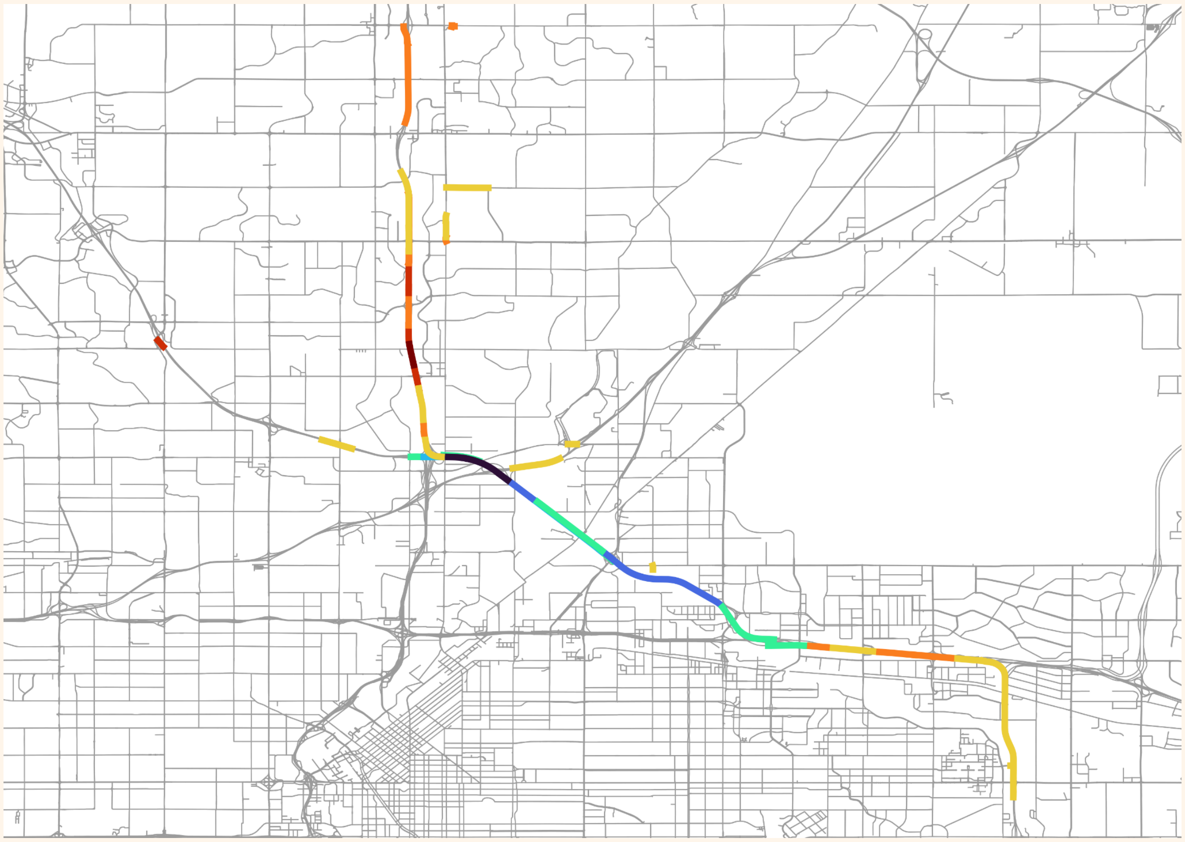
Moving the Bottleneck?

An Independent Technical Analysis of Two Scenarios for I-270 in Colorado.



Ives STREET

1: Executive Summary

The Draft Environmental Impact Statement (DEIS) transportation modeling analysis for the I-270 Corridor Improvements Project is methodologically unsound because it fails to account for the way that adding new roadway capacity will induce an increase in travel.

We present an alternative analysis, using industry-standard techniques and including assignment of induced travel to the roadway network. We find that widening I-270 with the addition of toll lanes would only move bottlenecks from I-270 to I-70 and I-25, resulting in no net change to regional traffic delay and a decrease in access to jobs. Applying a toll to the existing I-270 roadway, however, would reduce congestion delay while increasing access to jobs.

These results demonstrate that including induced travel in an analysis of widening I-270 will dramatically change the findings. A DEIS for I-270 should not be accepted as meaningful or legitimate unless it accounts for induced travel.

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Interstate 270 is an important component of Denver's regional transportation system. A change to I-270 will have impacts on the region as a whole. It is the nature of transportation systems that they are systems of organized complexity, characterized by feedback loops and indirect effects. Accurately predicting the impacts of possible changes to I-270 requires understanding the indirect effects of *induced travel*, the phenomenon of increased car use in response to expanded roadway capacity.

Induced travel means, first, that traffic does not inevitably increase of its own accord. It is perfectly realistic to imagine a Denver region in 2050 with more people, more economic activity, and less car travel. It is within the power of the Colorado Department of Transportation (CDOT) and the Denver Regional Council of Governments (DRCOG) to build such a future. Induced travel also means that any capacity expansion to I-270 would cause a net increase in driving at the regional level. This induced travel could not only eliminate many of the travel-time benefits of the capacity expansion but also cause new bottlenecks to emerge. We discuss induced travel in detail in Section 2, Introduction.

We examine two alternative scenarios, one based on CDOT's "Preferred Alternative" to widen I-270 by adding a toll lane, the other based on a community-driven proposal for a fully-tolled I-270. We detail both visions in Section 3, Scenarios.

In Section 4, Methods, we discuss the techniques used to model the implications of these scenarios. We establish a high-resolution representation of the Denver transportation network, using observed telemetric traffic speed and volume data. We apply induced travel based on an exogenous industry-standard tool and an approximate assignment function, and we account for consequent congestion delays using traditional volume-delay functions. To complete this study within the 60-day comment period, we have had to make a number of simplifying assumptions. In doing so, we have tried to err on the side of underestimating the traffic and delay that would be caused by induced travel from a wider I-270. For example, we do not account for time-of-day shifts.
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Our results, presented in Section 5: Results, paint a very different picture than does the DEIS. We find that widening I-270 by adding a toll lane, while it may reduce delay on I-270 itself, will also bring new traffic that will create new bottlenecks on I-25 and I-70. Widening I-270 will redistribute delay rather than eliminating it. CDOT's Preferred Alternative causes no net reduction in delay. For every driver who saves a minute on I-270, another driver will lose a minute on I-70 or I-25. Moreover, the redistribution of delay will be actively harmful to regional connections between locations of residence and employment, reducing average job access by about 0.5%. The traffic caused by induced travel will be particularly harmful to communities in the northern part of the Denver-metro region, dependent on I-25, where access to jobs will fall by as much as 10%.

To the contrary, converting I-270 into a fully-tolled facility would increase regional access by 0.6%, reducing delay on I-270 while reallocation of traffic causes much more modest delays on I-70 and I-25. Although the tolls would be an imposition on some travelers, most would find that the travel-time savings outweigh the monetary cost. While most of the region would enjoy improvements to travel, the greatest beneficiaries would be the northwestern suburbs along US 36. Overall traffic delay would fall by about 300 vehicle-hours in the A.M. peak hour alone.

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Our study is not meant as the final word on these alternatives. Rather, it is an accurate but imprecise analysis that includes factors which have been left out of the CDOT analysis. A legitimate study must:

1. Not include an assumed ambient growth in traffic volumes unless it is justified by induced travel caused by other projects that have already been fully approved and funded.
2. Include an estimate of induced travel from the project which is in line with the range found in the literature consensus, whether it is calculated endogenously or exogenously.
3. Include the effects that such induced travel would have on traffic conditions throughout the region, including on facilities far away from I-270.

We have demonstrated that including these three considerations does not require methodological complication, long analysis times, or large budgets. The CDOT Statement's modeling analysis does not include these factors and therefore cannot provide any meaningful insight into the planning process for I-270. We hope that a future modeling study will include these items and will be used to inform decisionmaking for the future of I-270, along with an inclusive community engagement process and respectful consideration of impacts for human and nonhuman communities in and beyond the Denver region.

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Table of Contents

This study was conducted under engagement with Earthjustice on behalf of GreenLatinos. All materials were prepared by Ives Street, and errors remain the responsibility of Ives Street alone.

Abbreviations

Abbreviation	Meaning
ACS	American Community Survey
A.M.	Ante meridiem; morning peak travel period
BPR	Bureau of Public Roads
CDOT	Colorado Department of Transportation
CO_2-eq	Carbon dioxide equivalent
DEIS	Draft Environmental Impact Statement
DRCOG	Denver Regional Council of Governments
FHWA	Federal Highway Administration
GHG	Greenhouse gas
GTFS	General Transit Feed Specification
LEHD	Longitudinal Employer-Household Dynamics
LODES	LEHD Origin-Destination Employment Statistics
MPO	Metropolitan Planning Organization
OSM	OpenStreetMap
RMI	Rocky Mountain Institute
RTD	Regional Transportation District
SHIFT	State Highway Induced Frequency of Travel
TMAS	Traffic Monitoring Analysis System
USDOT	United States Department of Transportation
VDOT	Virginia Department of Transportation
VMT	Vehicle-miles traveled
vph	Vehicles per hour
vphpd	Vehicles per hour per direction

2: Introduction

Transportation is a science of *organized complexity*. Unlike physics, human mobility cannot be described by linear relationships, it is not a question of one billiard ball ricocheting from another. Unlike chemistry, transportation cannot be described by statistical characteristics analogous to heat or acidity. Transportation is, instead, like the life sciences: it must be understood in terms of the interrelationships of many constituent entities of various scales and natures; transportation is a science of indirect effects, feedback loops, and, all too often, unintended consequences.

To predict the effects of proposed interventions in a transportation system – in this case, a widening or tolling of I-270 in Colorado – we must therefore reckon with complex systems of feedback. The Colorado Department of Transportation (CDOT), in their Draft Environmental Impact Statement (DEIS) for the I-270 Corridor Improvements Project, has failed to acknowledge, much less address, the way that feedback systems determine the impacts of transportation projects. The primary failure of the CDOT DEIS is the failure to understand the causes that lead to increases in travel by automobile. Neither growth in population size nor in economic activity, by themselves, reliably cause an ambient increase in vehicle-miles traveled. (Section 2.1.) What does reliably cause such an increase is the expansion of the roadway system, whether through new roads or the expansion of roadway capacity: induced travel. (Section 2.2.)

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This report presents an analysis of two possible scenarios for I-270 in Colorado (the *CDOT Widening Scenario* and the *Healthy Communities No-Widening Scenario*), taking a modeling approach which does not include an ambient increase in traffic but which does include the additional vehicle travel that would be caused by induced travel if I-270 is widened. This study is not the final word on these scenarios' impacts; rather, it demonstrates that any meaningful analysis must exclude ambient traffic growth and must include induced travel, and it provides a directionally-correct prediction of the impacts of the two scenarios.

Throughout our analysis, we follow two principles: First, we prioritize accuracy over precision, resulting in an analysis that incorporates all necessary factors for a meaningful and correct overall assessment of a scenario but with relatively high margins of error on detailed, disaggregated findings. (This is the opposite of the CDOT DEIS approach, which begins with a very roughly-approximated macroscopic regional model and uses it to produce very high-precision, but meaningless, detailed trip-level results).

Our second principle is to predict as little as possible, preferring to describe the *potential* for trips rather than claiming to forecast actual trips that individuals will take. Although it is possible to gather data on actual commuting patterns in the present day, it is neither realistic nor necessary to imagine that these commuting patterns will remain fixed in future years. Individuals will change their places of residence and work, land-use patterns will begin to shift, and the characteristics of populations will change. Rather than forecasting the lengths of specific commutes, we believe that it is both more rigorous and more useful to speak about the potential for people living in a certain area to reach places of employment – that is, to measure 'access to jobs' (Section 4.4).
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This study is not intended as the final word on the potential impacts of widening or tolling I-270. Although these results are more realistic than those of the CDOT DEIS because of their inclusion of induced travel, there are many important factors that we were not able to include because of the short window provided by the 60-day public comment period on the DEIS. For example, we were only able to assess the A.M. peak period, we could not include peripheral areas of the Denver region such as Boulder, and we were not able to endogenously model time-of-day shifts. Including these factors would have been ideal, and they should be included in future full modeling done by CDOT, but they are less impactful than induced travel.

Above all, this report should be interpreted to show that the spatial allocation of induced travel is a necessary factor in forecasting the potential impacts of any scenario that involves widening I-270. Any modeling assessment that does not include an allocation of induced travel (and the resulting changes in congestion and delay) is not an assessment of sufficient rigor to be used for funding allocation or transportation planning.

2.1: Ambient Increases in Traffic

CDOT assumes that car travel will increase over time, from 926,995 daily vehicle-miles traveled (VMT) in 2023 to 1,443,023 daily VMT in 2050. (CDOT 2025, State Air Quality Technical Report, Table 3). There is no grounding for this assumption. As documented by the Frontier Group in Fig. 1 below, forecasts of increased vehicle travel have time and again failed to materialize since the beginning of this century.

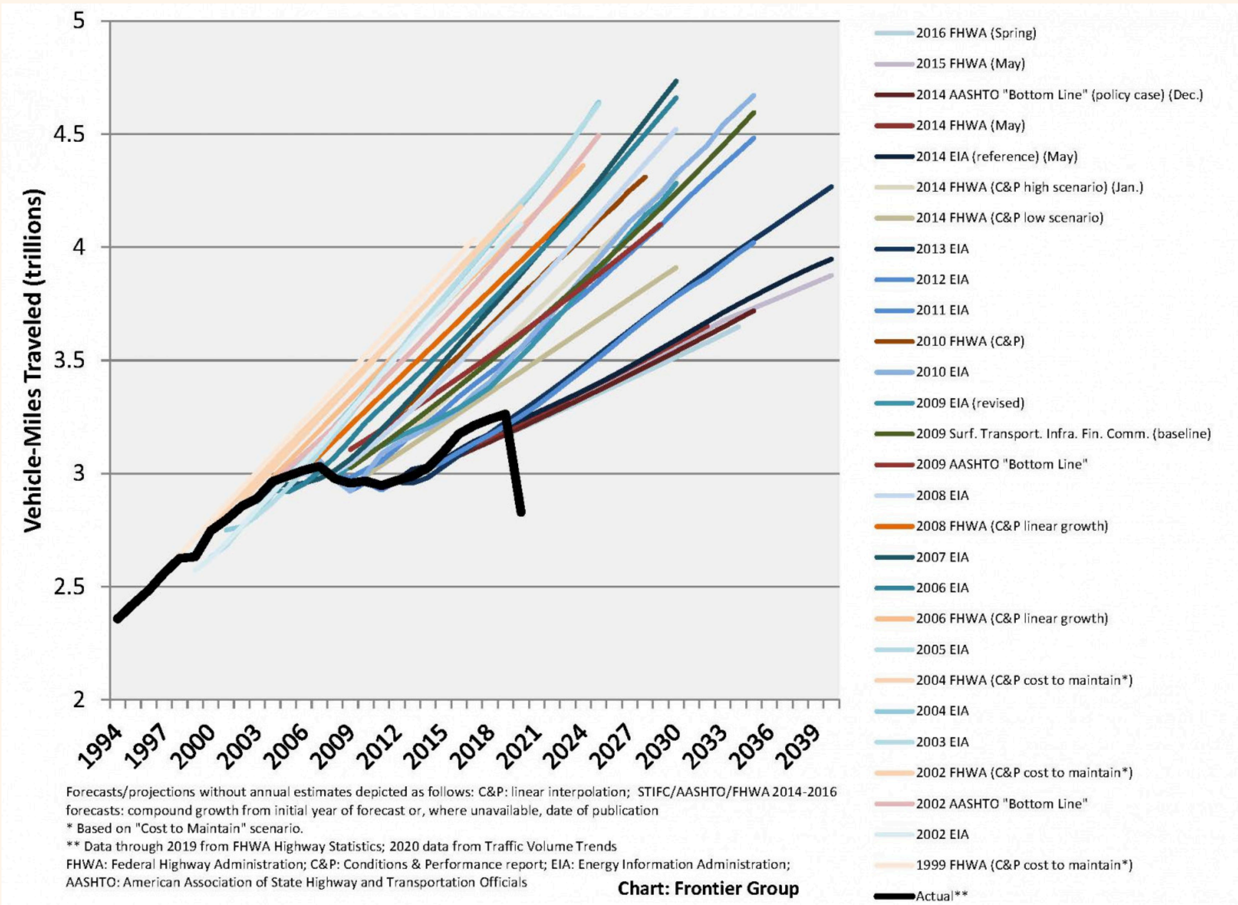

Fig. 1: Linear projections of VMT growth are not borne out in reality.

Moreover, there are many examples of places where vehicle travel has declined even as population, commerce, and employment have grown. Between 1980 and 2000, Arlington County, Virginia, added thousands of new residents along with job and amenity locations along the Wilson Boulevard corridor, above the Washington Metro's Orange Line, and average daily traffic on Wilson Boulevard fell from 19,785 to 18,873 over the same period. It is entirely within CDOT's power to bring about a future in which traffic becomes less, rather than more, intense. All that is required is investments in public transport, walking, and bicycling, along with the concentration of development around high-access public transport corridors and central locations.

2.2: Induced Travel

Traffic does not get worse of its own accord. Traffic gets worse because we build more highways, which attract more cars, in a vicious cycle.

It has been known for decades that widening a roadway will cause an increase in travel activity and vehicle-miles traveled (VMT), a phenomenon called ‘induced travel’ (sometimes ‘induced demand’.) Extensive research has documented this phenomenon across the United States and in other countries, measured its quantitative nature, and explored the mechanisms by which it operates. (Duranton & Turner, 2011; Volker & Handy 2022; Littman 2025).

Consensus on the importance of induced travel has not been limited to the academy. In Colorado, CO Rev Stat § 43-1-128 (2024) requires that CDOT and MPOs provide for “consideration of the impact on emissions of greenhouse gas pollutants of induced travel resulting from regionally significant transportation capacity projects alongside traffic modeling.”

Induced travel results from improved driving conditions on a widened road. It is much like any other example of the relationship between supply and demand: if the supply of a good (in this case, roadway capacity) increases, demand will rise to match it. Induced travel comes from several sources, documented in Table 1 below.

Table 1: Mechanisms of Induced Travel

1. Short-term mechanisms:
    - 1.1. Substitution of driving for travel by other modes of transportation
    - 1.2. Substitution of solo driving for carpooling
    - 1.3. Choice of more distant destinations
    - 1.4. Choice of longer routes to the same destination
    - 1.5. New / additional trips that would not previously have been made
2. Long-term mechanisms:
    - 2.1. Residential & business relocation to more distant and newly-accessible sites in existing structures, leading to longer trips.
    - 2.2. Residential & commercial growth through new construction in more distant and newly-accessible locations, leading to longer trips relative to where that growth might have taken place if not for the capacity expansion.

(see Volker & Handy, 2022)

Induced travel can carry some benefits. New or longer trips represent an improvement in daily life for travelers: perhaps a higher-paying job that was previously outside of a reasonable commute, or the ability to squeeze a social visit into a busy schedule. These benefits to access in different alternatives for the I-270 Corridor Improvements Project are measured in Sections 5.1.4 and 5.2.4, below.

The proposed I-270 Corridor Improvements Project is a highway widening project and would induce substantial new travel activity and VMT. The CDOT DEIS does not properly account for this increase in VMT. The only way in which the Statement claims to account for some aspect of induced travel is the use of the DRCOG Focus 2.3.2 regional model to capture the rerouting of traffic from other modes and routes to driving on I-270 as a result of increased capacity in both Build alternatives. However, the Statement's analysis does not actually indicate that any demand will be induced: it finds that re-routing of traffic from surrounding roads to I-270 will not result in an increase in regional VMT. (State Greenhouse Gas Technical Report, Section 11.)

The Statement's analysis does not include any of the other mechanisms for the induction of travel. It ignores other short-term mechanisms (especially new trips, but also time-of-day shifts), and dismisses long-term mechanisms out of hand: "The project corridor is largely built out with a mix of industrial, commercial, and residential land uses, so the proposed Build Alternatives are not expected to induce substantial new development or land-use changes that would generate additional long-term travel demand (often referred to as 'induced travel')."(State Greenhouse Gas Technical Report, Section 11.)

To the contrary, the Denver region is growing rapidly and it is very likely that an I-270 widening might incentivize new development in places where it would not otherwise have taken place. Such development may be in neighborhoods near the highway, where the value of land may be immediately raised by improved transportation connections, or in more distant peripheral developments where the impact of the I-270 widening may be smaller but nevertheless felt.

The literature has demonstrated that both short-term and long-term induced travel is a critical element of the impacts of any roadway widening. These factors must be included, and not merely dismissed, in any complete analysis of the impacts of the I-270 Corridor Improvements Project.

3: Scenarios

We begin by modeling *Existing Conditions*, the current state of transportation and job access in the greater Denver region. In addition to this baseline, we investigate two potential scenarios for interventions in the regional transportation system. First, we study the *CDOT Widening Scenario*, a representation of what is described in CDOT's Draft Environmental Impact Statement (DEIS) as "The Two General-Purpose Lanes and One Express Lane That Accommodates Transit Alternative." Second, we also assess the *Healthy Communities No-Widening Scenario*, a representation of the alternative proposed by GreenLatinos and Earthjustice and informed by public consultation and an Architects Foundation "Design Assistance Team" report.

The *CDOT Widening Scenario* envisions a Denver region in which I-270 has been widened to at least three lanes per direction along its entire length, with the third lane tolled under a dynamic tolling scheme that ensures free-flowing traffic up to the lane's maximum capacity even when the general-purpose lanes are congested, with a toll value of roughly $1.00/mile at A.M. peak. This scenario also includes a widening to four lanes per direction along the 1.8-mile stretch of I-270 between I-76 and Vasquez Boulevard, as well as general roadway design improvements reflected in an adjustment of per-lane vehicle capacities from 1,500 veh/hr to 1,900 veh/hr.

The *Healthy Communities No-Widening Scenario* envisions a region in which I-270 is made into a fully-tolled express facility across all lanes, without the addition of any new through-lanes, with a toll value of roughly $0.66/mile at A.M. peak. This scenario includes the auxiliary lanes between I-76 and Vasquez Boulevard as well as the general roadway design improvements that increase per-lane capacity to 1,900 veh/hr. All residents of 'Old Commerce City,' defined as the census tracts indicated in Fig. 2 below, are exempted from the toll. This is not meant to represent a policy or planning proposal, only to provide an illustrative example of what a potential plan might look like.

Toll costs in both scenarios are further discussed in Section 4.2.

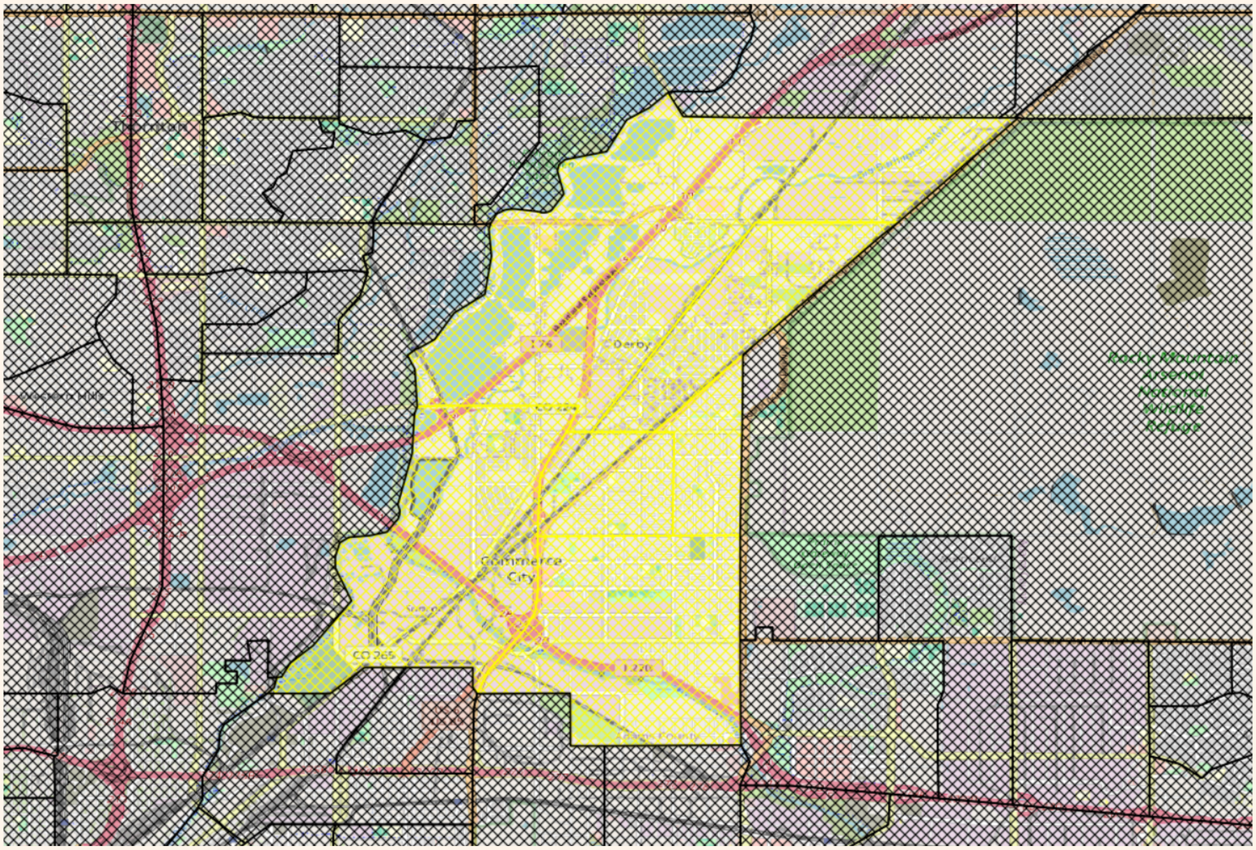

Fig. 2: Residents of Old Commerce City, highlighted in yellow, are exempted from tolls in the Healthy Communities No-Widening Scenario.

For both scenarios, our analysis focuses narrowly on the I-270 mainline: the number of lanes and tolling conditions. Our scenarios do not include proposed interventions in walking and bicycling infrastructure nor in public transit service. The walk, bicycle, and transit interventions described in the CDOT DEIS “Two General-Purpose Lanes and One Express Lane That Accommodates Transit Alternative” are so minor that their impacts will be entirely negligible in comparison to the impacts of the mainline widening. The effects of these interventions would not even come within orders of magnitude of our study’s margin of error. The GreenLatinos Healthy Communities No-Widening Alternative suggests interventions, but it does not describe these interventions in sufficient detail for geospatial modeling.

Our scenarios also omit modeling of the ramp / interchange modifications, including ‘direct connects,’ described in The Two General-Purpose Lanes and One Express Lane That Accommodates Transit Alternative. Although these modifications would have meaningful impacts for the region, they are still small in comparison to the impacts of the mainline widening. Moreover, these impacts would serve only to accentuate the implications of the mainline widening as we model it here. Much like mainline widening, they would serve as a capacity expansion for I-270 within the regional highway network: they would improve driving conditions at the locations where they were built, resulting in reduced delay at those locations, at the expense of inducing travel which would cause congestion in other locations. As such, the omission of the ramp / interchange modifications may slightly alter the extent of the impacts reported for our scenario, but it is highly unlikely to alter their interpretation.

4: Methods

4.1: Summary of Methods

Our analysis consists of three phases. In the first phase, Model Calibration (Section 4.2), we establish a high-resolution geospatial model of the greater Denver region, including all roadways, pedestrian and bicycle infrastructure and public transit service, as well as demographic and employment data at the level of census tracts. Using telemetry data, we populate the roadways with free-flow and peak-hour speeds as well as peak-hour traffic volumes. We calibrate Bureau of Public Roads (BPR)-style volume-delay functions for each segment of roadway.

The second phase is Congestion Forecasting (Section 4.3). In this phase, we examine the effects that each scenario might have on traffic volumes on I-270 and other roadways and we estimate the potential implications for congestion and delay. For the *CDOT Widening Scenario*, this phase is mostly concerned with the way that widening I-270 will reduce congestion on that highway even as induced travel increases traffic and congestion on connecting roadways; for the *Healthy Communities No-Widening Scenario* scenarios, this phase is mostly concerned with reduction of traffic and redistribution from I-270 to alternative/parallel roadways.

Finally, we conduct Access Measurement (Section 4.4), in which we evaluate the implications of the various scenarios for Coloradans' ability to reach job locations. Taking into account varying levels of income, car ownership, and willingness to ride a bicycle, we identify the most convenient mode and route for each individual to reach each potential job location. After calculating a measure of 'generalized access', the value that each individual derives from their ability to reach various jobs locations, we aggregate that measure geographically and demographically. Finally, we compare the various scenarios to assess which one would provide Coloradans with the greatest overall improvement in access to jobs.

4.2: Model Calibration

We use Ives Street's source-available *Connectome* software to establish and calibrate a model of the greater Denver region using data from a variety of sources, summarized in *Table 2* below and subsequently described in greater detail.

Ours is not a full four-step travel demand model, although it includes many of the essential components of such a tool. Our model, like TransCAD, is capable of predicting the *distribution* of changes in traffic – that is, the *assignment* of increased or decreased vehicle travel to particular roadways. However, the key difference is that we rely on exogenous tools to predict the *extent* of these changes. This limitation, however, is not a weakness: see Section 4.3 for more information about how exogenous approaches allow us to understand induced travel more clearly than by using a model such as TransCAD (which ignores induced travel altogether).

Notwithstanding this difference in scope, the mechanics of our model are very similar to those of a traditional, industry-standard four-step approach. Most importantly, we examine peak-hour travel conditions (focusing on the A.M. peak) and we employ the time-tested Bureau of Public Roads (BPR) volume-delay function. We examine aggregate flows between origin and destination zones by routing them over a geospatial network.

Table 2: Sources of Data Used in Model Calibration

Data Category	**Source**
Study area bounds	N/A
Road network, walking and cycling infrastructure	OpenStreetMap
Public transit service	GTFS
Free-flow traffic speeds	TomTom speeds
A.M. peak hour traffic speeds	TomTom speeds
Traffic volumes	TomTom sample sizes, calibrated to FHWA TMAS counts
Roadway capacities	Derived from functional classes
Volume-delay function alpha / beta values	Derived from functional classes
Toll costs	CDOT existing facilities
Parking costs	Parkopedia
Analysis area geometry (census tracts)	US Census
Demographic data	US Census ACS
Job location data	US Census LEHD LODES

Study Area Bounds

Our study area includes all census tracts in the Denver region within a 12.4 mile (20km) radius of the center of I-270, amounting to some 452 tracts with a population of 1.9 million, shown in Fig. 3 below. This is a smaller area, with fewer analysis zones, than the full DRCOG TransCad model, but this area contains the majority of the DRCOG regional population and is sufficient for an accurate assessment of the two scenarios. A larger or higher-resolution study area would provide greater detail, but would be unlikely to change the overall findings of the analysis.

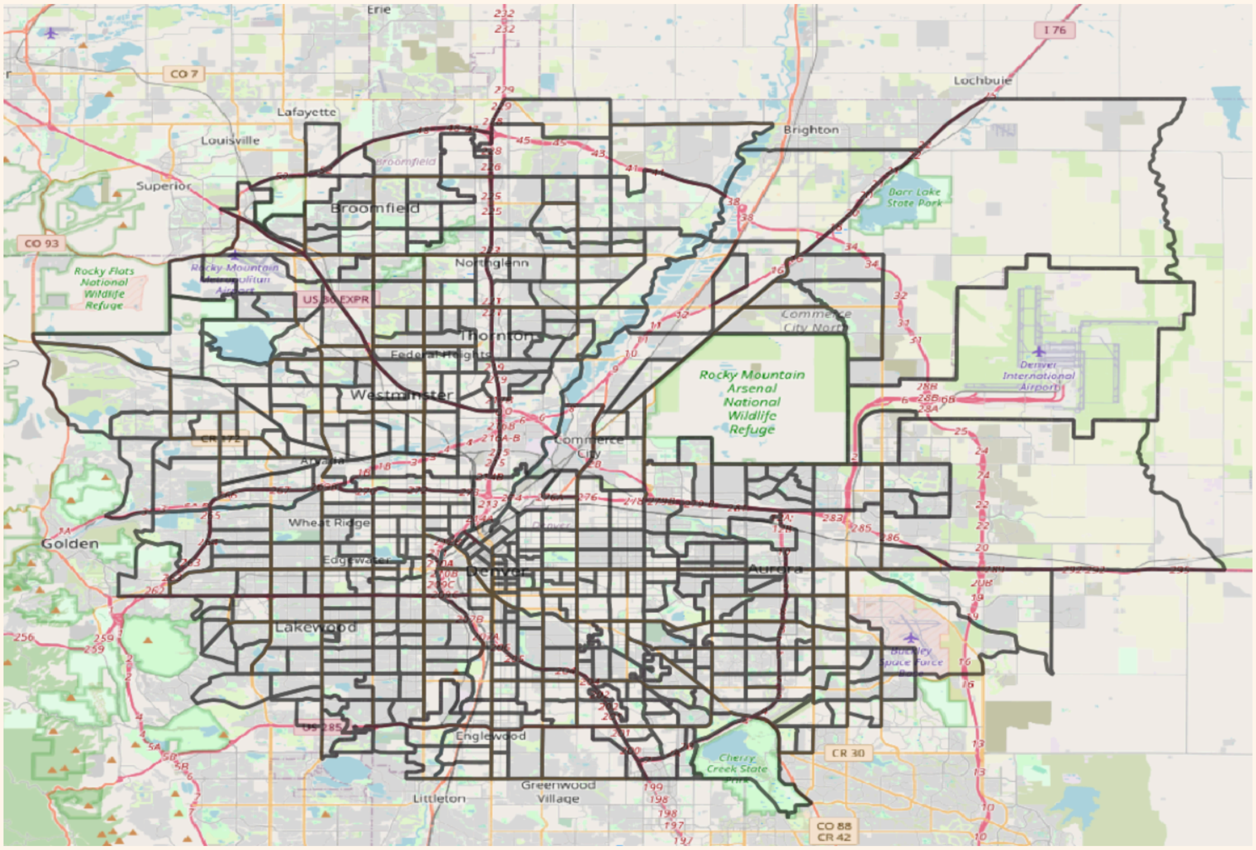

Fig 3: Study area bounds and analysis areas

Throughout this report, whenever we use the phrase “Denver region” or “study area”, we intend to refer to these boundaries.

Road Network, Walking, and Cycling Infrastructure (OpenStreetMap)

We derive the full roadway, pedestrian, and bicycle network from OpenStreetMap (OSM). OSM provides the most comprehensive, mode-inclusive, and spatially detailed representation of transportation infrastructure currently available at metropolitan scale. Unlike legacy planning networks that are often simplified or car-oriented, OSM includes local streets, ramps, trails, sidewalks, crossings, and bicycle facilities—elements that are essential both for realistic congestion modeling and for access analysis. A particular advantage of OSM is short segment lengths, often in the hundreds or even tens of meters, which carries into our model and permits us to identify congestion hotspots at high resolution.

OSM data quality can vary by location and facility type, particularly with respect to lane counts, turn restrictions, and bicycle attributes. To mitigate these risks, we apply conservative defaults where tags are missing, cap implausible values, and validate resulting speeds and capacities against observed traffic conditions.

Public Transit Service (GTFS)

Public transit service is represented using General Transit Feed Specification (GTFS) data published by the Denver-area Regional Transportation District (RTD). GTFS is the global standard for representing scheduled transit service and provides a consistent description of routes, stops, headways, and travel times across all modes of fixed-route transit.

GTFS reflects scheduled rather than observed performance and does not directly capture reliability or crowding effects. In view of this limitation, the study's results concerning transit must be viewed as representing typical scheduled conditions rather than best-case or worst-case performance. Because the comparative analysis focuses on differences between scenarios, systematic schedule bias is unlikely to affect relative conclusions.

RTD is not the only operator offering transit service in the study area. Others, such as Bustang or Kimball County Transit Service, are also relevant, although their contributions to regional mobility are an order of magnitude smaller than RTD's. However, the GTFS feeds published by these operators failed the data quality validation necessary for use by the routing engine employed in this study (r5py; see Section X.X). Within the timeframe of the public comment period it was not feasible to include service provided by these operators in the model. As such, we conclude that the study results may understate the contribution of public transit to access to jobs across the region.

Free-Flow and A.M. Peak Hour Traffic Speeds (TomTom)

We use TomTom historical speed data to populate both free-flow speeds and observed A.M. peak-hour speeds on the roadway network. TomTom data is derived from large-scale passive telemetry and provides empirically observed travel speeds at fine spatial resolution across nearly the entire network.

We use TomTom to include real-world speed data for all streets and roads in TomTom's functional classes 0-6, corresponding to all highways, arterials, and collectors as well as the majority of residential streets.

We derive free-flow speeds by averaging a sample of traffic during nighttime hours of 1:00a.m.-4:00a.m. over ten weekdays: Monday, August 5th, 2024 - Friday, August 16th, 2024, not including weekends. We derive A.M. peak hour speeds by averaging a sample from 6a.m. to 9a.m. over the same range of dates. Throughout the analysis, we only use input data representing weekdays. Our choice of weekdays here is for the sake of consistency.

We select a sample during August for the sake of conservatism. Traffic congestion is generally lighter during August during other times of year because school is not in session and many commuters are enjoying vacations. August is therefore the time of year when induced traffic is likely to have the least dramatic effect on congestion delay. Any conclusions from this study are therefore likely to underestimate the delay caused by induced travel in the *CDOT Widening Scenario*.

Telemetry data permits us to represent road conditions at much higher resolution and accuracy than traditional methods. The key advantage of using the same source for both free-flow and congested speeds is internal consistency. Free-flow speeds represent uncongested conditions inferred from nighttime observations, while peak speeds reflect real congestion patterns rather than model assumptions. Among other advantages, this enables segment-specific calibration of volume-delay relationships rather than reliance on generalized speed-flow curves alone.

Telemetry data may be subject to sampling bias by vehicle type, trip purpose, or routing preferences. We mitigate these risks by selecting a large, industry-standard data provider, aggregating observations over sufficient time windows to reduce noise, and validating resulting congestion patterns against independent volume counts (see *Traffic Volumes* below). TomTom speeds are not used in isolation but are integrated with volume data during calibration.

As discussed in the Introduction (Section 2), we do not forecast any increase in vehicle travel relative to the present day except for demand induced by the widening of I-270 itself. There is no *a priori* reason to assume that traffic levels will increase in the Denver region unless they are caused to do so by CDOT's expansion of roadway capacity. It is just as plausible for CDOT to invest in multimodal transportation options that reduce traffic over the coming quarter-century.

Traffic Volumes (TomTom Sample Sizes Calibrated to FHWA TMAS)

We estimate A.M. peak-hour traffic volumes by calibrating TomTom probe sample sizes (over the full two-week sampling period) to observed traffic counts from the Federal Highway Administration (FHWA) Traffic Monitoring Analysis System (TMAS). TMAS provides direction-specific hourly volumes at count stations and serves as the authoritative reference for absolute traffic demand, but its spatial coverage is limited. TomTom data, by contrast, provides continuous network-wide coverage but cannot directly report volumes.

To integrate the two datasets, we first match TMAS station–direction records to specific directed roadway segments using a multi-criteria scoring process that accounts for proximity, directional alignment, functional class consistency, and route number agreement. Only high-confidence matches are retained, and stations with incomplete hourly data during the analysis window are excluded.

For matched stations, we compute mean A.M. peak-hour volumes and treat these as fixed observations on the corresponding roadway segments. We then estimate a single proportional conversion factor relating TomTom sample counts to observed TMAS volumes using a regression constrained through the origin (identifying a coefficient of 0.105 cars / TomTom sample, for an R^2 of 0.82: see Fig. 4 below). This factor is applied uniformly across the network to infer peak-hour volumes on all segments with TomTom data. This approach anchors inferred volumes to federal count data while preserving the spatial detail of telemetry.

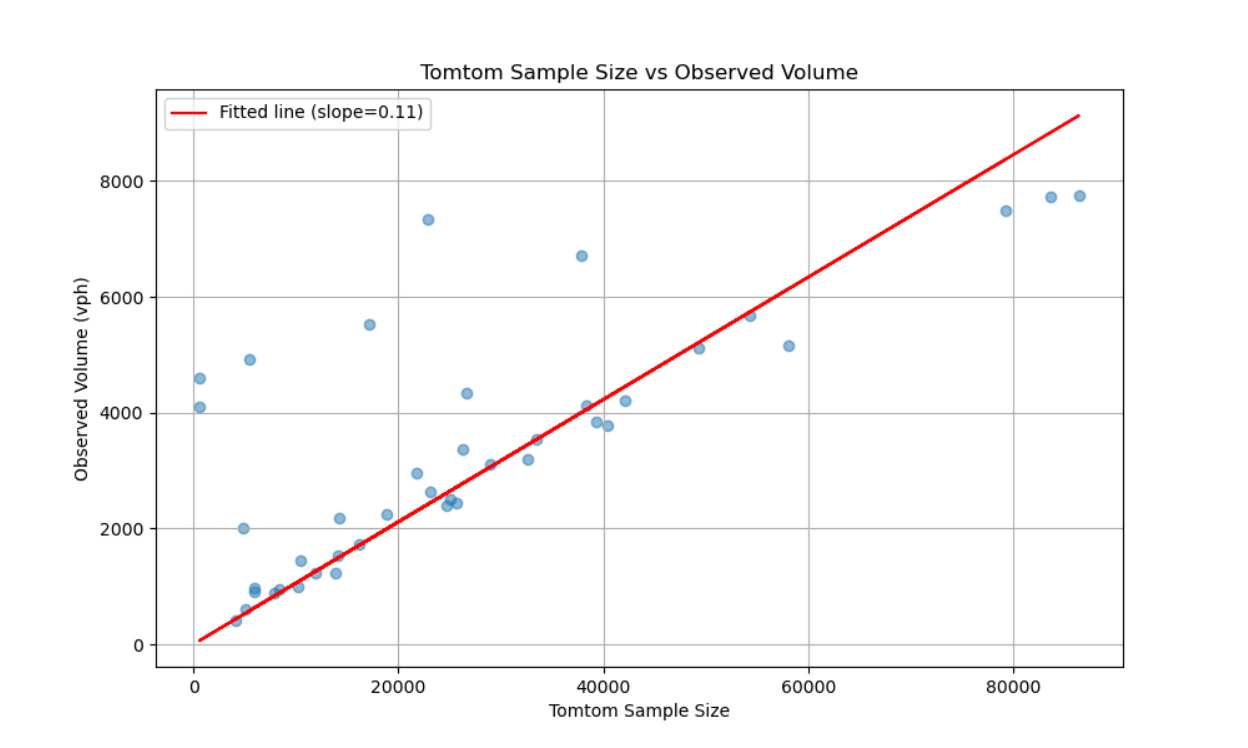

Fig. 4: Observed traffic volumes from FHWA TMAS correlate relatively well with TomTom sample sizes within the study area.

Roadway Capacities (Derived from Functional Class)

We assign directional roadway capacities using a functional-class–based approach that integrates OpenStreetMap geometry, lane information, and a unified configuration of per-lane capacities. Each roadway segment is classified into a functional class based on its OSM highway tag and inferred number of lanes per direction. Where lane counts are explicitly tagged, we use them directly; where they are missing or ambiguous, we apply conservative default lane counts by roadway type.

Per-lane capacity values are specified by functional class and reflect typical peak-hour throughput under prevailing traffic control conditions: see *Table 3* below. These values are intentionally conservative: they are lower than most of the values used in the DRCOG/CDOT TransCAD model, and they are applied directionally, consistent with the directed graph structure of the network. For segments approaching signalized intersections, effective capacity is reduced using functional-class–specific signal adjustment factors. Signal influence is propagated upstream along the network to reflect queue spillback and intersection control effects rather than treating signals as point disruptions.

Table 3 — Per-Lane Capacity Assumptions by Functional Class

Functional class	Typical facility description	Capacity per lane (vph)	Signal treatment
Freeway	Fully access-controlled facilities	1,600	N/A
Multilane arterial	High-capacity arterials with signals	1,300	Reduced near signals
Smaller arterial	Urban/suburban arterials	1,100	Reduced near signals
Collector	Collectors and minor arterials	1,000	Reduced near signals
Local	Local and access streets	700	Reduced near signals

The selection of 1,600 vph/lane for freeways reflects the high proportion of trucks on I-270 and many other Denver-area freeways, as well as the observed capacities of general-purpose lanes in the current decade, as the average size of passenger cars has grown since the 20th century. (Gao & Levinson, 2025). This value is validated as it provides the best fit for speeds and volumes observed in the TomTom data.

In the *Existing Conditions Scenario*, we apply a capacity of 3,000 vphpd (total, not per lane) all along I-270 to reflect poor conditions as described in the CDOT DEIS.

This hybrid approach balances realism with robustness: it avoids overfitting while ensuring that capacity assumptions are internally consistent and defensible across the region.

Volume–Delay Function Parameters (α, β) (Derived from Functional Class)

Congestion effects are modeled using a Bureau of Public Roads (BPR)-style volume-delay function, parameterized by functional class. For each roadway segment, we assign α and β parameters based on its functional classification, ensuring that facilities with different design standards and traffic controls exhibit appropriately different congestion responses, as shown in *Table 4,* below. These parameters govern the sensitivity of speed and travel time to increases in the volume-to-capacity ratio.

Higher-order facilities such as freeways are assigned relatively low α values and high β values, reflecting stable performance under moderate congestion followed by rapid breakdown near capacity. Lower-order facilities are assigned higher α and lower β values, reflecting earlier onset of delay and a more gradual degradation of performance. These choices are consistent with empirical observations and with standard practice in regional travel modeling, while remaining transparent and easy to audit.

Table 4 — Volume-Delay Function Parameters by Functional Class

Functional class	α (alpha)	β (beta)	Congestion behavior
Freeway	0.15	6	Late, sharp breakdown

Multilane arterial	0.3	5	Moderate sensitivity
Smaller arterial	0.6	3	Early delay onset
Collector	0.8	2.5	Gradual degradation
Local	0.9	2	Highly delay-sensitive

Toll Costs (CDOT Existing Express Lane Facilities)

We estimate toll costs using pricing on existing CDOT-operated express lane facilities in the Denver region: I-25 Central and I-70 Central. These facilities provide the closest real-world analogs to the tolled scenarios evaluated in this study. Current tolls are a combination of fixed pricing (on I-25) and dynamic pricing (on I-70), and capture the range of prices users actually face during peak conditions.

Across existing facilities, as illustrated in *Table 5* below, peak-period tolls span a wide range depending on corridor, time of day, and congestion intensity. On I-25 Central, fixed peak tolls during the A.M. commute correspond to approximately $1.50–$1.80 per mile. On I-70 Central, dynamic tolls vary substantially, with lower-bound prices near $0.15 per mile under uncongested conditions and upper-bound prices exceeding $0.50 per mile (presumably at peak hours). When normalized by distance, these facilities collectively suggest a plausible peak-hour toll range of roughly $0.40–$1.80 per mile.

For modeling purposes, we adopt a representative toll rate of $1.00 per mile for the *CDOT Widening Scenario* and a value of $0.66/mile for the *Healthy Communities No-Widening Scenario*. This value lies near the midpoint of observed peak tolls on comparable facilities.

Table 5 — Toll Values in Regional Context

Corridor (direction)	Pricing type	Peak-period toll range	Segment length (mi)	Implied cost per mile
I-25 Central South (inward)	Fixed	$7.75–$8.95	~5.0	$1.55–$1.79
I-25 North (outward)	Fixed	$3.25	~6.0	$0.54
I-70 Central WB/EB	Dynamic	$1.55–$6.00	~10.5	$0.15–$0.57
Modeling value: *CDOT Widening Scenario*	—	—	—	$1.00 / mile (≈ $0.62 / km)
Modeling value: *Healthy Communities No-Widening Scenario*				$0.66 / mile (≈ $0.41 / km)

Parking Costs (Parkopedia)

Referencing data from Parkopedia[1], we estimate an average daily parking cost of $10 for eight hours in parts of Denver with a job density of more than 40,000 jobs/km^2.

Analysis Area Geometry (U.S. Census Tracts)

Census tracts are used as the primary spatial units for aggregating population, employment, and access outcomes. Tracts offer a stable, nationally standardized geography that balances spatial resolution with data availability and statistical reliability. The advantage of using census tracts is their compatibility with multiple federal datasets, including the American Community Survey (ACS) and Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES), enabling consistent integration of demographic and employment information. Tracts are also commonly used in equity and environmental justice analysis, facilitating interpretation by a policy audience.

As a relatively large analysis unit, tracts can mask fine-grained neighborhood variation. In a study assessing the impacts of a smaller intervention, such as a bicycle facility or change to a neighborhood road, tracts would be a poor choice. However, because the present study is examining the regional implications of a massive infrastructure investment, the advantage of tracts is that they enable us to model a larger area, including more of the greater Denver region.

Demographic Data (American Community Survey)

Demographic characteristics are drawn from the ACS, including population, racial/ethnic distribution, income, and vehicle ownership. ACS provides the most comprehensive and regularly updated source of small-area demographic data in the United States. These attributes are used to parameterize generalized access calculations, such as sensitivity to travel cost or the feasibility of different modes.

ACS estimates are subject to sampling error, particularly for small populations. To mitigate this, we rely on multi-year estimates and focus on relative differences across scenarios rather than precise point estimates. The analysis does not attempt to predict individual behavior but rather to characterize structural accessibility patterns across groups.

Job Location Data (LODES)

We represent employment locations using the Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES) dataset. LODES provides extensive and high-resolution spatial information on job locations, making it well suited for access-to-jobs analysis.

LODES data may under-represent informal or very small employers. These limitations are mitigated by aggregating access outcomes across many destinations and focusing on comparative scenario changes. Because the same job dataset is used consistently across all scenarios, relative conclusions are meaningful.

[1] https://en.parkopedia.com/

4.3: Congestion Forecasting

After establishing and calibrating a multimodal model of the Denver region, we proceed to use that model to forecast the implications that each of our scenarios might have for traffic conditions. The *CDOT Widening Scenario* and *Healthy Communities No-Widening Scenario* offer different challenges.

In studying the *CDOT Widening Scenario*, we must ask: how much additional vehicle activity will this widening bring about? If more cars are traveling on I-270, they must also be traveling on other roads along their journeys: which ones? What effect will they have on congestion on those roads? As described in Section 4.3.1, we answer these questions by employing the exogenous *State Highway Induced Frequency of Travel* calculator to estimate the total increase in vehicle-miles traveled, by assigning this travel to the network according to potential commuting patterns, and by using volume-delay functions to calculate the resulting implications for traffic delay.

Different questions pertain to the *Healthy Communities No-Widening Scenario*. In addition to a smaller amount of VMT that will be induced by the addition of auxiliary lanes (which we model using the same procedure documented in Section 4.3.1), we must also consider the effects of reduction and redistribution of travel from I-270 to other facilities in response to the imposition of tolling. Our approach to this consideration is described in Section 4.3.2.

4.3.1: Induced Travel

For the *CDOT Widening Scenario*, congestion forecasting is driven primarily by induced travel. Expanding roadway capacity will increase speeds on I-270 in the short term, which in turn leads to additional vehicle travel that would not otherwise occur. As discussed in Section X.X, induced travel comes about through many direct and indirect mechanisms. This additional travel does not remain confined to the expanded facility itself: it propagates across the broader network as travelers make complete door-to-door trips. Our induced-demand analysis therefore proceeds in three steps: estimating the total increase in vehicle-miles traveled (VMT), assigning that travel spatially across the network, and calculating the resulting impacts on congestion and delay.

Estimating Total Induced Travel

There are two ways that an analyst may attempt to predict induced travel, summarized as 'bottom-up' (endogenous) or 'top-down' (exogenous). The bottom-up approach is to attempt to understand, measure, and model each of the many phenomena that contribute to induced travel, including short-term changes in travel behavior and long-term changes in land use and the built environment. To estimate induced travel in a bottom-up way requires detailed analysis of dozens of components of behavioral psychology, land economics, and transportation mechanics; there is little evidence of researchers accurately predicting induced travel at the project level using an endogenous approach. The top-down, exogenous approach is much more effective: it relies on the many decades of experience in the United States and other countries in which roadway capacity expansions have almost invariably resulted in increased travel. In this well-studied history, there is a remarkable consistency in the ratio between the extent of a capacity expansion and the aggregate resulting increase in car travel. This consistent ratio can be used for a top-down estimate of the travel that will be caused by an urban highway widening. (CDOT's DEIS takes neither an exogenous nor endogenous approach to induced travel, providing only a stated assumption that induced travel will not apply in the case of an I-270 widening and providing neither justification nor citation for that claim.)

We estimate the total increase in vehicle travel exogenously using the *State Highway Induced Frequency of Travel* (SHIFT) calculator developed by the Rocky Mountain Institute. SHIFT is a peer-reviewed, elasticity-based tool designed for evaluating induced travel from highway capacity expansions. It incorporates empirical evidence from decades of U.S. roadway expansions and provides conservative, policy-appropriate estimates of long-run changes in VMT attributable to added capacity. SHIFT uses the same rigorously-established methodology as the California Induced Travel Calculator developed by the USDOT's National Center for Sustainable Transportation at the University of California, Davis. The authors describe this methodology as appropriate for toll lanes such as those described in our scenarios, finding that there is no reason to believe that toll lanes would cause lower induced travel than general-purpose lanes. (Volker & Handy, 2022)

SHIFT produces an estimate of the net increase in annual VMT associated with the *CDOT Widening Scenario*, accounting for multiple mechanisms of induced travel. These mechanisms include latent demand (previously suppressed trips), longer trip distances, shifts from other modes, shifts from shorter routes, and land-use–mediated effects over time. Importantly, SHIFT estimates net new travel rather than simply reallocating existing traffic, making it well suited for regional-level evaluation.

Because SHIFT returns a range of potential annual induced VMT, we divide that range by 260 weekdays / year for an estimated range of average weekday induced VMT. We then take the midpoint of that range and adjust it by a K-factor of 0.12 (12% of induced travel takes place during the morning peak hour). This is on the high end, but within the standard range, of FHWA guidance on K-factors (FHWA 2018). We have chosen a relatively high factor to account not only for new travel taking place during the peak hour, but also for time-of-day shifts as travel currently taking place outside of the peak takes advantage of new capacity by shifting to the peak hour.

We treat the adjusted SHIFT output as an exogenous input for total induced travel in the Connectome model. That is to say: Connectome is required to accommodate the specified increase in VMT, rather than determining induced travel endogenously through repeated assignment iterations. This choice reflects both the time horizon of roadway expansion impacts and the need for a conservative, transparent methodology that does not depend on "bottom-up" speculative behavioral assumptions embedded in a full regional model.

Time-of-Day Shifting

Like the CDOT DEIS, our approach omits one crucial factor that would make an assessment of induced travel more accurate: time-of-day shifting. This has the effect of making our analysis of induced travel, and resulting implications for congestion and access, more conservative.

In order to avoid traffic congestion, many Denverites often make trips at times of day that they do not consider ideal. For example, someone may prefer to arrive at work at 9a.m., but because traffic congestion is worst at that hour of the morning, they commute at 7a.m. instead. When capacity is added to the roadway system, that person - and many of their neighbors - may respond by shifting their time of departure to be closer to their preference, taking advantage of the wider highways. This time-of-day shift represents a meaningful improvement in quality of life, as people are better able to approximate their ideal daily schedule; the shift also compounds the effects of induced travel and saturates a capacity expansion even more fully than is reflected in our analytical approach.

Our selection of a K-factor of 0.12 (as opposed to, say, 0.10) is the only way that we represent time-of-day shifts, and the overwhelming likelihood is that this is an underrepresentation. In reality, it is almost universal that capacity expansions in urban areas return to congested flow within a few years of project completion, largely as a result of time-of-day shifting. In light of our omission of time-of-day shifts, our analytical results are conservative: they underestimate the volume of traffic that will ply I-270 after a widening, and they overestimate post-widening speeds.

Spatial Assignment of Induced Travel

Once total induced VMT is estimated, we distribute that travel across the roadway network. Induced trips generated by an I-270 widening are not random; they are shaped by the region's travel patterns, land-use distribution, and network topology. To capture these dynamics without introducing a full four-step model, we assign induced VMT to all roads in the region that are likely to be used on trips involving I-270 in proportion to the likelihood of their being used for such trips.

To do this without introducing a full four-step travel demand model, we leverage the access-to-destinations analysis described in Section 4.4. For every resident–job pair in the study area, we identify the most convenient mode and route based on generalized travel cost, including both time and monetary cost. This produces a large set of origin–destination connections, each with an associated "access-value" that reflects the relative attractiveness of that connection.

We then isolate the subset of these connections for which driving or ridehail is the most convenient mode and for which the driving route includes I-270 on any leg of the trip. These connections represent the universe of car trips that likely involve I-270. Each such trip is weighted by its access-value, reflecting its relative contribution to regional travel demand. We distribute this weighted demand across every roadway segment used by the trip and then sum across all qualifying trips. The result is a network-wide weighting in which each roadway link is indexed by how likely it is to be used by car trips that involve I-270.

Finally, we distribute the total induced VMT estimated by the SHIFT model across roadway links in proportion to this weighting. In effect, induced travel is allocated more heavily to roads that already play a larger role in I-270–related trips, while still allowing induced travel to propagate across the broader network. Roadways that are unlikely to be used in trips involving I-270 are unaffected. This approach preserves realistic spatial patterns of travel without requiring explicit behavioral simulation or equilibrium assignment.

This is a first-order approximation. It is plausible that induced travel resulting from I-270 widening would cause 'ripple' effects even in roadways and neighborhoods at some distance from the highway itself as motorists seek alternative routes to the emerging congestion. Similarly, it is also plausible that a certain amount of traffic would redistribute from I-70 and I-25 to I-270 taking advantage of higher speeds, although that effect would certainly be mitigated by the new delays caused by induced travel. Within the timeframe of the public comment period, it was not feasible to measure those indirect effects, but they should be included in a full study of alternatives for this project.

Translating Induced Travel into Congestion and Delay

After induced volumes are assigned to the network, we estimate their effects on traffic conditions using the calibrated volume-delay functions described in Section 4.2. Each roadway segment's additional volume is combined with its baseline peak-hour volume to compute a new volume-to-capacity ratio, which in turn determines changes in speed and delay.

This approach captures a central insight of induced travel analysis: even modest percentage increases in traffic volumes can produce disproportionate increases in delay on facilities operating near capacity. Because many adjoining road segments in the region already operate under constrained conditions during the A.M. peak, induced traffic can significantly degrade performance on facilities that are not themselves expanded.

We emphasize that, in many respects, our Connectome model is an estimate, more accurate than precise. The estimates should not be used to focus on precise impacts to specific roads. Instead, the analysis sheds light on the magnitude of the traffic problems that will be caused by widening I-270 and whether or not those problems will outweigh the benefits enjoyed by motorists on a wider I-270.

4.3.2: Reallocated Travel

In modeling the *Healthy Communities No-Widening Scenario*, we must reallocate car travel from I-270 to other routes to reflect travel redistribution in response to tolling. Because the Connectome model is not capable of carrying out this reallocation in an endogenous, equilibrated manner, we must rely on a rough but directionally-correct proxy. We identify the total *excess volume* being carried on I-270 (after accounting for induced travel), and we reallocate that excess volume to a parallel route in order to maintain I-270 in laminar flow, as will be guaranteed in operation by use of a dynamic tolling system.

We identify the total excess volume by identifying the single segment of I-270 in which volume exceeds capacity by the greatest amount. We remove that volume from the entire length of I-270, not only that segment. We multiply the excess volume quantity by a 'rerouting factor' of 0.75 to calculate a *reallocation quantity*. This represents the fraction of travelers, 75%, who will respond to I-270 tolling by rerouting to a different roadway, rather than changing their travel time, carpooling, shifting to a different mode, changing their travel destination, or choosing not to travel.

We then add this reallocation quantity to the traffic volumes on the entire I-25 and I-70 "triangle" in the same direction as the I-270 traffic, before recalculating the volume-delay function and resulting travel speeds for all segments in the "triangle".

This approach serves as a directional and order-of-magnitude approximation of the impacts to be expected from tolling the entire I-270 mainline. A future study could employ an approach capable of estimating the many various different diversions that might be taken by travelers in response to the tolling scheme, most of which will be shorter than the full length of the I-25-to-I-70 route. Such a future study would provide more granular detail on the specific new bottlenecks that might emerge in the *Scenario*, perhaps on Vasquez Boulevard or I-76 rather than I-25 and I-70 . Our approach, however, functions as a 'worst-case' conservative scenario, and indicates the general nature - though not the specific details - of the impacts to be expected in the *Healthy Communities No-Widening Scenario*.

4.4: Access to Jobs

This study evaluates scenarios using an access-to-destinations framework, which measures how easily people can reach the places they may want to go. Rather than focusing exclusively on mobility outcomes such as vehicle-hours of delay, this approach provides a performance metric that is more directly related to everyday lived experience. Access is shaped jointly by proximity (where destinations are located) and mobility (how costly it is to reach them), and changes in either can meaningfully affect people's ability to participate in economic and social life.

The modeling framework implemented here builds on a growing body of research arguing for the use of general access metrics in transportation planning, including formal treatments such as Levinson and Wu's theory of general access (Levinson & Wu, 2020), and the increasing operational use of accessibility measures by agencies such as Caltrans and VDOT in funding and performance assessment (CalTrans 2025, VDOT 2025). In this study, access-to-jobs serves as a unifying metric that allows changes affecting different modes, costs, and travel times to be evaluated on a common basis.

4.4.1 Multimodal Routing

Each scenario is defined as a coherent set of assumptions about transportation networks, costs, and operating conditions, as described in Section 3. All scenarios share a common set of analysis zones, representative origin points, population characteristics, and destination weights, ensuring that differences in results reflect scenario assumptions rather than changes in geography or demographics.

For each scenario, multimodal routing is performed independently for car, public transit, walking, and bicycling. Routing is carried out between representative points for each analysis zone, producing complete origin–destination travel time matrices by mode. For car travel, routing is based on a directed roadway network with link-level travel times that reflect scenario-specific congestion conditions. For transit, routing incorporates scheduled service, transfers, and access and egress walking. Walking and bicycling routing use the same underlying network geometry, with mode-specific assumptions about speed and facility eligibility.

In addition to travel time matrices, the Connectome model produces supporting matrices that record route distances, monetary costs, and, where relevant, whether shortest paths cross specific network elements such as priced facilities or control points.

4.4.2 Generalized Impedance and Mode Choice

For each unique combination of (1) scenario, (2) demographic subgroup (or 'user class'), (3) origin zone, and (4) destination zone, our approach identifies the mode and route that presents the lowest *generalized cost* - the lowest combination of time and monetary cost. Monetary costs include operating costs such as fuel, parking charges, transit fares, and tolls where applicable. These costs are converted into equivalent minutes of travel using income-specific conversion factors, reflecting current research on the value of travel time. (Littman, 2023).

This generalized impedance formulation is explicitly not a behavioral choice model. Instead, it is a deterministic cost-minimization device that identifies, for each origin–destination pair and user class, the mode that offers the lowest generalized cost under the assumptions of the scenario. User classes differ in income, car availability, and willingness or ability to use specific modes, which constrains the set of modes considered available for a given trip.

The outcome of this step is, for each user class and origin–destination pair, a selected mode and an associated generalized travel cost. These selections are internally consistent across scenarios and provide a transparent mapping from scenario assumptions to implied travel conditions, without introducing additional behavioral parameters.

4.4.3 Access Evaluation

General access-to-destinations is calculated by valuing each origin–destination connection as a function of its generalized travel cost and the number of destinations available at the destination. Rather than applying a hard travel-time cutoff, the model uses a continuous decay function in which nearer destinations contribute more to access than more distant ones, but distant destinations still retain some value. Our decay function, which uses an exponent of $0.05t$, is shown in Fig. 5 below. This approach better reflects observed travel behavior and avoids artifacts associated with threshold-based measures.

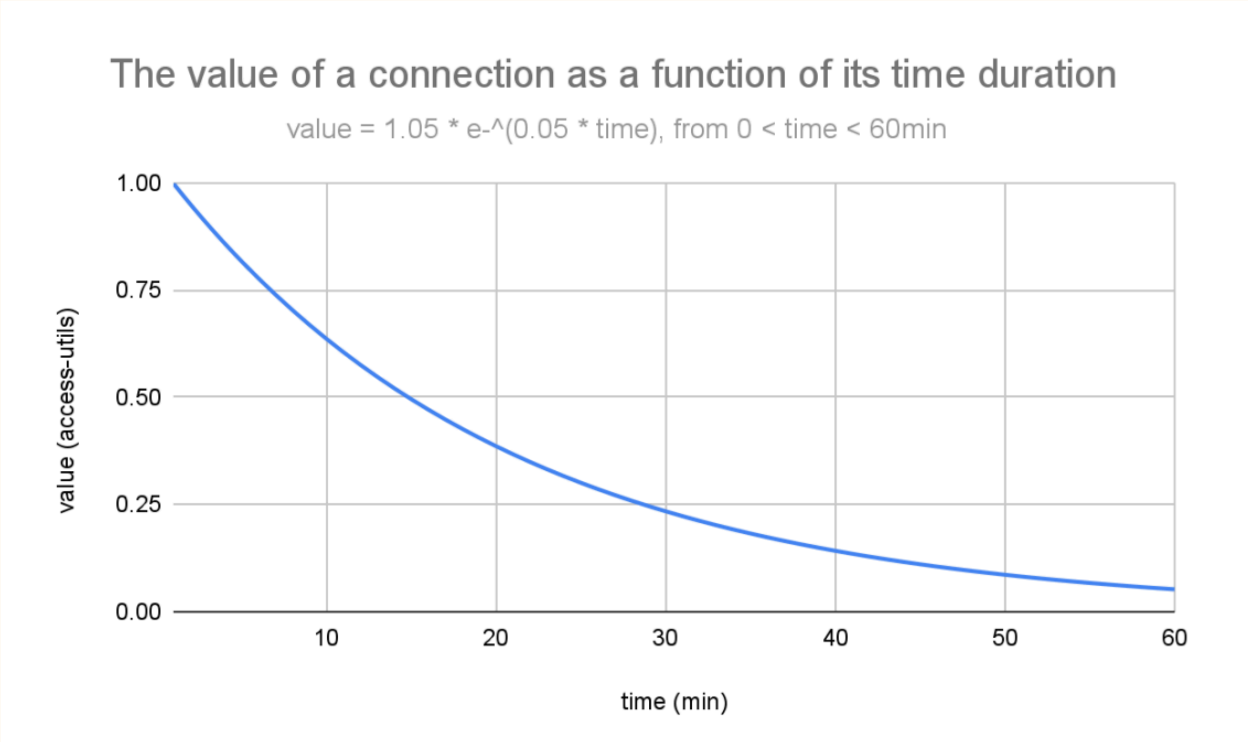

Fig. 5: A decay function in which the value of a destination is roughly halved with every fifteen minutes of additional travel time is a function which reflects observed trends in trip-making.

Destinations are weighted using an employment-based measure of destination intensity, representing the concentration of job opportunities in each analysis zone. For each user class, the value of access from a given origin is computed as the sum of the decayed values of all reachable destinations. These values are then aggregated across user classes using population weights, producing measures of average access per person as well as total access for larger geographies.

Jobs are an important destination in their own right as well as a meaningful proxy for economic activity in general. Although a full analysis appropriate for decisionmaking should include other destinations such as social services, recreational and social activities, and education, calculating access to jobs is common in the field as a simplified, but meaningful, metric.

Because accessibility is expressed in consistent units across modes and scenarios, changes in access can be compared directly between alternatives. Increases or decreases in access reflect the combined effects of changes in travel time, monetary cost, and network structure, providing a holistic assessment of how each scenario alters people's ability to reach destinations. This framework is particularly well suited to evaluating policies that may improve some aspects of travel while worsening others, such as pricing or capacity changes, and forms the basis for the scenario comparisons in Sections 5.1.4 and 5.2.4.

5: Results

Either the *CDOT Widening Scenario* or the *Healthy Communities No-Widening Scenario* would substantially alter Denver's regional transportation network, having impacts far beyond the neighborhoods immediately surrounding I-270. We quantify those impacts in two principal metrics: first, changes in overall traffic congestion delay, measured in vehicle-hours of delay (Section 5.2); second, changes in access to jobs, measured by comparison to current levels of access and in terms of the equivalent value of the number of jobs reachable within a 45-minute commute (Section 5.3). We also provide estimates of impact for the total vehicle-miles of travel that will be induced in each scenario (Section 5.1) and the resulting greenhouse gas emissions (Section 5.4).

We find that the *Healthy Communities No-Widening Scenario* will bring a meaningful benefit to the people of the Denver region, increasing average levels of access to jobs while decreasing total vehicle-hours of delay. The *CDOT Widening Scenario*, to the contrary, brings no meaningful benefit - in fact, it reduces levels of access to jobs while providing no improvement at all to vehicle-hours of delay. What's more, the *CDOT Widening Scenario* entails substantially higher climate impacts than the *Healthy Communities No-Widening Scenario*. Metrics are shown in Table 6, below.

Both scenarios involve geospatial trade-offs. Either scenario would benefit certain travelers to the detriment of others. But this is not a zero-sum game: the *CDOT Widening Scenario* would result in a net reduction of access to jobs (despite some beneficiaries), while the *Healthy Communities No-Widening Scenario* would result in a net increase in access to jobs (despite some populations experiencing a small loss of access.)

Table 6: Summary of Results

	CDOT Widening Scenario	*Healthy Communities No-Widening Scenario*
Total induced travel (vehicle-miles traveled per year)	100,000,000	20,000,000
Total change in vehicle-hours of delay during A.M. peak hour	~0	Reduction of 300 vehicle-hours
Change in access to jobs (Percentage change in convenience of travel for an average resident to an average job location)	Decrease of 0.5%	Increase of 0.6%
Change in access to jobs (Equivalent to number of jobs reachable at a 45 minute trip for the average Denver-area resident)	Decrease of 10,000	Increase of 14,000
Greenhouse gas emissions (Cumulative emissions caused through 2050, not	1,200,000	300,000

including construction, metric tonnes CO_2-eq.)		

Note that we round numerical results to a single significant figure unless the first digit is 1, in which case we provide two significant figures. This reflects the high levels of uncertainty inherent in any kind of traffic forecasting.

5.1: Induced Travel

Employing the RMI SHIFT calculator as described in Section 4.3.1, we assess a capacity expansion of 16.6 lane-miles (see *Table 7*, below) of Interstate highways ("Class 1") in the Denver-Aurora-Lakewood, CO, Metropolitan Statistical Area.

Table 7: Lane-Miles of Added Capacity

Capacity expansion	**Lane-miles**
I-270 Eastbound Express Lane	6.7
I-270 Westbound Express Lane	6.7
I-270 Eastbound Auxiliary Lane (I-76->Vasquez)	1.8
I-270 Westbound Auxiliary Lane (Vasquez->I-76)	1.8
Total: *CDOT Widening Scenario*	**17.0**
Total: *Healthy Communities No-Widening Scenario*	**3.6**

For the sake of conservatism, we do not include ramps nor 'direct connects', although these also represent capacity expansions that will result in induced travel.

Results for *CDOT Widening Scenario*

The SHIFT calculator estimates that 17 lane-miles of capacity added to I-270 would result in between 83 and 124 million additional VMT per year, from which we take a value of 104 million VMT / year. Dividing this number by 252 non-holiday weekdays/year and then applying a peak-hour "K-factor" of 0.12, we estimate that the peak hour-long window in the A.M. period will see an increase of about 46,000 vehicle-miles traveled across the Denver region under the *CDOT Widening Scenario*.

Results for *Healthy Communities No-Widening Scenario*

The SHIFT calculator estimates that 3.6 lane-miles of capacity added to I-270 would result in between 18 and 26 million additional VMT per year, from which we take a value of 22 million VMT / year. Dividing this number by 260 weekdays/year and then applying a peak-hour “K-factor” of 0.12, we estimate that the peak hour-long window in the A.M. period will see an increase of about 10,000 vehicle-miles traveled across the Denver region under the *Healthy Communities No-Widening Scenario*.

5.2: Change in Congestion and Delay

Congestion and delay under the *CDOT Widening Scenario*

The *CDOT Widening Scenario* will not provide any overall improvement to traffic congestion in the Denver region. Improvements in traffic flow on I-270 will be balanced by worsened congestion in other parts of the network, especially I-70 to the east and I-25 to the north, shown in Fig. 6 below.

Taking into account both the direct effects of widening I-270 and the indirect effects of induced travel resulting from that widening, the study area will see very little, if any, change in overall delay, and certainly not a meaningful improvement in average congestion. (Our analysis registers a net reduction in delay of less than 10 vehicle-hours at the A.M. peak; given the uncertainties involved in this or any such traffic analysis, this is not significantly different from zero.)

The increase in capacity on the I-270 mainline will be sufficient to accommodate the induced travel that occurs on I-270 itself, with travel on I-270 remaining in free flow even after the effects of induced travel are felt. I-270 will see a reduction of about 700 vehicle-hours of delay during the A.M. peak hour. However, this improvement in traffic will be balanced out by an equal increase in congestion across many other parts of the network, especially on eastbound I-70 from North Central Park Boulevard to I-225 (and on southbound I-25 from 120th Avenue to the I-270 junction. The *CDOT Widening Scenario* will not improve traffic congestion, only move it from one place to another.

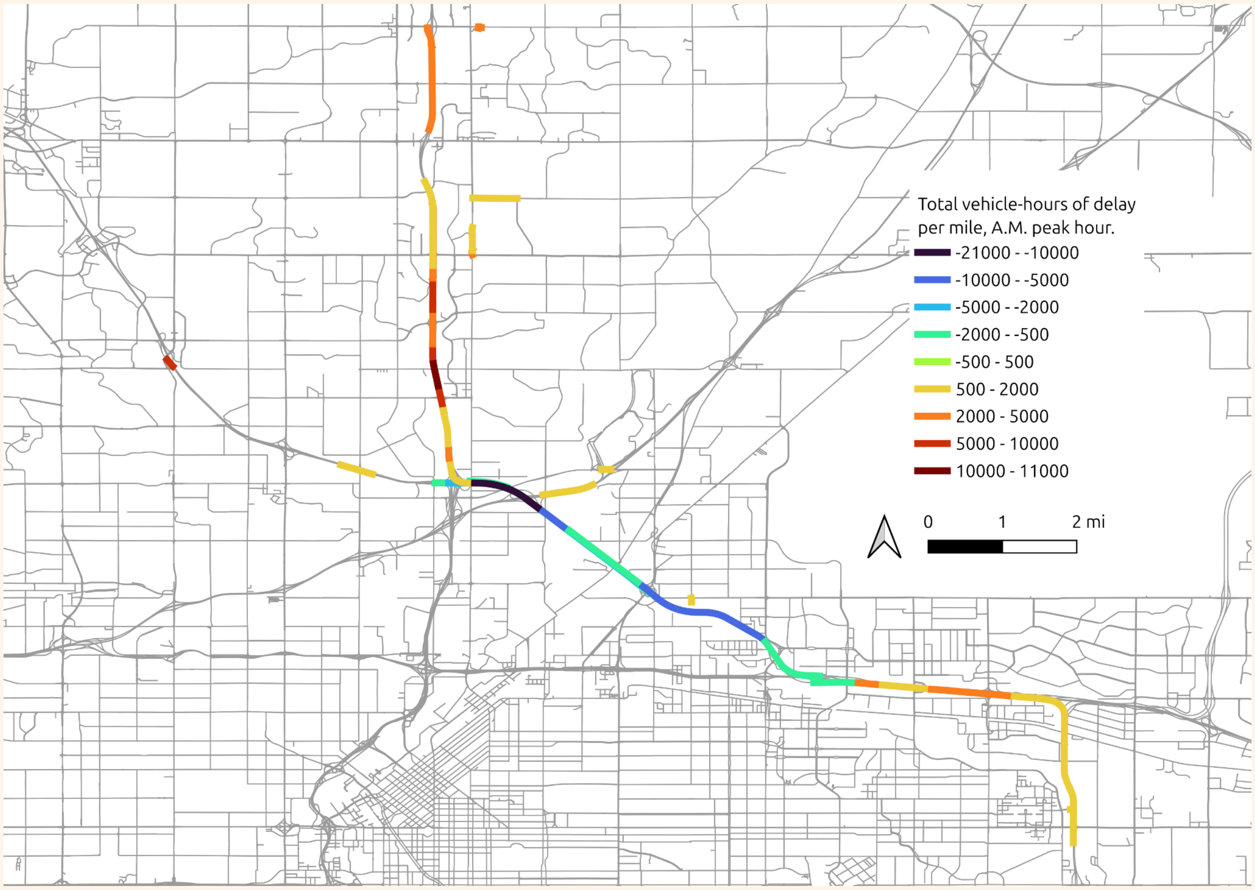

Fig. 6: Changes in Traffic Delay under the CDOT Widening Scenario

Remember that two methodological decisions imply that this is a conservative under-estimation of traffic delays under the *CDOT Widening Scenario*. First, we use traffic speed and volume data from a sample week in August 2024, rather than the May date used by CDOT, as described in Section 4.2. Because school holidays mean that August ordinarily has less urban travel than most other months, we are working from a lower-traffic baseline. And because the incremental delay caused by each additional car on a roadway is exponential rather than linear, the induced travel on I-70 and I-25 will very likely cause even more delay than we predict in this analysis.

Second, our omission of time-of-day shifts also means that these results almost certainly underestimate traffic levels in the *CDOT Widening Scenario*, especially on I-270 itself. As described in Section 4.3.1, we only account for new travel, and not for travel shifting to a preferred time of day. Time-of-day shifts are a major mechanism for the saturation of expanded roadway capacity in urban areas. By omitting this mechanism, we overestimate roadways speeds and underestimate delay on the I-270 mainline in the *CDOT Widening Scenario*.

Congestion and delay under the *Healthy Communities No-Widening Scenario*

The *Healthy Communities No-Widening Scenario* will likely cause a statistically significant, but relatively minor, net reduction in traffic delay from congestion in the Denver region. The worst slowdowns will be seen on the stretch of I-70 between I-25 and I-270 and on the ramp connecting southbound I-25 to eastbound I-70. I-270 itself will see a substantial increase in speeds as the tolling system manages congestion. These impacts are shown in Fig. 7, below.

In this scenario, unlike in the *CDOT Widening Scenario*, the benefits of faster travel on I-270 will more than offset the detrimental effects of increased traffic on other facilities, leading to an overall benefit to Denver-area travelers: a reduction of approximately 300 vehicle-hours of delay during peak period.

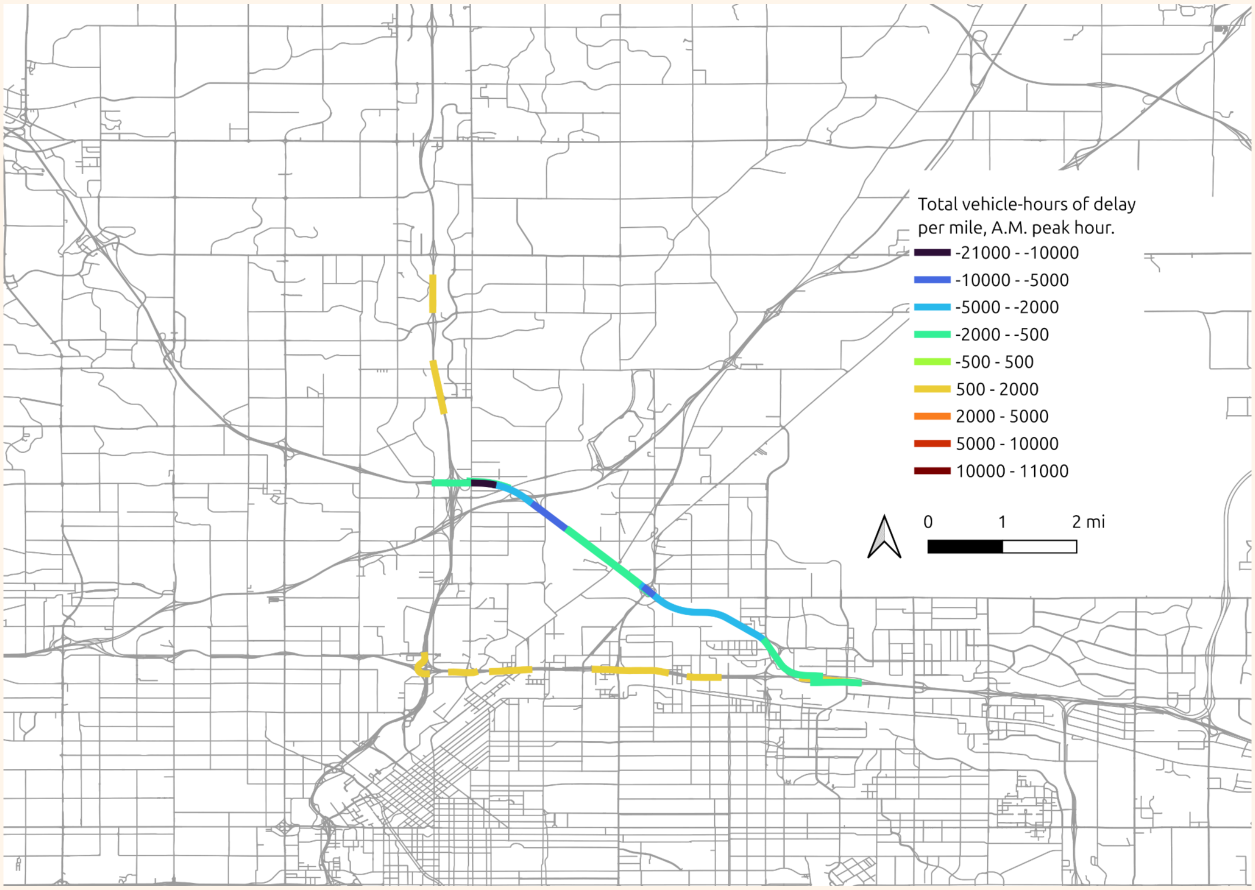

Fig. 7: Changes in Traffic Delay under the Healthy Communities No-Widening Scenario

5.3: Change in Access

The indicator of percentage change in access-to-jobs is the change in the convenience of travel for the average Denver-area resident to job locations. It takes into account a variety of factors, as described in Section 4.4: it includes the cost of a trip as well as the travel time, and it accounts for the marginal impact of a given change in travel time (turning a 10-minute trip into a 20-minute trip is much more impactful than turning a 60-minute trip into a 70-minute trip). Although it is not exactly the same as measuring travel times to work in existing commuting patterns, this indicator is a more complete and sophisticated way of understanding the way that different scenarios will affect the ability of different populations to reach places of employment.

The percentage values may appear small. Remember that this represents a percentage of all 1.9 million residents, and all jobs, in the entire study area. A loss of 1% of access for 1.9 million people is equivalent to a total loss of access for 19,000 people. The loss of 19,000 Denverites to the job market would be a dramatic economic blow.

Access-to-jobs under the *CDOT Widening Scenario*

Although the *CDOT Widening Scenario*'s net effect on total vehicle-hours of delay will be neutral, its effect on access to jobs will be negative. The new congestion on I-70 and I-25, described in Section 5.2 above, will substantially degrade access to jobs for residents of the study area, with people in regions like Northglen and Thorncreek losing up to 10% of their ability to conveniently reach places of employment (See Fig. 8, below).

The average resident of the study area will see a reduction of 0.5% in their overall level of convenient access to jobs, a number equivalent to the average Denverite being able to reach about 10,000 fewer jobs within 45 minutes. In the particular, the effects can be dramatic: due to increased delay on I-25, the worst-affected residents of Thorncreek will lose the equivalent of over 200,000 jobs 45 minutes away.

The benefits in this scenario mostly accrue to the residents of northwestern suburbs along US 36, with some benefits being felt by residents of southeastern suburbs toward Aurora. These benefits, however, are more modest than the benefits enjoyed by residents of both areas under the *Healthy Communities No-Widening Scenario.* Loss of access is felt across the rest of the region in response to increased congestion on I-70 and especially on I-25. A dramatic reduction in access is felt in the areas most dependent on I-25 north of I-270.

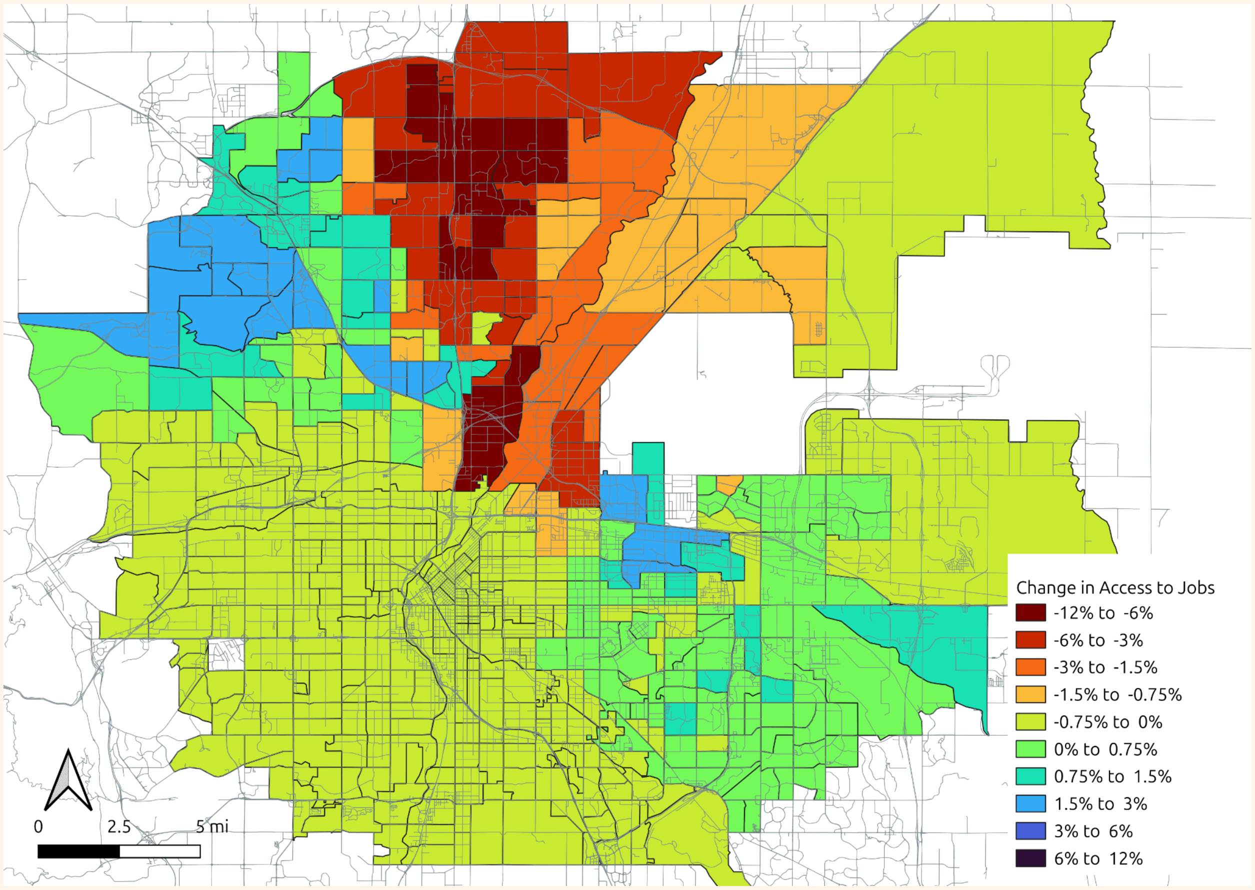

Fig. 8: Changes in Access-to-Jobs under the CDOT Widening Scenario

It may seem unintuitive that a net neutral effect on traffic delay could cause a net negative effect on access to jobs. This difference has to do with the fact that only about 20% of total U.S. urban passenger travel is for commuting. Many of the vehicles on the road in the morning in Denver are going to destinations other than a place of employment. It seems very likely that the routes from people to jobs are more likely to use I-70 and I-25, and therefore suffer from this redistribution of congestion, while I-270 is more often used for trips with other purposes (such as delivery).

Access-to-jobs under the *Healthy Communities No-Widening Scenario*

Under the *Healthy Communities No-Widening Scenario*, the average resident of the study area will see an increase of 0.6% in their ability to conveniently reach job locations. Remember that this calculation does not only include the time but also the money cost of travel. Even though travel on I-270 becomes more expensive for all travelers in this scenario, their travel time savings outweigh the additional costs.

As shown in Fig. 9, below, this varies geographically from a reduction of 3% in one particularly unfortunate census tract north of I-270, to improvements ranging from 3%-5% across wide areas of the northwestern suburbs, sections of Old Commerce City, and areas near the I-270/I-70 interchange. Broad benefits are felt by a majority of the region, even while residents of central Denver and southwestern areas will register a loss of access less than 0.75%.

The improvement in access to residents of Old Commerce City is due to the exemption of those areas from toll fees on I-270 in this scenario, as described in Section 3. If those areas were not exempted from fees, they would also see a loss of access.

It is important to note that the concentration of losses of access felt by residents near the I-25/I-70 interchange is likely overstated by the way that our approach to reallocation (Section 4.3.2) focuses on those two roadways. In reality, that loss of access will likely be more diffuse and less concentrated in that particular area.

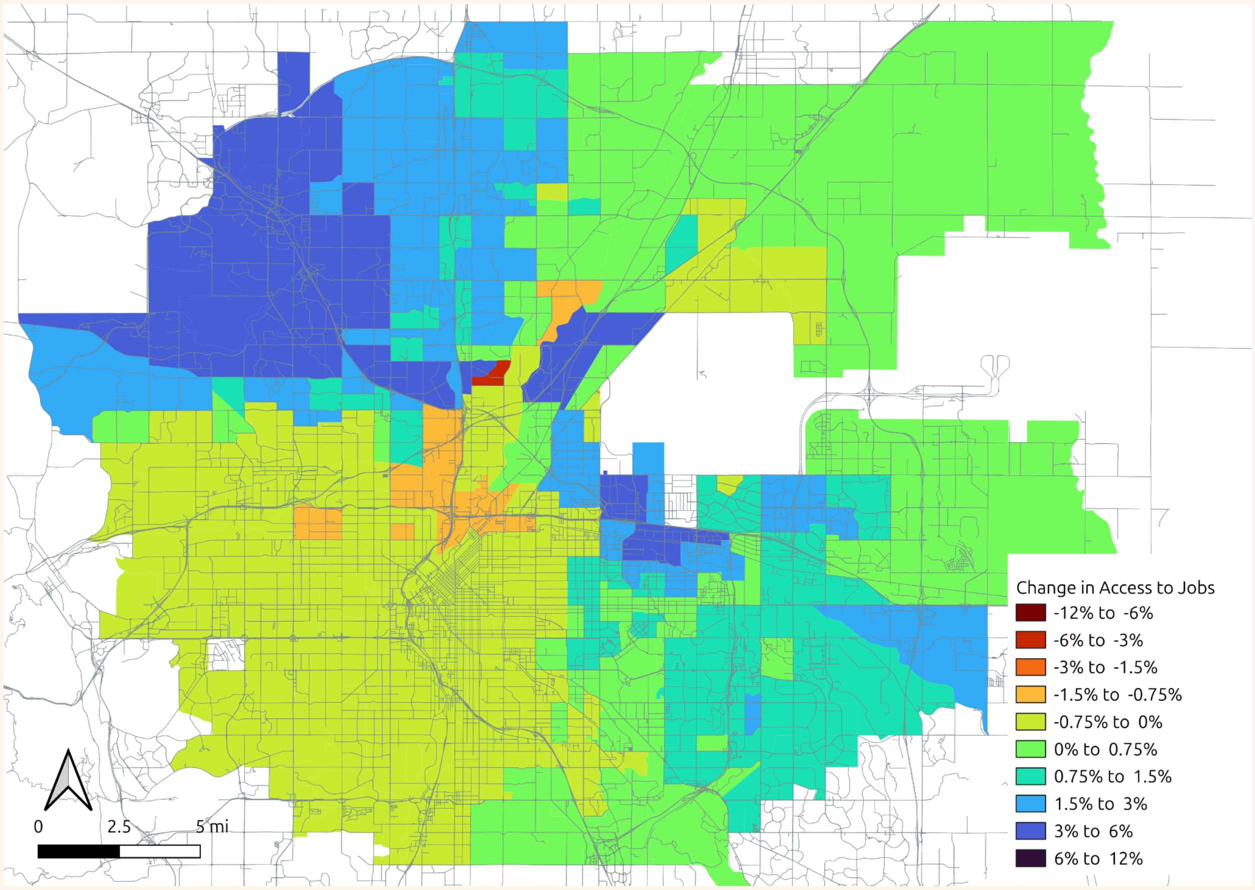

Fig. 9: Changes in Access-to-Jobs under the Healthy Communities No-Widening Scenario

5.4: Greenhouse Gas Emissions

We do not calculate greenhouse gas emissions endogenously in the Connectome model. While it is true that car travel emits different levels of greenhouse gases (GHGs) depending on the speed of traffic and other factors, the uncertainty involved in predicting these factors makes a high-resolution GHG prediction an exercise in futility. It is better to understand the underlying patterns that drive GHG emissions – more cars, more emissions – and apply those, at a large scale, imprecisely yet accurately.

The RMI SHIFT calculator includes a calculation of emissions resulting from induced travel. It includes 'lifecycle emissions' – not merely the emissions entailed by burning fuel, but also emissions from preparing and transporting fuel, maintaining roads, and manufacturing vehicles. We do not believe it is realistic to attempt to improve on that calculation, given the uncertainties involved in this study.

Results for *CDOT Widening Scenario*

Following the factors described in Section 5.1.1, the SHIFT calculator estimates that **1.2 million additional metric tons** of carbon dioxide-equivalent greenhouse gases will be emitted cumulatively through 2050 in the *CDOT Widening Scenario*. (This estimate assumes that the United States follows a 'business as usual' trajectory for vehicle electrification; considering that this 'business as usual' trajectory was based on electrification rates from before the second Trump administration, it may be an optimistic estimate).

Results for *Healthy Communities No-Widening Scenario*

Following the factors described in Section 5.2.1, the SHIFT calculator estimates that **0.3 million additional metric tons** of carbon dioxide-equivalent greenhouse gases will be emitted cumulatively through 2050 in the *Healthy Communities No-Widening Scenario*.

Estimates for both scenarios assume that the United States follows a 'business as usual' trajectory for vehicle electrification; considering that this 'business as usual' trajectory was based on electrification rates from before the second Trump administration, it may be an optimistic estimate.

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