Caltrans Transportation Equity Index (EQI) Documentation

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PUBLIC DISCUSSION DRAFT

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Introduction

The California Department of Transportation (Caltrans) acknowledges that communities of color and under-served communities have experienced fewer benefits and a greater share of the burdens associated with California's transportation system. These disparities largely reflect a history of transportation decision-making, policy, processes, planning, design, and construction that has quite literally put-up barriers, divided communities, and amplified racial inequities, particularly in Black and Brown neighborhoods.[1]

To operationalize Caltrans' commitments to equity, the department is developing the Caltrans Transportation Equity Index (EQI). The EQI is a screening and evaluation tool that utilizes multiple transportation-specific and socioeconomic indicators to identify transportation-based priority populations at the Census block level.

Many tools exist to evaluate the impact of the built environment. Still, these tools typically consider a wide range of factors that are not explicitly focused on burdens caused or exacerbated by the transportation system.

Caltrans aims to bridge this gap by creating an index to inform how the Department can best address and mitigate inequities exacerbated by the transportation system.

Broadly speaking, the EQI will be used for the following purposes:

1. Identify transportation-specific priority population areas for applicable funding programs (e.g., Reconnecting Communities: Highways to Boulevard Pilot Program).
2. Provide guidance to improve the analysis of project impacts and identify opportunities to advance equitable outcomes during project planning, development, and design.

Additionally, the EQI is designed in a manner to support partner agencies and other entities who may voluntarily use the EQI to analyze impacts and evaluate the effectiveness of various transportation projects and solutions.

[1] Caltrans Equity Statement December 2020

EQI Concept

The EQI contributes to the advancement of spatial analysis tools/methods by using Census blocks instead of larger geographies (such as tracts), enabling a more granular level of analysis. Given the nature of the EQI's transportation indicators, this level of granularity is necessary, as an indicator can have significant variance within a tract-scale area, such as a neighborhood, that the EQI is designed to capture.

Furthermore, the EQI only includes variables with spatial significance, meaning that their distribution across the state is largely determined by the spatial nature of the state's transportation system. Central to the EQI's concept is the identification of transportation-based priority populations and the targeting resources to said populations. This concept requires spatially significant data that does not have a uniform distribution throughout a geographic area. If the top 20% of Census blocks were screened using an indicator with a uniform distribution, approximately 80% of the population impacted by the indicator would be excluded. While such indicators may still be highly important when considering transportation equity, they require different approaches and are less useful in a spatial index such as the EQI. The use of thresholds with spatially significant variables confirms that geographies are screened for inclusion that contains a much higher share of burdened populations. This—however—does not preclude the use of non-spatial equity data in other Caltrans processes and decision rules.

Lastly, the EQI relies on both publicly available and internally developed datasets, including:

- Race/Ethnicity and Household Income data from the U.S. Census Bureau Decennial Census and American Community Survey (ACS) 5-year estimates
- Traffic proximity/volume data from Caltrans and the United States Department of Transportation (USDOT)
- Crash data from the California Highway Patrol and UC Berkeley Safe Transportation Research and Education Center (SafeTREC)
- Access to destinations data from the pooled-fund study and Caltrans tools

EQI Screens

Three distinct screens were developed for the EQI, each intended to identify and address distinct problems. All three are coupled with the Demographic Overlay. Below is a summary of the EQI's three screens, which are discussed in greater detail in this document's data sources and methodology section.

- **Traffic Exposure Screen.** The Traffic Exposure Screen identifies low-income and majority non-white Census blocks that bear a negative traffic burden as measured by proximity, volume, and vehicle type for all interstates, highways, principal arterials, and minor arterials in the state — or safety burden as measured through a statewide crash exposure calculation. The screen identifies Census blocks for inclusion with traffic proximity and volume at or above the 80th percentile or blocks with a crash exposure score at or above the 80th percentile. Traffic exposure is used as a proxy for multiple environmental burdens, including diesel particulate matter, diesel exhaust, noise, and traffic safety impacts on communities.
- **Access to Destinations Screen.** The Access to Destinations Screen identifies low-income and majority non-white Census blocks with poor relative multimodal access to destinations. For this screen, access to destinations is operationalized as the ratio of transit and walking access to jobs compared to auto access to jobs, with blocks having a score equal to or less than 0.2 being screened for inclusion as having poor relative multimodal access to jobs. Poor multimodal access to destinations leads to higher transportation costs and fewer reachable destinations via non-auto modes.[2] Caltrans is in the process of integrating non-work destinations into this screen and is currently seeking input on what non-work destinations should be included and/or prioritized. Caltrans is also in the process of operationalizing bicycle access to destinations as part of the calculations for relative multimodal access to destinations.
- **Priority Populations Screen.** This screen includes both the Traffic Exposure and Access to Destinations Screens and identifies the priority populations of the state that are the most burdened by traffic exposure but also benefit the least from the multimodal transportation network (as measured by access to destinations).

[2] https://htaindex.cnt.org/about/HTMethods_2016.pdf

EQI Data Sources and Methodology

The Caltrans Transportation Equity Index (EQI) includes three components:

1. Demographic indicators focused on household income and race/ethnicity measures.
2. Traffic indicators, as measured by traffic proximity and volume and crash exposure.
3. Access to destinations indicators, measured as the ratio of weighted transit/walk access to jobs to weighted automobile access to jobs.

2020 Census blocks are the geographic unit of measurement used in the EQI. All indicators are either measured at the block level or interpolated to the block level from the block group level.

Demographic Indicators

All EQI screening scenarios include demographic indicators of low-income status and race/ethnicity. If either of the household income level or race/ethnicity criteria are met (as outlined below), the block is screened for inclusion for further analysis with the transportation-specific indicators (traffic exposure and access to destinations indicators).

Income Data

To determine a block's status as either 'low-income' or 'not low-income,' two measures were used in alignment with AB 1550. A Census block group was designated as a 'low-income' community if either 1) its median household income[3] was at or below 80% of the statewide median household income, OR 2) it's median household income was at or below the 2022 county low-income limit[4] established by the California Department of Housing and Community Development. If either criterion was met, the block group was identified as a low-income community and screened for inclusion for the Demographic Overlay. Block group income data was joined to Census block data using the GEOID20 ID in both datasets.

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[3] Median household income was retrieved from the US Census Bureau API using 2020 ACS 5-year estimates table B19013_001.

[4] For the county low-income limit, the average household size was retrieved for each block group using the 2020 ACS 5-year estimates B25010_001 table and used to find the appropriate household-size-adjusted low-income limit.

Race/Ethnicity Data

2020 Census block-level redistricting data[5] was used to determine whether a block's population, as measured in the 2020 Census, was greater than 50% non-white. The non-white percentage was determined using the following formula:

1 – (Total Not Hispanic or Latino Population of One Race White Alone / Total Population)

If the resulting non-white percentage was greater than or equal to 50%, the block was screened for inclusion for the Demographic Overlay.

Traffic Exposure Indicators

The EQI utilizes two sets of traffic exposure indicators: 1) traffic proximity and volume from the highway system and arterial roads in the state and 2) Census block-level crash exposure based on collision history.

Traffic Proximity and Volume Data

1. **Input Data.** Highway Performance Monitoring System (HPMS) data was used and accessed via the Bureau of Transportation Statistics for this analysis. This spatial dataset contains all roads in the United States and car and truck Average Annual Daily Traffic (AADT) for highways and arterials.
2. **Traffic Exposure Python Script.** Using the data described in the previous step as the input, a Python script[6] is used to calculate block-level exposure. The script performs the following steps:
    a. A buffer is created around each road segment at a specified distance.
    b. That buffer is intersected with Census blocks.[7]
    c. For each block, the maximum AADT value for a given route is selected (in some cases, there is overlap between buffers for the same route, so the maximum AADT value is used to provide a more conservative estimate).
    d. For blocks with AADT exposure from multiple routes, the separate AADT exposure values are summed to capture the additive impact of proximity to multiple facilities.
    e. Steps a-d are repeated for all specified radii.
    f. A CSV file with the cumulative AADT exposure for each Census block at each specified radius is exported.
3. **Post-Processing in R.** After the Traffic Exposure data is created in ArcGIS/Python, a simple R script is used to create Traffic Exposure bands

[5] https://dof.ca.gov/forecasting/demographics/redistricting-data/#DLOADS
[6] To access the python script, contact Henry McKay (Henry.McKay@dot.ca.gov)
[7] 2020 Census blocks were used in this version of the EQI.

and apply decay weights[8], finalizing the Traffic Exposure data for inclusion in the EQI. First, the script creates individual traffic exposure bands for a given radius by subtracting the cumulative AADT of all narrower radii from a given radii. Once these unique bands are created, each value is decay weighted, and the resulting decay-weighted values are summed to create a final block-level Traffic Exposure value. For this version of the EQI, ten radii were used [500 meters, 450 meters, 400 meters, 350 meters, 300 meters, 250 meters, 200 meters, 150 meters, 100 meters, and 50 meters] and the corresponding inverse-distance decay weights were: [.1, .11, .125, .14, .166, .2, .25, .25, .33, .5, and 1]. Using this approach, traffic exposure occurring closer to the linear source was weighted heavier than traffic exposure occurring further away. Figure 1 shows the relationship between distance and decay weights used for the EQI traffic proximity and a volume indicator. Lastly, a percentile rank value was calculated for each Traffic Exposure score, with any block scoring above 0.8 being screened for inclusion.

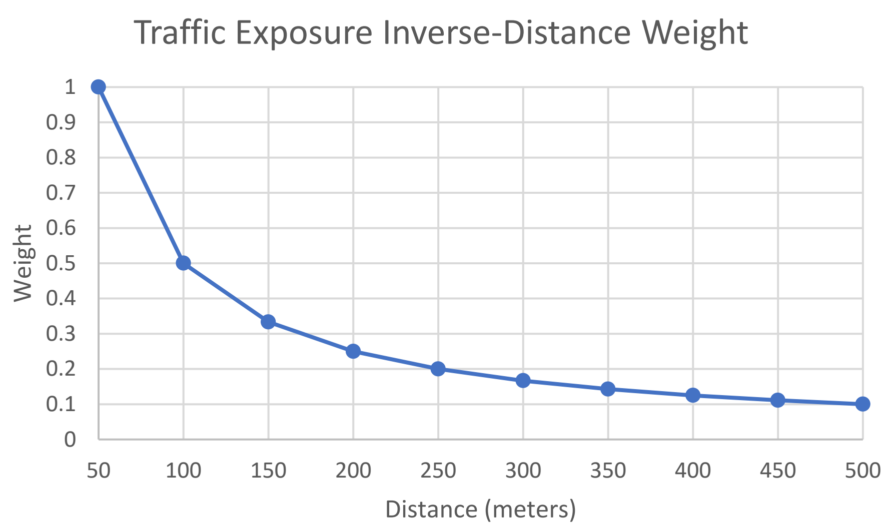

Figure 1. Traffic Proximity and Volume Weight

<u>Crash Exposure Data</u>

1. **Input Data.** The EQI's crash exposure indicator uses data from the Transportation Injury Mapping System (TIMS) developed by UC Berkeley

[8] Decay weighting is a quantitative method of giving some elements in a set more weight or influence than others, based on certain characteristics. In the EQI, decay weights are representative of spatial distance, discounting elements occurring further from the point being measured.

Safe Transportation Research and Education Center (SafeTREC).[9] This data is derived from the Statewide Integrated Traffic Records System (SWITRS), maintained by the California Highway Patrol. For the EQI, a five-year data window was used between 2015 – 2019.

2. **Data Cleaning and Weighting.** The EQI crash exposure indicator only considers crashes resulting in injuries or fatalities, so property damage-only crashes are filtered out. Next, each crash was weighted by the highest level of injury in the collision. Weighting factors were derived from the Cal-Benefit-Cost model[10] and are consistent with the costs used in other Caltrans benefit-cost analyses. The following weighting factors were used:
    - Injury (minor): 1
    - Injury (moderate): 1.96
    - Injury (severe): 7.19
    - Fatality: 157.97

   The EQI crash exposure indicator excludes crashes that occur on closed-access highways, as these crashes are less spatially relevant to their surrounding communities than crashes occurring on local roads or main street sections of the highway network. State Highway System (SHS) bicycle access status was used to determine highway access status, with crashes being removed from sections of the SHS with prohibited bicycle access.[11] Crashes occurring on highway ramps were kept in the dataset since ramp crashes have a greater impact on local traffic and safety. Figure 2 visually depicts which crashes were removed from or kept within the dataset for the City of Sacramento as an example.

[9] https://tims.berkeley.edu/

[10] https://dot.ca.gov/programs/transportation-planning/division-of-transportation-planning/data-analytics-services/transportation-economics

[11] https://sv03tmcpo.ct.dot.ca.gov/portal/apps/webappviewer/index.html?id=49cfd2cfa06b4e078d131df264fee437

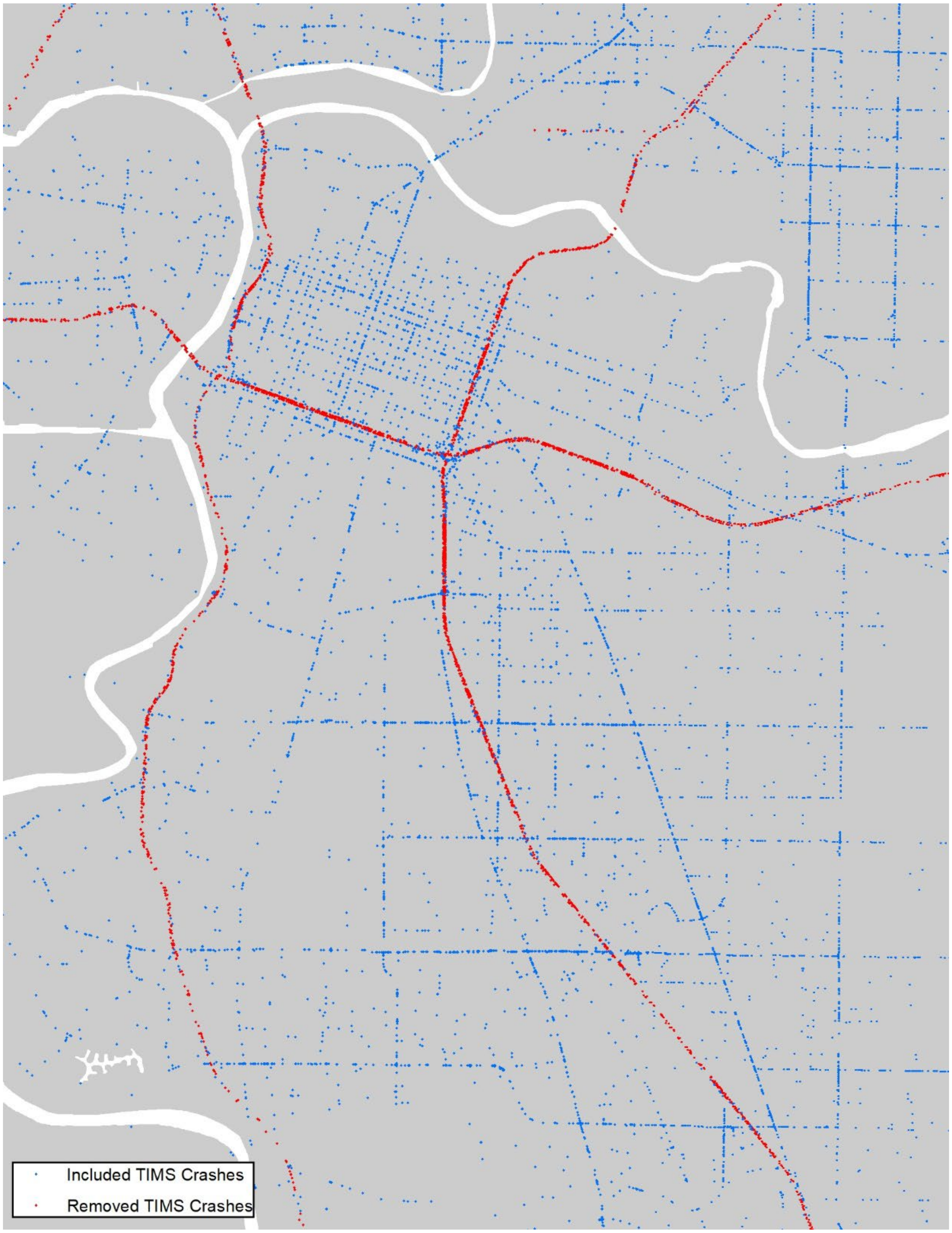

Figure 2. TIMS crash data in Sacramento, CA

3. **Data Aggregation.** Once crash data was processed and weighted, crashes were mapped and aggregated to Census blocks. A 200-foot buffer was applied around each Census block, and all crashes within that block (and surrounding buffer) were included in the block score. Since many block boundaries run along roads, crashes occurring along those roads should be associated with all immediately surrounding blocks, not just the block on the side of the road where the crash occurred. A 200-foot buffer was used since it is the approximate diagonal distance across a large intersection.

   The weighted crash values for all crashes occurring in the block and surrounding 200-foot buffer were summed to calculate a score for every Census block in the state. Lastly, a percentile rank was calculated for every Census block with a land area greater than zero and a population greater than zero. Blocks at or above the 80th percentile were screened for inclusion.

Access to Destinations Indicators[12]

The EQI measures multimodal access to destinations on the Census block level using data from the University of Minnesota Accessibility Observatory.[13] The access to destinations score used in the EQI is the ratio of weighted multimodal access to jobs (transit and walking) to weighted auto access to jobs for each Census block. Using this methodology, geographies with comparatively better multimodal access to jobs will have higher ratios. The following steps were used to develop an access to destinations score from the input Accessibility Observatory data:

1. **Decay Weights.** The Accessibility Observatory data reports access to jobs cumulatively on the Census block level.[14] Given this approach, there is significant overlap between the various time cutoffs. In order to apply decay weights, distinct job access bands were created by subtracting the cumulative number of accessible jobs from the previous time cutoff. To create a band for the 60-minute cutoff, the cumulative number of jobs

[12] Note: The data and methodology discussed regarding access to destinations will be superseded in the coming weeks as Caltrans deploys its own access to destinations tool capable of statewide analysis. The underlying concept of measuring multimodal access to destinations will not change, but the specific methodological approach and types of destinations being measured are subject to change.
[13] https://access.umn.edu/data/datasets/index.html
[14] Ex. The 20-minute accessibility dataset includes all jobs that can be reached within 20 minutes, while the 60-minute accessibility dataset includes all jobs that can be reached within 60 minutes.

accessible within 55 minutes was subtracted from the cumulative number of jobs accessible within 60 minutes. This process was repeated for both auto and transit modes, for all time cutoffs ranging from 5 to 60 minutes at 5-minute increments. Once individual access to jobs bands were created, decay weights were applied using decay functions[15] calibrated to the observed travel behavior of a given mode from the 2017 National Household Travel Survey (shown in Figure 3). These weighted bands were then summed together to create both a weighted multimodal and auto accessibility score.

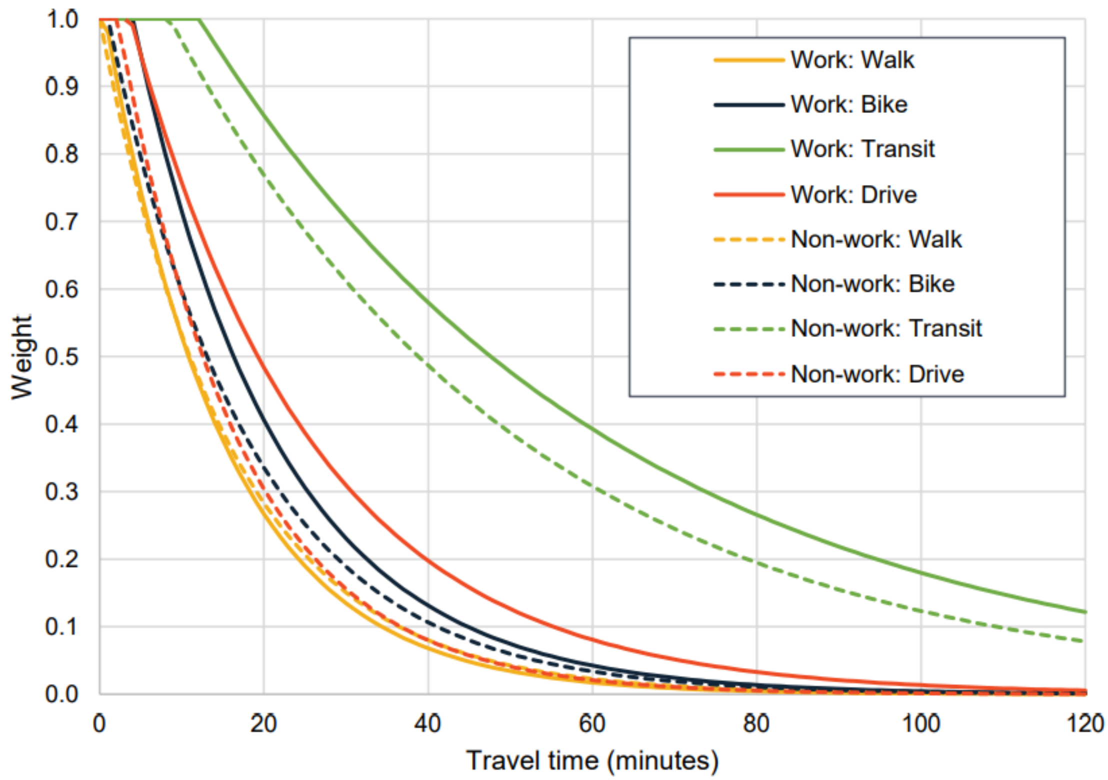

Figure 3. Access to Destinations Decay Functions (Source: SSTI)

2. **Multimodal Access to Destinations Ratio.** Once weighted multimodal and auto access to destinations scores have been calculated for each Census block in the state (or study area), a ratio can be determined by dividing the weighted auto access to destinations score by the weighted multimodal access to destinations score. On a basic level, this score

[15] https://ssti.us/wp-content/uploads/sites/1303/2020/12/Measuring-Accessibility-Final.pdf, Appendix: Decay Functions

represents a geography's relative multimodal access compared to its auto access.[16]

3. **Census Block Year Interpolation.** The Accessibility Observatory data used in this version of the EQI was only available at the 2010 Census block group level, whereas the EQI uses 2020 Census blocks. The following GIS procedure was used to convert 2010 block accessibility data into 2020 blocks:
   a. Using the 2010 block-level dataset, a new feature class of block centroids was created using the 'INTPTLAT10' and 'INTPTLON10' fields included in Census block-level datasets and show the X and Y coordinates of the block centroid.
   b. Step 1 was repeated for the 2020 Census blocks dataset resulting in a point layer for 2020 Census block centroids.
   c. A spatial join was performed for the point layer created in step 2, with the 2010 block accessibility layer created in step 1 used as the join feature. The join operation parameter was set to 'Join one too many,' and the match parameter was set to 'Closest.'. A search radius of 1 mile was used. Since 2010, California's total number of Census blocks has decreased sizably. While that would imply that blocks are being combined, it is also the case that blocks were subdivided in some cases. In future iterations of the EQI, Caltrans will produce its own access to destinations data, and the data will be compatible with 2020 blocks from the start.

[16] In most areas so the state, auto access to destinations is quite good. If auto access to destinations is low, this is generally due to a lack of destinations, not a lack of auto infrastructure. That is to say, auto access to destinations is a good proxy for what can be considered good access to destinations in a given region. Using this approach, a dense walkable downtown core in a small rural town in the north state would have a similar access to destinations score to that of downtown San Francisco or Los Angeles, despite a large difference in the actual number of jobs that can be reached in the two place types. The metric, in this case, is relative.

EQI Screening Thresholds

Once the three indicator datasets were created, they were merged into one dataset using the shared block 'GEOID20' variable. Before screens were applied, all Census blocks with either a land area of 0 or a 2020 population count of 0 were removed from the dataset. Using this combined dataset, screening thresholds were applied to create the EQI's three distinct screens.

<u>Demographic Overlay</u>

The Demographic Overlay contains a screen for both income and race/ethnicity.[17] If the criteria for either indicators were met, the block was screened for inclusion and was further analyzed with the traffic exposure and access to destinations indicators.

<u>Traffic Exposure Indicator</u>

The Traffic Exposure indicator includes a measurement for both traffic proximity and volume as well as crash exposure. The Traffic Exposure indicator identifies blocks at or above the 80th percentile[18] of traffic proximity and volume and/or the statewide crash exposure calculation.

<u>Access to Destinations Indicator</u>

The Access to Destinations indicator provides a ratio of the multimodal access to jobs (transit and walking) to automobile access to jobs. Census blocks with an Access to Destinations score less than or equal to 0.2 are screened as having poor relative multimodal access to destinations.

[17] These screens are detailed on pages 1-2 of this document.

[18] This percentile is only measured for blocks that have AADT exposure and or crash exposure (by being within 500 meters of the SHS and NHS or within 200ft of a crash location).

Screening Scenarios

Three distinct screening scenarios are envisioned for the EQI, each intended for different uses. Each of the three screening scenarios includes the demographic overlay by default.

Traffic Exposure Screen

The Traffic Exposure screen shows which areas of the state are most impacted by traffic and the negative externalities it produces (noise, pollution, etc.), as well as crash exposure. Figure 4 shows a map of the traffic exposure screen as currently operationalized.

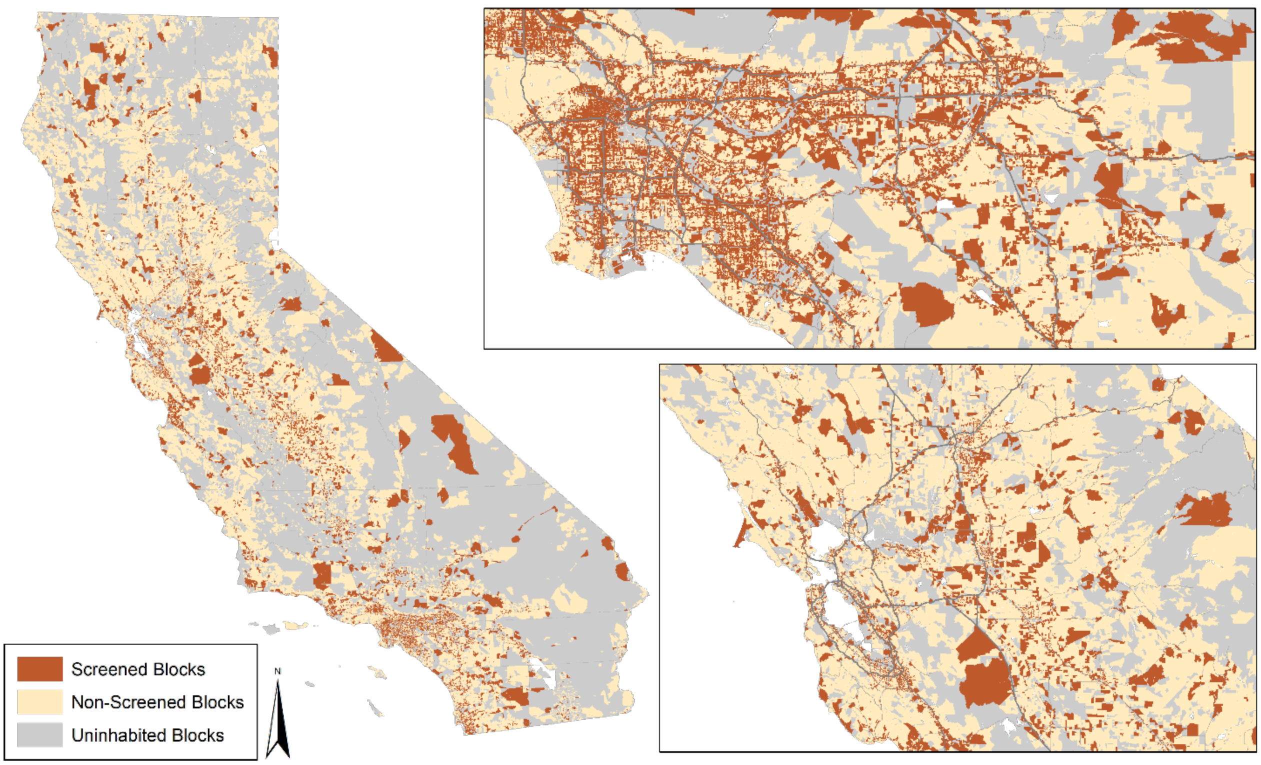

Figure 4. Traffic Exposure Screen

Access to Destinations Screen

The Access to Destinations screen shows which areas of the state have poor multimodal access to destinations and may disproportionately suffer from the negative impacts of having poor access, including but not limited to spending large amounts of money on owning and maintaining a vehicle. Figure 5 shows a map of the Access to Destinations screen.

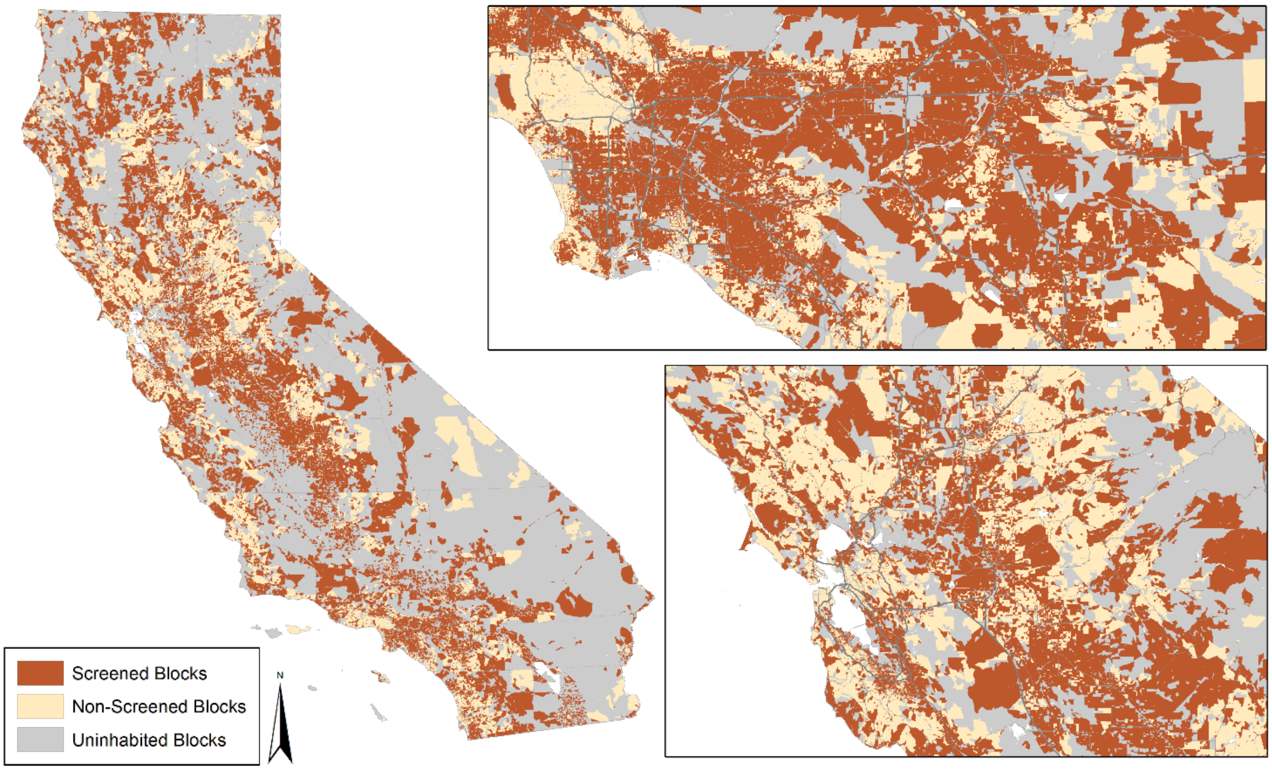

Figure 5. Access to Destinations Screen

Priority Populations Screen

The Priority Populations screen includes all previous screens and identifies the areas of the state that are the most impacted by traffic (traffic proximity and volume and crash exposure) and that benefit the least from the multimodal transportation network (multimodal access to destinations). Figure 6 shows a map of the Priority Populations screen.

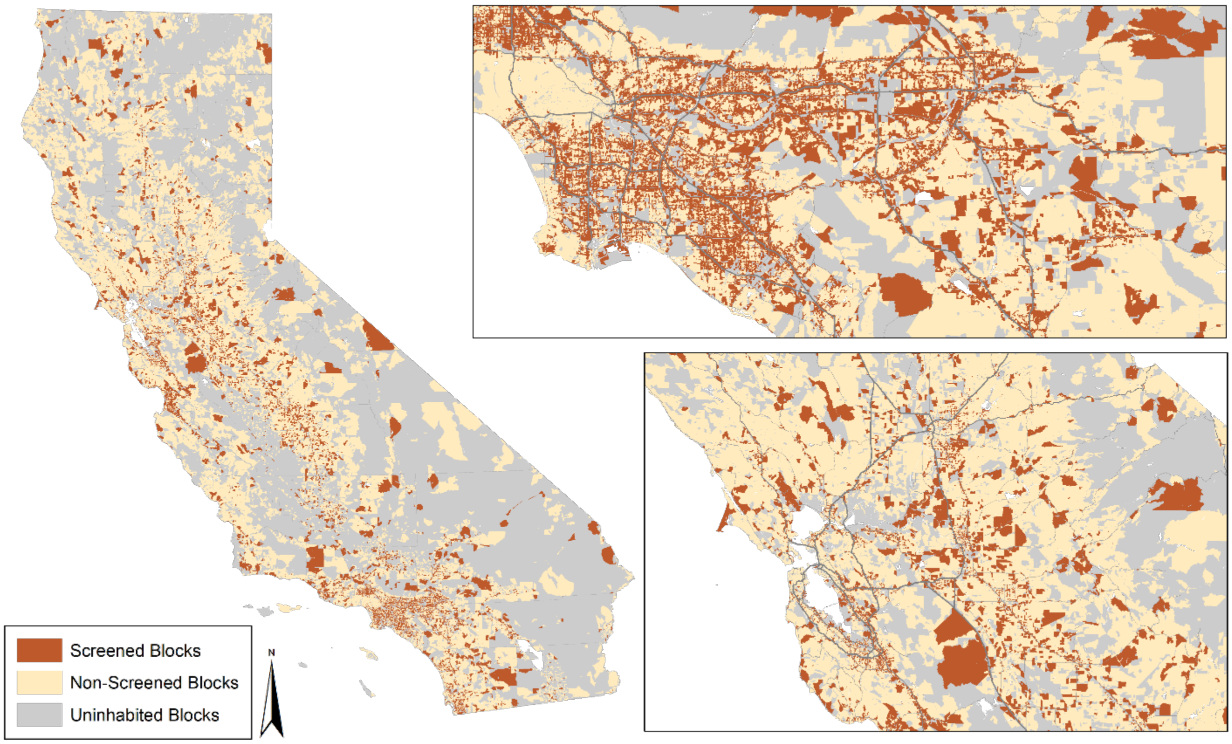

Figure 6. Priority Populations Screen

Lastly, figure 7 shows the relationship between the EQI's indicators, demographic data, and three screening scenarios.

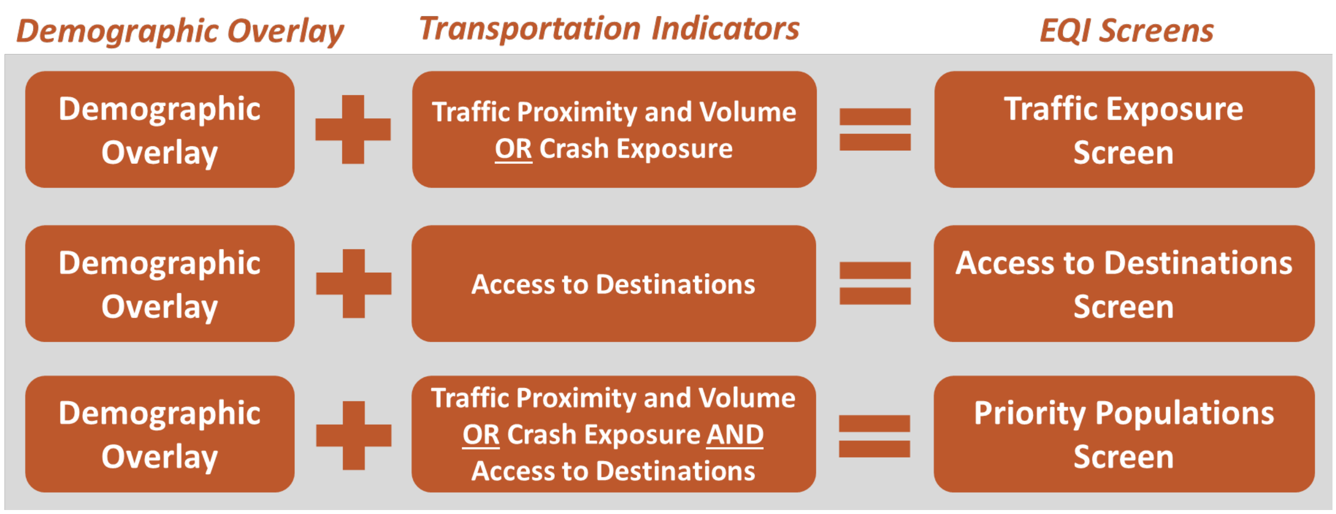

Figure 7. EQI Indicators and Screens