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Austin's Route Forward: An Exploration of Alternative Demand Estimation and the Transit Planning Process

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Austin’s Route Forward: An Exploration of Alternative Demand Estimation and the Transit Planning Process

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Abstract

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Alternative demand estimation techniques for transit planning have gained increased attention in recent years. These "sketch planning" models are often faster and easier to use than traditional four-step travel demand models, and can therefore play a significant role in preliminary feasibility analyses for major fixed-guideway transit planning initiatives. This paper uses one such sketch planning tool produced by Transit Cooperative Research Program (TCRP) Report 167 to explore ridership potential along two light rail corridors in the City of Austin. Planners recently completed a planning process for an initial segment of urban rai in central Austin that was ultimately defeated by voters in a 2014 bond election called to fund the project. The ridership results produced by the Report 167 model corroborate some claims made by transit advocates who opposed Proposition 1 that the highest ridership route was not advanced to voters in the election. By using a sketch planning tool to compare ridership along the ill-fated Project Connect route to a route advocated by critics of the process, this paper also provides insight into the role that sketch planning can play in the transit planning process, both generally and in the context of rail planning efforts in Austin.

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Chapter 1: Introduction

The city of Austin constantly finds itself on multiple "top 10" lists. Having emerged from the Great Recession relatively unscathed, the city and region has maintained its astronomical trajectory of growth as tech-fueled prosperity has propelled the city to new economic and population heights. While the rapid growth has been touted as an example of Austin's success, the boom has brought with it an equally rapid increase in traffic congestion. A variety of planning factors - lack of public transit investment, strong anti-density sentiments in many central city neighborhoods, development of employment centers along far-flung corridors like Research Boulevard and Capital of Texas Highway - have converged to keep 76% of Austin commuters confined to their single occupancy vehicles (U.S. Census Bureau, 2012). With environmental groups mounting successful campaigns against freeway expansions in the 70s and 80s, Austin now finds itself saddled with a transportation infrastructure network that is woefully unequipped to handle constantly increasing demand – and searching for a long-term solution.

Project Connect – the cooperative body of transit planners, city officials, and local stakeholders tasked with developing a comprehensive transportation plan for the region – recently completed a planning process for the highest priority Central Corridor that resulted in a recommended Urban Rail route connecting East Riverside with Downtown Austin, the University of Texas (UT), and the Austin Community College (ACC) campus at Highland Mall. To fund the project, the City of Austin proposed a bond issuance –

billed as Proposition 1 – that was ultimately rejected by voters. Several transit advocates in Austin pushed back against the project, claiming that the Project Connect planning team failed to explore other routes that they felt were more viable – namely a route serving the west side of UT's campus along Guadalupe Street and on to North Lamar Blvd. While there are likely numerous reasons that the Riverside/Highland route failed at the ballot box, one reason many transit advocates voted against it was the perception that the line would not be "successful."

The disagreement that emerged from the fallout of the failed rail vote highlights a critical question in transit planning – how is "success" defined? Previous research has pointed to ridership as one of the most reliable means of gauging the relative success of a transit investment, and certainly ridership forecasts became a point of contention between Project Connect officials and pro-transit opponents of the project. The reluctance of planners to perform route-level ridership analysis for both routes may have led many would-be supporters to discount the entire planning process and public engagement efforts.

Most transportation planning entities – whether public or private – rely on four-step travel demand models to generate estimates of current and future demand for most modes of transportation – which includes transit ridership. This process is codified by the Federal government as a requirement for receiving Federal transportation funding. The laborious process of updating, calibrating, and operating such models can be a barrier to exploring travel demand at a smaller scale, such as fixed-guideway transit planning. For as long as the traditional four-step model has been heavily used, researchers have explored alternative means for developing travel estimation tools that are faster and easier to utilize in these applications. Report 167 from the Transit Cooperative Research Program (a Transportation Research Board program) is one of these tools. TCRP 167 sought to guide policy for making effective fixed-guideway transit investments by developing a sketch planning spreadsheet tool based on comprehensive statistical analysis of fixed-guideway transit projects throughout the country. The research team developed a model that uses inputs that have been selected due to their importance in explaining ridership figures, and which are relatively easy to obtain – population density, employment totals and characteristics, downtown parking rates, and how much of the project will be built at-grade.

Given the uncertainty surrounding transit planning in Austin, and the availability of this tool, this paper will explore the role that sketch planning can play in the transit planning process by using the Report 167 tool to compare potential project ridership along the route proposed by Project Connect to a variation of routes along the Guadalupe/Lamar corridor in central Austin. By reviewing previous research about alternative demand estimation tools, the results produced by this specific tool can be understood in the context of the broader transit planning process, and help define a path for sketch planning to contribute to future transit planning efforts in Austin.

Chapter 2: Literature Review

Literature exploring the merits and methods of sketch planning date back to the 1970s and 80s. For almost as long as the traditional four-step travel demand model has been heavily used, researchers have explored alternative means for developing travel estimation tools. A careful review of some of the most prominent research on the topic reveals several advantages and disadvantages to sketch planning in general – as well as the spreadsheet tool that is used in this report.

Brief History of Sketch Planning

In TCRP Report 66, Boyle presents a comprehensive history of fixed-route ridership forecasting methods. The Urban Mass Transportation Administration (UMTA) – the predecessor to today's Federal Transit Administration (FTA) – produced two broad reports between 1977 and 1981 that explored ridership forecasting on public transportation services. The two reports – "Impacts of Changes in Fares and Services" and "Traveler Response to Transportation System Changes" – enabled transit planners to begin quantifying ridership impacts of various types of system adjustments (Boyle, 2006). A 1983 report catalogued ridership prediction methods used at the individual route level, but concluded that the information needed to produce replicable, accurate results was not readily available (Menhard and Ruprecht, 1983).

Boyle points to more recent studies that have attempted to update the initial research in light of emerging technologies. TCRP update to Report 95: Traveler Response to Transportation System Changes (Pratt, 2003) addressed, through case studies and examples, how travelers respond to changes in the following transportation system characteristics:

- Multimodal/Intermodal facilities
- Transit facilities and services
- Public transportation operations
- Transportation pricing
- Land use and non-motorized travel
- Transportation demand management

Additional studies have also focused more on rail transportation. The Chicago Transit Authority has developed a spreadsheet version of the Chicago Area Transportation Study's mode choice model on the West Corridor of the Chicago metro area. Most applicable to rail planning efforts, many forecasters have developed multivariate regression models to explore the impacts of station-level variables on rail system ridership. Even Metropolitan Planning Organizations (MPOs) – the traditional guardians of the four-step travel demand models required by federal planning regulations – have explored simpler methods for generating ridership estimates. The Maricopa Association of Governments developed a tool using trip rate factors from other western US light rail systems for use on Valley Metro's first implementation of light rail, and North Central Texas Council of Governments (NCTCOG) created a transit analysis tool nested within its four-step model that can be run separately in 4 hours (versus 12 hours needed to run the entire four-step model). (Boyle, 2006).

The overall conclusions of Boyle's broad review of ridership estimation techniques provide a holistic context for sketch planning's role in transit planning today. Tellingly, most transit agencies lack optimal data for forecasting ridership, although the increasing prevalence of automated passenger counters may improve data availability. Many agencies are concerned with the timeliness of demographic data (block-level census data is only available for Decennial Census years), as well as the reliability of ridership data. Four-step model alternatives are also becoming increasingly sophisticated thanks to adoption of Geographic Information Systems (GIS) software and other computer programs. Because most four-step models are managed by the MPO, transit agencies are increasingly turning to alternative forecasting tools for initial planning efforts, finding value in these tools for three reasons: they become the basis for project prioritization and decision-making at general planning levels; they encourage discipline in service planning; and lend the transit agency enhanced credibility among stakeholders and other agencies involved in the transit planning process. (Boyle 2006)

The TCRP Report 167 (Chatman et al., 2014) also provides a literature review of sketch planning history that gives further context to how the research team developed their methodology. The most pivotal sources that inspired the research in Report 167 were two reports by Pushkarev and Zupan – Public Transportation and Land Use Policy (1977) and Urban Rail in America (1982).

Public Transportation and Land Use Policy (1977)

The first report by Pushkarev and Zupan was groundbreaking in its use of land use characteristics to create regression models that estimated transit system ridership. The duo used non-residential CBD floor space, dwelling units per residential acre near stations, and distance to CBD to estimate transportation demand for various modes of public transportation. Per-passenger operating costs were calculated and service frequency recommended based on the estimated travel demand, represented in terms of average daily trip origins produced per square mile. The report concluded with suggested minimum thresholds for residential densities and downtown sizes to make various modes of transit feasible – thresholds that are still used as rules of thumb today.

Urban Rail in America (1982)

Five years after their first report, Pushkarev and Zupan created a more refined methodology for estimating transit ridership that was focused solely on rail transit. Using a decay function model, the researchers were able to estimate trips from residential areas to 24 CBDs in the New York Tri-State region as a function of downtown non-residential floor space, residential area population distribution, and the distance between CBD and residential zones. Not surprisingly, their model found that areas with fewer competing non-residential trip attractors produced more trips to the CBD. The demand for downtown trips was incorporated into a mode share model to examine the appeal of fixed-guideway transit serving the employment core.

While these two models formed the basis of sketch planning tools used to estimate rail ridership, researchers have much more sophisticated methods for updating these models at their disposal today. Data used as inputs for these models is more readily available than it was in the late 70s/early 80s, and – as noted with Boyle's research – GIS allows for more advanced spatial analysis than was available to Pushkarev and Zupan. Changes to the urban fabric since then also necessitate refreshing their methodology. Principally, development patterns have changed dramatically in most metropolitan areas, with CBDs no longer being the only – and in some cases primary – employment hub for metropolitan areas. Additionally, the proliferation of rail transit in the United States beyond large metropolitan areas provided TCRP Report 167 researchers with an impetus to explore a more comprehensive review of factors that influence demand for fixed-guideway transit.

Advantages and Disadvantages of Sketch Planning

Several key advantages of sketch planning tools are made apparent by a review of previous research. The most important advantage of sketch planning is that it is both faster and less labor-intensive than the traditional four-step travel demand model. (Boyle, 2006). The four-step model requires extensive imputation from travel surveys and traffic observations, thorough validation and calibration based on local conditions (which often requires local knowledge of unique trip destinations, also referred to as "special generators"), and expensive, proprietary computer software as well as hardware with enough computing power to calculate the results from the various algorithms that inform each step of the process. Alternatively, sketch planning is often based on simple regression equations that only require users to compute the independent variables. As noted in Boyle's meta-study of ridership estimation techniques, because the four-step model is typically maintained by the MPO, other organizations may face barriers to using these models for two primary reasons: they may lack the specialized labor necessary to operate the model; or, even if they employ staff with the required skill-set, the cost of acquiring a license from the MPO to use the model may be prohibitive.

Because the four-step model often requires carefully coded transportation networks calibrated for specific transportation investment alternatives, testing multiple unique transportation situations can be a painstakingly involved – and lengthy – process. Sketch planning only requires planners to calculate unique independent variables for each alternative – a process that is expedited with simple GIS manipulation. This makes it possible to run analyses on multiple alternative transit alignments, or quickly compare different land use scenarios. (Boyle, 2006)

Cervero (2006), analyzing alternatives to the four-step model in the context of "smart growth," also highlights a potential advantage of sketch planning that is often overlooked. In the report, Cervero states that "four-step travel demand forecasting models were never meant to estimate the travel impacts of neighborhood-level smart growth initiatives like transit villages, but rather to guide regional highway and transit investments." Four-step models are well suited to exploring regional transportation interactions, but may miss the fine-grained impacts that rail transit can have on a local scale – particularly the impact that non-motorized access has on rail ridership, as bike and walk trips are often excluded from the surveys used to calibrate many four-step models. Upchurch and Kuby (2014), using Cervero's research to discuss the pros and cons of using sketch planning for station-level ridership estimation on Phoenix's new light rail line, also note that because there was no existing rail transit in the city there was no ridership data available to properly calibrate the four-step model.

Several of the qualities noted in the research that give sketch planning an advantage over four-step modeling for general planning applications also serve as disadvantages for using these rough estimation tools to produce more careful ridership projections. Chiefly, while the process of four-step model calibration and validation is more labor-intensive, it also produces a model that is more attuned to unique local and regional travel demand characteristics that are lost in the national data used to create the regression equations that most sketch planning tools employ. Additionally, while sketch planning tools are becoming more sophisticated thanks to GIS, they cannot match the quality and reliability of four-step model results. The Federal government acknowledges this limitation by required applicants for Section 5309 New Starts/Small Starts funding to justify federal investment in local transit systems with defensible ridership estimates. While these estimates typically come from four-step models, the current statutory language from FTA calls for "quality data paired with straightforward analysis," which can provide "more direct representation of travel than a regional model." (Chatman et. al., 2014). In 2013, FTA produced their own proprietary sketch planning tool called Simplified Trips On Project Software (STOPS) that would satisfy the travel forecast requirements of New Starts applications. Given the availability of FTA technical support for STOPS, applicants for 5309 funding may find other sketch planning tools less appealing.

The TCRP Report 167 Methodology

As this report will use one particular sketch planning tool – the spreadsheet tool created under TCRP Report 167 – it is worthwhile to analyze the process that formed the model in order to acknowledge its strengths and weaknesses.

Defining "Success"

The fundamental research question that drove the process of TCRP Report 167 is one that transit planners have asked for years: how is a transit project deemed a "success"? To that end, the research team spent a substantial portion of the methodology report explaining how success was considered in the research process. The team conducted interviews with transit practitioners and planning entities, supplemented by previous research. The results of both indicate that there are many interpretations of success – however, the research team chose to focus on measures of success that could be quantified in some way, since the goal of the project was to develop a mathematical model that could predict success.

The Report 167 team first compiled a comprehensive literature review of research on indicators of success and factors that impact those indicators. From this review, the team developed a list of relevant measures and predictors, including population density and income measures (Taylor et al., 2009), network configuration (Thompson and Brown, 2006, 2010 and 2012), service frequency (Evans, 2004), and bus line connections and park-and-ride spaces (Kuby et al., 2004). Guerra and Cervero (2011) found that several of these indicators – namely jobs and population in the service area, park-and-ride spots, frequency, and GDP were correlated with transit ridership. Figure 1 from the report presents the primary and secondary measures of success considered by the research team:

Measures of Success	Predictors of Success
1. Cost and Ridership Metrics **(Primary)** Cost (capital and operating) *Average cost per passenger, per passenger-mile, per mile, per hour of time savings, per new transit trip.* *Operating cost recovery ratio* Ridership *Ridership totals, change in ridership, ridership per capita*	**1. Transit Supply Costs/Revenues** Capital costs Change in operating costs Service supply (frequency by time of day) Transit fares Network attributes (e.g., route alignment)
2. Economic Cost-benefit Analysis **(Primary)** Net present value > 0 Marginal benefits > marginal costs (including external costs such as congestion and pollution)	**2. Transit Demand** Socioeconomics of user Costs and travel time of alternatives (e.g., car, local bus) Land use and transit ridership (built-environment factors) *Employment and population density* *Station-area characteristics (e.g., distance from CBD)*
3. Land Use Impacts **(Secondary)** Increased development and densification Higher land value & property tax revenues	**3. Development Potential** Available land Strong real estate market Permissive regulations Targeted infrastructure expansion Tax incentives
4. Equity Measures **(Secondary)** Benefits and costs to disadvantaged individuals, populations, or regions	

Figure 1: Measures and Predictors of Success Considered for Analysis[1]

The second phase of determining how the research team would define success came through focus group interviews of prominent transit professionals and academics. The consensus of these interviews was that defining "success" is a complex process. Specifically, many interviewees named ridership, service quality, and manageable costs as primary measures of a project's success. Interviewees also listed development near

[1] Source: TCRP Report 167, Page 2-9

transit, regional efficiency/mobility, and creation of transit friendly environments as secondary measures of success.

The process of defining "success" by the Report 167 team is in line with other academic efforts. Mackett and Sutcliffe (2003) sought to develop a framework to determine wither or not a new urban rail system had been successful, and similarly came to the conclusion that success could be defined as whether or not the system had met its objectives for development. They note objectives that are commonly stated in planning studies – reducing traffic congestion, improving public transportation, stimulating development, improving access to the city center, and improving the environment – as well as two "obvious" objectives that are not typically stated: developing a system that both attains high ridership, and is built and operated cost-efficiently. Mackett and Sutcliffe also explored which factors and policies influence success, exploring physical and socio-economic characteristics of urban areas, route location, cost, operating policies (frequent service, free transfers, etc.), transportation planning policies (regional coordination, city center parking policy, etc.), and urban planning policies (TOD, etc.). While their framework is qualitative in its approach, the researchers indicated that it could be used in a similar manner to the Report 167 model as an initial screening tool early in the planning process.

Conceptual Framework

The project team chose to focus on transit ridership as its primary metric of success for a variety of reasons. Chiefly, ridership was particularly well suited for this type of research project because it is quantifiable and relatively easy to obtain. Furthermore, the number of passengers using transit can be used as a direct measure of the number of people who are benefitting from the transit investment, and can serve as a proxy for other measures of success such as mobility, accessibility, and sustainability. To a lesser extent, it can also serve as a proxy for land use and economic development potential.

Other recent research takes a similar regression-based approach to estimating factors that can predict rail ridership. Kuby et al., (2004) explored a cross-sectional regression analysis of station-level data, incorporating many independent variables from previous studies as well as new ones like climate. Their study differed from many previous studies by seeking to challenge the “privileged” role CBD stations are typically assigned in order to properly explore the influence of the polycentric metropolis on light rail boardings. Guerra et al. (2011) also explored station level ridership regression modeling, although the goal of their research was to establish a justifiable buffer distance from transit stations that transit planning professionals and academics should gather data from to accurately predict transit usage.

Project-level ridership was the chief metric analyzed by the Report 167 team, but other quantitative transit project data were also considered – namely project cost and system-wide transit system usage. The team used average weekday boardings and alightings at project stations as the data type for project-level ridership, while they used annual person miles traveled (PMT) across the entire fixed-guideway transit to quantify system-level ridership as it provided a better measure of the project’s impact on regional congestion, emissions, and energy consumption. Both data served as the dependent variables in the regression models tested by the research team.

The independent variables that were used to test significance of impact on ridership were of two types: variables that could be directly affected by the transit agency and those that were outside of its control. The variables within the agency's control include: reliability, fare, frequency, speed, comfort, route alignment, and connectivity. Variables outside of the agency's control include: population growth, economic conditions, demographic attributes, density, mix of uses near project stations, and the cost of driving. Additionally, the team explained the variables explored as belonging to four different categories:

- Project and system characteristics (like the extent of the project and number of bus connections) are partially within the agency's control, however some service characteristic decisions are often made in response to demand – not only to encourage usage.
- Service population and metropolitan area characteristics were tested since studies have shown higher transit use correlating with certain socioeconomic indicators
- Land use characteristics are implicitly necessary to explore given the complex interconnectivity between transportation demand and land use types. In this case, density was explored through catchment areas and gravity modeling. Walk Score was considered as a metric of walkability and therefore transit accessibility. Employment types were compared through NAICS-coded job data provided by the Longitudinal Employer-Household Dynamics (LEHD) data produced by the Census Bureau. Finally, special trip generators such as stadiums, hospitals, and universities were also considered.

- Competition from other modes is another critical factor that can impact ridership. To this end, gas and parking prices, and the supply of driving infrastructure (lane-miles of freeways and observed roadway usage) were tested.

The observation set for data was limited to metropolitan areas where the team could obtain data on both ridership and project/area characteristics, and therefore excluded some recently completed transit projects (notably Washington DC, Charlotte, and Boston). In total, the team compared 55 fixed-guideway transit projects in 21 metro areas, of which 13 were heavy-rail transit (HRT), 36 were light-rail transit (LRT), 3 were commuter rail, and 3 were bus-rapid transit (BRT). Not enough data was available to analyze urban circulators/streetcars, and the limited inclusion of BRT projects in the dataset limits the utility of this particular model for fixed-guideway bus modeling.

Quantitative Analysis: Methods and Findings

In total, the team tested 140 different factors for statistical significance on project level ridership and system-wide PMT in two separate models. Variables that represented decisions made by transit agencies were highly correlated with usage, but were problematic because they both reflect and generate demand (what the team refers to as "endogenous" variables). For example: travel speed and frequency were not significant predictors of ridership when controlling for other factors, likely because transit managers adjust both in response to observed demand. The goal of the team was to produce a parsimonious (i.e. "restrained") model that would accurately predict ridership. The best project-level model included the following variables: catchment area jobs, catchment area population, CBD parking rate, a variable that measures interaction between jobs/population/parking, the percent of the project at grade, and the age of the project. Figure 2 provides a comparison of variables for several project-level models that were considered, as well as a statistical summary of each. Mathematically, the best model also included number of park-and-ride spaces at project stations, but the final model did not include this variable as it was determined to also be an endogenous factor (both causing – and caused by – ridership demand). The percentage of project at-grade was included as a compromise for other similarly problematic variables like reliability and speed, as grade-separated transit has the ability to be generally more reliable, frequent, and faster than at-grade transit.

Variable Name	Final Models		Rejected Models		
	Endogenous	*Defensible*	*Model C*	*Model D*	*Model E*
Catchment jobs	0.117**	0.155	0.0646	0.122**	0.324**
Catchment population	0.0384	-0.0140	0.00103	0.0441	0.309*
CBD parking rate	-393.6	-491.9*	-354.2	-462.7	
Ridership interaction term	0.0455**	0.0773***	0.0441*	0.0470**	
Percent at grade	-9,971.6*	-17,846.2*	-10929.1*	-3028.4	
Missing at-grade dummy		3,294.39			
Park-and-ride spaces	3.383**		3.170*	3.139**	
Age of project	707.9**	1,040.3**	574.3*	659.0*	
Number of bus lines			100.4		
Level of service			340.2		
HRT dummy variable				7,757.3	
BRT dummy variable				880.2	
CONSTANT	8,235.4	20,672.69**	5,917	2,854	-11,258.3
Number of observations	50	55	50	50	56
Adjusted R^2	**0.939**	**0.894**	**0.942**	**0.939**	**0.656**

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 2: Summary of Project-level Ridership Models[2]

It is interesting to compare the final variables included in the Report 167 ridership models to the variables in the model explored by Kuby et al., (2004). Several factors explored by Kuby et al. would seem to make intuitive sense as having an outsized impact on ridership – particularly climate and percentage of regional employment accessible to transit – but neither factor were significant in Report 167's model. Kuby et al. similarly found that park-and-ride availability had a small influence on transit ridership. The variation between factors from different studies implies that there will likely never be one "definitive" method for predicting transit usage, and that transit planning professionals

[2] Source: TCRP Report 167, Page 2-32

should use whatever data and research available to explore factors that could influence ridership.

The system-level model was intended to capture the impact of the transit project on the entire transit system without double counting ridership that may have shifted from other transit routes. The final defensible model included the following variables: metropolitan area population, metropolitan area congestion level, and project catchment area variables (population, jobs, jobs associated with food/shopping/entertainment, and higher wage jobs). Figure 3 provides a comparison of variables for several system-level models that were considered, as well as a statistical summary of each. The system-level model tells a complex story. The inclusion of leisure jobs as a predictor variable could capture those workers' commutes on fixed-guideway transit, but it could also reflect the impact of activity centers and dense, transit-friendly development on transit usage, as these areas tend to have higher concentrations of these types of jobs. The significance of higher wage jobs could be due to these workers having less resistance to fixed-guideway transit versus local bus modes. It is interesting to note that the project team tested lower-wage jobs under the theory that lower income individuals have been shown to be more likely to commute via transit (either by choice or by necessity), but that the ridership model found a *negative* influence on ridership. The team theorized that this could be due to declining economic fortunes, particularly in metro areas hit hard by the Great Recession, or because the PMT model was intended to capture new transit trips, and low wage workers are already more likely to use transit.

Variable Name	Final		Census
	Catchment-Level	*MSA-Level*	*MSA Variables*
Catchment jobs	-2.542***	-2.608***	-2.212***
Catchment population	-0.223	-0.202	-0.661***
Catchment leisure jobs	8.441***	8.299***	7.412***
Catchment high-wage jobs	3.279***	3.464***	3.157***
FHWA congestion index	-1.088	-1.282*	-1.123*
PMT interaction term	0.061***	0.056***	0.048***
MSA jobs		0.120*	-0.322***
MSA high-wage jobs		-0.076	0.486***
MSA leisure jobs		0.355	0.189
MSA population (U.S. Census)			0.273***
MSA population (BEA)	0.147***	0.115***	
Constant	-18,977.0	-29,783.5*	-64,450.4
# of observations	1,641	1,641	1,641
Cluster-specific variance	145,053.9***	141,380.8***	147,803.0***
Other variance	14,624.4***	14,531.2***	13,129.8***
BIC score	37,789.2	37,781.0	37,519.3

*$p < 0.05$, ***$p < 0.001$, BIC = Bayesian information criterion.

Figure 3: Summary of System-level PMT Models[3]

Methodology Analysis

The benefits and drawbacks of using the TCRP Report 167 to estimate ridership on new transit projects expand beyond the advantages and disadvantages inherent to the model as a sketch-planning tool. Using a simple regression equation as the engine of the model makes it adaptable to a user-friendly, downloadable Excel spreadsheet. By using an intuitive interface featuring pre-loaded, drop-down menus for many of the inputs – and leveraging a software platform that is familiar to a wide variety of users – the team has created a tool that can be used by individuals with diverse skill sets and experience levels.

[3] Source: TCRP Report 167, Page 2-36

Compared to highly technical travel demand models, the spreadsheet tool can be used by a wider variety of transportation planning professionals, public officials, and even interested citizens.

Because results can be obtained much faster than a full TDM, the model lends itself to easier adaptation to participatory planning methods. For example, transit agencies could create an interactive website where users could draw their own transit lines, and using an internal web-based GIS server, the inputs requiring geospatial calculations can be computed and applied to show users the implications of station location on ridership for new transit investments. Additionally, the researchers noted that this report is likely the first time system-wide changes in PMT induced by new transit projects have been systematically explored, which makes the tool particularly valuable for transit planners seeking to expand systems in transit-rich metropolitan areas.

The national dataset used to produce the regression equation provides a benefit and a detraction for using the model. On the one hand, users all over the country can simply download the spreadsheet and plug in their calculations for catchment area jobs and population without additional, time-consuming local model calibration. However, as is the case with many sketch-planning tools, using national data to estimate ridership may not accurately reflect local conditions, even though the majority of inputs are tailored to local conditions. The relatively high R^2 value of 0.890 for the project-level model lends greater credibility to the model results to compensate for the lack of local sensitivity.

As mentioned previously, the presence of endogenous variables has led to the selection of grade separation as a variable in the model that can serve as a proxy for other variables that may be highly associated with higher ridership but whose influence is difficult to explain statistically. This argument is problematic for using the model to predict new transit investments because it assumes an *implied* relationship between grade separation and variables like speed, frequency, and reliability that is not always true. There are just as likely to be many situations where other factors affect speed and frequency that are either unrelated to grade separation or run counter to the justification given by the research team. For example, the DART light-rail system in Dallas has been built almost entirely in exclusive ROW outside of the downtown core, with grade separation limited to intersections of major streets. This has allowed the system to run at speeds comparable to subways or elevated rail systems, but which would not be reflected in the model simply by the percentage of grade separation. Also, because all four lines of the system share the same, at-grade ROW in the downtown core, the frequency of service on all lines in the system is extremely constrained – allowing single-line service to run at minimum 12 minute headways during the peak period (DART, 2015). The cause of limited frequency bears no relationship to grade separation – the frequency would be the same even if the entire system outside of the core was 100% grade separated – which heightens the risk that the model would over-estimate ridership based solely on its physical characteristics.

Another limitation of the model is that it does not address multi-modal connectivity to stations by ignoring the street grid in the calculation of catchment area variables. Attempting a network analysis to define catchment areas for all 755 stations in the observation set is an understandably daunting task for a variety of reasons. High-quality street centerline data necessary to complete such an analysis is difficult to obtain and may not accurately reflect on-the-ground conditions that affect walkability, and such a detailed level of analysis would be difficult to replicate for the less technical audience of the spreadsheet tool (potentially defeating its initial purpose). However, generating simple airline buffers to define catchment areas can mask influential impediments to transit accessibility. This could result in potentially large ridership over-estimation if high-density areas are included in the catchment area that would otherwise be unreasonably accessible on foot from the station.

Implications for this Report

Exploring the merits of both sketch planning in general and TCRP Report 167 provides a framework for applying the model to a real-world example – in the case of this paper, a comparison of the urban rail route that was the subject of the 2014 City of Austin Proposition 1 bond election to several variations of the route that was advocated by a vocal group of local transit supporters. Understanding the various nuances that warrant using caution to interpret the results not only makes it easier to anticipate points of contention, but can also shed light on areas in which the model can be improved. The research team that created the model has created its suggestion for how model inputs should be calculated based on the assumption that the model should be accessible to someone with limited technical knowledge. Given the longer timeline and more advanced skill-set available with this report, there is an opportunity to perform a more innovative input calculation process for several of the variables.

First, since the lack of network-sensitive catchment area definitions could inflate ridership, this paper uses the street grid to generate catchment areas that fall within a real-world walking distance of ½ mile, compared to the "as-the-crow-flies" ½ mile suggested in the spreadsheet user guide. The other major opportunity to improve the model is in the population and employment computation. The user guide suggests allocating both figures by calculating the percentage of Census block groups (or tracts) that falls within each station catchment area and assigning the station the same percentage of population and job totals from those Census geographies. Given the uneven spatial distribution of population and employment density at the tract or even block-group level, however, this method could assign catchment areas wildly inaccurate demographics. By using block-level population and employment data, this report attempts to calculate both inputs more precisely.

There are likely more variables for which adjustments to the model input calculations could be explored. However, embarking on an overly-thorough analysis of each variable would run counter to the inherent time-saving advantage of sketch planning. The following sections of this report provide a more detailed explanation of how each model input was calculated, and a discussion of the model results and the implications that using this particular tool can have on planning for the future of transit in Austin.

Chapter 3: Description of Model Inputs

The data used to operate the TCRP Report 167 model comes from a variety of sources, including: the United States Census Bureau, the City of Austin, Capital Metro, Capital Area Metropolitan Planning Organization (CAMPO), and the University of Texas Parking Study. This section describes each data input required by the model, and – where applicable – what steps were taken to augment the data format to follow the requirements outlined in the Report 167 Spreadsheet User Guide. Deviations from the processes recommended in the user guide are noted and explained. Figure 4 presents the regional context for which data was collected, while Table 1 provides an overview of the data source for each model input.

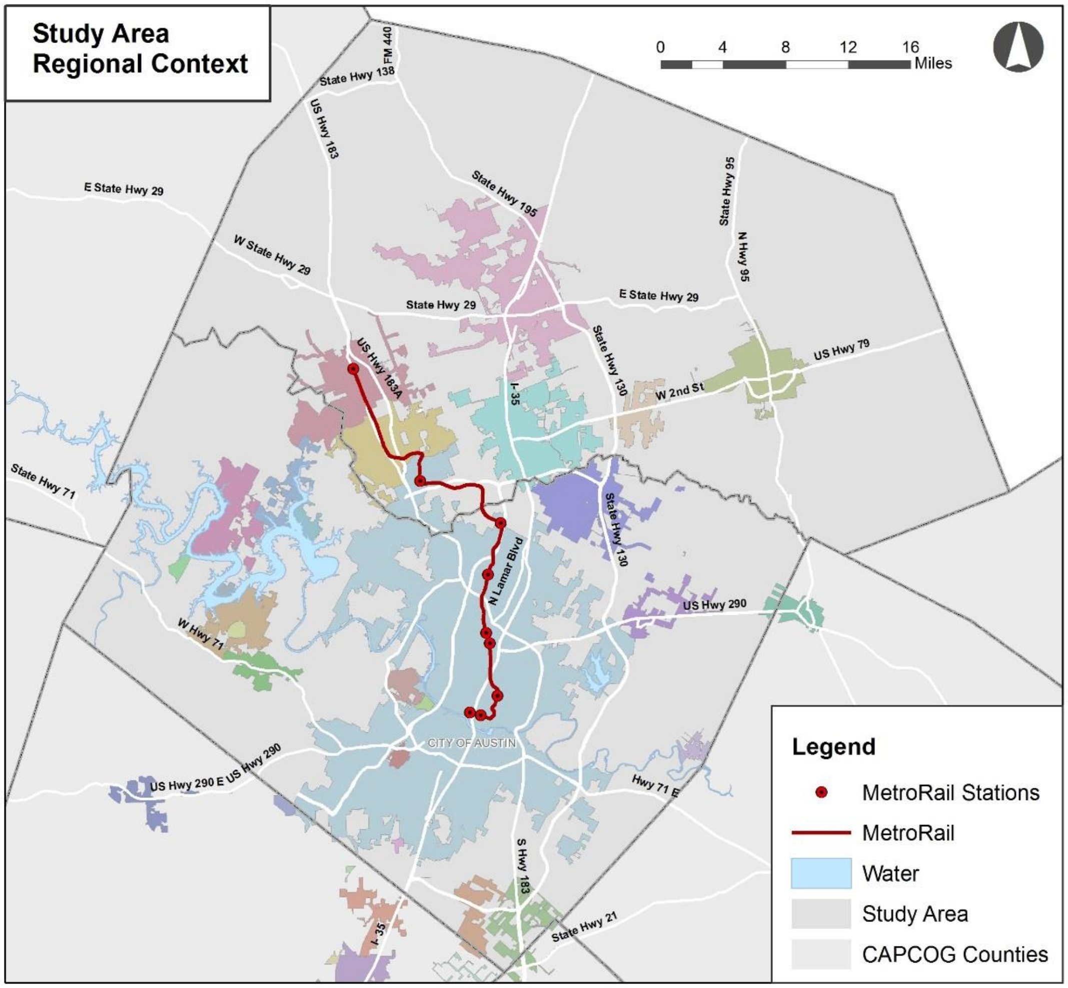


Figure 4: Regional Context Map

Input	Data Source	Type/From	Year	Model Use
Metropolitan Statistical Area	Census Bureau – ACS	Pre-loaded in spreadsheet	2008	PMT Only
Jobs within ½ mile of project stations	Census Bureau – LEHD	GIS shapefile downloaded from "On the Map"	2011	Ridership & PMT
Population within ½ mile of project stations	Census Bureau – Decennial Census	Table downloaded from American FactFinder (joined to GIS layer)	2010	Ridership & PMT
Retail, entertainment, and food ("leisure") jobs within ½ mile of project stations	Census Bureau - LEHD	GIS shapefile downloaded from "On the Map"	2011	PMT Only
Higher-wage jobs within ½ mile of project stations	Census Bureau – LEHD	GIS shapefile downloaded from "On the Map"	2011	PMT Only
Percent of project alignment at grade	User-defined[1]	Computed from GIS shapefile	2015	Ridership only
Daily parking rate in the CBD	UT – Parking and Transportation Services	Obtained from Lisa Smith	2014	Ridership only
Jobs within ½ mile of all fixed guideway stations in system	Census Bureau – LEHD	GIS shapefile downloaded from "On the Map"	2011	PMT only
Population within ½ mile of all fixed guideway stations in system	Census Bureau – Decennial census	Table downloaded from American FactFinder (joined to GIS layer)	2010	PMT only
Leisure jobs within ½ mile of all fixed guideway stations in system	Census Bureau – LEHD	GIS shapefile downloaded from "On the Map"	2011	PMT only
Higher-wage jobs within ½ mile of all fixed guideway stations in system	Census Bureau - LEHD	GIS shapefile downloaded from "On the Map"	2011	PMT only
Average daily VMT per freeway lane mile	FHWA	Pre-loaded in spreadsheet	2008	PMT only

Table 1: Data Description Overview

Note: Alternative A based on Project Connect alignment produced by Capital Metro and City of Austin

Several of the model input rows rely on pre-loaded data specific to the Metropolitan Statistical Area (MSA) where the project is located, and this data is not described. The pre-loaded data includes: 2008 MSA population estimates from the American Community Survey (ACS), which is a Census Bureau product; and 2008 estimates of existing CBD employment (also from the ACS). Because this data is critical to the model's functionality, it cannot be changed.

Base Network Data

Many of the model inputs require geospatial data to determine population and employment figures for areas within ½ mile of project stations. The user guide recommends creating a ½ mile circular buffer using a GIS platform such as ESRI's ArcGIS. The ½ mile circular buffer captures inputs to the model regardless of the connectivity of streets and pedestrian paths. Because walking is the predominant access mode to light rail transit (Korf and Demetsky, 1981), this method may produce a larger station "catchment" area than can be reasonably accessed using the configuration of the existing pedestrian network.

ArcGIS features a Network Analyst extension that allows users to compute service areas based on the street network. Network analyst requires more time and a more advanced skill set than a simple airline buffer, and so it is understandably not recommended by the user guide given that the intention of the spreadsheet tool is to be quick and easy to understand and operate by a wide variety of users. However, this report uses network-based ½ mile catchment areas as one method to improve upon the data quality required to operate the model.

Computing network buffers required the functionality of two layers: the street centerline file from the City of Austin, and the project level station shapefiles that were user-defined. In order to properly execute network analyst commands, the street centerline file must be properly formatted and contain certain attributes. Fortunately, the City's centerline file is formatted for use with network analyst, so there was no need to make major adjustments to the data structure. The City of Austin produces a sidewalk file that distinguishes between existing and missing sidewalks, however, this data is not formatted to properly function within network analyst and so was not selected to represent walkability. Because the street centerlines are serving as a proxy for pedestrian paths, it was critical to manually adjust the street data to add links that the city does not consider "streets" but which could serve as important pedestrian connections to stations in key areas – particularly on the University of Texas campus. Other missing pedestrian paths close to stations were added by examining Google Maps aerial photography from September 2014 and comparing areas with new construction or on large blocks with publicly accessible paths to the street network in the centerline file. In addition to new paths on the University of Texas campus, the street network at the Concordia redevelopment site in the Hancock neighborhood was expanded to reflect the current build-out of the site. Figure 5 shows all links that were added to the street centerline file. Finally, limited-access expressways and entrance ramps were removed from the centerline file entirely so that Network Analyst would not model pedestrian paths on freeways which pedestrians are not permitted to use. Because many of the frontage roads near the alternatives explored provide critical points of connection to the limited number of routes that cross IH-35, they remained in the final pedestrian network despite their otherwise hostile walking environment.

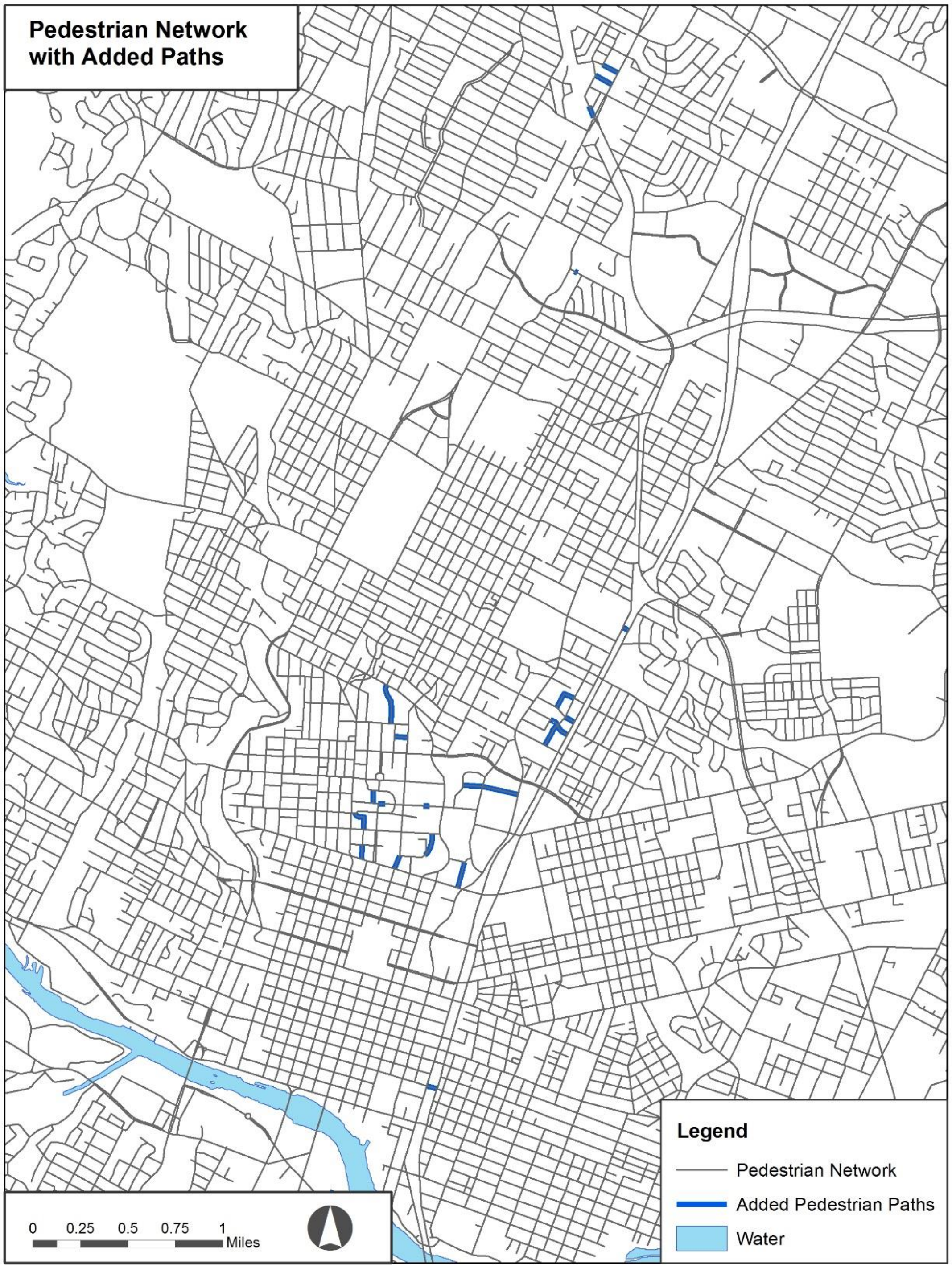


Figure 5 Pedestrian Network (Showing Added Pedestrian Connections)

The last step for preparing the street centerline file for use in Network Analyst was to build a network dataset based on this augmented street layer. This was accomplished by creating a blank network dataset within a new file geodatabase, adding the street centerline file to this dataset, and then building the network within the dataset by using the Build command within the Network Analyst extension for ArcGIS.

The other major component required for Network Analyst was the shapefile that defined the locations of project stations. As none of the stations for these hypothetical projects currently exist, new shapefiles were created manually for three different routes: the Project Connect route that was the subject of the 2014 City of Austin general election; a route that followed the Project Connect alignment along East Riverside, but which deviated at the point where the Project Connect route would follow a new bridge over the Colorado River – instead crossing the river on the South First Street bridge and following the current Route 801 alignment up Guadalupe/Lavaca through Downtown, Guadalupe through campus, and North Lamar – terminating at Crestview Station at Justin Lane and North Lamar; and finally, a route that duplicates the previous route, but extended north along North Lamar to an additional station at the North Lamar Transit center. Figure 6 shows the location of each station, noting which alternatives shared the same station locations.

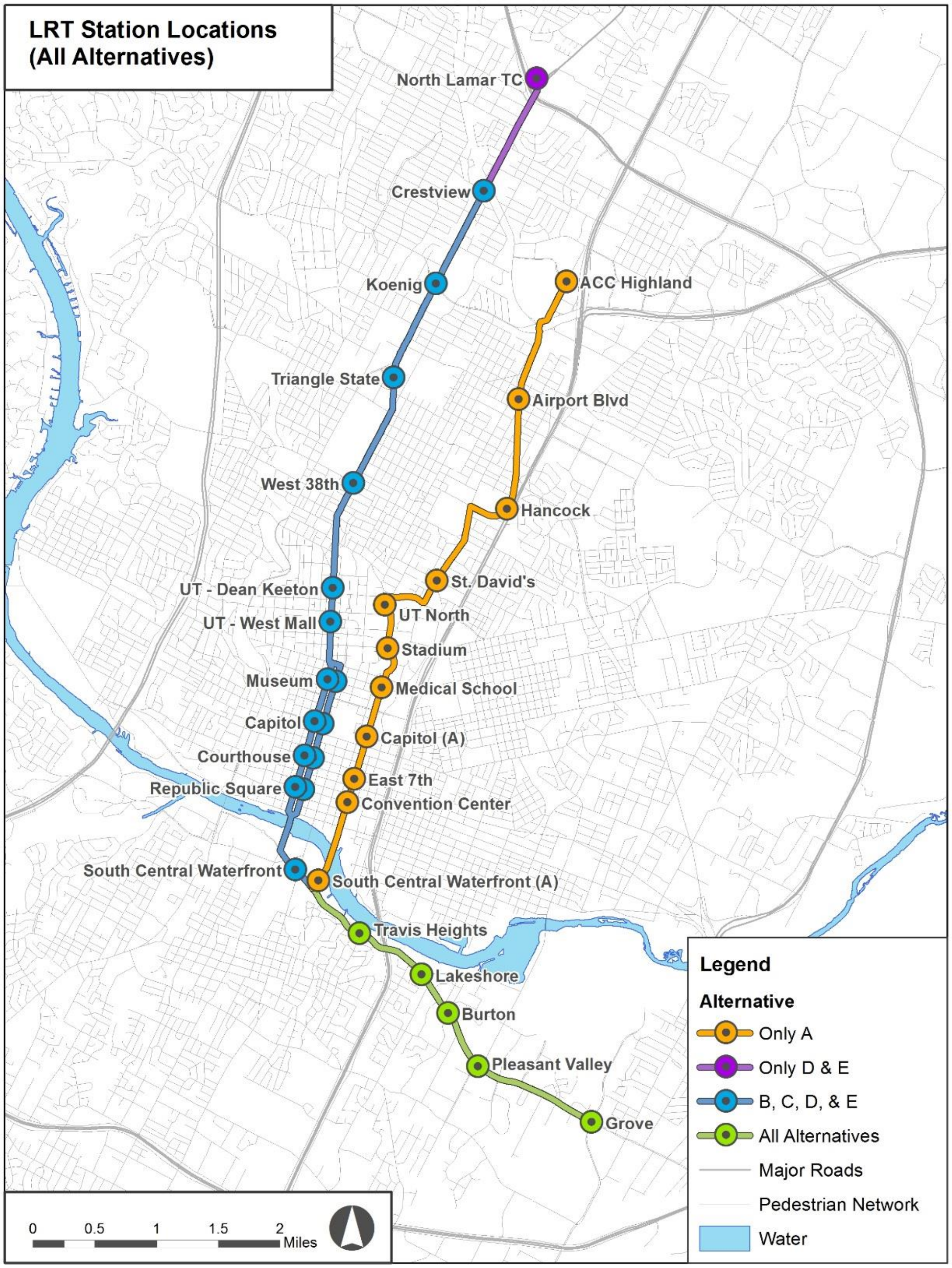


Figure 6: Station Map

Network buffers around the stations were created using the Service Area feature of Network Analyst. The tool requires the designation of “facilities” to be served – in this case the three different station location files – and the parameters by which the service area would be defined. Network analyst can compute both time- and distance-based service areas, but to maintain consistency with the spreadsheet tool recommendations, a distance of ½ mile was selected as the service area extent. Additionally, it was important to adjust the tool to ignore one-way streets, since pedestrian connectivity would be unimpeded by limitations on automobile directionality. Non-overlapping, detailed polygons were chosen as the output type in order to ensure accuracy. Figure 7 shows the resulting service area definitions for each of the three station alternative variations, including the ½ mile circular airline buffers to highlight the difference in coverage resulting from the two different catchment area calculation methods.

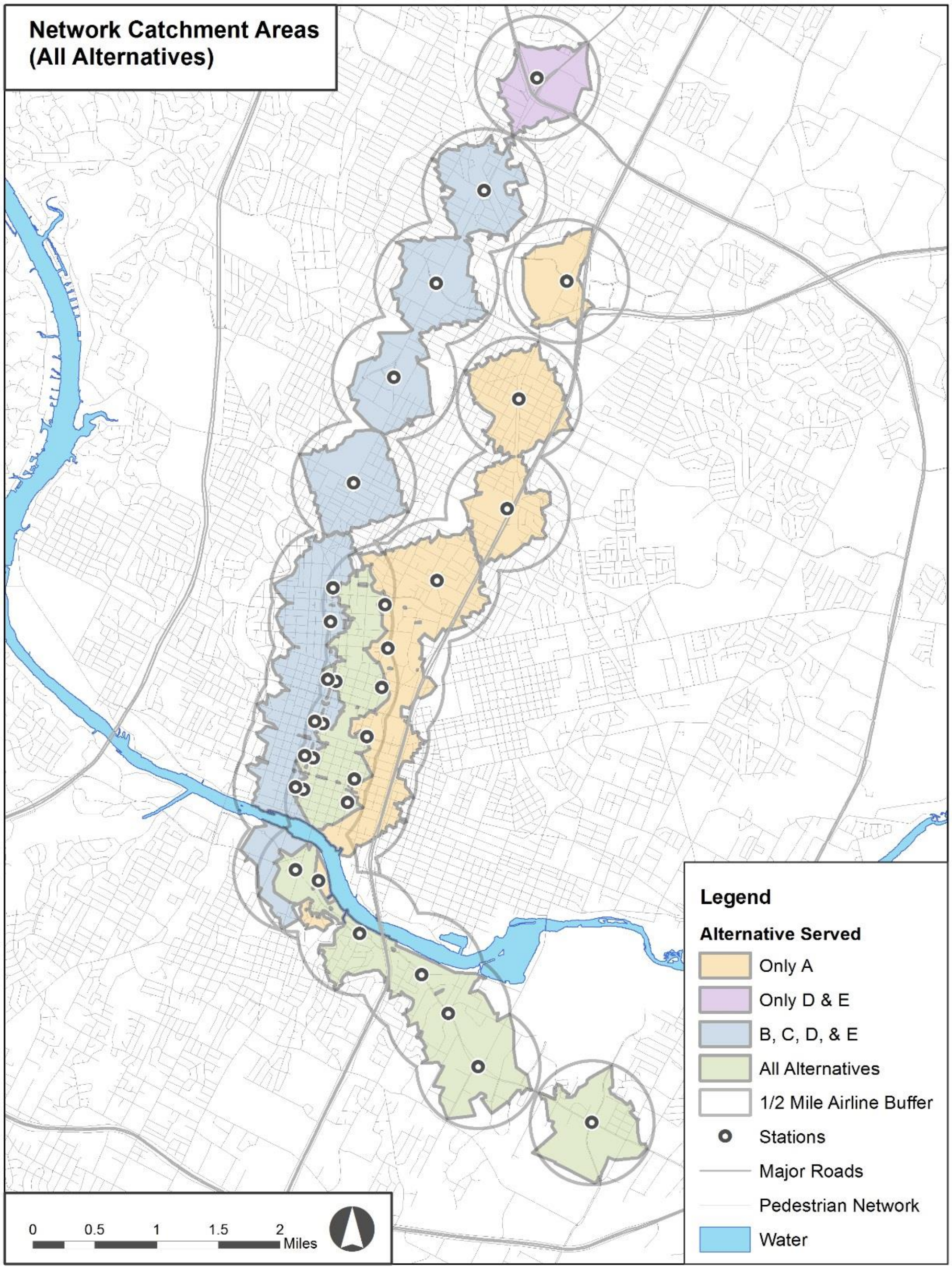


Figure 7: Catchment Areas for All Alternatives

Notwithstanding a few quirks of the network buffers in some areas with large blocks (notably in the Grove Station service area at the eastern terminus of the line), using Network Analyst to compute the catchment area of each alignment produces a more realistic depiction of what parts of the city would be accessible to project stations.

Project Physical Attributes

The first set of variables the model relies upon describe various physical attributes of the project alignments. The ridership model only requires the percentage of at grade alignment, but the model also uses other physical attributes to create rough cost estimates for preliminary cost/benefit analysis, including: number of stations, percentage of alignment that is *below* grade, type of project (new construction vs. rehabilitation), mode, route miles, and either user-estimated capital cost (per mile) or user-estimated total capital cost. Most of these attributes were easily computed using a shapefile created for each alternative that delineated which portions of the alignment were elevated, underground, or at-grade. Table 2 shows the resulting calculation of each physical characteristic for all alignments. Refer to Appendix A for each alternative's physical location as well as location and type of grade separation (where applicable).

	A	B	C	D	E
Number of Stations	17	16*	16*	17*	17*
Length (Miles)	9.06	10.62	10.57	11.58	11.58
% At Grade	90.40%	97.33%	80.54%	80.40%	0.00%
% Below Grade	6.51%	0.00%	11.70%	10.67%	47.08%
Type	New Construction				
Mode	LRT				
Est. Capital Cost (2009 $)	$1,129,186,605	$1,005,858,460	$1,199,028,074	$1,304,138,195	$2,133,450,414
Est. Cost per mile (2009 $)	$124,656,708	$94,692,668	$114,740,698	$112,574,196	$184,161,054

Table 2: Physical Attributes of Alignments Considered

The cost estimates for Alternative A represent the cost estimates published by the Project Connect team, and provide a rough "planning-level" estimate of capital costs (Project Connect, 2014). Capital costs for the other alignments were informed by a presentation given at the 2012 TRB/APTA Joint Light Rail Transit Conference by Lyndon Henry and David Dobbs. Their cost evaluation of New Starts projects completed since 2000 found that LRT installation costs ranged anywhere from $28 million per mile for the St. Louis Metrolink St. Clair Extension – a line with minimal constraints and need for grade separation - to $182.6 million per mile for Seattle's first LRT line, which is a completely grade separated transit line that involved a bored tunneling component for at least part of its route. Phoenix Valley Metro's first light rail line, which was completely at-grade and involved minimal detailed engineering (similar to this report's Alternative

B) cost an average of $82 million per mile. (Henry and Dobbs, 2012). Recent Sound Transit documents show much higher cost estimates – about $500 million per mile - for the currently under-construction University Link LRT, which is completely below grade (Sound Transit, 2013). The figures used by Henry and Dobbs were calculated for 2012 dollars, so it seemed reasonable to use the following cost estimates for the alternatives explored in this report: $100 million per mile for at-grade construction; $150 million per mile for above-grade construction; and $250 million per mile for below-grade construction (using 2012 dollars). The estimates shown in Table 2 have been converted to 2009 dollars to function properly within the spreadsheet model.

Employment Data

The Report 167 spreadsheet model relies on three different statistics on employment to estimate project ridership, computed for areas within ½ mile of both project stations and all existing fixed-guideway stations: total jobs; retail, food, and entertainment ("leisure") jobs; and higher-wage jobs. The user guide recommends gathering this data from the Longitudinal Employer-Household Dynamics (LEHD) Origin-Destination Employment Statistics (LODES), produced by the Census Bureau. Although the Census Bureau operates an FTP site where users can download block-level employment information in tabular form, the data could not be joined to the TIGER shapefiles provided by the census. Using the LEHD's "On the Map" tool, however, allowed the LODES data to be downloaded directly as a shapefile.

LODES data is split into three different file types: Origin Destination (OD) data that provides information on journey-to-work; Residence Area Characteristics (RAC) data that details job characteristics for residents at the Census block level; and Workplace Area Characteristics (WAC) data that details job characteristics for employees at the Census block level. For the purpose of this report, WAC is the appropriate file type, as it describes employment characteristics necessary for model functionality (like industry type) geo-coded to the employee's location of employment. LEHD's "On The Map" tool was used to download a point shapefile of jobs at the census block level for the latest year available – in this case, 2011. Once this data was added to ArcGIS, it was spatially joined to the TIGER Census Block boundary shapefile so that geospatial analysis could be performed using the block boundaries.

One major manual adjustment was made to the location of employment on the University of Texas campus. When analyzing the initial output of the LODES data, it became evident that almost all UT jobs had been allocated to the block containing the Music, Fine Arts, and Law schools, while most of the blocks between Dean Keeton, Speedway, 21st, and Guadalupe had far fewer jobs than expected. As it is highly unlikely that most UT employees commute to one of the most low-density blocks on campus, the point containing most of these jobs was moved to the center-most block on campus. Although it is also not likely that every one of the employees represented by that point reports to that specific part of campus, the greater density of office and classroom space on that side of campus seemed like a more logical place to aggregate UT employment to better reflect commute patterns to campus.

Before the job information was added to the spreadsheet, it was important to choose which blocks were included in the catchment areas for each alignment. This was accomplished using the “select by location” tool of ArcGIS to select blocks that intersected the ½ mile catchment area shapefile described earlier in this report, and then exporting the selection set as a new layer for each of the three alignment configurations. Some blocks were manually removed from the catchment area employment shapefiles in instances where the vast majority of the jobs attributable to that block were actually located far away from the catchment area (this was only a problem for a few larger blocks at the ends of the line). Figure 8 shows the final block boundaries that correspond to the catchment areas that were used to compute each employment variable.

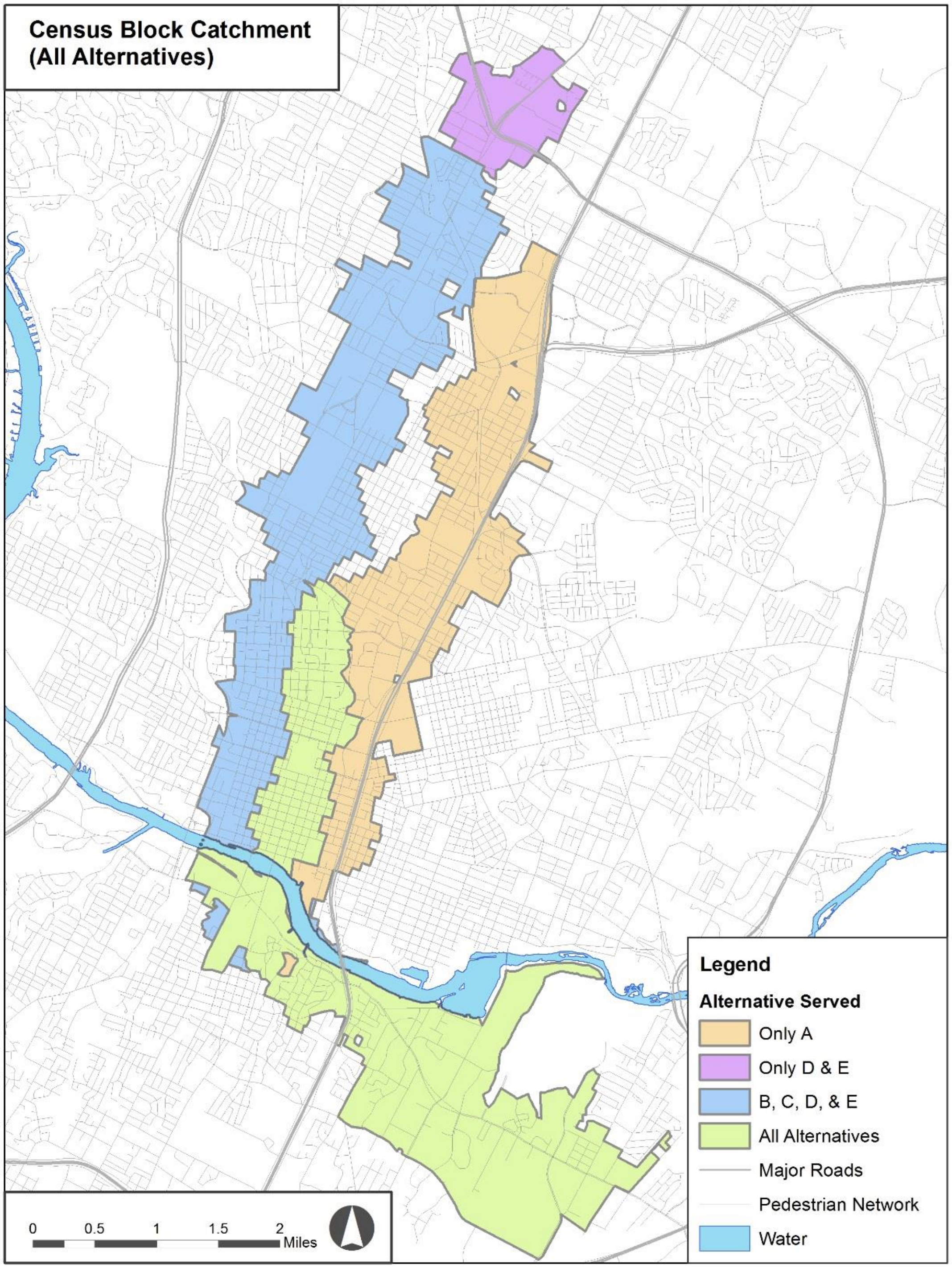


Figure 8: Final Census Block Catchment Area Definition

Table 3 describes the five different variables within the WAC data that are needed to compute inputs for the spreadsheet model, while Figure 9 displays the geographic distribution of all jobs within the catchment areas. Refer to Appendix B for figures depicting total employment by type within each alignment's catchment area.

	Variable Name	Definition	Alternative A	Alternative B/C	Alternative D/E	System (Red Line)
All Jobs	**C000**	**Total Jobs**	**154,596**	**197,257**	**199,621**	**103,754**
Leisure Jobs	CNS07	Jobs in NAICS sector 44-45 (Retail Trade	4,609	4,592	4,926	3,936
	CNS17	Jobs in NAICS sector 71 (Arts, Entertainment, and Recreation)	880	1,071	1,117	408
	CNS18	Jobs in NAICS sector 72 (Accommodation and Food Services)	10,032	12,203	12,378	8,270
		Total	**15,977**	**17,866**	**18,421**	**12.451**
Higher-wage Jobs	**CE03**	**Jobs with earnings greater than $3,333/mo.**	**82,310**	**105,854**	**106,396**	**58,256**

Table 3: Summary of LODES Employment Input Data

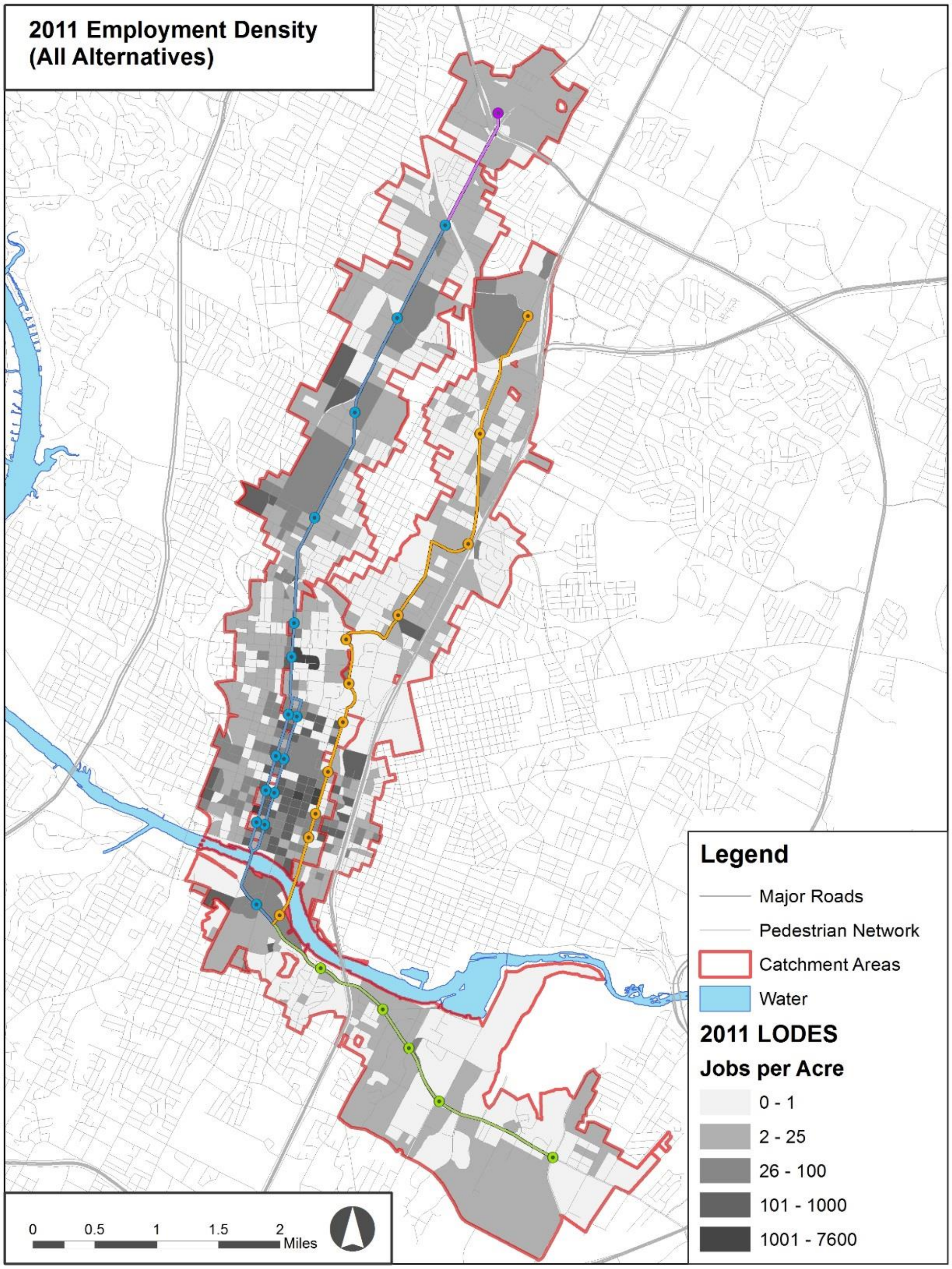


Figure 9: Catchment Area Employment Density (All Jobs)

Although the LODES data represents a more “complete” employment picture than the survey-based ACS (which bases job information on a sample of total jobs), it is not without its faults. The primary limitation of the LODES data is that the “place of work” is defined by the mailing address reported by employers. As explained in the Census Bureau’s technical document that describes the difference between the LODES and ACS employment:

> …an address from administrative data may or may not be the actual location that a worker reports to most often….Nonreporting of multiple worksites is especially common with state and local governments and school districts. In such a case, LEHD infrastructure files assign all workers for that employer (within the state) to the main address provided. (Graham et. al., 2014)

Typically, this limitation may not significantly affect job numbers in larger cities with a diverse mixture of public and private sector jobs. However, it is likely problematic in Austin given the State of Texas’ relatively high percentage of employment within the central city.

Population Data

The spreadsheet model only requires population data for two of the input rows: population within ½ mile of project stations, and population within ½ mile of all fixed-guideway transit. To maintain consistency with the geographic area used to compute employment data, these inputs were based on block-level population data. The ACS does not provide block-level population estimates, and so population is based on 2010 Decennial Census data. Using American FactFinder, tabular data for Travis and Williamson counties was downloaded and successfully joined to the appropriate blocks using a simple table join in ArcGIS. The same process of selecting blocks that intersected each alternative's ½ mile station catchment area resulted in final shapefiles of population that could be summed and entered into the spreadsheet. Table 4 shows the total population within each catchment area, while Figure 10 shows the spatial distribution of population density within ½ mile of each alignment.

	Alternative A	Alternative B/C	Alternative D/E	System (Red Line)
2010 Population	53,409	71,394	76,266	19,944

Table 4: 2010 Population (Census Blocks within Catchment Areas)

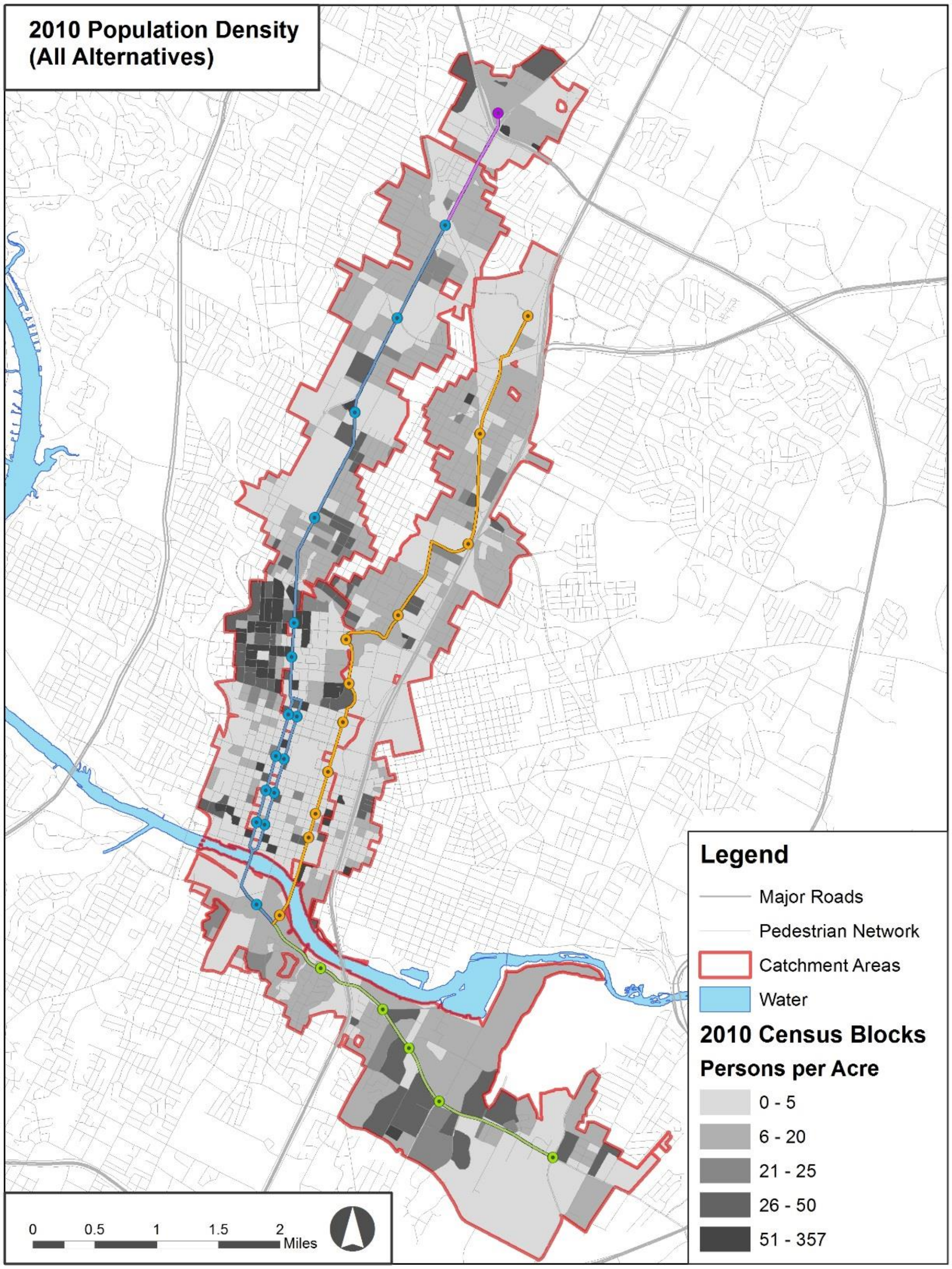


Figure 10: Catchment Area Population Density

Parking Data

The spreadsheet user guide describes the method for computing the parking rate necessary to run the model as simply computing the average daily posted rate at surface lots and garages in the CBD – regardless of any subsidized parking. As part of the Parking Strategies Committee's study published in 2015, the University of Texas gathered data on parking rates at garages and lots within the Austin CBD (in addition to campus). Table 5 shows the daily maximum rates on garages captured in that survey.

Entity	**Location**	**Daily Max**	**Type**	**Spaces**
University of Texas	All Garages – non-permit holders	$18.00	Garage	
Central Parking	21st & University	$10.00	Surface	
Central Parking	20th & Whitis	$10.00	Surface	
Central Parking	7th & I-35	$10.00	Surface	
Central Parking	3rd & Congress	$10.00	Surface	
Central Parking	8th & Trinity	$5.00	Surface	
Central Parking	11th & San Antonio	$10.00	Surface	
Central Parking	6th & Lavaca	$18.00	Garage	
ABM (AMPCO)	4th & Brazos	$18.00	Garage	850
ABM (AMPCO)	6th & Congress (1 America Center)	$21.00	Garage	871
ABM (AMPCO)	7th & Brazos (Austin Center)	$24.00	Garage	585
ABM (AMPCO)	8th & Congress	$25.00	Garage	492
ABM (AMPCO)	3rd & Congress (Congress Visitor)	$18.00	Garage	850
Ace Parking	9th & Congress (Capitol Center)	$20.00		

Table 5: Daily Parking Rates at CBD Lots & Garages

Based on this information, the daily average posted parking rate in the Austin CBD was estimated to be $15.50 for use in this report.

Congestion Data

The spreadsheet model contains a tab with congestion data provided by FHWA through Table HM-72. This data represents the average daily VMT per freeway lane mile in each MSA for 2008. Because the model is calibrated to use this measure as its congestion metric, there was no alternative means for gathering data that may more accurately reflect congestion. However, because the PMT model is the only component that relies on the congestion data, it was determined that adjusting the congestion metric using some kind of weighting factor would not significantly affect the project-level ridership numbers produced by the model.

System-level Inputs

Given the limited extent of fixed-guideway transit in Austin at the time of this report, the results of the system wide change in PMT produced by the spreadsheet model were less important to this report. As such, figures depicting geographic distribution of inputs for existing MetroRail service were not included in the body of this report. Refer to Appendix B for figures depicting the catchment area definition for MetroRail stations, as well as the geographic distribution of jobs and population within those catchment areas.

Chapter 4: Ridership Model Results

Once all model inputs were gathered and adjusted to match the format required by the spreadsheet, ridership estimates were produced by running the model for the five different alternatives. Obtaining population and employment forecasts from CAMPO for 2035 allowed the model to compute ridership estimates for future conditions. This section presents a discussion of those results.

"Opening Year" Ridership

The first set of ridership results uses data from 2010 and 2011 for most model inputs. Because it would be unlikely that a new light rail line would be operational much before 2020 even if approved this year, most of the model inputs will represent data that is at least 10 years old at the time of opening. Rather than updating the inputs to reflect this reality, the results from the tool could instead be interpreted to represent a "conservative" estimate of opening-year system ridership, given that population growth in the Austin area (particularly the central city) has continued at a feverish pace since 2010/2011.

Table 6 presents a summary of all of the model inputs that were necessary to run the "opening year" model for each alternative.

Alternative	**A**	**B**	**C**	**D**	**E**
All Jobs (0.5mi)	154,596	197,257	197,257	199,621	199,621
Population (0.5mi)	53,409	71,394	71,394	76,266	76,266
Leisure Jobs (0.5mi)	15,977	17,866	17,866	18,421	18,421
Higher-wage Jobs (0.5mi)	82,310	105,854	105,854	106,396	106,396
% Project At-grade	90.4%	97.3%	80.5%	80.4%	0.0%
CBD Parking Rate	$15.50	$15.50	$15.50	$15.50	$15.50
All Jobs (existing system)	103,754	103,754	103,754	103,754	103,754
Population (existing system)	19,944	19,944	19,944	19,944	19,944
Leisure Jobs (existing system)	12,451	12,451	12,451	12,451	12,451
Higher-wage jobs (existing system)	58,256	58,256	58,256	58,256	58,256
Congested VMT per Freeway lane Mile	16,644	16,644	16,644	16,644	16,644
Number of stations	17	16*	16*	17*	17*
% Project Below Grade	6.5%	0%	11.7%	10.7%	47.1%
Mode	LRT	LRT	LRT	LRT	LRT
Route miles	9.06	10.62	10.57	11.58	11.58
Cost per mile (user defined)	$125,098,299	$100,000,000	$115,579,650	$115,135,403	$173,539,984

Table 6: Summary of Model Inputs

Table 7 presents the ridership results for each alternative, as well as the model's calculated project cost and cost-per-rider. The costs computed by the model represent 2009 dollars, so Table 7 also shows the costs adjusted to 2015 dollars to better frame cost estimates in a current financial context.

Results	A	B	C	D	E
Average Weekday Ridership	**30,000**	**42,000**	**45,000**	**47,000**	**61,000**
Margin of Error	**6,000**	**8,000**	**8,000**	**8,000**	**8,000**
Cost per Rider	$38,000	$24,000	$27,000	$28,000	$35,000
Margin of Error	$8,000	$5,000	$5,000	$5,000	$5,000
Cost per Rider (2015 dollars)	*$42,513*	*$26,850*	*$30,207*	*$31,325*	*$39,157*
Margin of Error (2015 dollars)	*$8,950*	*$5,594*	*$5,594*	*$5,594*	*$5,594*

Table 7: "Opening Year" (2020) Model Results

The model results seem to indicate that the Project Connect alignment (Alternative A) would have lower ridership than any variation of transit running along Guadalupe/Lamar. This conclusion is not surprising given the importance that jobs and population play in the model, and the fact that the Project Connect alignment has substantially lower totals of both. Alternative A also has the highest estimated cost per rider of any alternative – even a completely grade separated alignment along Guadalupe/Lamar (Alternative E).

As ridership estimates were not explored in the most recent planning efforts by Project Connect for alignments similar to Alternatives B through E, it was difficult to get a sense for how ridership computed by the Report 167 Spreadsheet deviated from ridership estimates produced by other methods. However, Project Connect did produce ridership estimates for a project essentially identical to Alternative A, and comparing the estimate produced by this model to the estimate produced by Project Connect reveals a much higher than anticipated gap. Table 8 compares both ridership estimates:

	Ridership	Year
Project Connect	18,000	2030
Report 167	30,000	2020*
Difference	+ 67%	

Table 8: Project Connect Ridership vs. Spreadsheet Ridership (Alt. A)

Not only is the Report 167 spreadsheet ridership estimate 67% higher than the figure produced by the Project Connect team, it is also intended to be a conservative estimate of ridership for 2020 – ten years before the official ridership projection of 18,000 is reached under Project Connect's assumptions, and does so without considering any of the transit-induced developments that are likely to take place along any urban rail route built in Austin. Although it is certainly conceivable that Project Connect could have under-estimated ridership, it is just as possible that Project Connect *over*-estimated ridership along the route, as several local transit supporters critical of the Project Connect proposal argued during the 2014 City of Austin election (Gonzalez Altamirano, 2014).

Given such a large discrepancy between the estimate produced by the spreadsheet and the estimate produced by Project Connect using a more refined Travel Demand Model, it seems likely that the spreadsheet has over-estimated ridership along all of the alternatives considered in this report. Without any recently completed estimates to compare to, the amount by which the estimates are inflated is unclear. As such, they are left in the form produced by the model for discussion in this report.

Future Year Ridership

The research team in Report 167 states that "to estimate ridership in some future year, it is necessary to enter job figures estimated for that year [which] may be derived from forecasts the region's MPO or local jurisdictions maintain for transportation planning." (Chatman et. al., 2012). At the time this report was being produced, CAMPO had completed draft population and employment forecasts for the 2040 Metropolitan Transportation Plan. However, given that none of the elements of the plan have been officially adopted by the CAMPO board, CAMPO staff could not share details of that model. Instead, CAMPO furnished population and employment estimates from the 2035 model, which was produced in 2010.

The CAMPO 2035 plan uses a demographic scenario developed through "an iterative technical process using a [GIS] tool that was developed for CAMPO." (CAMPO, 2010). The GIS tool allowed CAMPO planners to test different allocations of population and employment growth for different scenarios. The tool uses inputs such as developable land, maximum allowable densities ("goal densities"), accessibility, and attractiveness leveraging regional and jurisdictional data. CAMPO tested a Trend Scenario, which assumes growth to continue according to low-density policies that have been in place, and a Centers Scenario, which assigns more weight to attractiveness in growth centers identified under various planning entities throughout the region. The adopted scenario is a modified version of the Centers Scenario and assumes that cities across the region will adopt land use policies that support the centers concept (CAMPO, 2010). The demographic forecasts are constrained to county-level control totals computed using Texas State Data Center (SDC) population forecasts. The SDC figures represent two basic theories for extrapolating population growth. Using migration statistics from 2000-2010, SDC created a “high-growth” scenario (SDC 1.0) that assumes a continuation of 2000-2010 migration rates. Since such high growth is unlikely to be sustained, SDC also created a “moderate growth” scenario (SDC 0.5) that assumed a migration rate that was half the rate seen in the 2000s. Finally, SDC created a scenario that assumes a net migration rate of zero, which was used primarily for comparative purposes (State Data Center, 2014). CAMPO used a blend of SDC 0.5 and SDC 1.0 projections to define control totals for each county in the region.

Because the CAMPO forecast does not provide estimates at a greater detail than TAZ, it was necessary to allocate population and employment totals so that only the parts of the TAZ that intersected station catchment areas would be included to generate inputs for the spreadsheet model. This was accomplished in ArcGIS through the following steps: first, the INTERSECT geoprocessing tool was used to intersect the ½ mile network buffers for each of the three major station configuration alternatives and the existing MetroRail with the CAMPO 2035 TAZ layer; next, a field was added to the layer produced in step one called “ACRE_PART,” and the calculate geometry tool used to define the acreage within each TAZ that was captured by the network buffer; then, another new field was created – PCT_PART – which calculated the percentage of land within each TAZ that was captured by the network buffer; and finally, several new fields were created for population, total employment, and retail employment for both 2010 and 2035 using the field calculator tool to multiply [PCT_PART] by each field's respective attribute. Aggregating the totals for those fields resulted in 2010 and 2035 estimates of population, total employment, and retail employment for use in the spreadsheet model. All other inputs were unchanged. Table 9 shows the results of using these inputs to estimate 2035 ridership.

Results	A	B	C	D	E
Avg Weekday Riders	**35,000**	**44,000**	**47,000**	**49,000**	**64,000**
Margin of Error	**5,000**	**6,000**	**6,000**	**6,000**	**6,000**
Cost per Rider	$32,000	$23,000	$26,000	$27,000	$33,000
Margin of Error	$5,000	$3,000	$3,000	$3,000	$3,000
Cost per Rider (2015 dollars)	*$35,801*	*$25,732*	*$29,088*	*$30,207*	*$36,919*
Margin of Error (2015 dollars)	*$5,594*	*$3,356*	*$3,356*	*$3,356*	*$3,356*

Table 9: 2035 Ridership (Based on CAMPO Demographic Forecast Data)

The most immediate observation of ridership estimates based on CAMPO 2035 forecasts is that they seem lower than expected given the population and job growth rates that have historically been observed in Austin. Alternative A shows an increase of 17% from current year ridership, while every other alternative shows an increase of between

4% and 5%. Both of those are far lower than the 88% population growth and 87% employment growth CAMPO anticipates for the Austin region between 2010 and 2035 (CAMPO, 2010).

A closer examination of the 2010 and 2035 model inputs reveals the likely reason for lower than expected 2035 ridership figures. In order to make a direct comparison for all inputs, 2035 forecast totals were computed for the Census data by applying the 2010 to 2035 population and employment growth rates of each Census block's respective TAZ. The results of the comparison are shown in Table 10.

Alternative		½ Mile Population	½ Mile Total Jobs	½ Mile Leisure Jobs	½ Mile Higher-wage Jobs
A	2010 (Census)	53,409	154,596	15,977	82,310
	2010 (CAMPO)	54,657	113,911	19,494	
	% Difference	**-2%**	**36%**	**-18%**	**n/a**
	2035 (Census)	86,494	197,756	48,217	105,289
	2035 (CAMPO)	86,365	152,273	32,056	
	% Difference	**0%**	**30%**	**50%**	**n/a**
	% Growth (Census)	62%	28%	202%	28%
	% Growth (CAMPO)	58%	34%	64%	
	% Difference	**4%**	**-6%**	**137%**	**n/a**
B & C	2010 (Census)	71,394	197,257	17,866	105,854
	2010 (CAMPO)	72,343	130,387	21,369	
	% Difference	**-1%**	**51%**	**-16%**	**n/a**
	2035 (Census)	110,728	259,218	49,949	139,104
	2035 (CAMPO)	106,456	176,333	29,267	
	% Difference	**4%**	**47%**	**71%**	**n/a**
	% Growth (Census)	55%	31%	180%	31%
	% Growth (CAMPO)	47%	35%	37%	
	% Difference	**8%**	**-4%**	**143%**	**n/a**
D & E	2010 (Census)	76,266	199,621	18,421	106,396
	2010 (CAMPO)	77,697	132,598	22,050	
	% Difference	**-2%**	**51%**	**-16%**	**n/a**
	2035 (Census)	118,560	264,139	51,081	140,783
	2035 (CAMPO)	111,773	179,624	30,281	
	% Difference	**6%**	**47%**	**69%**	**n/a**
	% Growth (Census)	55%	32%	177%	32%
	% Growth (CAMPO)	44%	35%	37%	
	% Difference	**12%**	**-3%**	**140%**	**n/a**

Table 10: Population and Employment Inputs (CAMPO vs. Census)

Total population computed using the Census data was remarkably similar to the CAMPO estimates for both 2010 and 2035 for all alternatives – only ranging from 2% lower than the CAMPO estimates to 6% higher. This is attributable to the high quality of data available from the decennial census at the block level. The employment variables tell an entirely different story, however. Total employment calculated from block-level LEHD data was consistently higher than the CAMPO estimates across all alternatives for both years, ranging from 30% higher in Alternative A to 51% higher in Alternative D/E. The explanation for this can be attributed to the method by which LEHD data is gathered. As noted in the previous section of this report, the most common geographic data errors for LEHD data stem from State and Local governments reporting the same address for workers who may actually report to different physical locations. Given the high concentration of State of Texas jobs in the Austin CBD and along North Lamar Blvd, it is reasonable to assume that LEHD has over-estimated the number of jobs that are physically located in central Austin. The discrepancy in leisure employment can largely be explained by the different method by which CAMPO classifies employment type compared to the Report 167 team. Rather than providing data on each industry (as defined by NAICS codes), CAMPO only divides employment into four categories: Retail, Service, Primary Education (K-12), and Higher Education. Table 10, then, compares the "Retail" category of employment to the "Leisure" category from the spreadsheet, which includes entertainment, arts, and food in addition to retail. This makes a direct comparison between the two data sources difficult. Finally, CAMPO does not produce demographic forecasts that include income data (resident or employee), and so a comparison between these inputs was also difficult to accomplish.

Figure 11 provides a visualization of the geographic difference in population estimates resulting from extrapolating 2010 Decennial Census population figures to 2035 using CAMPO defined growth rates compared to the 2035 population estimates allocated to TAZs within each alternative's catchment area. Figure 12 similarly provides a visualization of the geographic difference in employment estimates resulting from extrapolating 2011 LODES numbers for all jobs to 2035 using CAMPO defined growth rates compared to the 2035 CAMPO employment estimates allocated to TAZs within each alternative's catchment area.

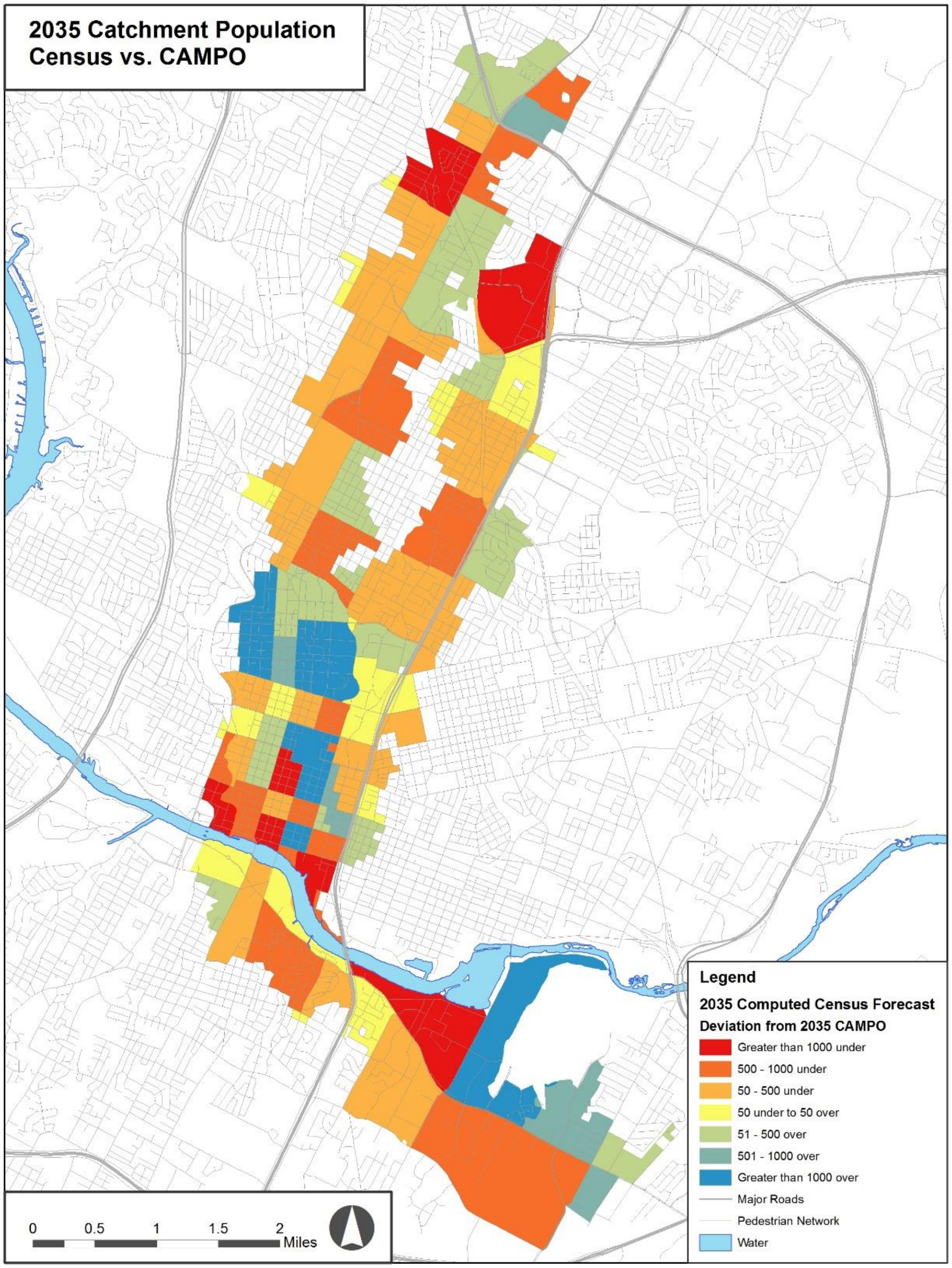


Figure 11: 2035 Census/CAMPO Population Difference by TAZ

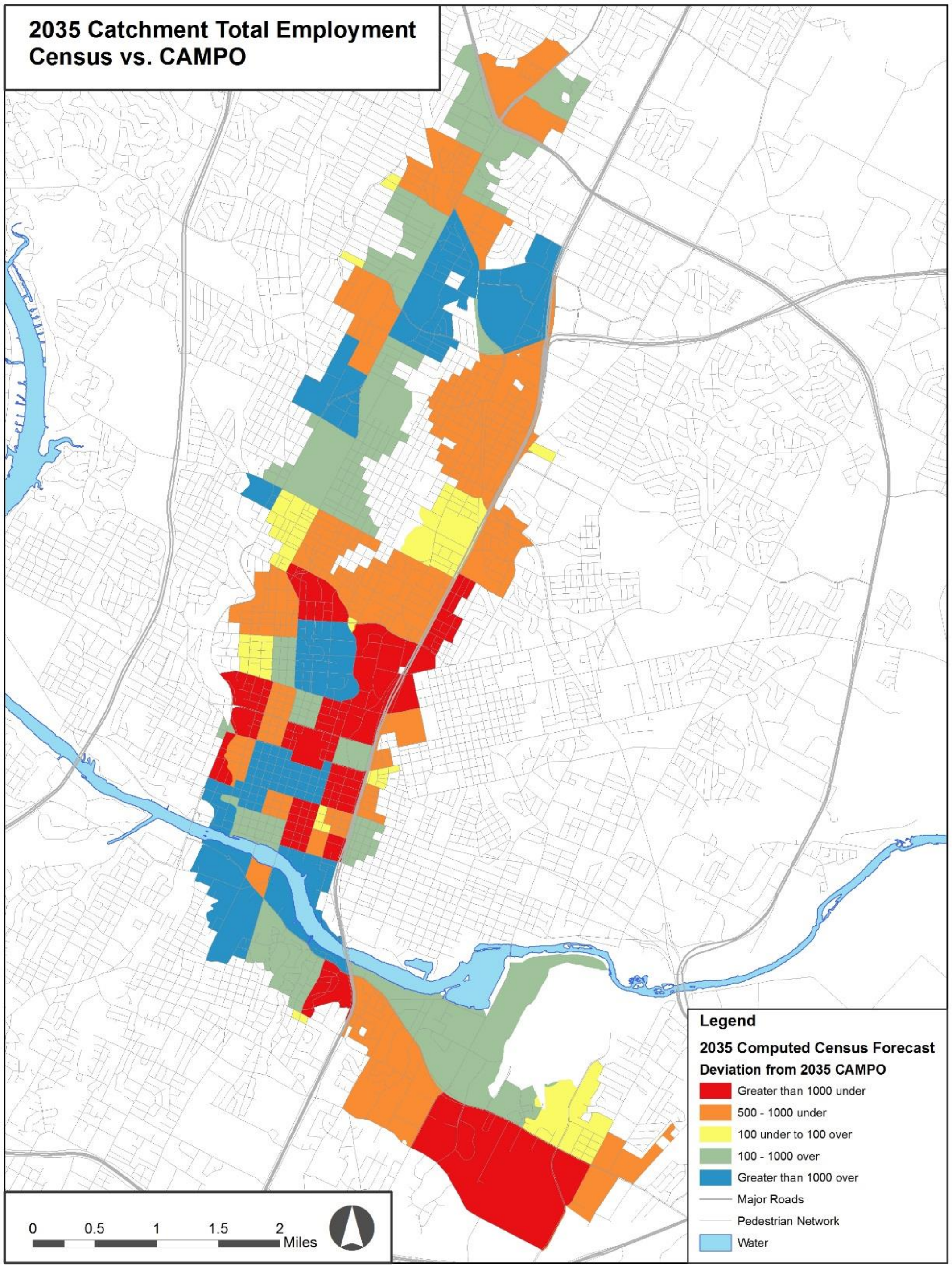


Figure 12: 2035 Census/CAMPO Employment Difference by TAZ

Adjusted Current and Future Year Ridership

Given the data discrepancies between the Census and CAMPO data, new ridership figures were computed for 2020 and 2035 using a blend of the Census and CAMPO data in order to draw a direct comparison between the two years.

2010 Census Data remained the source of population data for the “opening year” forecast, given its consistency with the CAMPO population data, while 2011 LEHD data remained the same for leisure and higher-wage jobs since the CAMPO data does not provide enough information to compute these. 2035 population from the CAMPO data remained the same for the future year forecast. 2010 total employment was adjusted to be the average between the CAMPO 2010 estimate and the 2011 LEHD data, while 2035 retail and higher-wage employment estimates computed from Census figures were reduced by 15% for alternative A and 25% for the other alternatives. These percentages reflect half of the percentage amount difference between the 2010 CAMPO total employment estimate and 2011 LEHD total employment data. 2035 higher-wage employment was calculated by multiplying the adjusted 2010 higher-wage employment estimate by the anticipated growth rate of all jobs from 2010 to 2035 based on the adjusted 2010 and 2035 inputs. Table 11 summarizes the changes made to each input.

Alternative		½ Mile Population	½ Mile Total Jobs	½ Mile Leisure Jobs	½ Mile Higher-wage Jobs
A	2010 Consensus	53,409	134,254	17,736	74,149
	2035 Consensus	86,365	179,466	29,164	99,120
	Growth Rate	**62%**	**34%**	**64%**	**34%**
B & C	2010 Consensus	71,394	163,822	19,618	127,458
	2035 Consensus	106,456	221,550	26,868	172,372
	Growth Rate	**49%**	**35%**	**37%**	**35%**
D & E	2010 Consensus	76,266	166,110	20,236	127,861
	2035 Consensus	111,773	225,020	27,789	173,207
	Growth Rate	**47%**	**35%**	**37%**	**35%**
System	2010 Consensus	25,037	90,891	13,011	66,500
	2035 Consensus	101,542	107,997	21,970	79,016
	Growth Rate	**306%**	**19%**	**69%**	**19%**

Table 11: Adjustments to Population and Employment Inputs

Table 12 displays the new ridership estimates based on the adjusted population and employment inputs for both 2010 and 2035. Because the model runs on 2009 dollar amounts, the estimate of CBD daily parking cost was left unchanged. However, due to increasing development pressure on parking lots and garages in the central core, parking rates in 2035 are likely to grow far faster than the rate of inflation, and so the $15.50 estimate used in the future year forecast is likely conservative. Because one of the most significant variables in the regression equation represents an “interaction” variable that also includes CBD parking rates, the 2035 forecast is likely to be somewhat conservative as well.

Results	A	B	C	D	E
Avg Weekday Riders (2020)	**26,000**	**34,000**	**37,000**	**39,000**	**53,000**
Margin of Error	**5,000**	**6,000**	**6,000**	**6,000**	**6,000**
Cost per Rider (2009 dollars)	$43,000	$30,000	$32,000	$33,000	$40,000
Margin of Error (2009 dollars)	$8,000	$5,000	$5,000	$5,000	$5,000
Avg Weekday Riders (2035)	**42,000**	**57,000**	**60,000**	**63,000**	**77,000**
Margin of Error	**6,000**	**8,000**	**8,000**	**8,000**	**8,000**
Cost per Rider (2009 dollars)	$27,000	$18,000	$20,000	$21,000	$28,000
Margin of Error (2009 dollars)	$4,000	$3,000	$3,000	$3,000	$3,000
2020-2035 Growth Rate	**62%**	**68%**	**62%**	**62%**	**45%**

Table 12: Adjusted "Opening Year" and "Future Year" Ridership

Refer to Appendix D for graphs produced by the spreadsheet model comparing model-predicted ridership to other systems from the TCRP Report 167 dataset.

Adjusting the 2010/2011 model inputs seems to produce a more realistic depiction of opening year ridership for every alternative. The low end estimate for Alternative A falls within the range of ridership figures released by Project Connect, although the spreadsheet model still forecasts ridership that is ten years ahead of Project Connect's numbers. The growth rates depicted between 2020 and 2035 for each alternative are also remarkably similar, with the exception of Alternative E. The lower growth estimate for Alternative E can likely be attributed to one or both of the following factors: either that Alternative E had a much higher 2020 ridership estimate, and so even large raw growth results in a lower percentage growth rate; and/or the regression equation that the model uses could indicate that there is a point of "diminishing return" to grade separating transit where the added capacity that is afforded begins to approach the absolute "demand ceiling" for transit along a specific corridor. This notion could also be reflected in the estimates for "cost per rider." In 2020, Alternative A has the highest cost per rider, while in 2035, Alternative E is the most expensive option – both outright and per rider.

Overall, the spreadsheet model indicates that a fixed-guideway transit investment using the Project Connect alignment would produce lower ridership figures than any route situated along Guadalupe/Lamar, and that while a completely grade-separated route through the heart of Austin may produce higher ridership figures than any other route configuration, the most cost effective alternative (on a per rider basis) is actually a route that features little to no grade separation using Guadalupe/Lamar.

Chapter 5: Planning Implications

This section will re-examine the benefits and drawbacks of the TCRP Report 167 spreadsheet tool now that it has been used to compare five different fixed-guideway transit alternatives in Austin, situate the results (and the process undertaken to produce them) within the context of the 2014 City of Austin Proposition 1 election, and offer suggestions for how this tool – or others like it – could inform future transit planning in Austin.

Sketch Planning Limitations

Using the TCRP Report 167 spreadsheet tool on a real-world example helps elucidate some of the inherent model shortcomings. The most important challenge faced in this report was the quality of employment data available from the Census. Because the Census uses addresses provided by employers to geocode employment counts within the LODES data, it makes no guarantees that an employee is actually counted at his or her primary place of work. Given Austin's unique position as the seat of state government, and given the disclaimer from the Census that state and local governments are more likely to misreport employee places of work, it seems likely that LODES has overestimated employment counts for central Austin. This not only has the effect of inflating ridership estimates produced by the spreadsheet tool, but also calls the entire model's validity into question. The research report provides no acknowledgement of this particular LODES data shortcoming or any documentation of efforts made to account for the potential over-estimation of employment numbers in cities with high concentrations of state or local government offices near transit. Future applications of the tool should seek to incorporate other, more reliable employment estimates, possibly from state governments or local economic development consultants.

While the model does provide a great deal of flexibility for users to calculate spreadsheet inputs, attempting to add precision to the input calculation process is something of a double-edged sword. The more users pursue data manipulation techniques, the more complex and time-consuming the process becomes. While it is possible to explore adjustments to every variable, there is the potential to reach a point where the input data no longer conforms to the parameters of the model, casting doubt on the validity of the results. Because the "point of no return," so to speak, is impossible to identify, it is unclear if (and how much) adjustment to the model inputs actually improves the quality of the estimates.

This report explored methods for improving the catchment area delineation process, population and employment calculations, and future year ridership estimates, but did not make improvements to other variables. The congestion metric provided by the research team is problematic, as a ratio of VMT to freeway lane miles only measures demand for road space, not congestion. Future users of the spreadsheet model could explore creation of a weighting factor to apply to the FHWA congestion metric taking into account other congestion data (like delay or reliability) for both current and future year ridership estimation. The future year data would also benefit from a more thorough approach to estimating CBD parking price using a market research study, and future year population and employment estimates should also be able to take into account induced and redistributed demand generated by the transit investment itself. It is important to note that quality and availability of data will be a limiting factor in the degree to which any attempt to enhance model inputs will be successful.

Despite these limitations, there are still some readily apparent benefits to using this tool to explore ridership along different fixed-guideway alternatives. Comparing the modeled ridership to ridership estimates from other sources was difficult due to a lack of previously published studies specific to Austin, making it difficult to gauge the "reality" of the projections. However, it was still reasonable to compare the ridership estimates *between* the alternatives explored in this report, which satisfies the ability for this tool to screen a large number of different potential investments through a "preliminary feasibility" analysis. Similarly, although the cost per rider estimates produced by the model were difficult to place in a real-world context, they did provide a valuable indication that full grade-separation can only improve ridership forecasts to a certain point, which assuages some initial concern that the importance this tool assigns to grade-separation as a predictor variable could induce transit planners to use this tool to justify costly and potentially wasteful heavy infrastructure investments.

Sketch Planning and the Project Connect Process

This report demonstrates the application of one sketch planning tool in the context of fixed-guideway transit planning in Austin, and provides a valuable point of comparison with Project Connect – which is the most recent effort by public transportation planning officials in Austin to implement rail transit in the central core.

The Project Connect team employed the use of a traditional four-step model to estimate ridership along the Locally Preferred Alternative (LPA) (Alliance Transportation Group, 2014). A review of planning documents posted on the project's website show that ridership estimates were never considered for any other alternative, giving little context to frame the estimates produced for the LPA. This could be due to the onerous process of operating the four-step model eliminating the ability for the time-constrained project team to compare the route to any other alternatives. However, the project team could have employed one of the various sketch planning tools at their disposal to provide rough estimates of other routes to provide a point of comparison with the route that ultimately failed to gain public support.

Some of the most vocal critics of the planning process pointed to the official ridership estimates as one of their chief concerns. A few went so far as accusing the project team of "deliberately" ignoring other routes – namely, Guadalupe/Lamar – because they knew the LPA could not match those corridors' potential ridership (Austin Rail Now, 2015). Others questioned the validity of the demographic forecasting methods used by the team, arguing that the "inflated" growth projections along the LPA exposed the already "lackluster" ridership figures to be over-estimated (Gonzalez Altamirano, 2014). Regardless of the motives or technical methodology employed by the project team, it appears obvious that the ridership estimation procedure chosen for this planning process did not build public trust – and could have contributed to the project's defeat at the ballot box. Here again sketch planning tools could have contributed to the conversation on both sides of the argument, using data-driven analysis to diffuse a contentious scenario. Sketch modeling ridership along different routes may not have saved the proposal as it appeared before voters, but could have at least provided an impetus to make changes earlier in the planning process.

Finally, although no other routes were explored to the detail of ridership estimation beyond the LPA, the project team did consider all of the various “sub-corridors” in the Central Corridor planning area to determine generally where the initial starter line would be developed. The planning team did not produce any kind of ridership estimation for the sub-corridors, but did explore several qualitative and quantitative criteria such as current transit use, congestion, and future development plans – among others. The closest the project team came to exploring corridor level “demand forecasting” was by exploring current ridership vs. potential ridership. The Lamar sub-corridor scored highest for potential ridership – defined by the Transit Orientation Index, which measures household, employment, and retail employment densities – and scored second highest for current bus boardings after East Riverside (Project Connect, 2013). It should be noted that highly used stops along Guadalupe near the UT Campus were not included in these figures due to the delineation of the “Core” sub-corridor to encompass UT and West Campus. The Lamar sub-corridor also had the highest number of work trips to the Core, which is another common indication of high transit demand since the predictability of home-based work trips make them easy to serve by transit. As noted in the literature review, this is typically the stage of the planning process where sketch planning is most applicable. Sketch planning tools like TCRP Report 167 perform a similar ranking function that is inherent to the regression modeling process. They determine which factors – both endogenous and exogenous – correlate to increased transit use, while the magnitude of each coefficient of significant variables essentially functions as a weighting factor. The resulting equation tells users of the model which factors to explore along a corridor and how much value to place in each to determine which corridors have the highest ridership potential. Although ridership maximization was not the only goal of the Project Connect process, it was certainly one of them. It seems that the process used to evaluate sub-corridors had the effect of diluting factors that would have encouraged routes with higher ridership potential to be explored further, which could have been corrected by employing sketch planning principles (if not the tools themselves) before making final sub-corridor selections.

Lessons for Future Transit Planning in Austin

By exploring the use of one particular sketch planning tool, this report can offer several valuable contributions to the direction of future fixed-guideway transit planning in Austin. First of all, the results of the sketch planning tool – though not definitive – do point to a clear advantage that the Guadalupe/Lamar corridor enjoys as a preferable route to initiate urban rail in Austin in a cost effective way. Although the corridor faces many constraints, the ridership potential exhibited by all of the alternatives along Guadalupe/Lamar suggest that any planning process that does not seriously consider a route in this corridor will face skepticism similar to that encountered by Project Connect. Furthermore, planners should be prepared to utilize whatever tools that are available – whether based on sketch planning or four-step models – to produce ridership figures that are directly comparable for multiple alternatives. Doing so early in the planning process can enhance transparency and build trust in the planning process (particularly within organizations that otherwise support transit in Austin).

This report provides a comparison of routes within the Project Connect Central Corridor – which is one of only five high-priority corridors in the region that were identified in the broader transit plan for the Austin MSA. Voters in the 2014 Proposition 1 election were asked to approve funding for a project in a very small geographic area, which is one possible reason that the project was denied approval. Not surprisingly, vote results by precinct showed that areas near the LPA voted in favor of Proposition 1 by a significant margin, while voters closer to the edge of the city limits voted no, as shown in Figure 13 (City of Austin, 2014). While voters at the ballot box make decisions for any number of reasons, it is reasonable to posit that some of the voters on the outskirts of the city who voted no did so because they felt left out of a central-city focused planning process. Given the limited nature of planning resources, making more use of sketch planning tools available could help transit planners in Austin broaden their scope and engage the community in a truly regional transit plan.

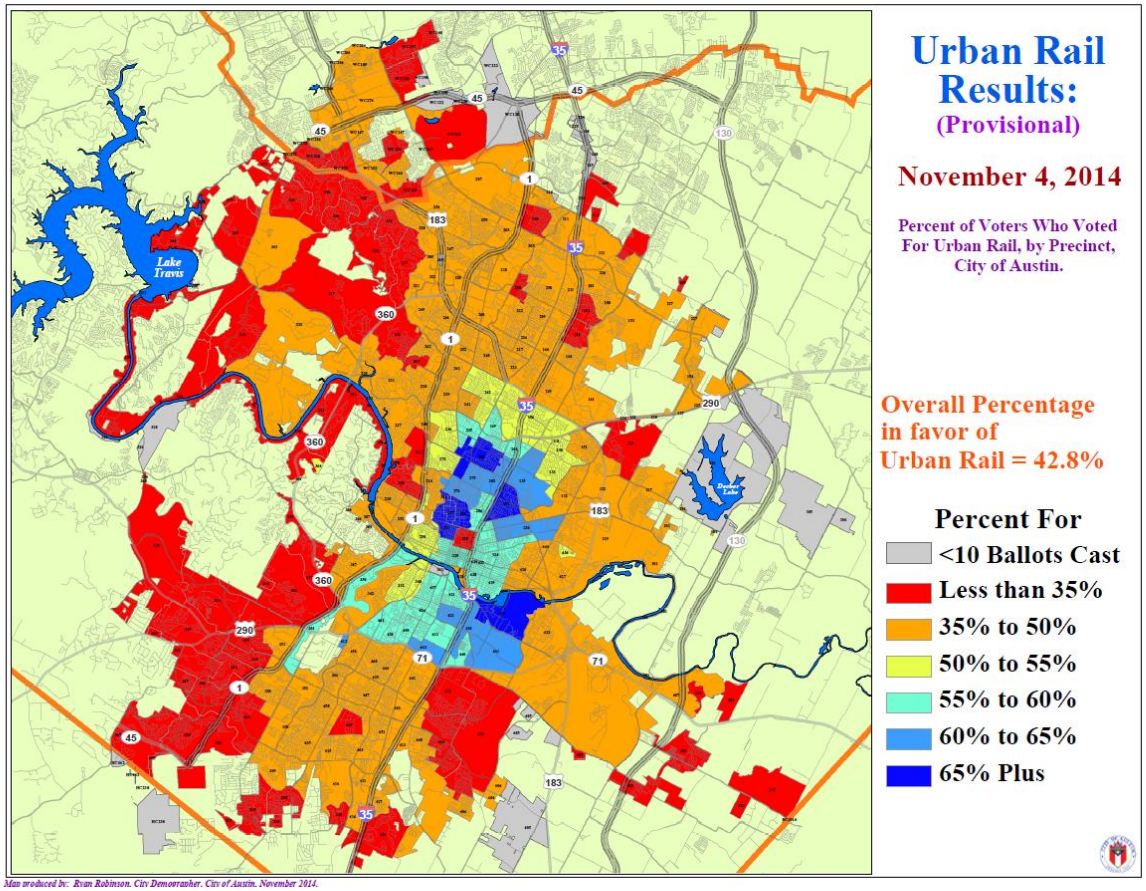


Figure 13: 2014 City of Austin Urban Rail Election Results

Perhaps the most exciting possibility exhibited by this tool and many others is the ability for sketch planning to enrich the public engagement process. Regression-based models can be easily adapted to online interfaces given their simplicity. One increasingly popular example is TransitMix, which lets users create and re-align bus routes "freehand" – i.e. with no constraints – and then immediately see the resulting ridership, cost effectiveness, and equity outcomes of their route choices. Similar tools could be employed for regional transit planning efforts or major corridor studies, giving members of the public the chance to directly explore the implications that transit route and/or station location have on indicators like number of transit trips, congestion, and financial feasibility. By removing the veil of mystery that ridership estimation is so often shrouded behind, transit planners in the public and private sectors can enhance the level of trust that members of the public place in their ridership estimates, and increase the likelihood that projects receive public approval when put to a vote.

Chapter 6: Conclusion

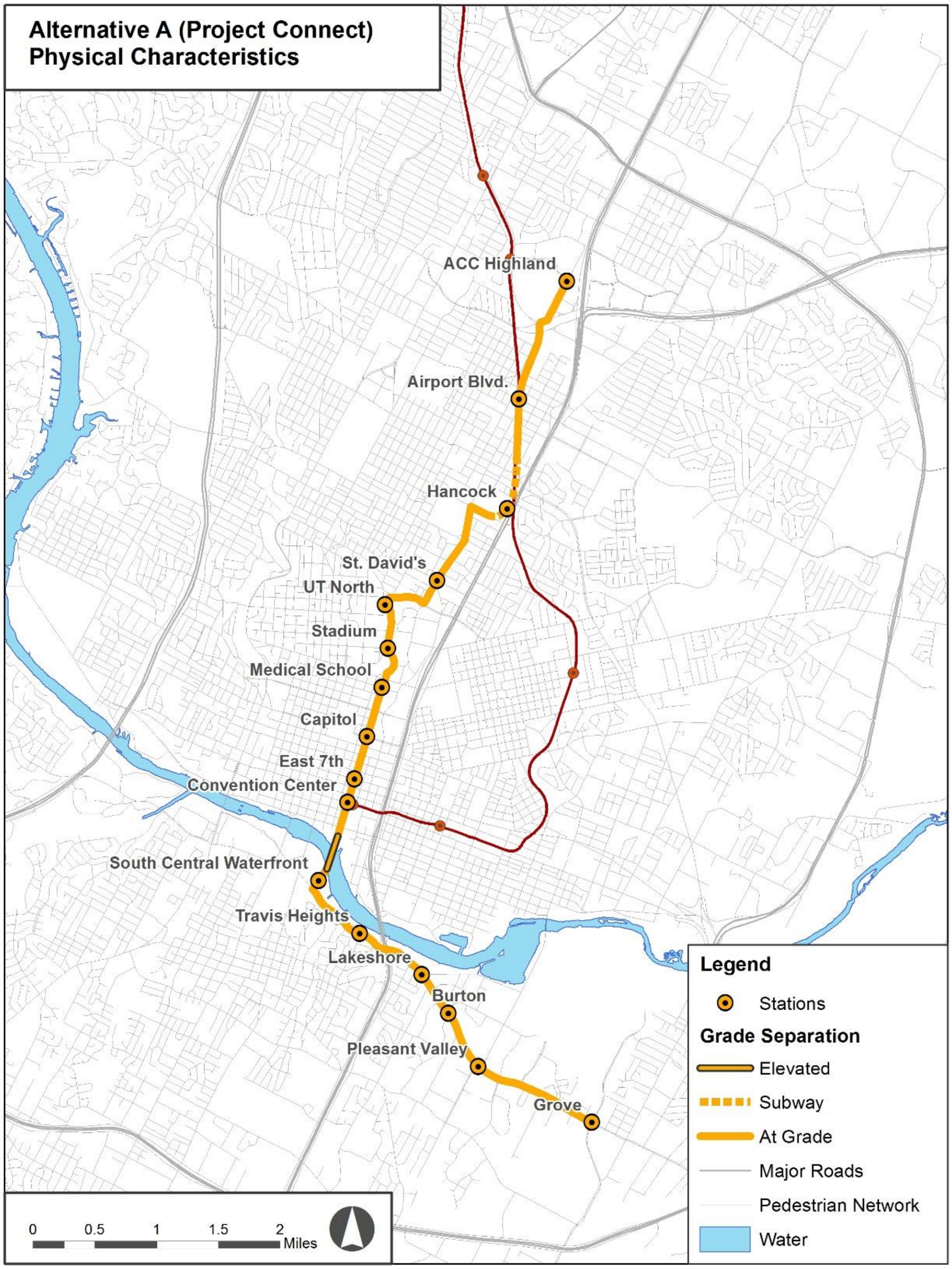
This report has used the TCRP Report 167 spreadsheet tool to compare potential fixed-guideway transit ridership along two different corridors and five different central Austin route configurations. Analyzed in conjunction with findings from previous research on sketch planning, the results of the spreadsheet tool indicate that sketch planning can play a valuable role in the transit planning process. Sketch planning is both faster and less labor intensive than four-step travel demand models that are traditionally used to estimate transit ridership, which has many implications. 1) Sketch planning has the potential to significantly reduce costs to resource-limited public planning efforts, as preliminary alternatives analyses can be completed in-house. 2) It can speed up the notoriously sluggish transit planning process, as routes can be eliminated from consideration early in the process, therefore reducing the level of detailed analysis that must be performed in later phases (such as the NEPA environmental review process). 3) Sketch planning has the potential to enrich the public engagement process by giving members of the public a “hands-on” instrument to explore the implications that route and station location choice have on measures of success.

The results of the spreadsheet model indicate that the Guadalupe/Lamar corridor has higher rail transit ridership potential than the route proposed by Project Connect in the 2014 City of Austin Proposition 1 election. However, not even cursory ridership estimates were ever explored for any other route than the Locally Preferred Alternative (LPA). Lessons learned from applying one sketch planning model to the Austin context suggest that future fixed-guideway transit planning efforts in Austin should make use of alternative demand estimation tools to build public trust in the planning process and perform a comprehensive review of potential alternatives before placing one route to a public vote.

Sketch planning tools may never completely replace four-step travel demand models, but their ease of use and accessibility point to an increasingly prominent role they will play in the transit planning process. Given the ability that sketch planning tools have to strengthen the relationship between transit planners and the general public, anyone with an interest in transportation planning should expect to see the proliferation and refinement of these tools to continue for years to come.

Appendices

Appendix A: Alternative Physical Characteristics



Alternative A (Project Connect)
Physical Characteristics
ACC Highland
Airport Blvd.
Hancock
St. David's
UT North
Stadium
Medical School
Capitol
East 7th
Convention Center
South Central Waterfront
Travis Heights
Lakeshore
Burton
Pleasant Valley
Grove
Legend
Stations
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Water
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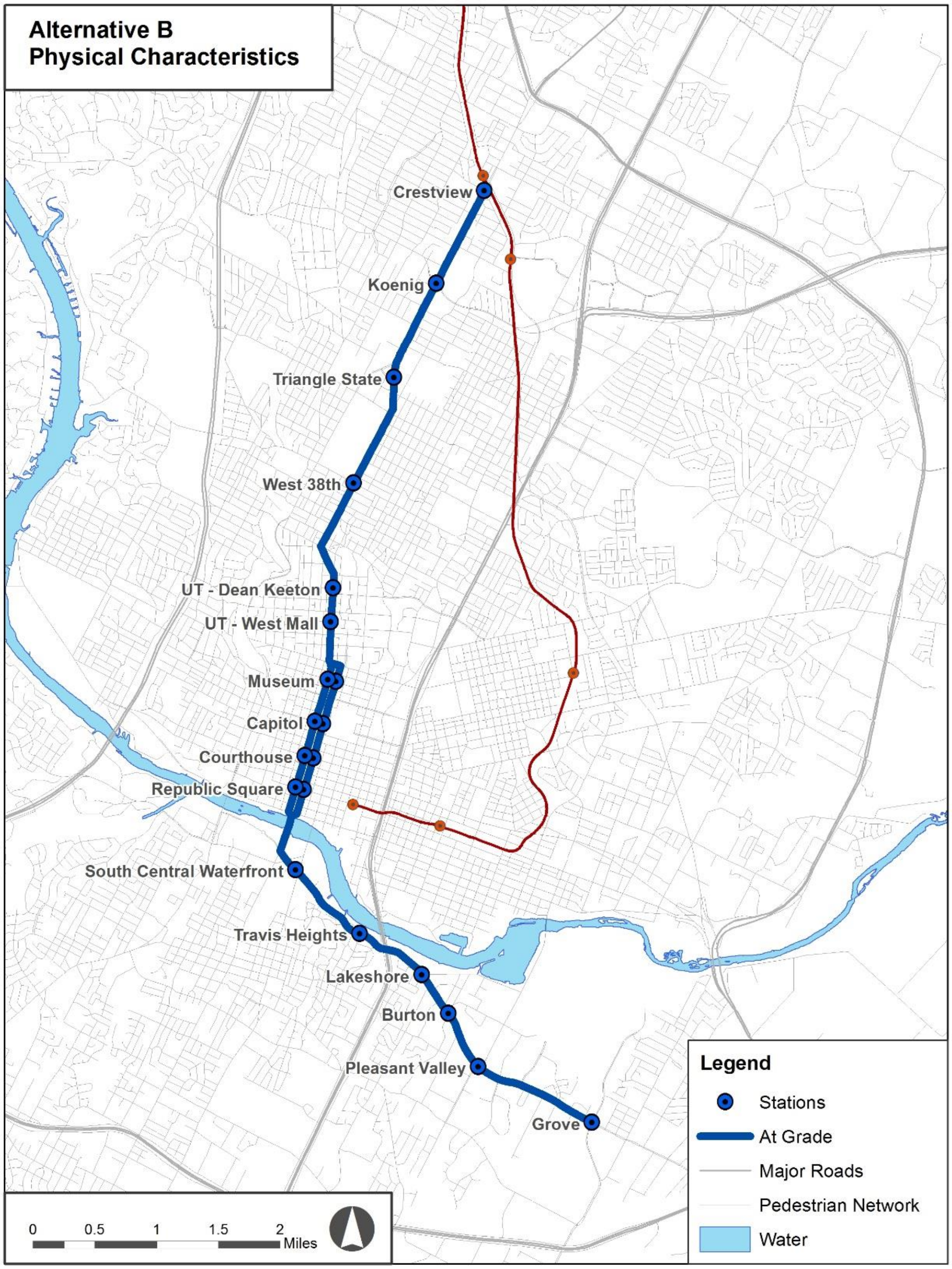
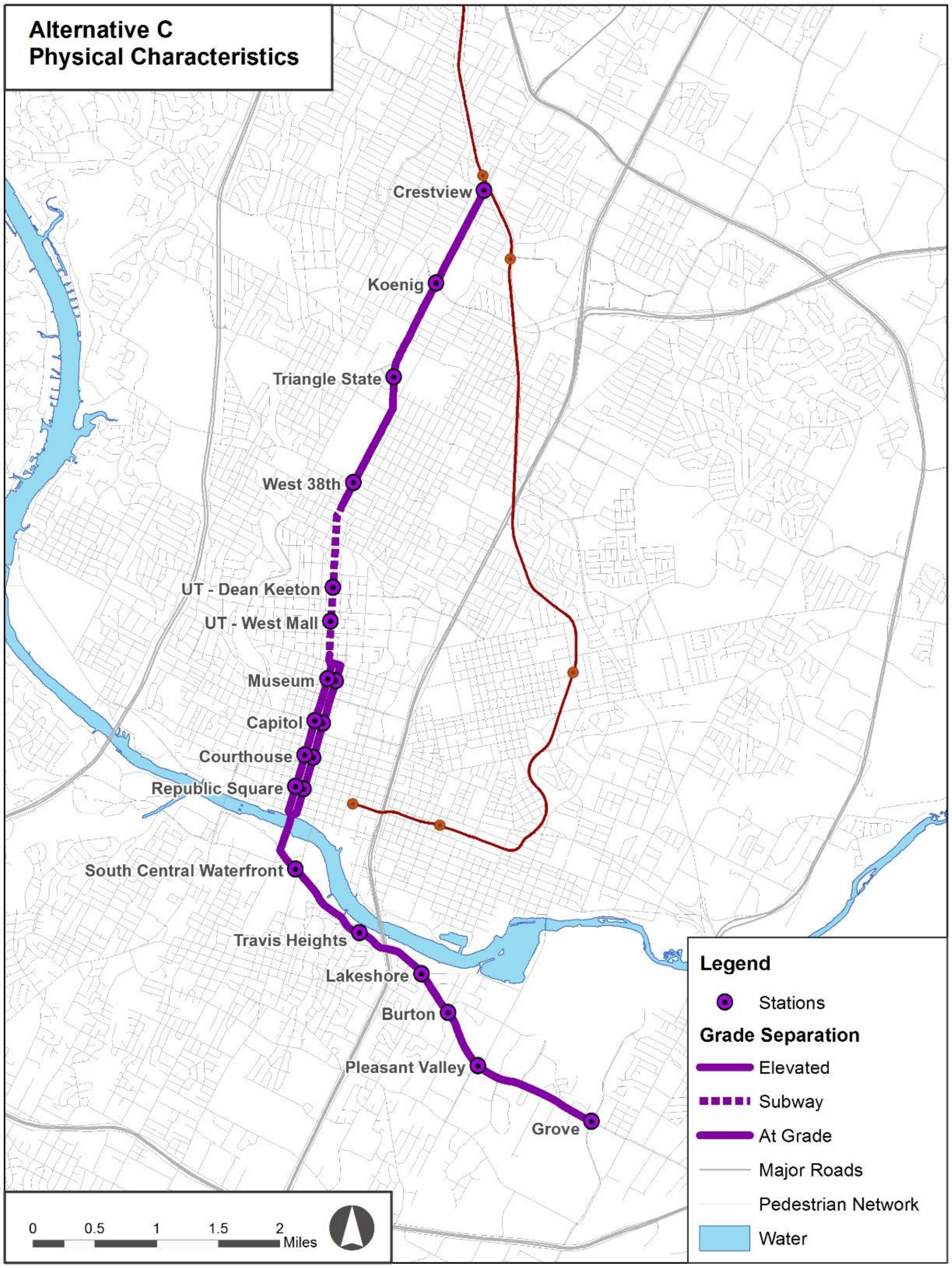
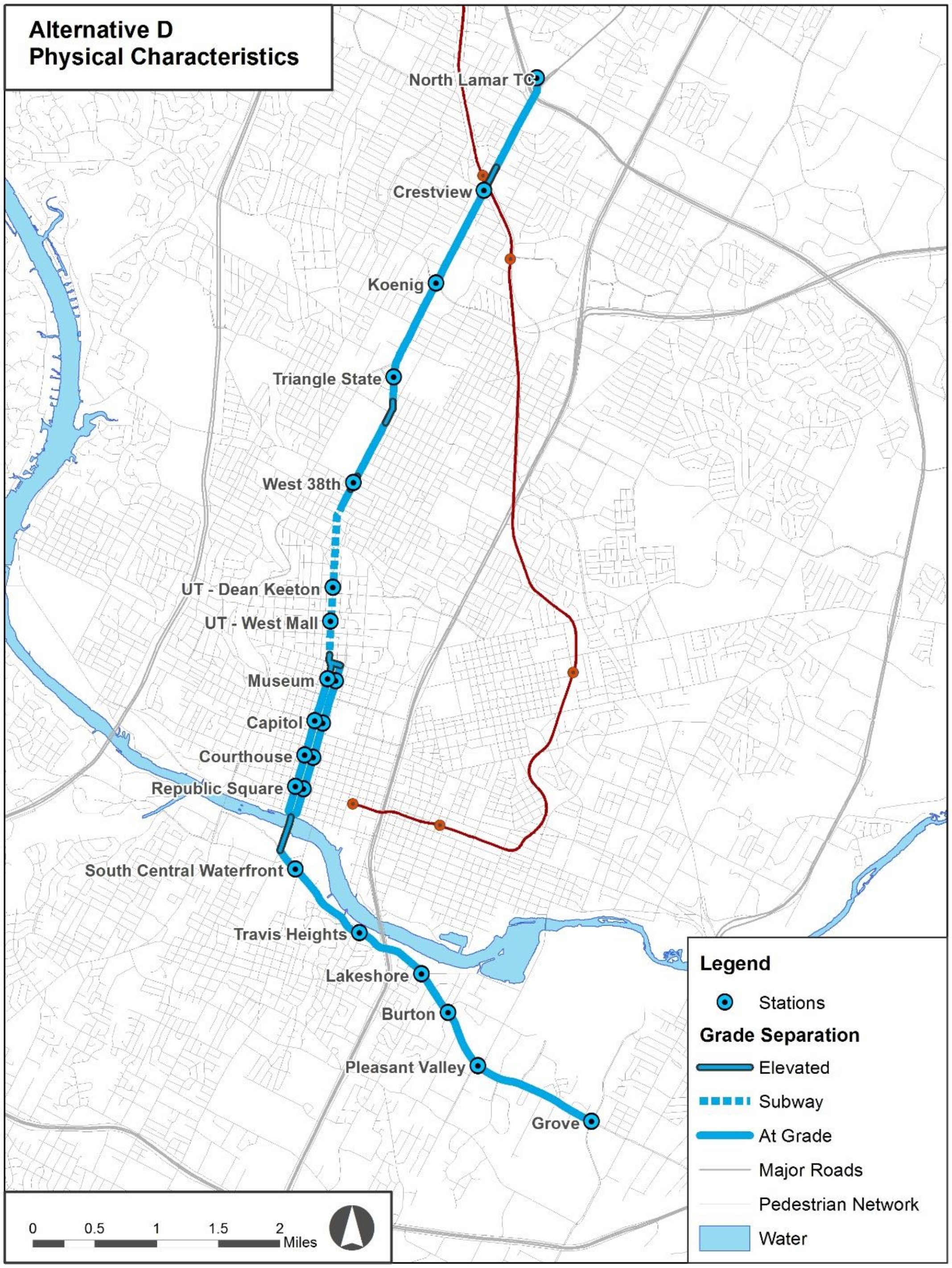
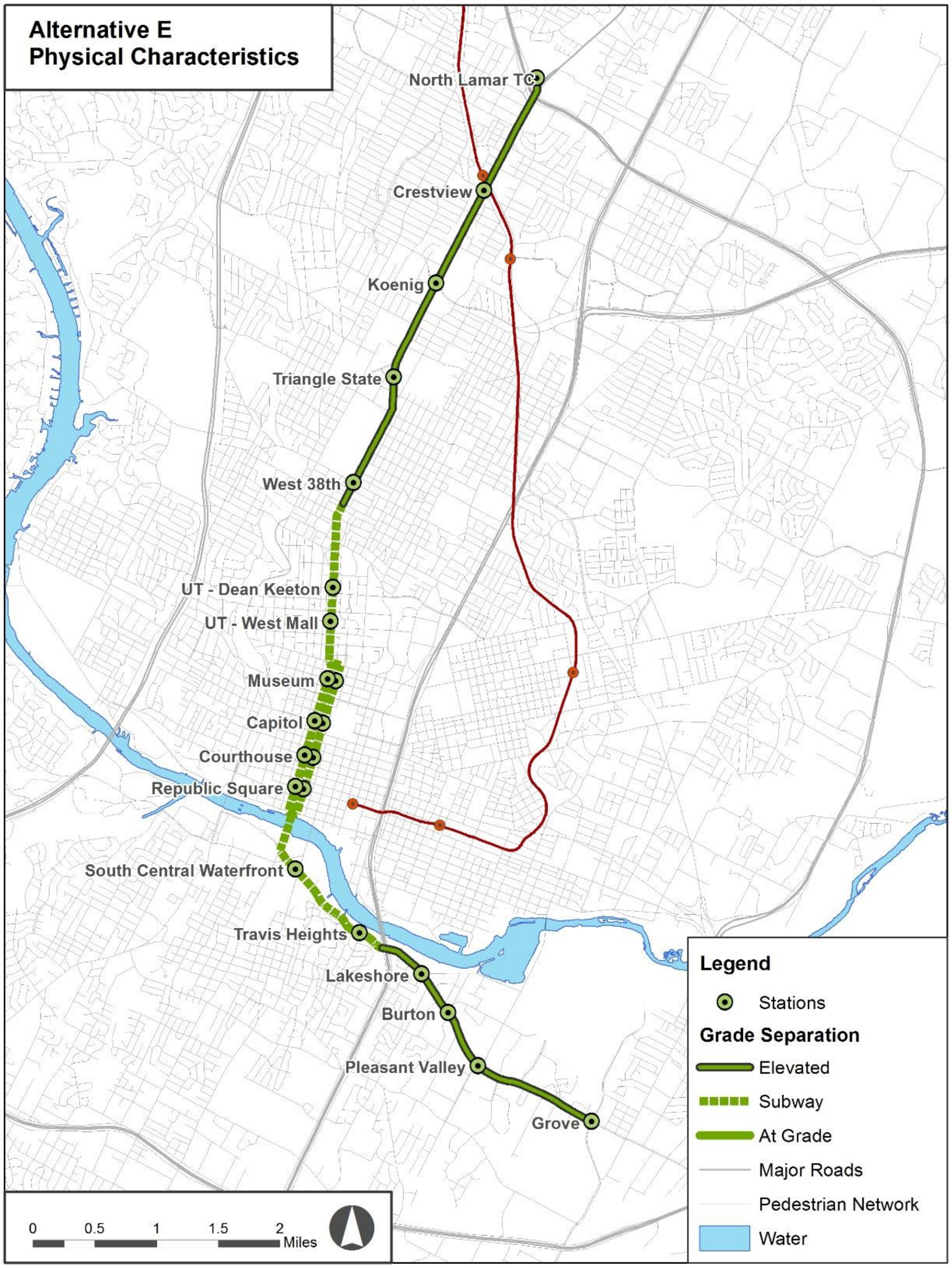
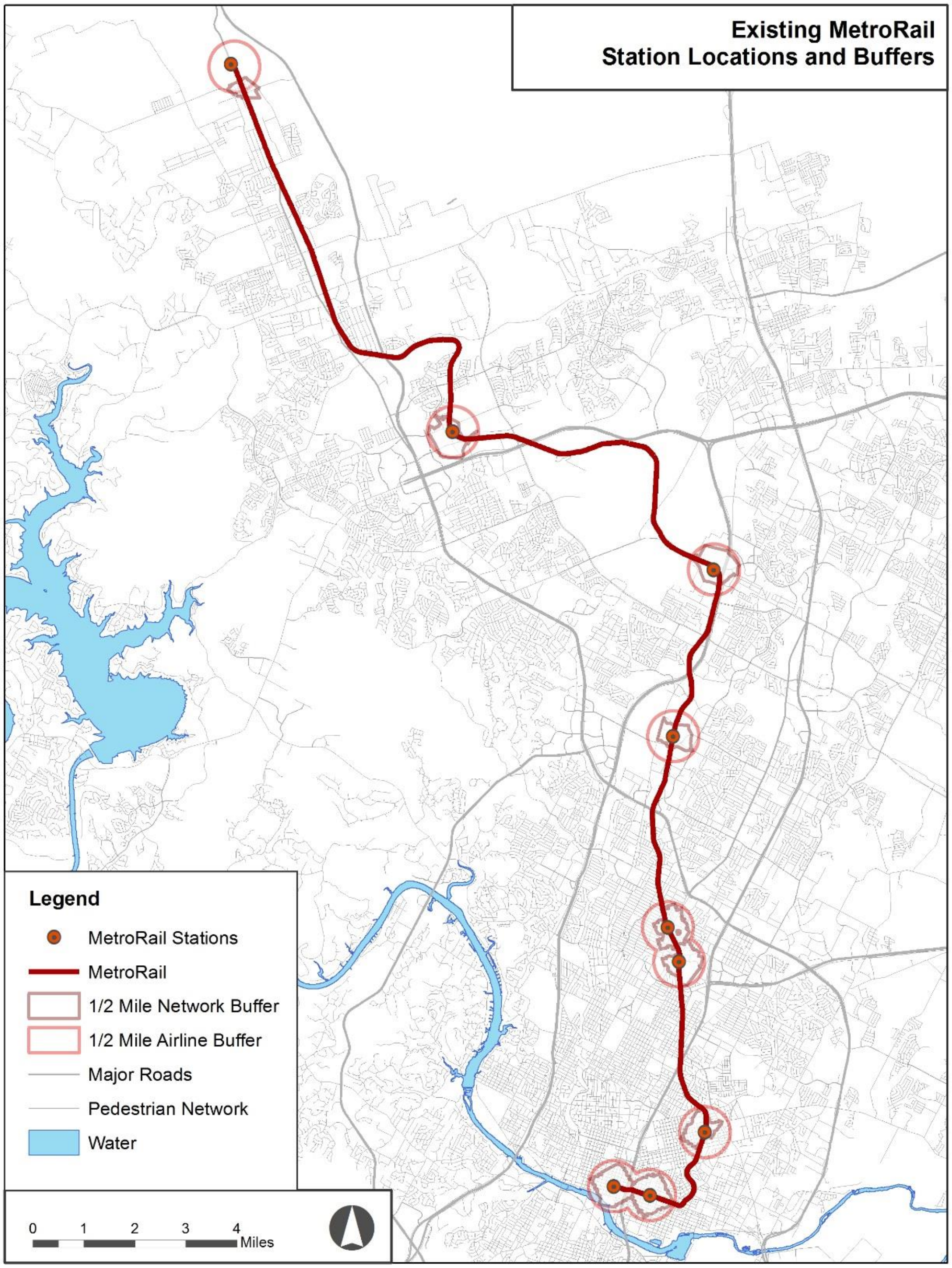

Alternative B
Physical Characteristics
Crestview
Koenig
Triangle State
West 38th
UT - Dean Keeton
UT - West Mall
Museum
Capitol
Courthouse
Republic Square
South Central Waterfront
Travis Heights
Lakeshore
Burton
Pleasant Valley
Grove
Legend
Stations
At Grade
Major Roads
Pedestrian Network
Water
0
0.5
1
1.5
2
Miles

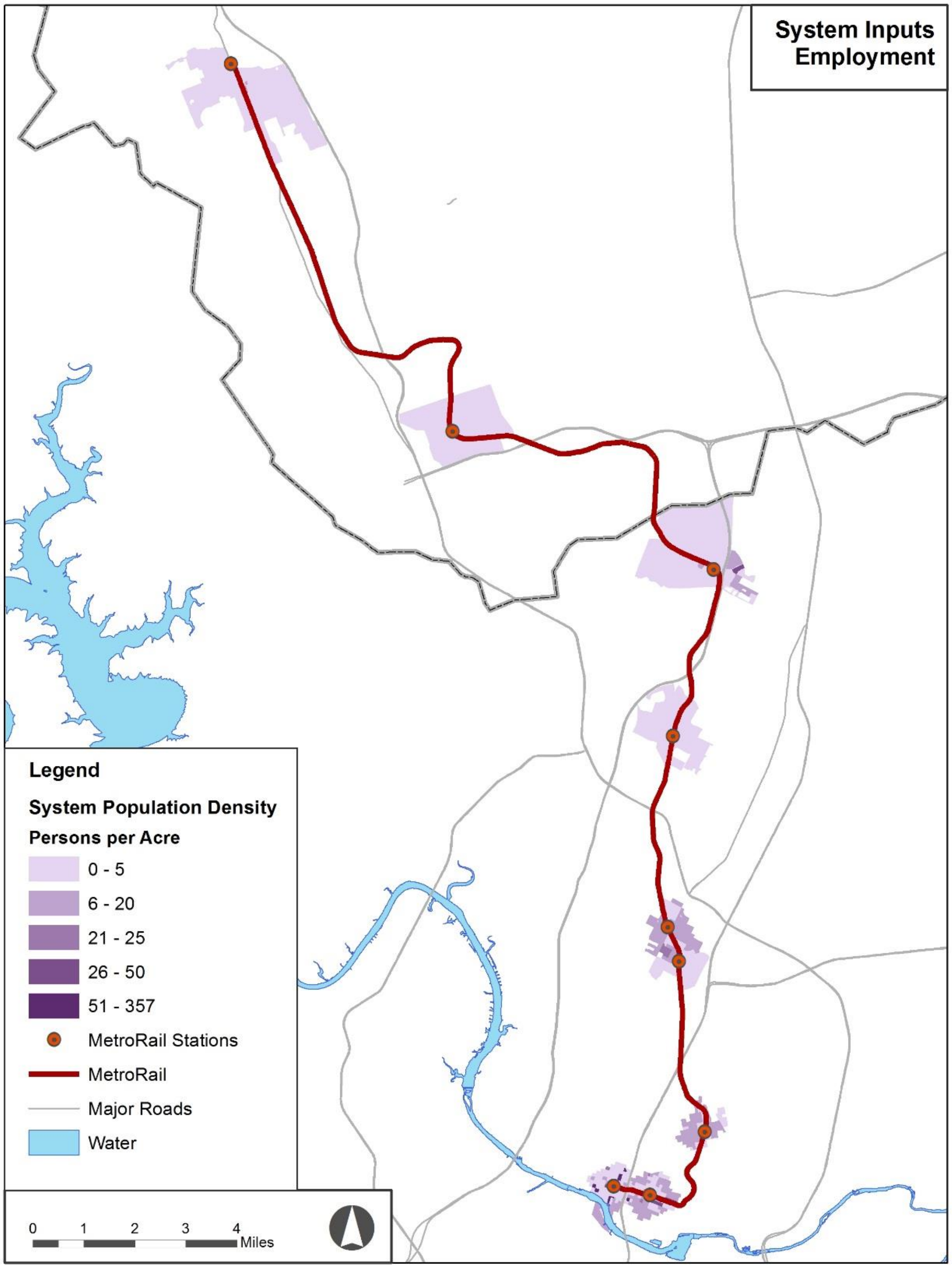

Alternative C
Physical Characteristics
Crestview
Koenig
Triangle State
West 38th
UT - Dean Keeton
UT - West Mall
Museum
Capitol
Courthouse
Republic Square
South Central Waterfront
Travis Heights
Lakeshore
Burton
Pleasant Valley
Grove
Legend
Stations
Grade Separation
Elevated
Subway
At Grade
Major Roads
Pedestrian Network
Water
0 0.5 1 1.5 2 Miles

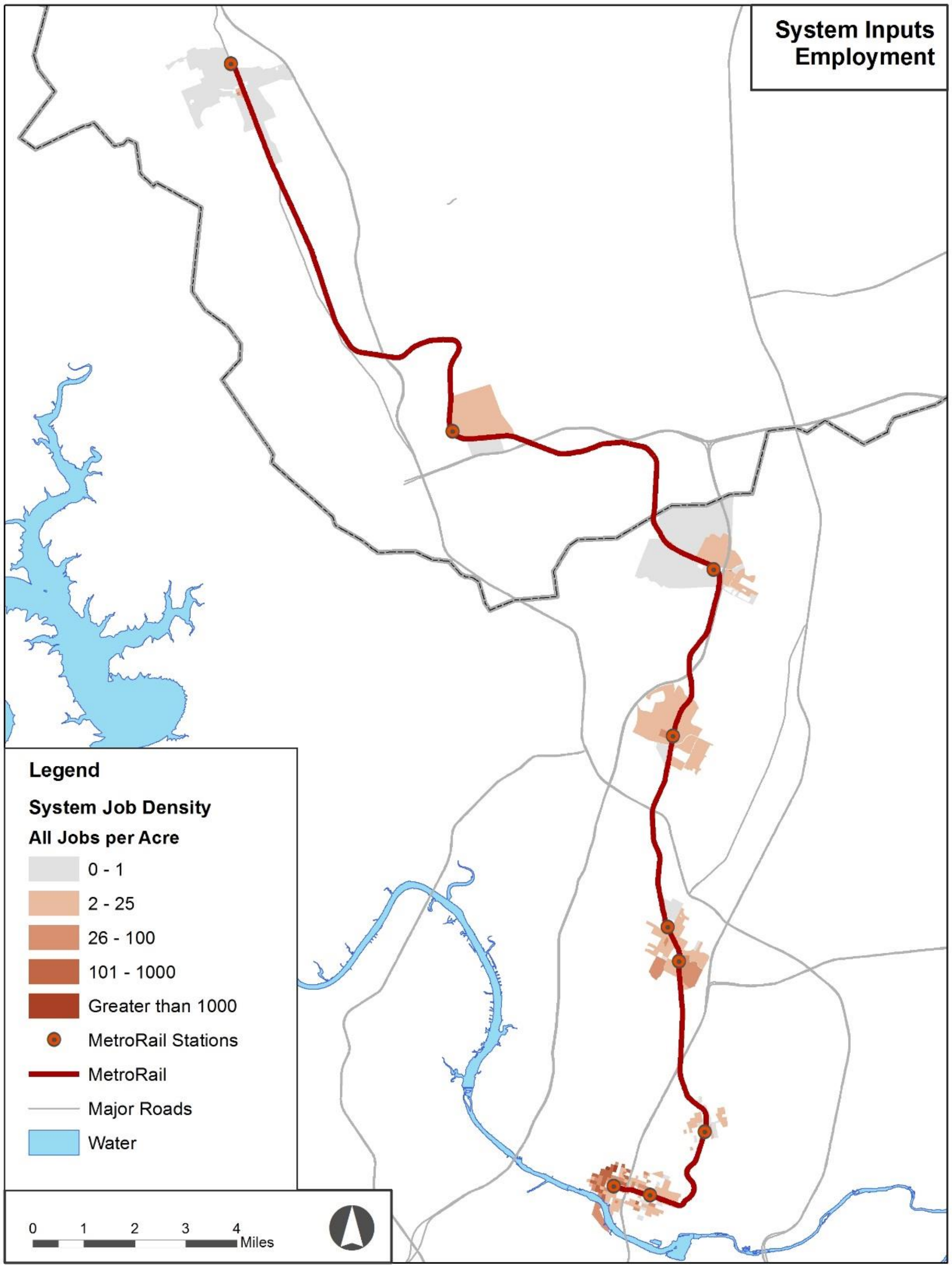

Alternative D
Physical Characteristics
North Lamar TC
Crestview
Koenig
Triangle State
West 38th
UT - Dean Keeton
UT - West Mall
Museum
Capitol
Courthouse
Republic Square
South Central Waterfront
Travis Heights
Lakeshore
Burton
Pleasant Valley
Grove
Legend
Stations
Grade Separation
Elevated
Subway
At Grade
Major Roads
Pedestrian Network
Water
0 0.5 1 1.5 2 Miles


Alternative E
Physical Characteristics
North Lamar TC
Crestview
Koenig
Triangle State
West 38th
UT - Dean Keeton
UT - West Mall
Museum
Capitol
Courthouse
Republic Square
South Central Waterfront
Travis Heights
Lakeshore
Burton
Pleasant Valley
Grove
Legend
Stations
Grade Separation
Elevated
Subway
At Grade
Major Roads
Pedestrian Network
Water
0
0.5
1
1.5
2
Miles

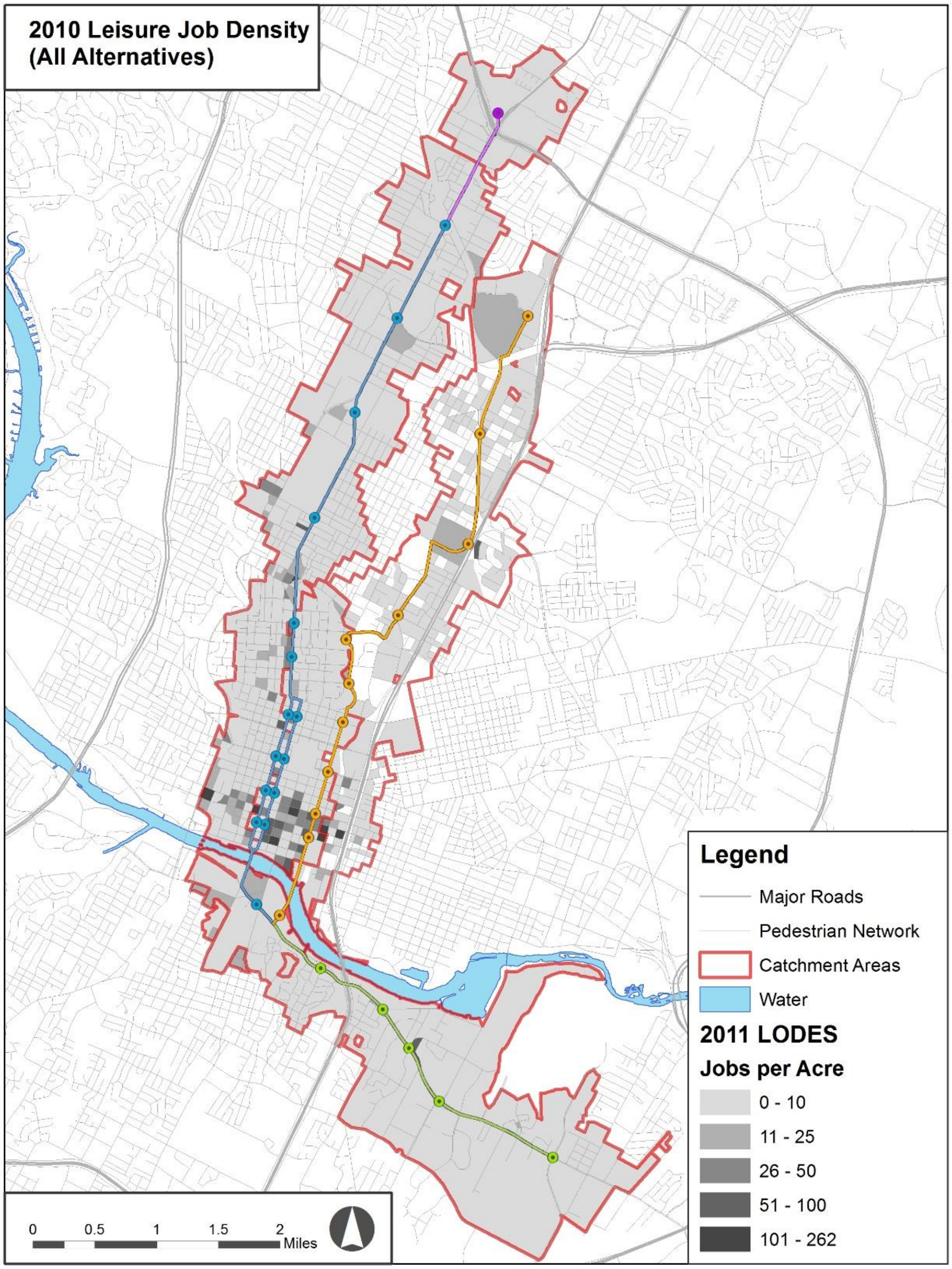
Appendix B: System Inputs

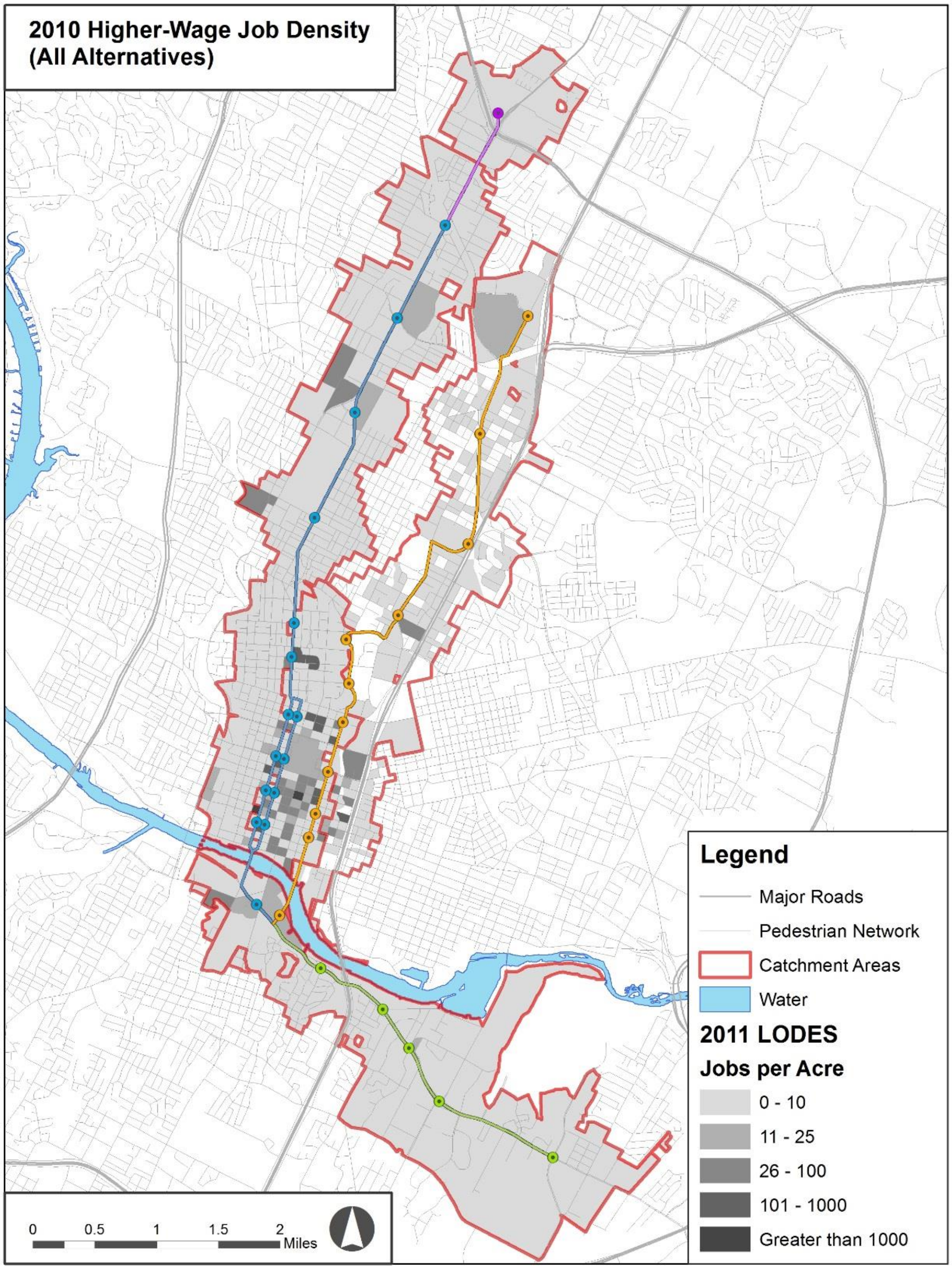

Existing MetroRail
Station Locations and Buffers
Legend
MetroRail Stations
MetroRail
1/2 Mile Network Buffer
1/2 Mile Airline Buffer
Major Roads
Pedestrian Network
Water
0 1 2 3 4
Miles


System Inputs
Employment
Legend
System Population Density
Persons per Acre
0 - 5
6 - 20
21 - 25
26 - 50
51 - 357
MetroRail Stations
MetroRail
Major Roads
Water
0
1
2
3
4
Miles


System Inputs
Employment
Legend
System Job Density
All Jobs per Acre
0 - 1
2 - 25
26 - 100
101 - 1000
Greater than 1000
MetroRail Stations
MetroRail
Major Roads
Water
0 1 2 3 4
Miles

Appendix C: Employment Density Maps





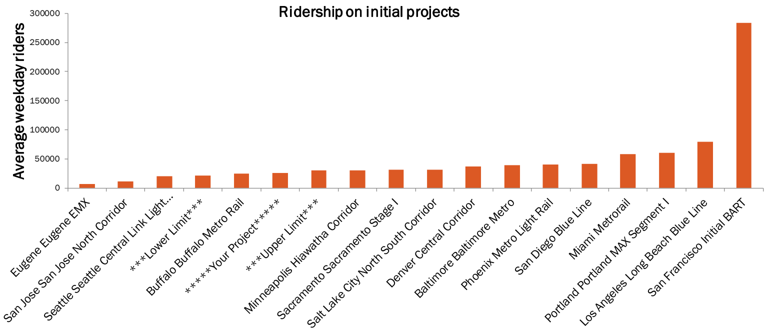
2010 Higher-Wage Job Density
(All Alternatives)
Legend
Major Roads
Pedestrian Network
Catchment Areas
Water
2011 LODES
Jobs per Acre
0 - 10
11 - 25
26 - 100
101 - 1000
Greater than 1000
0
0.5
1
1.5
2
Miles

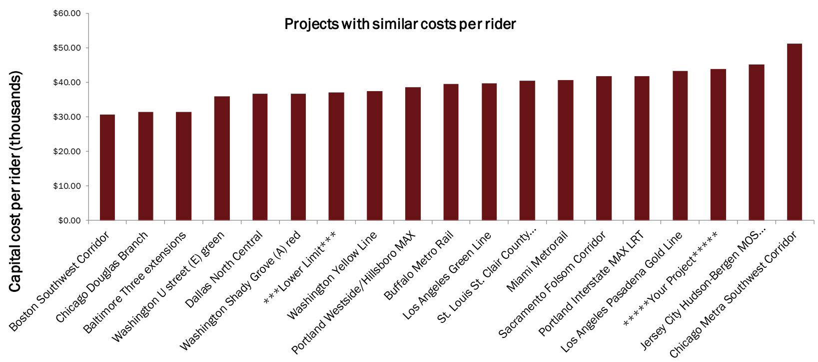
Appendix D: Report 167 Spreadsheet Outputs

The Report 167 Spreadsheet tool uses its national database of transit projects to populate a series of charts and graphs comparing the user-defined project with projects from across the country. This appendix presents the final output charts from the 2020 and 2035 “consensus” models for each alternative.

Alternative A – 2020 Consensus Model Outputs

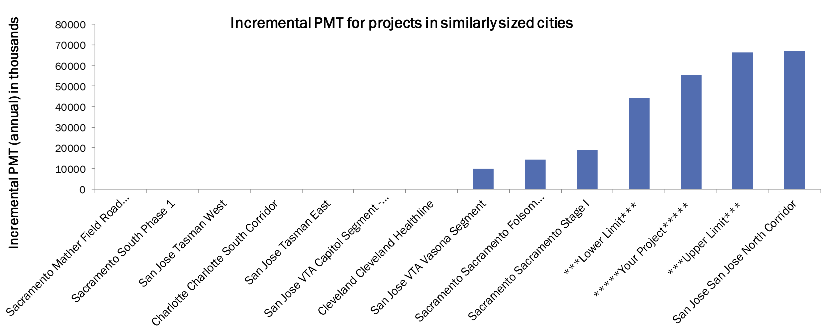
Project Ridership Output					
				Uncertainty	
Riders on the project		26,000	±	*5,000*	per average weekday
Capital cost per rider	$	43,000	±	*$8,000*	





Capital Costs Output		
Capital cost (total)	$1,129	MILLION (2009)
Capital cost per mile	$124.61	MILLION/Mile (2009)

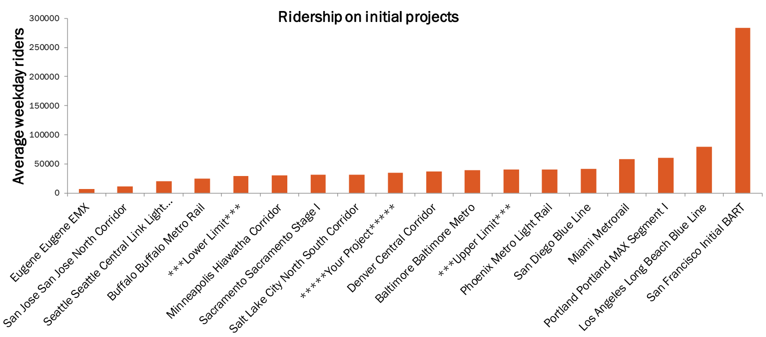
System-wide PMT Output				
			Uncertainty	
New PMT on the system	55,000,000	±	*5,000,000*	pax miles per year
Capital cost per new PMT	$20	±	*$2*	

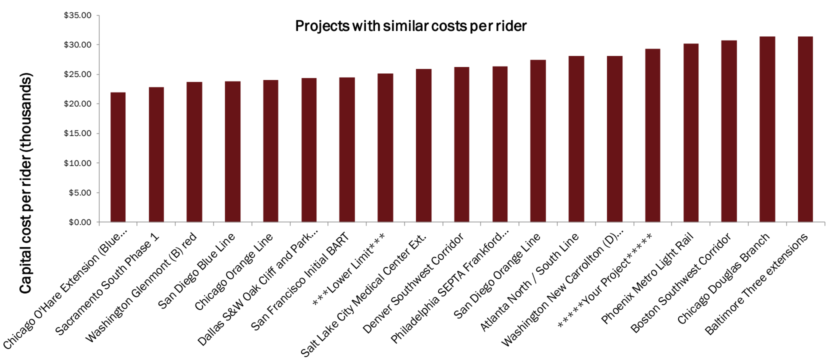


Alternative B – 2020 Consensus Model Outputs

Project Ridership Output

			Uncertainty	
Riders on the project	34,000	±	*6,000*	per average weekday
Capital cost per rider	$ 30,000	±	*$5,000*	



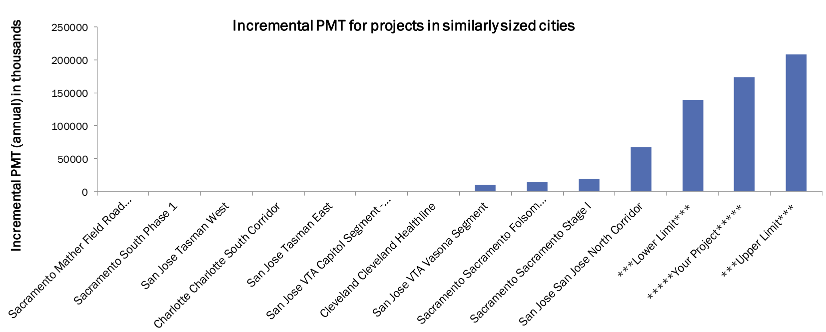


Capital Costs Output

Capital cost (total)	$1,005	MILLION (2009)
Capital cost per mile	$94.81	MILLION/Mile (2009)

System-wide PMT Output

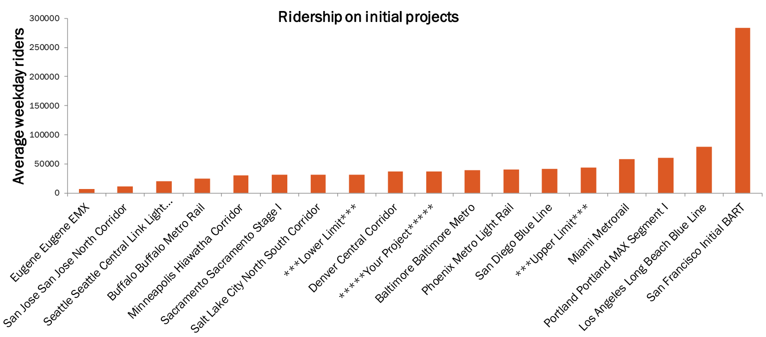
			Uncertainty	
New PMT on the system	170,000,000	±	*8,000,000*	pax miles per year
Capital cost per new PMT	$6	±	*$0*	

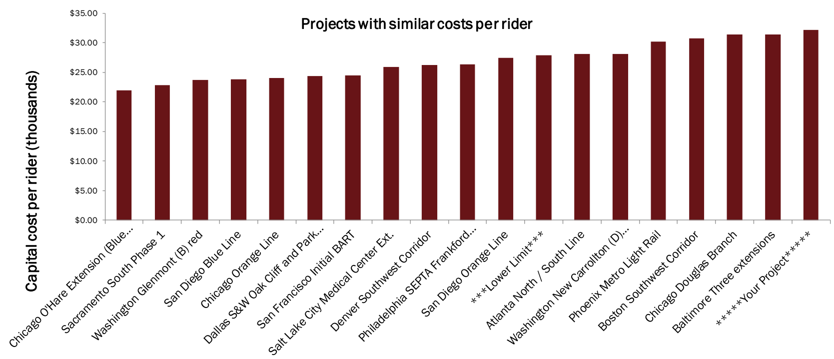


Alternative C – 2020 Consensus Model Outputs

Project Ridership Output

				Uncertainty	
Riders on the project		37,000	±	*6,000*	per average weekday
Capital cost per rider	$	32,000	±	*$5,000*	



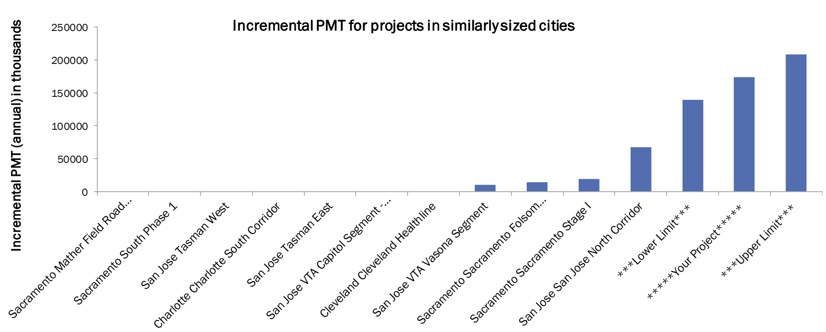


Capital Costs Output

Capital cost (total)	$1,199	MILLION (2009)
Capital cost per mile	$114.74	MILLION/Mile (2009)

System-wide PMT Output

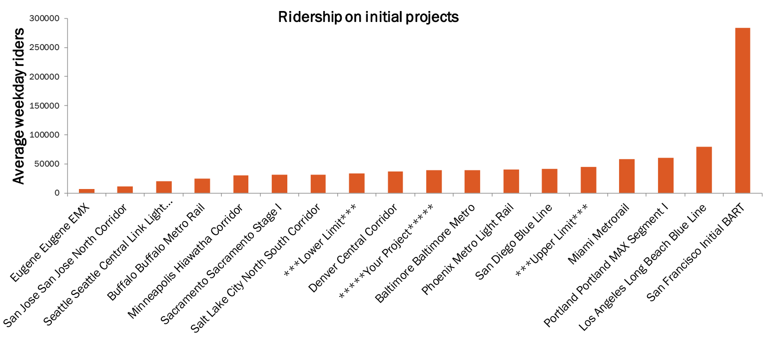
			Uncertainty	
New PMT on the system	170,000,000	±	*8,000,000*	pax miles per year
Capital cost per new PMT	$7	±	*$0*	

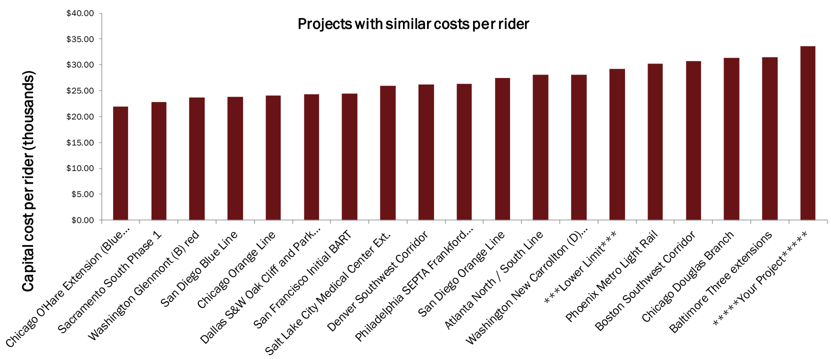


Alternative D – 2020 Consensus Model Outputs

Project Ridership Output

			Uncertainty	
Riders on the project	39,000	±	*6,000*	per average weekday
Capital cost per rider	$ 33,000	±	*$5,000*	



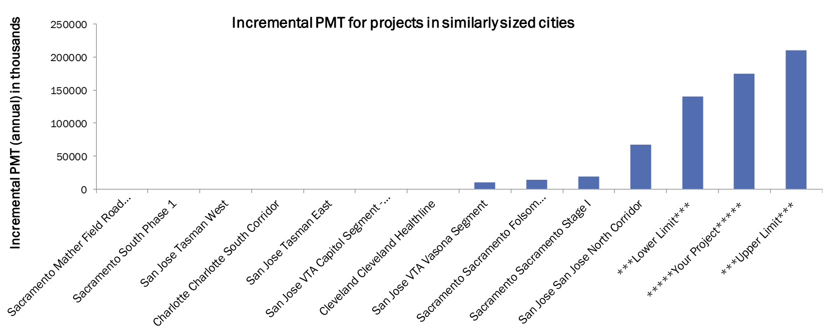


Capital Costs Output

Capital cost (total)	$1,304	MILLION (2009)
Capital cost per mile	$112.61	MILLION/Mile (2009)

System-wide PMT Output

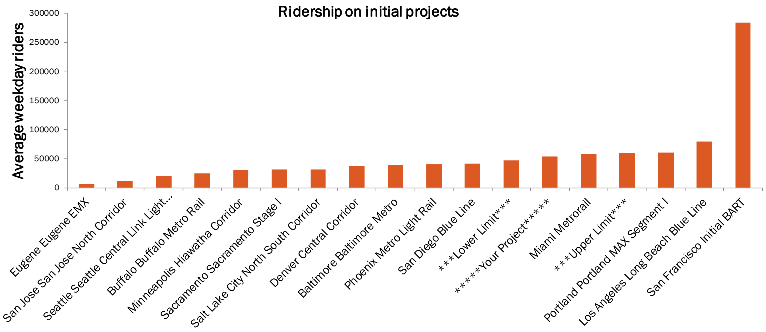
			Uncertainty	
New PMT on the system	170,000,000	±	*8,000,000*	pax miles per year
Capital cost per new PMT	$8	±	*$0*	

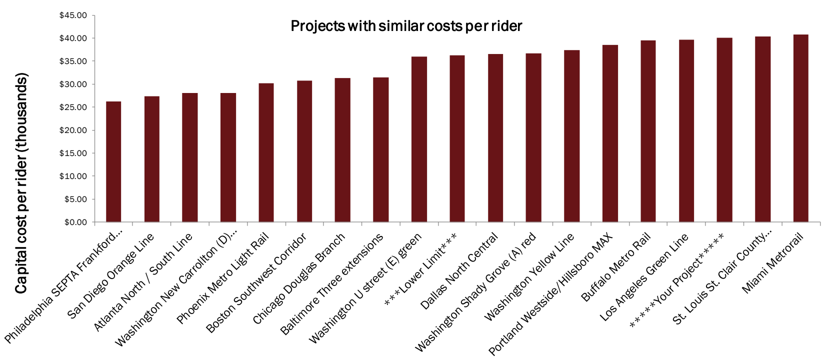


Alternative E – 2020 Consensus Model Outputs

Project Ridership Output

			Uncertainty	
Riders on the project	53,000	±	*6,000*	per average weekday
Capital cost per rider	$ 40,000	±	*$5,000*	



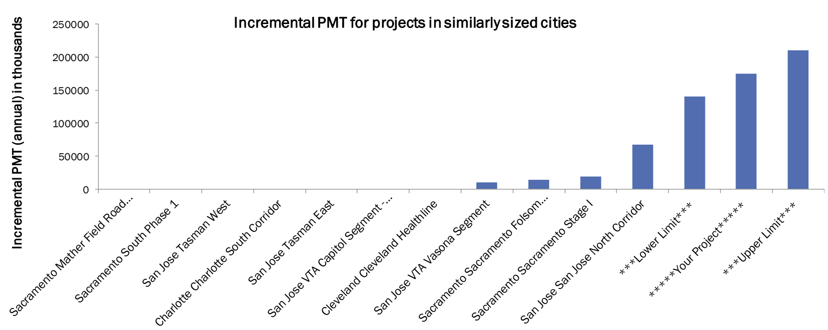


Capital Costs Output

Capital cost (total)	$2,134	MILLION (2009)
Capital cost per mile	$184.28	MILLION/Mile (2009)

System-wide PMT Output

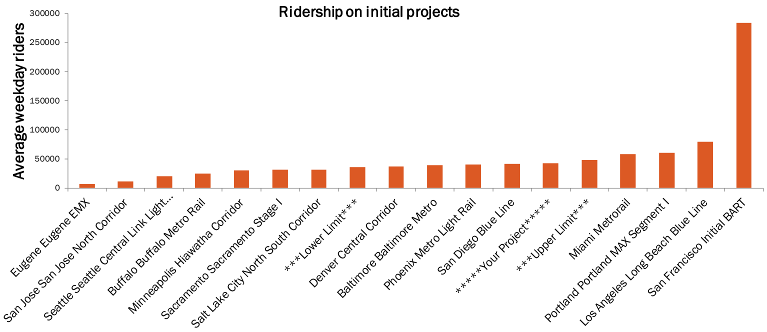
			Uncertainty	
New PMT on the system	170,000,000	±	*8,000,000*	pax miles per year
Capital cost per new PMT	$10	±	*$1*	

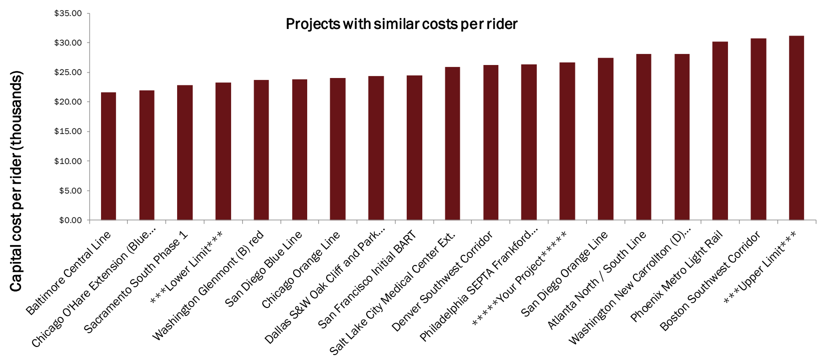


Alternative A – 2035 Consensus Model Outputs

Project Ridership Output

				Uncertainty	
Riders on the project		42,000	±	*6,000*	per average weekday
Capital cost per rider	$	27,000	±	*$4,000*	



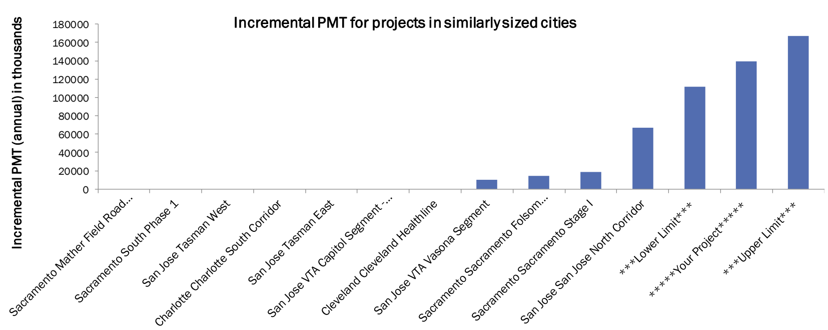


Capital Costs Output

Capital cost (total)	$1,129	MILLION (2009)
Capital cost per mile	$124.61	MILLION/Mile (2009)

System-wide PMT Output

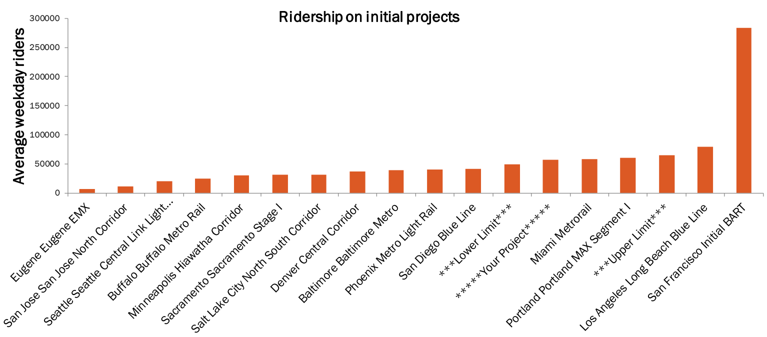
			Uncertainty	
New PMT on the system	140,000,000	±	*8,000,000*	pax miles per year
Capital cost per new PMT	$8	±	*$1*	

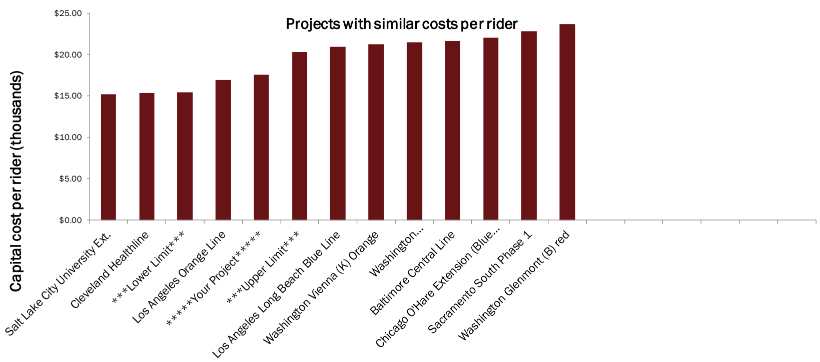


Alternative B – 2035 Consensus Model Outputs

Project Ridership Output

			Uncertainty	
Riders on the project		57,000 ±	*8,000*	per average weekday
Capital cost per rider	$	18,000 ±	*$3,000*	



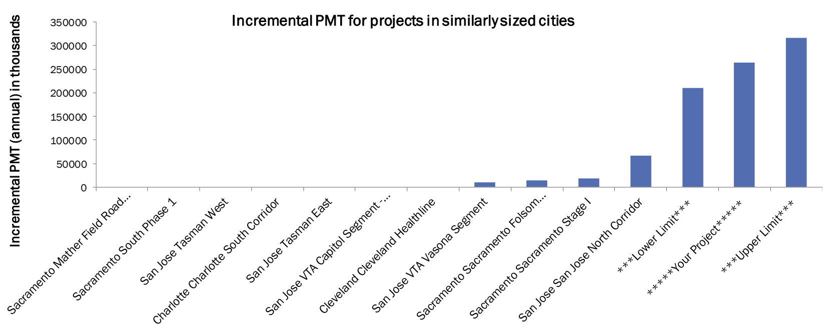


Capital Costs Output

Capital cost (total)	$1,005	MILLION (2009)
Capital cost per mile	$94.81	MILLION/Mile (2009)

System-wide PMT Output

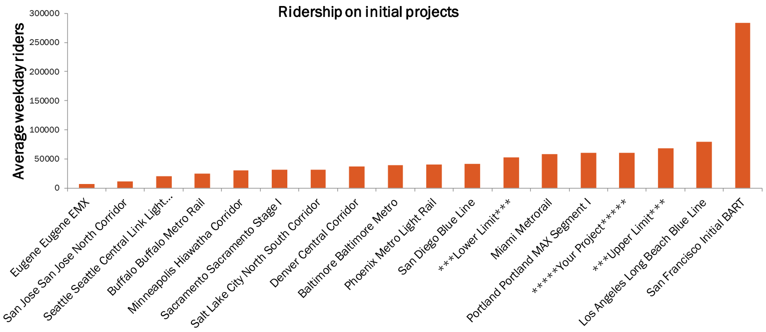
		Uncertainty	
New PMT on the system	260,000,000 ±	*10,000,000*	pax miles per year
Capital cost per new PMT	$4 ±	*$0*	

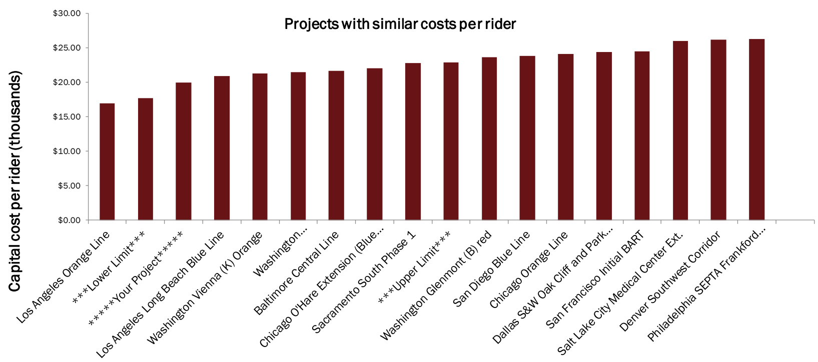


Alternative C – 2035 Consensus Model Outputs

Project Ridership Output

		Uncertainty	
Riders on the project	60,000 ±	*8,000*	per average weekday
Capital cost per rider	$ 20,000 ±	*$3,000*	



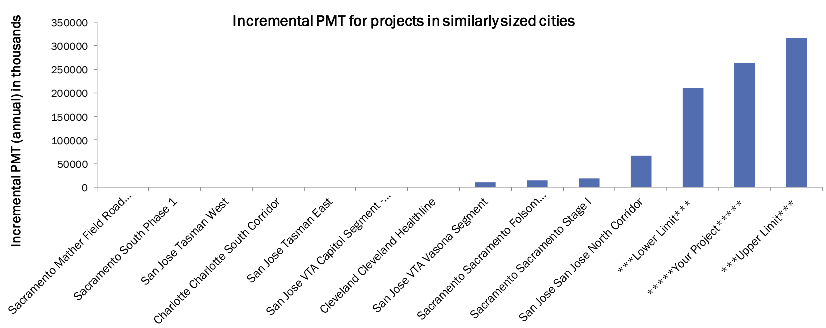


Capital Costs Output

Capital cost (total)	$1,199	MILLION (2009)
Capital cost per mile	$114.74	MILLION/Mile (2009)

System-wide PMT Output

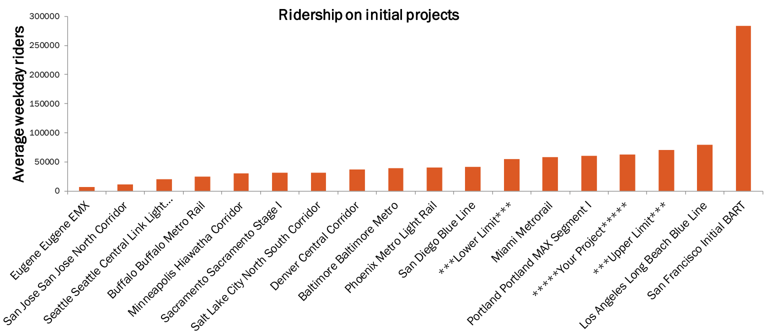
		Uncertainty	
New PMT on the system	260,000,000 ±	*10,000,000*	pax miles per year
Capital cost per new PMT	$5 ±	*$0*	

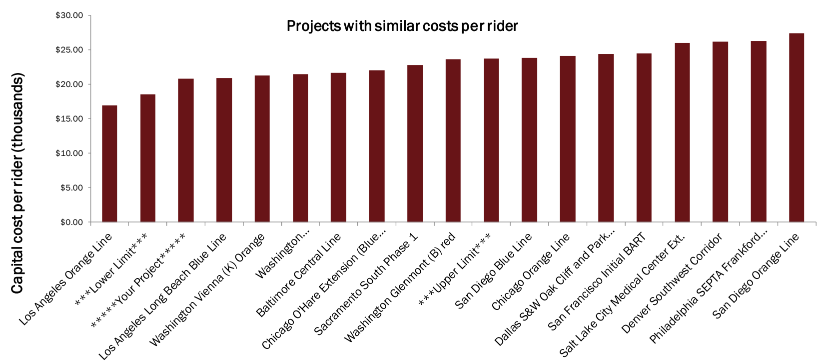


Alternative D – 2035 Consensus Model Outputs

Project Ridership Output

			Uncertainty	
Riders on the project	63,000	±	*8,000*	per average weekday
Capital cost per rider	$ 21,000	±	*$3,000*	



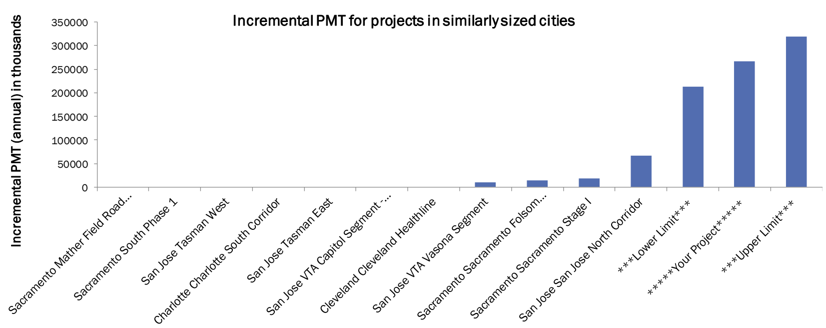


Capital Costs Output

Capital cost (total)	$1,304	MILLION (2009)
Capital cost per mile	$112.61	MILLION/Mile (2009)

System-wide PMT Output

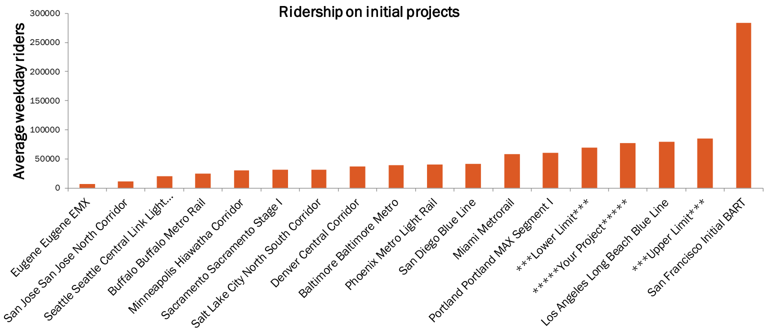
			Uncertainty	
New PMT on the system	270,000,000	±	*10,000,000*	pax miles per year
Capital cost per new PMT	$5	±	*$0*	

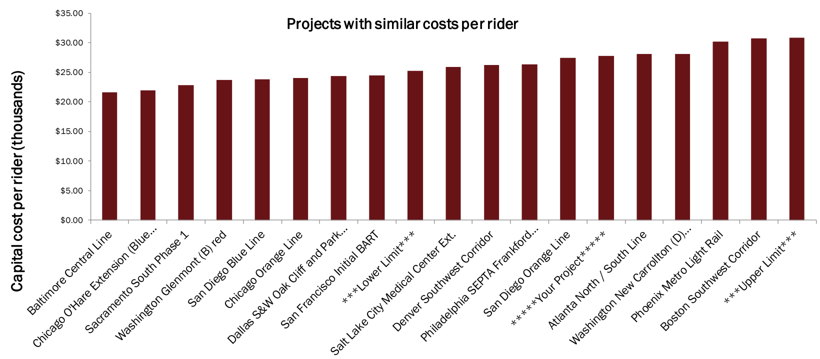


Alternative E – 2035 Consensus Model Outputs

Project Ridership Output

			Uncertainty	
Riders on the project	77,000	±	*8,000*	per average weekday
Capital cost per rider	$ 28,000	±	*$3,000*	



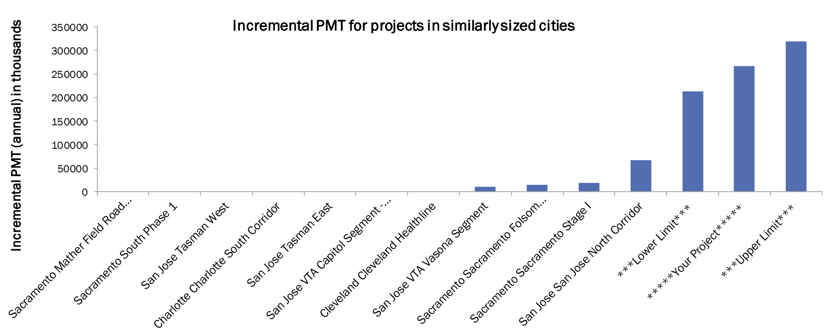


Capital Costs Output

Capital cost (total)	$2,134	MILLION (2009)
Capital cost per mile	$184.28	MILLION/Mile (2009)

System-wide PMT Output

			Uncertainty	
New PMT on the system	270,000,000	±	*10,000,000*	pax miles per year
Capital cost per new PMT	$8	±	*$0*	



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