Volume Forecast

External volume forecasts located in "1_Inputs\5_External\Ext_Vol_Control" were updated reflecting the version 9 external locations. Historic count data through 2020 and updated traffic factors were used to create the new external volume forecast. The version 9 forecasts go from 2010 through 2060. A direct comparison of the version 8 and 9 external volume forecasts is not provided because the external locations are so different.

The USTM model was updated to reflect the v9 model coverage area and new external seed matrices were provided. The Wasatch Front subarea extraction script in USTM was rewritten to provide more accurate production and attraction information and to streamline the subarea extraction process. The new script now outputs "WF_DY_PA_ExtTripEnds.csv" and "WF_DY_PA_VehicleTrips.mtx" files stored in the "1_Inputs\5_External\WF_External" folder.

The “2_External_TripTable.s” script was also rewritten in the WF TDM for version 9 to use the new USTM files and data formats and to improve the model’s data processing

5.3 Calibration

5.3.1 Trip Generation Rates

Trip generation rates were updated in version 9 as part of the model’s base year calibration. Person-trip production rates (e.g. HBW, HBShp, HBOth, etc.) were increased in the model script by approximately 5% over version 8 rates resulting in a regional increase of both productions and attractions of 5% (see Figure 5.12). County-level adjustments were left the same as the previous model. When combined with the changes in the 2019 socioeconomic data, the total person-trip productions and attractions in individual counites was slightly different with the most notable differences in Weber, Salt Lake, and Utah counties. The county production/attraction balance stayed fairly consistent.

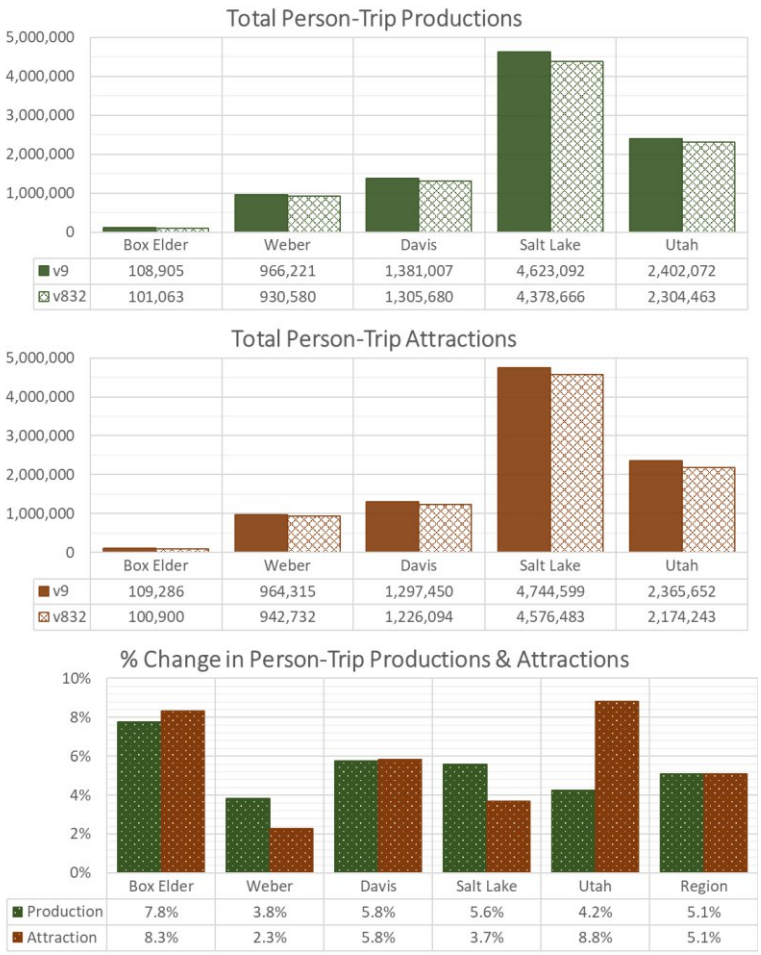


Figure 5.12 Person-Trip Productions & Attractions by County

Short haul tuck calculations were revamped and simplified mirroring changes made to truck trip calculations in USTM. The moving people, goods, and services by light, medium, and heavy truck detailed calculations were collapsed to just light, medium, and heavy categories. (Note, the trip generation script still includes code for the more detailed calculations, however most of this code is not being used.) The new short haul truck trip variables and coefficients were combined based on the original code structure. The short haul truck trip rates were then adjusted by county. Significant changes were made to the county light, medium, and heavy truck adjustment factors resulting in a 34% increase in overall short haul truck productions and attractions. Light trucks accounted for the majority of this change with a regional increase of 50%. Medium trucks saw a regional increase of 29%. Heavy trucks decreased by 1%. In addition to the changes in regional truck trip ends and vehicle classification makeup, significant changes occurred in the county-level distribution of the trip ends with Salt Lake County truck trip ends held constant yielding more than twice the regional change in the other counties (see Figure 5.13).

The changes to the short haul trip end calculations constitute a new behavioral model.

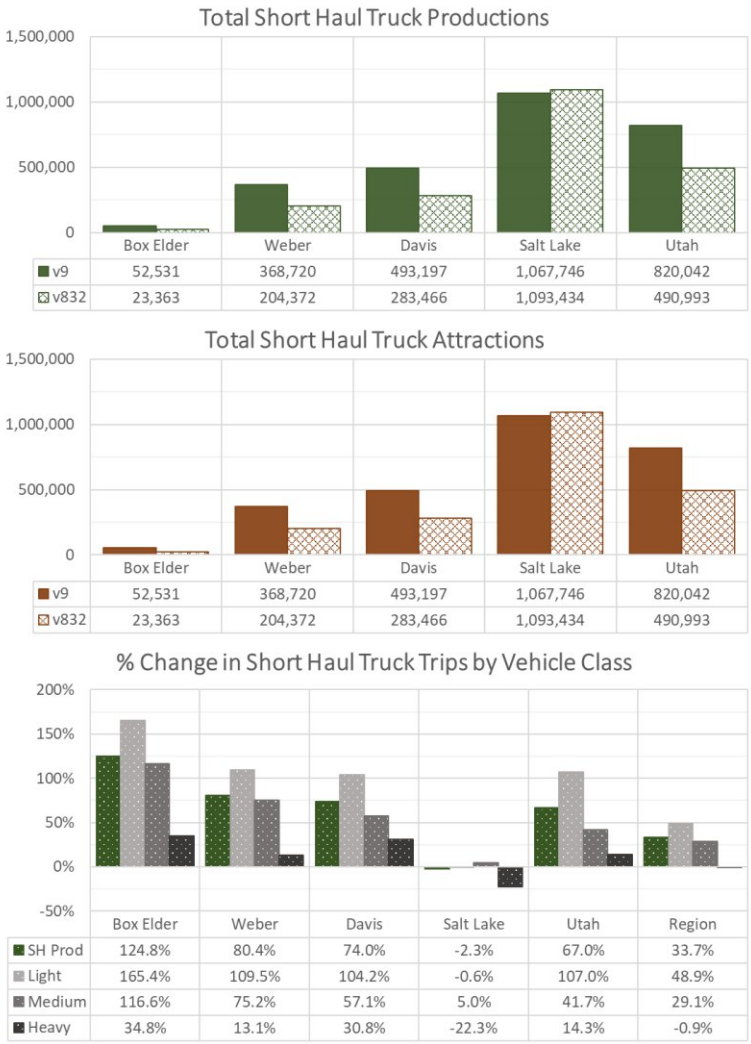


Figure 5.13 Short Haul Truck Productions & Attractions by County

5.3.2 Distribution Friction Factors

The observed time, distance, and generalized cost trip length frequencies and average trip lengths, which serve as the targets for friction factor calibration and validation, were updated in version 9 to reflect the 2019 base year network and refreshed data processing. The updated average trip length frequencies are found in Figure 5.14.

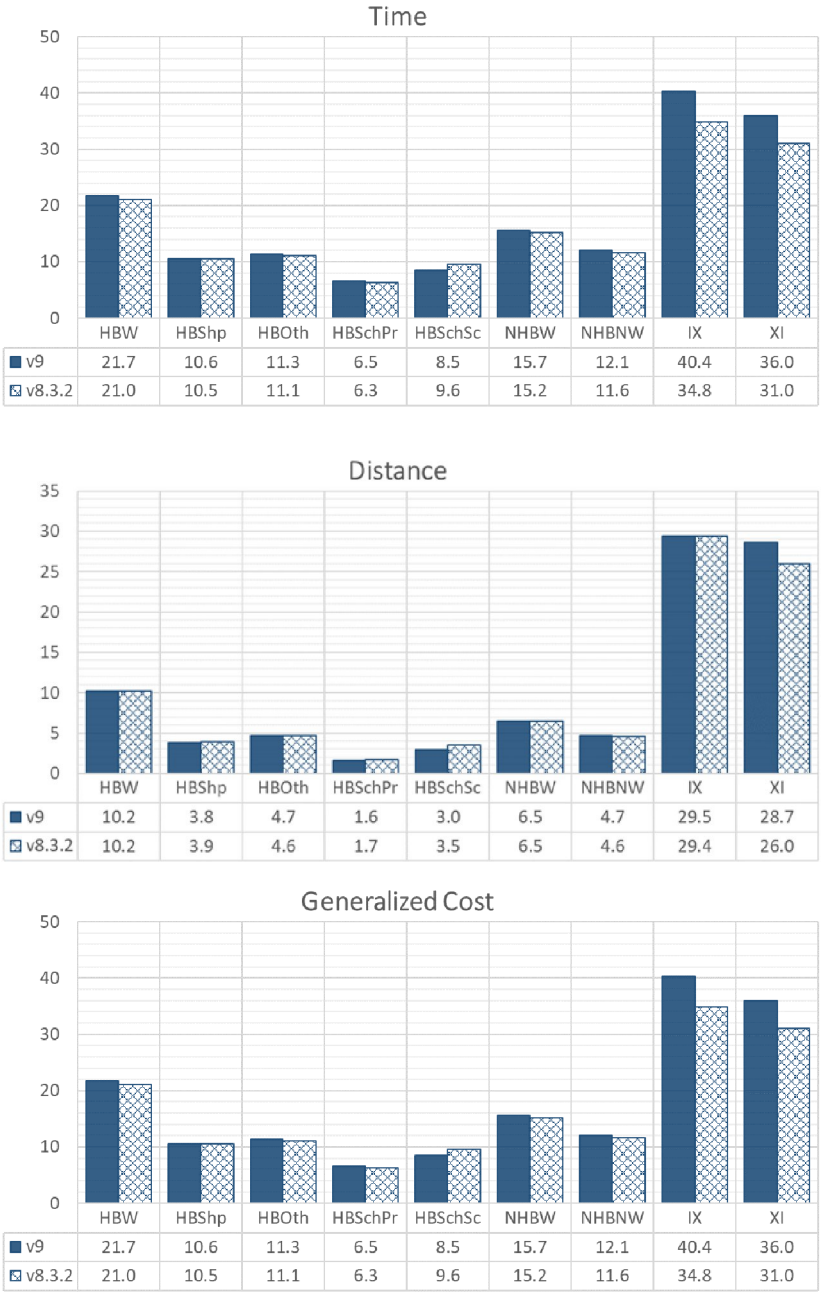
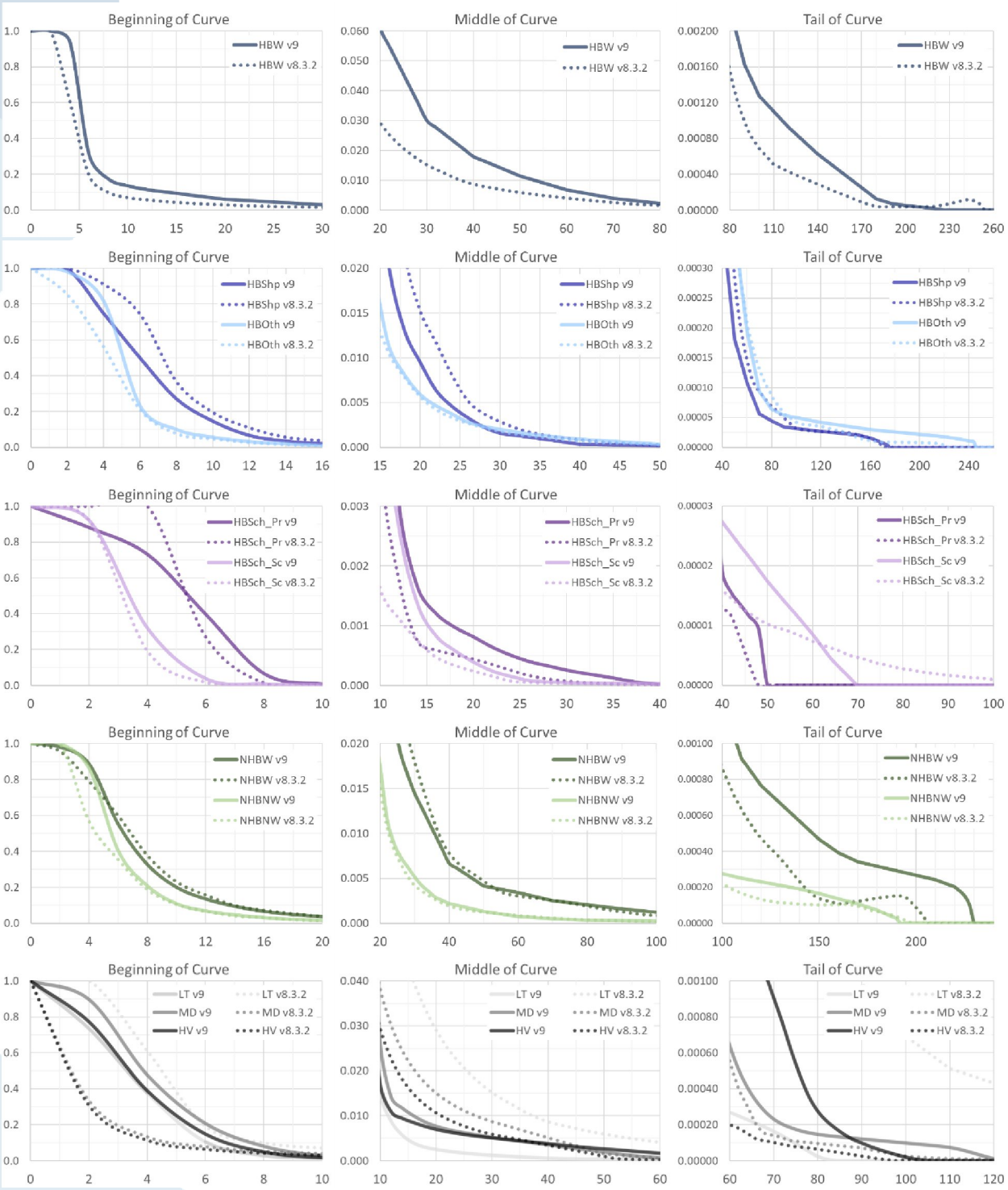


Figure 5.14 Observed Average Trip Length

Trip distribution friction factors were updated in version 9 as part of the model's base year calibration. Six new external-truck friction factors were added: IX_LT, IX_MD, IX_HV, XI_LT, XI_MD, and XI_HV. Note however that IX_LT and XI_LT friction factors were set equal to IX and XI, respectively. StreetLight truck origin-destination data was used to help calibrate the internal truck and external friction factors. A comparison of the version 9 and version 8 friction factors is found in Figure 5.15.



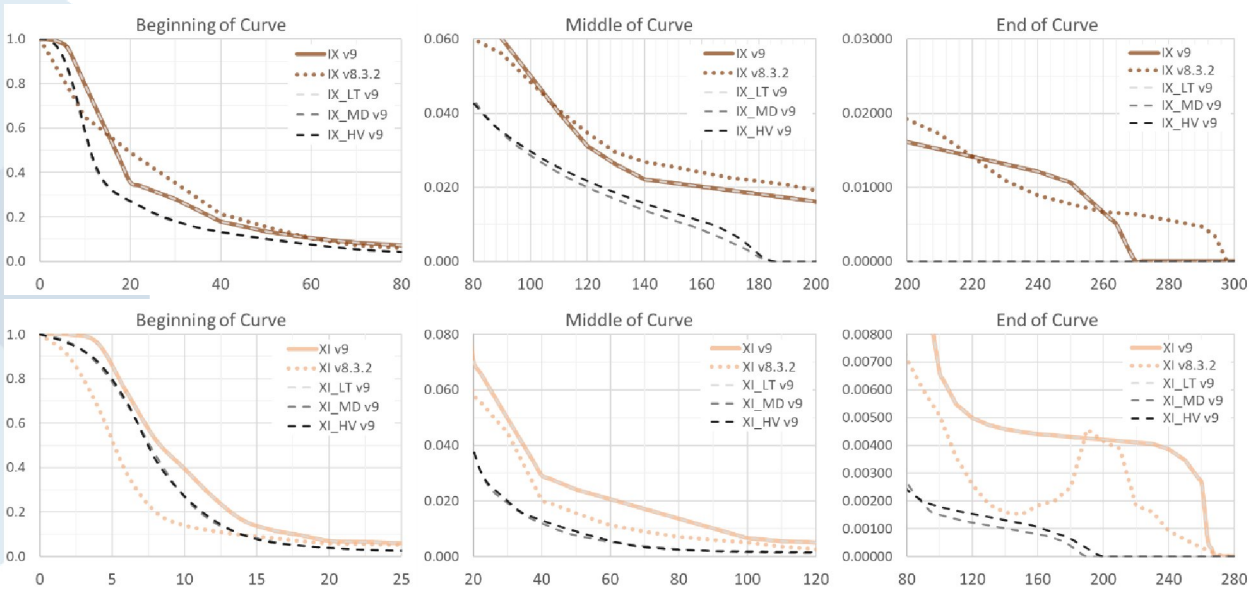


Figure 5.15 Friction Factors

5.3.3 K-Factors

K-factor variables were expanded by trip purpose to allow for more flexibility in calibrating the distribution model. However, no K-factors were needed for calibration. All K-factors were reset to 1.

Table 5.12 Reset K-Factors

Area	v9 Parameter	v9 Value	v8 Parameter	v8 Value
between Salt Lake and Utah counties	SL_UT_KFAC_Wrk	1.00	SL_UT_KFAC	0.85
	SL_UT_KFAC_Oth	1.00		
	SL_UT_KFAC_Trk	1.00		
	SL_UT_KFAC_Ext	1.00		
between Salt Lake and Davis counties	SL_DA_KFAC_Wrk	1.00	SL_DA_KFAC	0.95
	SL_DA_KFAC_Oth	1.00		
	SL_DA_KFAC_Trk	1.00		
	SL_DA_KFAC_Ext	1.00		
between Box Elder and Weber counties	WE_BE_KFAC_Wrk	1.00	WE_BE_KFAC	1.00
	WE_BE_KFAC_Oth	1.00		
	WE_BE_KFAC_Trk	1.00		
	WE_BE_KFAC_Ext	1.00		

5.3.4 Mode Choice Constants

Mode choice constants were updated in version 9 as part of the model's base year calibration.

In addition, the parameter used to set the Core Bus constant was renamed and lowered to 0.33. The effect of this change makes mode 5 in the model a little less attractive in version 9 than it was in version 8.

Table 5.13 Core Bus Constant Multiplier

v9 Parameter	v9 Value	v8 Parameter	v8 Value	Notes
RAIL2COR_MULTIPLIER	0.33	RAIL2BRT_MULTIPLIER	0.40	factor to set Core Route constant relative to LRT constant

Adjustment factors were added to the mode choice logit model to adjust CRT ridership in Davis and Utah counties. The parameters are applied in the utility calculation and represent a penalty/incentive in equivalent minutes.

6 Model Enhancements

6.1 Distribution

6.1.1 Distribution Convergence

The convergence criteria in the "1_Distribution.s" script was updated.

Trip Table Convergence

For trip table convergence, the percent change threshold was tightened from 10% to 7.5%. For each iteration, only cells where the trips in the current iterations are greater than zero are considered. Also, cells with trips greater than zero are counted as significant trips and form the denominator in the percent converged calculation. A cell in the trip matrix is now considered converged if either of the following conditions is met:

- The percent change from previous iteration is within 7.5%.
- Trips from the current iteration are less than 1, except when trips from the current iteration are greater than zero and the trips from the previous iteration equals zero.

Link Convergence

For link volume convergence, the percent change threshold was loosened from 5% to 7.5%. Centroid connectors were removed from consideration when determining convergence. Only cells where the trips in the current iterations are greater than zero are considered and are counted as significant trips forming the denominator in the percent converged calculation. A link is now considered converged if either of the following conditions is met:

- The percent change from previous iteration is within 7.5%.
- Volume from current iteration equals zero and volume from previous iteration equals zero, except when the volume from the current iteration is greater than zero and the volume from the previous iteration equals zero, or the volume from the current iteration is zero and the volume from the previous iteration is greater than zero.

Check Criteria

The requirement for a minimum of 5 iterations was removed from the check convergence criteria.

Check Network

A loaded network file ("@unloadednetprefix@_@n@_convg.net") was added to "Temp\3_Distribute" folder to track link convergence between the distribution feedback loop iterations. A network is output for each distribution feedback loop iteration after the first iteration. The link attributes include the volume changes from the current and previous iteration for each time period.

6.1.2 RGAP in Distribution

The "RelGapCriteria" parameter was moved from "block\4pd_mainbody_distribution.block" to "1_Distribution.s" and placed before each assignment call in order to accommodate a stricter RGAP threshold for the evening period. For the evening period, the RGAP parameter value is now divided by 10 increasing the network assignment stability and reducing the RMSE for the evening period.

6.1.3 Reports

The following reports were added to the scenarios "3_Distribute" output folder to better track convergence in the model:

- *"_Stats - Distrib Assign - @RID@.csv"* – Combines the highway assignment convergence reports for each feedback loop iteration, time period, and assignment iteration into one file.
- *"_Stats - Distrib Loaded Net - @RID@.csv"* – Provides summary statistics of the number and percent of converged links in the assigned network as well as the total VMT, VHT, and average speed by major functional class (freeways, arterials, and total).
- *"_Stats - Distrib Trip Table - @RID@.csv"* -- Provides summary statistics of the number and percent of converged trip table cells as well as the total number of trips by purpose for each feedback loop iteration.

6.2 Mode Choice

6.2.1 Mode Name Change

In version 9, names for the following modes were changed:

- Mode 5
  - LONGNAME: from 'Bus Rapid Transit' to 'Core Bus'
  - NAME: from 'BRT' to 'CoreBus'
- Mode 9
  - LONGNAME: from 'Mode 9 Bus Rapid Transit' to 'Bus Rapid Transit'
  - NAME: from 'BRT9' to 'BRT'

6.2.2 Prefixes for Transit Skims

Prefixes to identify transit skim output files have been coded directly into the scripts in version 9. As such, the following parameters were removed from the "0_GeneralParameters.block" file.

- W_LCL_skims = 'skm_w4' ;walk-to-local skims
- D_LCL_skims = 'skm_d4' ;drive-to-local skims
- W_BRT_skims = 'skm_w5' ;walk-to-BRT skims
- D_BRT_skims = 'skm_d5' ;drive-to-BRT skims
- W_EXP_skims = 'skm_w6' ;walk-to-express bus skims
- D_EXP_skims = 'skm_d6' ;drive-to-express bus skims

- W_LRT_skims = ‘skm_w7’ ;walk-to-light rail skims
- D_LRT_skims = ‘skm_d7’ ;drive-to-light rail skims
- W_CRT_skims = ‘skm_w8’ ;walk-to-commuter rail skims
- D_CRT_skims = ‘skm_d8’ ;drive-to-commuter rail skims
- W_mode9_skims = ‘skm_w9’
- D_mode9_skims = ‘skm_d9’

6.3 Assignment

6.3.1 Diurnal Factors

Diurnal (time-of-day) factors were updated in version 9 for the internal-external (IX) and external-internal (XI) trip purposes based on 2019 StreetLight origin-destination data. IX and XI diurnal factors in version 8 were inherited from previous model versions which were derived using observed truck count data and an averaged factor was used for IX and XI. A comparison of version 8 and 9 IX and XI diurnal factors can be seen in Table 6.1 IX & XI Diurnal Factors.

Table 6.1 IX & XI Diurnal Factors

Factor	v9 Value	v8 Value	Change
IX_AM_PCT	0.1909	0.1786	0.0123
IX_MD_PCT	0.3136	0.3291	-0.0155
IX_PM_PCT	0.2567	0.2604	-0.0037
IX_EV_PCT	0.2388	0.2319	0.0069
XI_AM_PCT	0.1969	0.1786	0.0183
XI_MD_PCT	0.3263	0.3291	-0.0028
XI_PM_PCT	0.2617	0.2604	0.0013
XI_EV_PCT	0.2151	0.2319	-0.0168
IX_AM_PA	0.6604	0.8563	-0.1959
IX_MD_PA	0.5593	0.5627	-0.0034
IX_PM_PA	0.4044	0.3288	0.0756
IX_EV_PA	0.3968	0.3290	0.0678
XI_AM_PA	0.7709	0.8563	-0.0854
XI_MD_PA	0.6087	0.5627	0.0460
XI_PM_PA	0.3111	0.3288	-0.0177
XI_EV_PA	0.3170	0.3290	-0.0120

Diurnal factors were removed from the “0_GeneralParameters.block” file in version 9 and are now read in via an input file (“1_Inputs\0_GlobalData\5_Assignment\Time Of Day Factors.csv”). A source spreadsheet (“_source - Time Of Day Factors.xlsb”) is also included in the input folder. The new factors file includes factors for additional trip purposes (e.g. home-based college stratified by campus), although the model code has not yet been modified to account for the additional factors.

A new script ("2_ModelScripts\0_InputProcessing\e_TimeOfDayFactors\1_CalculateTimeOfDayFac.s") was added to the model stream, which included an update to the "HailMary.s" script. This script reads in the "Time Of Day Factors.csv" file and writes out a text file ("0_InputProcessing_TimeOfDayFactors.txt") containing the diurnal factors expressed as parameters for use in the model. Scripts that use diurnal parameters in version 9 were updated to read in the text file containing the diurnal parameters.

6.3.2 RGAP in Assignment

The "RelGapCriteria" parameter was moved from the "block\4pd_mainbody_managedlanes.block" and "4pd_mainbody_managedlanes_SelectLink.block" files and placed in the "02_Assign_AM_MD_PM_EV.s" and "03_Assign_PM1Hr.s" scripts to accommodate a stricter RGAP threshold for the evening period. For the evening period, the RGAP parameter value is now divided by 10 increasing the network assignment stability and reducing the RMSE for the evening period.

6.3.3 Assigned Network

Medium and heavy truck speed and time and buffer time index (BTI) calculations were added to the "04_SummarizeLoadedNetworks.s" script (calculations were previously in the "5_AssignHwy\07_PerformFinalNetSkim.s" script). Weighted average daily summaries were also added. The following fields were added to the assigned output network:

- Weighted average daily values for:
  - Ramp Penalties (DY_RAMPPEN)
  - Buffer Time Index (DY_BTI_TME)
- Medium Truck Speed
  - FF_TKSPD_M
  - AM_TKSPD_M
  - MD_TKSPD_M
  - PM_TKSPD_M
  - EV_TKSPD_M
  - DY_TKSPD_M
- Medium Truck Time
  - FF_TKTME_M
  - AM_TKTME_M
  - MD_TKTME_M
  - PM_TKTME_M
  - EV_TKTME_M
  - DY_TKTME_M
- Heavy Truck Speed
  - FF_TKSPD_H
  - AM_TKSPD_H
  - MD_TKSPD_H
  - PM_TKSPD_H
  - EV_TKSPD_H
  - DY_TKSPD_H
- Heavy Truck Time
  - FF_TKTME_H

- AM_TKTME_H
- MD_TKTME_H
- PM_TKTME_H
- EV_TKTME_H
- DY_TKTME_H

The following fields were removed from the assigned output network:

- lw_Spd_Auto_1
- lw_TrkSpd_MD_1
- lw_TrkSpd_HV_1
- lw_Time_Auto_1
- lw_TrkTime_MD_1
- lw_TrkTime_HV_1

6.3.4 Final Skims

The "5_AssignHwy\07_PerformFinalNetSkim.s" script was updated in version 9 to include ramp penalty information for general purpose (GP), managed lane (ML), medium truck (MD), and heavy truck (HV) for each time period. The version 9 script also produces a daily skim matrix with the same attributes as the period skim matrices.

6.3.5 Reports

The following report was added to the scenarios "5_AssignHwy\0_ConvergeReports" output folder to better track convergence in the model:

- *"_Stats - Final Assign - @RID@.csv"* – Combines the highway assignment convergence reports for each time period and assignment iteration into one file.

6.4 Miscellaneous Updates

The following changes were also made to the model in version 9:

- The following parameters were removed from the "0_GeneralParameters.block" file in version 9 because they were no longer being used in the model. These are in addition to the other parameter changes identified in other sections of this report.
  - County Identification Parameters
    - CountyRange = '1-5'
    - CountyName1 = 'Weber'
    - CountyName2 = 'Davis'
    - CountyName3 = 'SaltLake'
    - CountyName4 = 'Utah'
    - CountyName5 = 'BoxElder'
    - CO_Name1 = 'WE'
    - CO_Name2 = 'DA'
    - CO_Name3 = 'SL'

        - CO_Name4 = 'UT'
        - CO_Name5 = 'BE'
    - Air Quality Conformity Report Parameters
        - RE_ID = 0 ;Entire region
        - WE_ID = 1 ;Weber
        - DA_ID = 2 ;Davis
        - SL_ID = 3 ;Salt Lake
        - UT_ID = 4 ;Utah
        - BE_ID = 5 ;BoxElder
        - OC_ID = 55980 ;Ogden
        - SC_ID = 67000 ;Salt Lake City
        - PC_ID = 62470 ;Provo
    - Assignment Type Flag
        - AssignType = 'managed'
- The folder setup routine was integrated into the "HailMary.s" script to run automatically. It is no longer necessary to copy empty folders or run the "_CreateOutputFolders.s" prior to running the model.
- The "3_Distribute\1_Distribution.s" script was updated so that initializing the summary statistics variables that will be printed to the log file is no longer needed and the section to initialize these variables was removed. In addition, the trip table and link convergence reports in the log file were updated based on information generated in the new summary statistics reports.
- The "04_SummarizeLoadedNetworks.s" script was modified to point the geometry input reference to the input processing output folder instead of the highway inputs folder.
- The "PrintProgress" code block found in various scripts throughout the model was updated to account for multithread processing. This code block provides percent complete progress updates for specific, matrix-based Voyager modules.

6.5 Bug Fixes

- A bug in the Connected and Autonomous Vehicle (CAV) calculation was fixed where the column index needed to be incremented by 1 to link up with lookup tables.
- A bug was fixed in the portion of the "04_SummarizeLoadedNetworks.s" script that consolidates the select link trip tables. The total trips were being summarized into a matrix that was not being assigned to the output matrix. The correct working matrices have been updated with the correct index for the output file.

7 Compare Model Results

This section compares the model results between version 9 and version 8.

7.1 Road Volume Comparisons

The comparison between daily volumes at the segment level can be found in Figure 7.1 for 2019 and 2050. Decreases in volume in version 9 compared to version 8 are shown in blue, while increases are shown in red.

For 2019, Salt Lake and northern Davis counties display a drop in roadway volumes, most apparent on I-15. Weber, southern Davis, and Utah Counties show increases. Most of the changes are relatively minor, with the largest decreases occurring on the freeways in Salt Lake County. However, given the large daily volume for these roadways, the percent change is relatively low.

For 2050, there are decreases in volumes on I-15 in Salt Lake and northern Davis counties. Weber and northern Davis counties show overall increase in roadway volumes. Utah County shows the most change with the two Utah Lake crossings not part of the 2050 fiscally constrained scenario. The resulting drop in volumes is evident with increases on I-15.

The comparison of daily medium and heavy truck volumes is found in Figure 7.2**Error! Reference source not found.** for 2019 and 2050. Truck volumes decreased in the northwest portion of Salt Lake County.

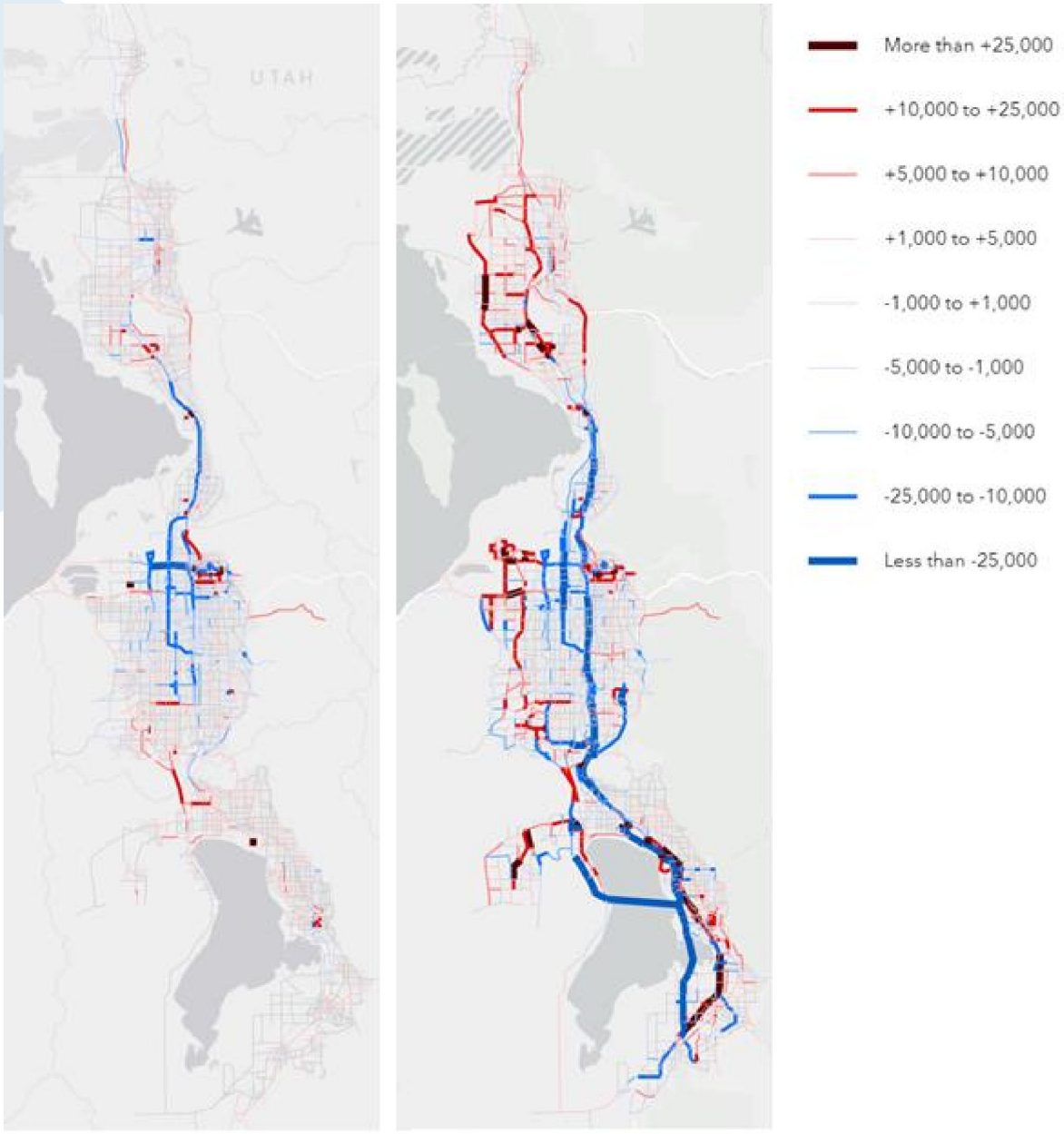


Figure 7.1 Daily Total Volume Comparison (version 9 vs. version 8)

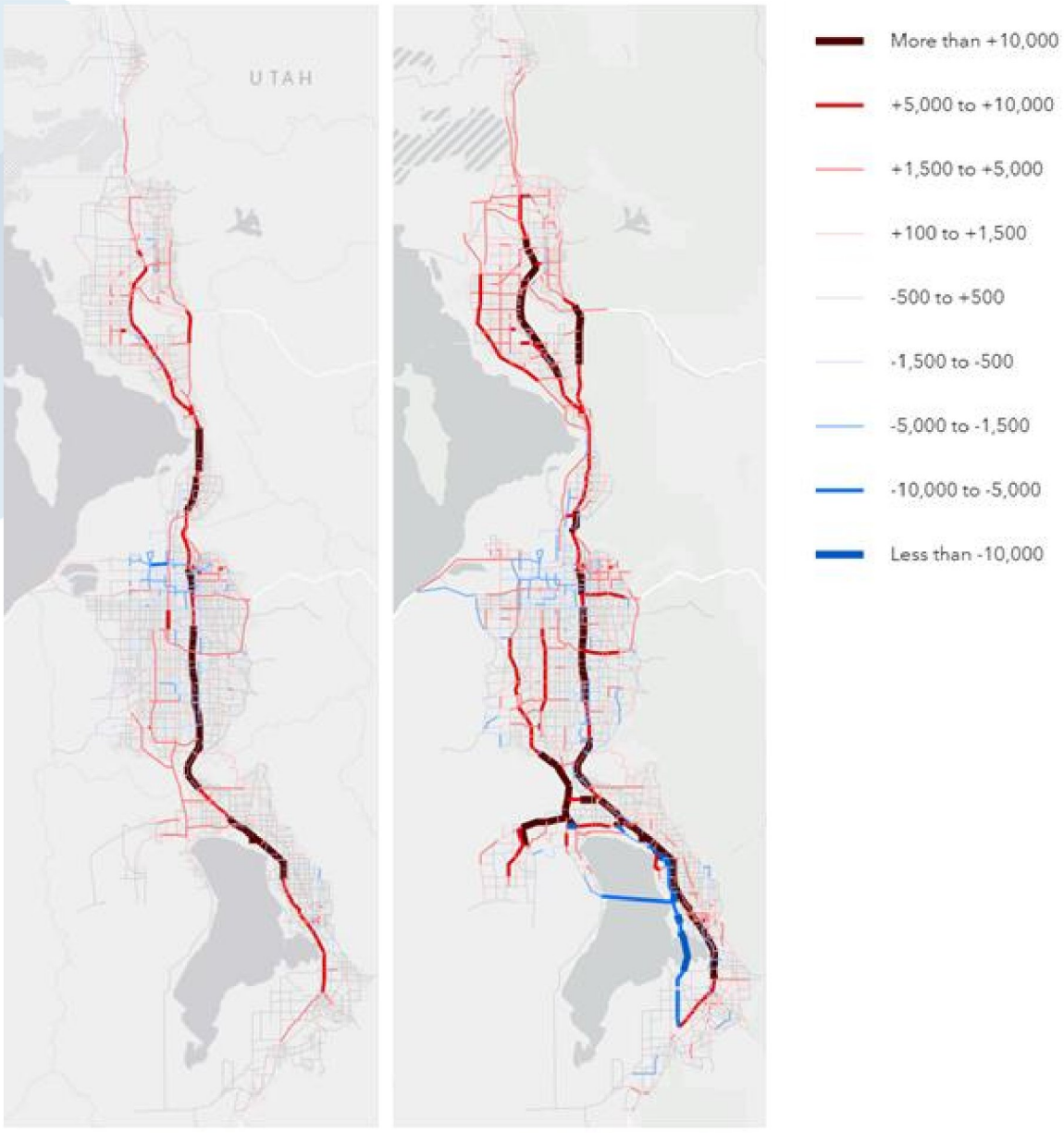


Figure 7.2 Daily Truck Volumes Comparison (version 9 vs. version 8)

7.2 Transit Comparisons

Transit comparisons were done with ridership, trips mode share, and boardings mode share. Overall ridership increases significantly in version 9, and Core Bus ridership takes a larger share of trips and boardings than in version 8.

7.2.1 Transit Ridership

Transit ridership in version 9 compared to version 8 shows significant increase in 2032, 2042, and 2050 (see Figure 7.3). The total ridership in 2050 for version 9 is 327,000 daily trips compared to the version 8 model that showed 258,000 daily trips, which equates to 26% more trips. The additional trips are largely due to the improvements in commuter rail with increased frequency and speed together with the change in the model sensitivity to changes in headway.

Transit ridership by modes is shown in Figure 7.3 through Figure 7.9. Light-Rail Transit sees an increase through 2028 and then a large decrease in 2032. This large decrease can be explained by the shift of riders from Light Rail to Core Bus routes, with many core routes coming online in 2032.

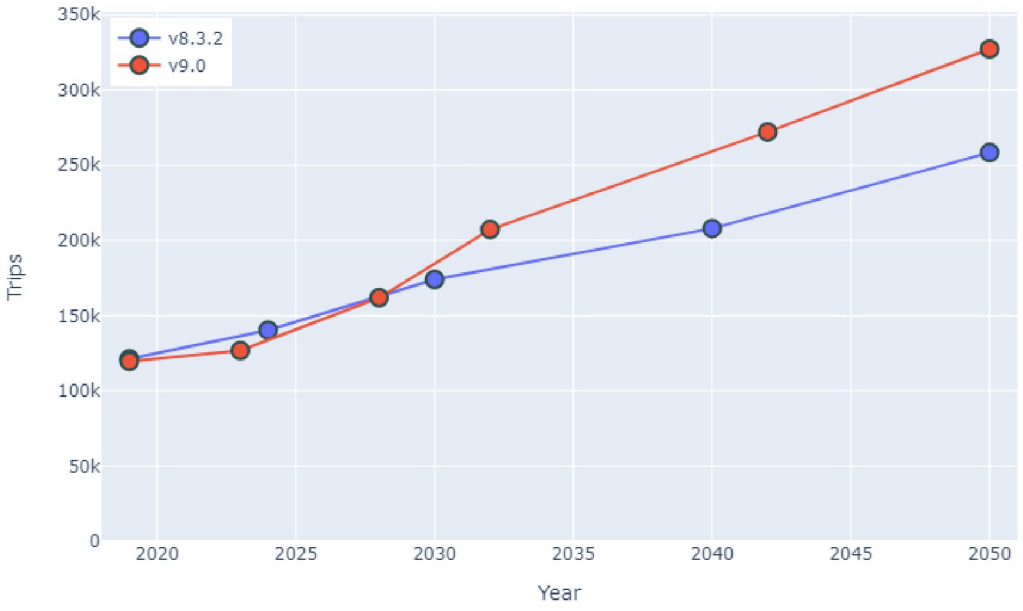


Figure 7.3 Daily Transit Ridership - All Modes

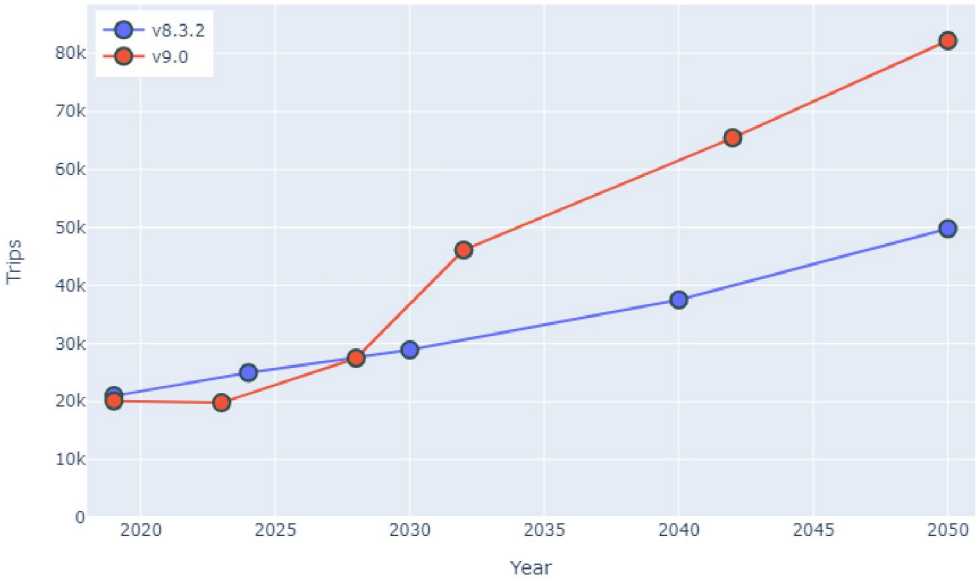


Figure 7.4 Daily Transit Ridership - Commuter-Rail Transit

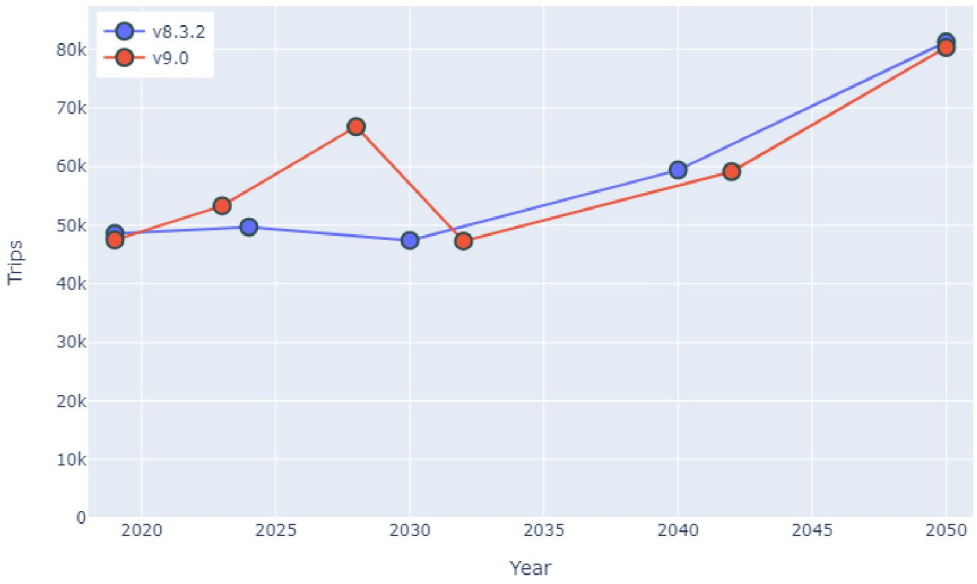


Figure 7.5 Daily Transit Ridership - Light-Rail Transit

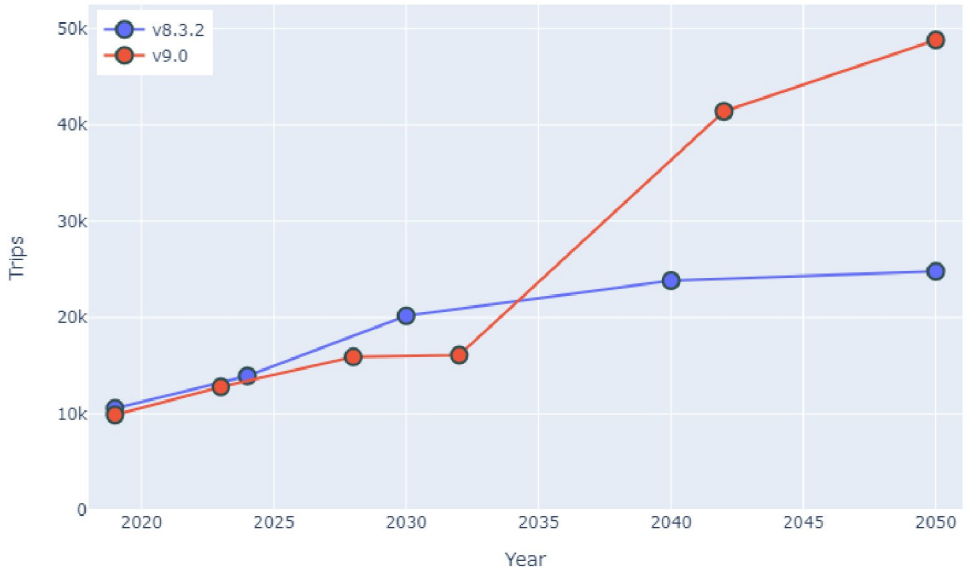


Figure 7.6 Daily Transit Ridership - Bus Rapid Transit

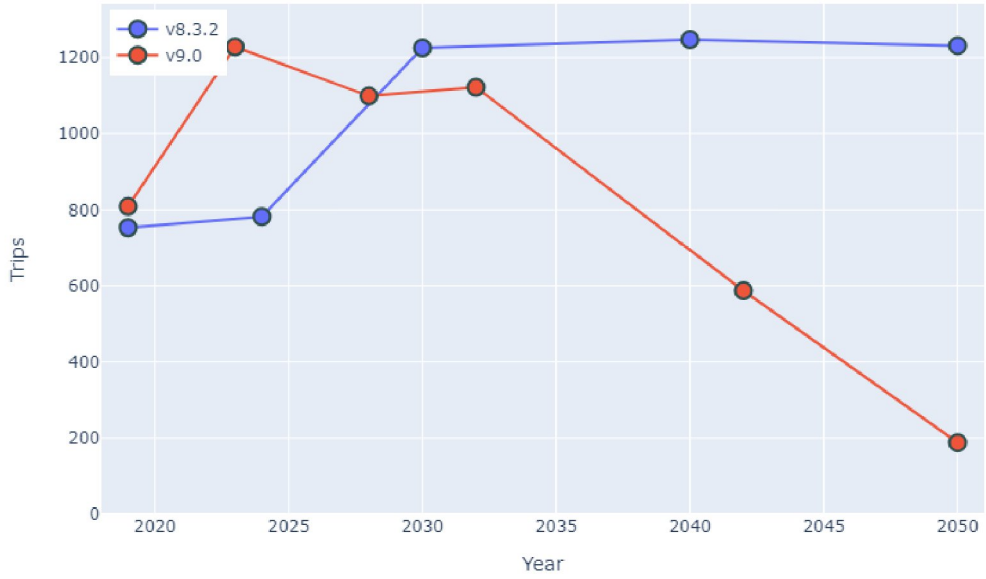


Figure 7.7 Daily Transit Ridership - Express Bus

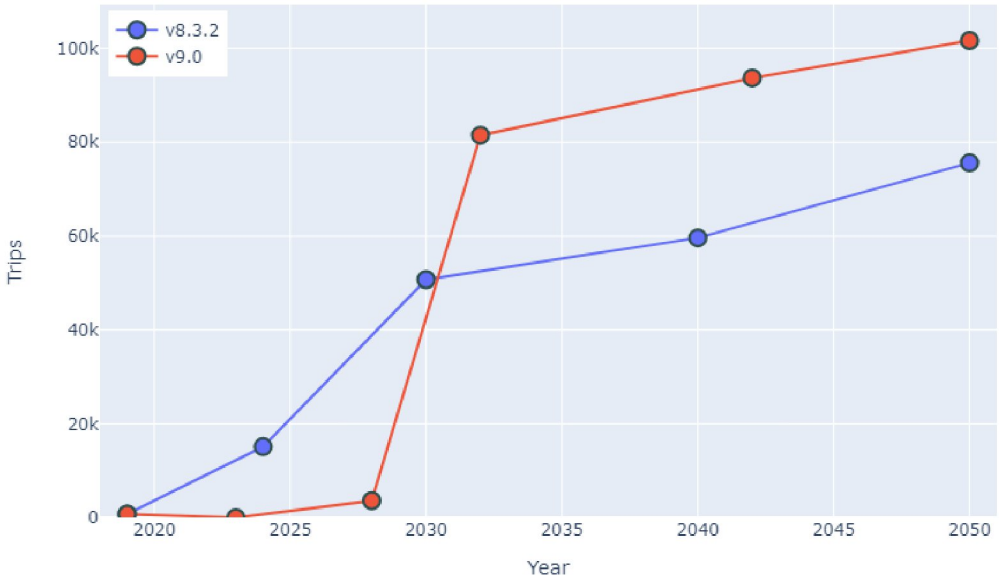


Figure 7.8 Daily Transit Ridership - Core Bus

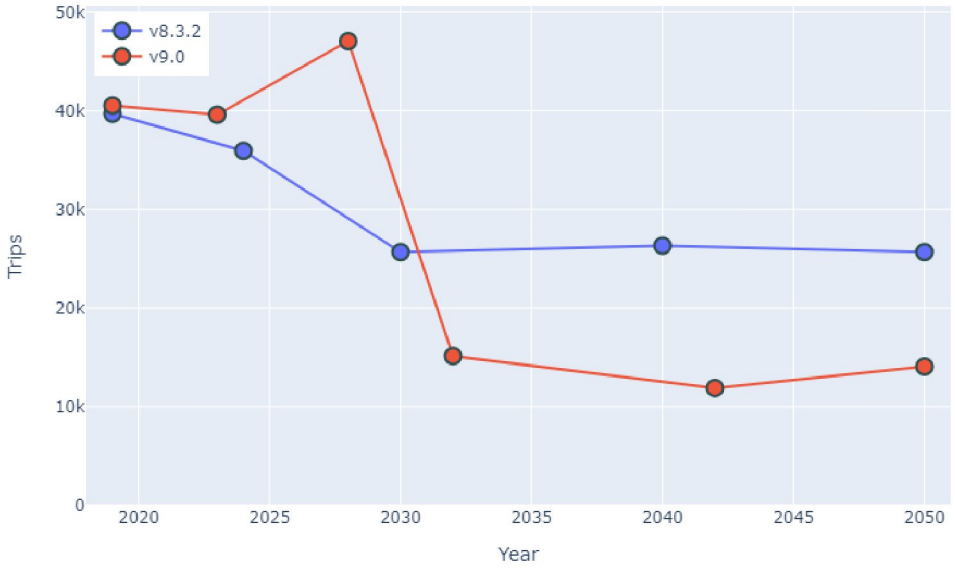


Figure 7.9 Daily Transit Ridership - Local Bus

7.2.2 Transit Share

A comparison of the share of trips amongst the various modes of transit was made for both Trips and Boardings.

The transit ridership trip shares by mode can be found in Figure 7.10 for version 9 and

Figure.7.11 for version 8. The main difference in version 9 trip share by mode is the large increase in Core Bus trips in 2032 from almost nothing in 2028, while in version 8 the increase in Core Bus trips is spread out between 2024 and 2030. This large increase is consistent with the transit inputs into the model with many Core Bus routes coming into production in 2032, replacing mostly local bus service. The new Core Bus takes most of the local bus ridership it is replacing, but also quite a lot of ridership from Light Rail Transit (Mode 7).

Transit boardings for version 9 are found in Figure 7.12 and for version 8 are found in Figure 7.13. Boardings follow the same pattern as trips, but boardings can differentiate between modes better than trips that are categorized hierarchically.

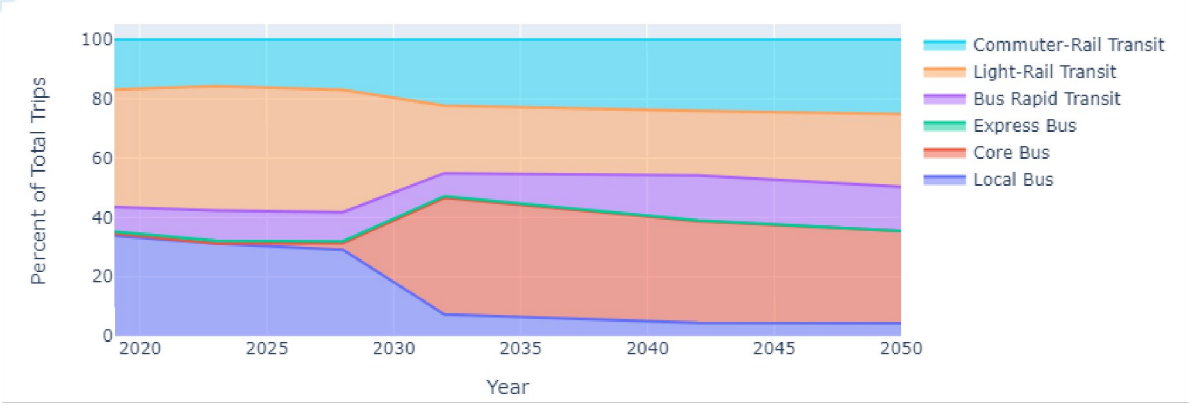


Figure 7.10 Transit Trips Share by Mode – Version 9

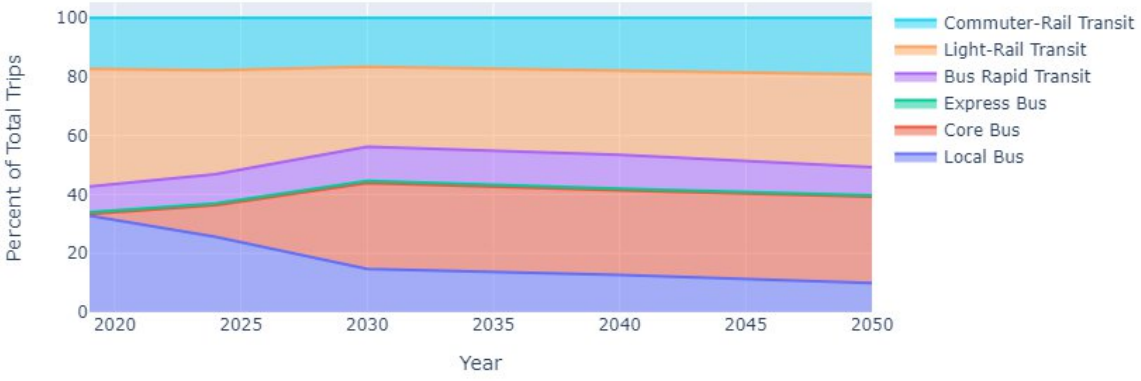


Figure.7.11 Transit Trips Share by Mode – Version 8

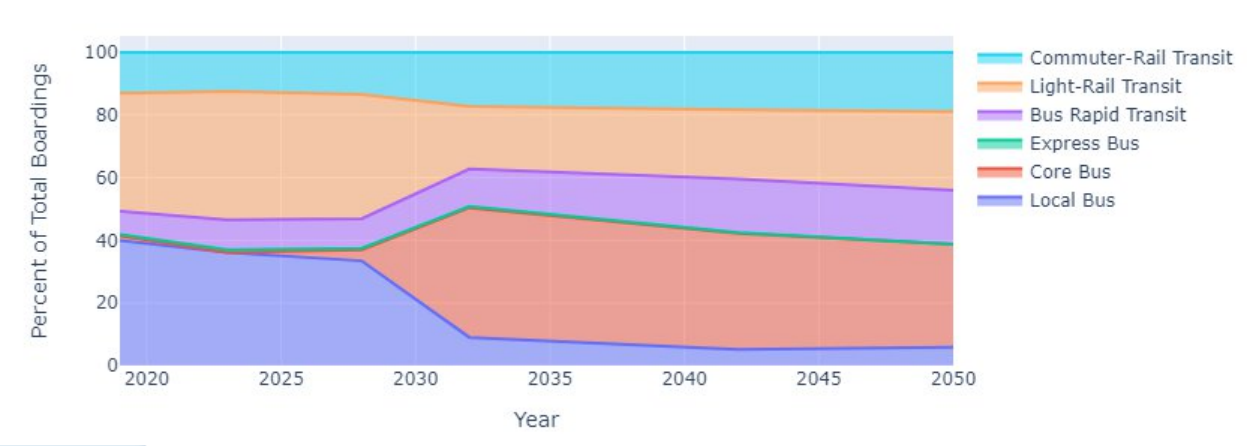


Figure 7.12 Transit Boardings Share by Mode – Version 9

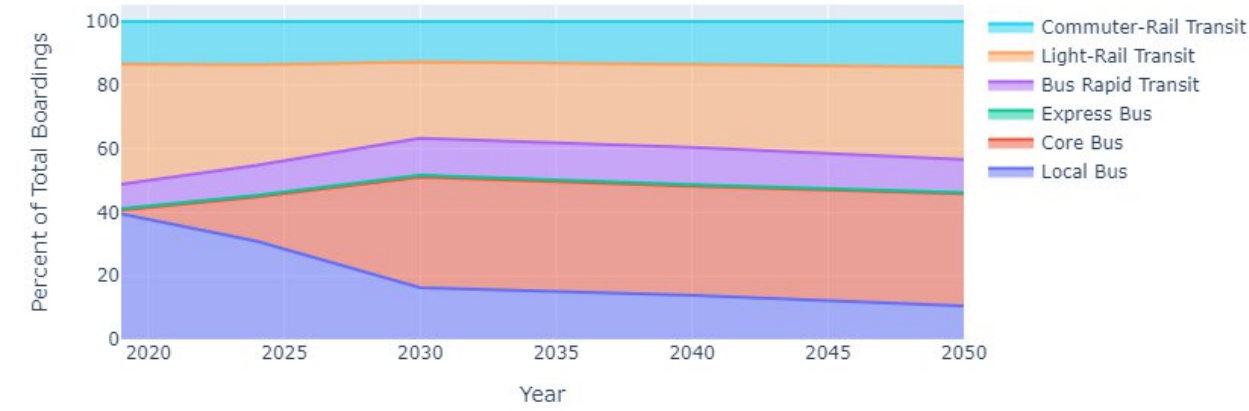


Figure 7.13 Transit Boardings Share by Mode – Version 8

7.2.2.1 Commuter Rail Station Boardings

The comparison of base year (2019) station-level boardings for commuter-rail transit (CRT) is found in Figure 7.14. CRT boardings were found to be higher than observed for Davis County and lower than observed for Utah County. An adjustment of 5 additional minutes to in-vehicle-time for trips to/from Davis County and 5 fewer minutes to in-vehicle-time for Utah County was made to attempt to bring the model more in-line with observations.

Additional investigation was conducted into why Provo and Lehi were particularly low in the model. The findings did not turn up any obvious errors in the transit or model network. So, the conclusion is that further adjustments to CRT will be possible in the Mode Choice Update project that is currently being undertaken for the next release of the model.

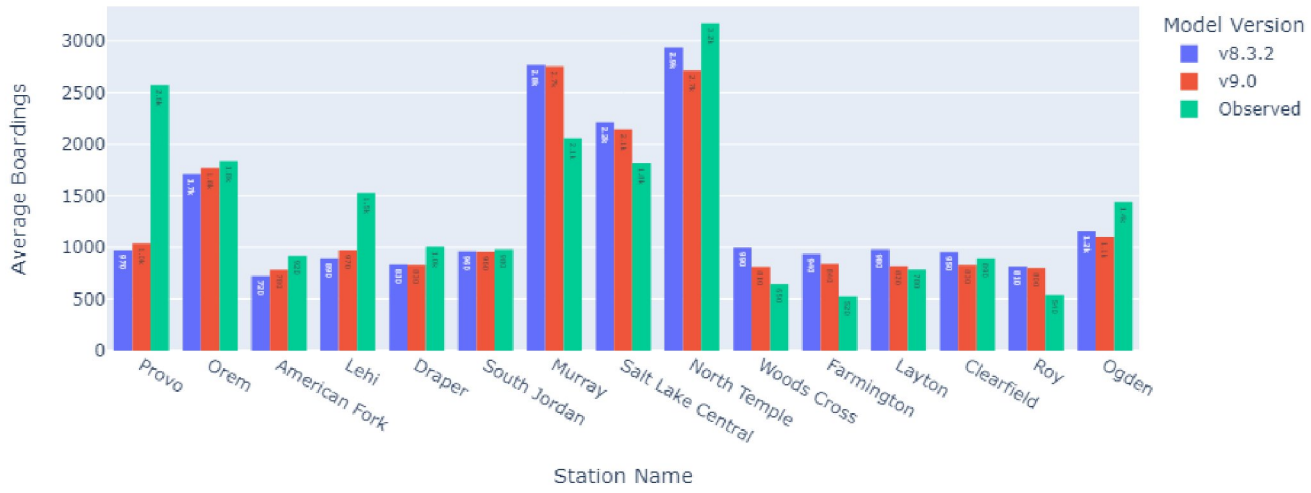


Figure 7.14 Daily CRT Boardings by Station - Model vs Observed