California Department of Transportation

2010-2012 California Household Travel Survey Final Report

Version 1.0

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Table 1: List of Abbreviations and Acronyms

ARB	Air Resources Board
ACS	American Community Survey
AMBAG	Association of Monterey Bay Area Governments
Caltrans	California Department of Transportation
CASRO	Council of American Survey Research Organizations
CATI	Computer Assisted Telephone Interview
CEC	California Energy Commission
CHTS	California Household Travel Survey
CM	Complete
CPH	Completes Per Hour
DS	Call Center Team
GPS	Global Positioning System
HH	Household
LD	Long Distance
MSG	Marketing Systems Group
MTC	Metropolitan Transportation Commission
NHTS	National Household Travel Survey
NMEA	National Marine Electronics Association
OBD	On Board Diagnostic
RTPA	Regional Transportation Planning Agency
SACOG	Sacramento Area Council of Governments
SANDAG	San Diego Association of Governments
SCAG	Southern California Association of Governments
TMPO	Tahoe Metropolitan Planning Organization
TB	Trip Builder
TT	Trip Tracer

1.0 Executive Summary

The 2010-2012 California Household Travel Survey (CHTS) was a unique statewide, collaborative effort to gather travel information needed for regional and statewide travel and environmental models using the same instrument and methods across the state. Led by the California Department of Transportation (Caltrans), the survey was jointly funded by the California Strategic Growth Council, the California Energy Commission (Energy Commission), and eight transportation planning agencies across the state. Guidance and direction for the survey effort was provided by an Administrative Committee, composed of representatives from the funding agencies, and a Steering Committee composed of all stakeholders, including the California Air Resources Board, the California Department of Public Health, the California Department of Housing and Community Development, and all transportation planning agencies.

1.1 Survey Overview

The CHTS was designed to collect travel information from households in all of California's 58 counties, plus portions of three adjacent counties in Nevada, using combination of computer assisted telephone interviewing (CATI), online, and three types of global positioning systems (GPS) devices--wearable, in-vehicle and in-vehicle plus an on-board diagnostic (OBD) unit. The survey design was pretested in late fall, 2011, and the main survey effort began in January, 2012. Travel information was collected for every day for a full year. All participating households were first recruited to record their travel in a diary for a pre-assigned 24-hour period, plus report long distance travel in the prior eight weeks. Households that participated in the GPS assisted survey used the wearable GPS devices for a total of three days, and the in-vehicle or in-vehicle plus OBD devices for a total of seven days. The travel data was retrieved either by CATI, online, or by returning the travel diaries, long distance log and GPS devices (if applicable) by mail.

There were 42,431 completed households, which includes 36,714 non-GPS households and 5,717 GPS households. Of the GPS households 3,855 were wearable GPS, 422 used in-vehicle GPS only, and 1,440 used in-vehicle GPS plus OBD. In addition, NuStats delivered 20,651 households that were partially complete, as several funding partners considered these data as being useful.

The overall recruit response rate for the main survey was 4.9%[1], which is slightly lower than the pretest response rate of 5.9%. The overall retrieval rate was 67.3%.

The final weights were developed at the county level, but demographic controls were balanced at the statewide level only. Also trip correction factors for the CHTS were developed at the statewide level only. Users of the CHTS final data are cautioned in applying these weights to lower geographic levels, such as sampling strata, counties or MPO.

1.2 Key Statewide Statistics

Table 1.2.1 presents the survey trip characteristics for key demographic characteristics. The average number of daily trips per household was 8.3 and the average number of trips per person was 3.6.

[1] Based on the Council of American Survey Research Organization's (CASRO's) calculation of response rate, which includes all eligible and assumed eligible sampled households in the denominator,

Table 1.2.1: 2010-2012 CHTS Average Trip Rates by Demographic Characteristic (Weighted)

Item	Trips per household/person per day
Household	
Person	
Household size	
1	3.3
2	5.7
3	9.7
4+	17.3
Household vehicles	
0	7.5
1	7.3
2	11.5
3+	9.3
Household employee	
0	4.8
1+	10.6
Income Level	
Less than $10,000	8.8
$10,000 to $24,999	8.6
$25,000 to $34,999	8.6
$35,000 to $49,999	8.6
$50,000 to $74,999	8.6
$75,000 to $99,999	9.6
$100,000 to $149,999	10.5
$150,000 to $199,999	11.1
$200,000 to $249,999	10.9
$250,000 or more	10.8
Gender	
Male	3.4
Female	3.7
Age	
Less than 20 years	3.3

Item	Trips per household/person per day
20 - 24 years	3.2
25-34 years	3.7
35 - 54 years	4.3
55 - 64 years	3.7
65 years or older	2.9
Hispanic Status	
Yes	3.5
No	3.6
Employment Status	
Yes	4.0
No	3.2
Driver License	
Yes	3.8
No	3.1

Table 1.2.2 presents summary trip statistics, including average travel time for trips. Total trips include all household trips by all modes of travel. Auto trips include driver/passenger trips of household vehicles, carpool/vanpool, motorcycle, and rental car trips. Driver trips include household vehicle driver trips. Included in transit trips are private shuttle, greyhound bus, local bus, rapid bus, express bus, commuter bus, premium bus, public transit shuttle, Dial-a-Ride/paratransit, Amtrak Bus, Other bus, Bart, Metro lines, ACE, Amtrak, Caltrans, Metro lines, and MUNI.

Table 1.2.2: Key 2010-2012 California Household Travel Survey Trip Statistics (Weighted and expanded)

	Weekdays	Weekend	Total
Total Household Trips[1]	101,107,350	31,211,141	132,318,491
Total Household Auto Trips[2]	76,390,785	25,406,487	101,797,272
Total Household Driver Trips[3]	51,438,843	14,168,011	65,606,854
Total Transit Trips[4]	4,643,281	1,070,130	5,713,411
Avg. Daily Household Trips (Per Person)	9.8	7.7	9.2
Avg. Daily Person Trips (Per Person)	3.8	3.0	3.6
Avg. Daily Driver Trips Per Household	5.0	3.5	4.6
Avg. Daily Transit Trip per Household	0.5	0.3	0.4
Avg. Trip Length (All Trips in U.S. In minutes)	17.1	19.6	17.7
Avg. Trip Length (Home to Work Trips[5])	26.0	23.9	25.8

[1]Total trips include all household trips by all modes of travel.

[2]Auto trips include driver/passenger trips of household vehicles, carpool/vanpool, motorcycle, rental car.

[3]Driver trips include household vehicle driver trips.

[4]Transit trips include private shuttle, greyhound bus, local bus, rapid bus, express bus, commuter bus, premium bus, public transit shuttle, Dial-a-Ride/paratransit, Amtrak Bus, Other bus, Bart, Metro lines, ACE, Amtrak, Caltrans, Metro lines, MUNI.

[5]Home to Work Trips include unlinked trips between home and work place.

Comparing the 2010-2012 CHTS with the 2000 CHTS, the most frequent mode of travel continued to be auto driver (49.3% of all reported trips) followed by auto passenger (25.9%). However, the 2010-2012 survey showed an increased share of walk trips (16.6%), public transportation trips (4.4%), and bicycle trips (1.5%), as may be seen in Table 1.2.3.

Table 1.2.3: Comparison of 2010-2012 and 2000 CHTS Travel Mode Distribution

Mode	2010-2012 Mode Share	2000 Mode Share
Auto/Van/Truck Driver	49.3%	60.2%
Auto/Van/Truck Passenger	25.9%	25.8%
Walk Trips	16.6%	8.4%
Public Transportation Trips	4.4%	2.2%
Bicycle Trips	1.5%	0.8%
Private Transportation Trips	0.6%	
School Bus Trips	0.6%	
Carpool/Vanpool	0.6%	
All Other	0.5%	0.7%
Total	100.0%	100.0%

The key trip statistics are presented in Table 1.2.4.

Table 1.2.4: Key Trip Statistics (Unlinked Trips)

Key Trip Statistics	
Average household trip	9.2
Average person trip	3.6
% zero trip household	14%
% auto trips	76.9%
% transit trips	4%
Average trip duration (minutes)	17.7
Average work trip duration (minutes)	21.3
Average school trip duration (minutes)	14.6
Average travel distance (route distance in miles)	6.8

2.0 Introduction

2.1 Survey Objectives and Overall Approach

The 2010 - 2012 California Household Travel Survey (CHTS) was a multi-modal study of the demographic and travel behavior characteristics of residents across the entire State of California, and the largest single regional household travel survey ever conducted in the United States. Detailed travel behavior information was obtained from over 42,500 households, using multiple data collection methods, including Computer Assisted Telephone Interviewing (CATI), Online, Mail surveys, wearable and in-vehicle GPS as well as using On-Board Diagnostic (OBD) sensors that gathered data directly from a vehicle's engine, which was a new and innovative approach. Details of personal travel behavior within region of residence, and inter-regionally within the State, as well as adjoining states and Mexico, were gathered. The survey sampling plan was designed to ensure an accurate representation of the entire population of the State. Under the leadership of the California Department of Transportation (Caltrans), the study was jointly sponsored and funded by Caltrans, the California Strategic Growth Council, the California Energy Commission, and the following local transportation planning agencies:

- Association of Monterey Bay Area Governments (AMBAG)
- Fresno Council of Governments
- Kern Council of Governments
- Metropolitan Transportation Commission (MTC)
- San Joaquin Air Pollution Control District
- Santa Barbara County Association of Governments
- Southern California Association of Governments (SCAG)
- Tulare County Association of Governments.

Other state agencies, including the California Air Resources Board, California Department of Public Health, and California Department of Housing and Community Development as well as all of the State's Metropolitan Planning Organizations (MPOs) and Regional Transportation Planning Agencies (RTPAs) were survey stakeholders. The Federal Highway Administration (FHWA) had active involvement with the survey and assisted Caltrans with funding for a public outreach program.

The main objective of the survey was to be able to apply the data to develop and update transportation models in order to meet statutory requirements of both Federal (air quality analysis) and State (AB 32, SB 375 and SB 391). Other main objectives included gathering data from a considerably larger sample than in the past, a robust collection of all travel modes and use of tolled facilities data, proper targeting of long distance travel, and an accurate representation of weekday and weekend travel. The 2010 - 2012 CHTS included additional features to support advanced model development, which included more detailed data on vehicle acquisition decisions, parking choices, work schedules and flexibility, use of toll lanes/priced facilities, and walk and bicycle trips. Figure 2.1.1 shows a map of the State of California with counties color coded by MPO/RTPA, which comprised the study area for the CHTS.

Figure 2.1.1: County and MPO/RTPA Map of the Household Travel Survey Study Area

2.2 Description of the Survey Components

An overview of the three key aspects of the CHTS survey design is presented in Figure 2.2.1. These three aspects, Sample Type, Household Type, and Survey Mode, are described as follows:

- **Sample Type:** The sampling frame for the CHTS was an address-based sample. Households whose addresses were sampled fell into two types—those for which there was a telephone number matched to the address (Matched Sample) and those without a matching telephone number (Unmatched). In general, Matched Sample households have landline telephones, and Unmatched Sample households are those with cell phone numbers only.
- **Household Type:** Households were recruited as: 1) those using Global Positioning System (GPS) logging devices (GPS Households) to augment their travel reporting and, 2) those not (Non-GPS). In the CHTS design, GPS households were further recruited to use one of three different types of GPS devices:
  - ✓ Wearable GPS only,
  - ✓ Vehicle GPS only, or
  - ✓ Vehicle GPS and On-Board Diagnostic (OBD) engine sensors.
- **Survey Mode**: To provide potential respondents with multiple ways to respond, there were different survey modes offered in the Recruit and Retrieval phase of the survey. Recruitment was available to all Household Types through computer-assisted telephone interviewing (CATI) as well as on the Internet through the CHTS website. Retrieval of travel and activity information was offered through CATI and Online, as well as by Mail for Non-GPS Households.

Figure 2.2.1 presents the CHTS survey design in schematic format. The tables presented in this report use the terminology shown in the schematic and defined above for data reporting.

Figure 2.2.1: CHTS Survey Design Schematic

Sample Type	Household Type		Survey Mode				
			Recruitment		Retrieval		
			CATI	Online	CATI	Online	Mail
Matched or Unmatched Sample	GPS Households	Wearable GPS					
		Vehicle GPS					
		GPS & OBD					
	Non-GPS Households						

Traditionally, household travel surveys have two phases—Recruitment, in which households are screened for participation and Retrieval, in which the detailed travel and activity information is collected. The CHTS included a larger than typical number of questions in the Recruitment phase, with the addition of more vehicle specific questions, which included fuel and vehicle types. The Retrieval phase included the collection of detailed household travel information from all survey respondents, as well as additional information including:

- Detail from all CHTS respondents about the activities performed at each location, including an additional series of questions about up to three activities conducted at each location and the number of persons participating in each activity with the respondent. For respondents in the SCAG region only,

respondents were also asked to identify the relationship of persons participating with the respondent in each activity;

- A separate Long Distance Travel Log, which asked about long distance (LD) travel made in the eight weeks prior to the assigned travel day.

2.3 Survey Oversight Committees

Oversight of the CHTS was provided by two by two large committees; the Administrative Committee (AC) and the Steering Committee (SC) along with several Technical Advisory Committees (TAC). The full listing of each committee's members may be found in Appendix R.

- The AC was comprised of representatives from the Caltrans administration team, representatives of the sponsoring agencies, consultants and one technical advisor. All major decisions regarding survey design and methodology were presented to the AC for their review and approval. AC meetings were held on the second Wednesday of each month. SC meetings were held on the third Wednesday of each month.

- The SC was comprised of representatives of other survey stakeholders, including the local MPOs, RTPAs and the California Air Resources Board, in addition to the AC members. The SC received reports of the survey progress and the AC's decisions, and provided input into the survey methodology and deliverables. The SC members held a stake in this highly complex project. Due to the varied interest, the AC's oversight played an integral role in ensuring decisions would be agreed upon, executed, and properly documented.

- The TAC for Hard-to-Reach Populations Subcommittee provided guidance to the contractor tasked with public outreach targeted toward the hard to reach population groups. Subcommittee meetings were held monthly from April 2012 through November 2012.

- The TAC for CHTS Long Distance & Inter-regional Trips Subcommittee - This TAC was composed of Caltrans, NuStats team members, members of the Administrative Committee and technical experts on long distance data collection and modeling. It was active in early design phase of the CHTS (2010), and provided guidance in the development of the long distance survey including key decisions such as the definition of a long distance trip.

- The TAC for OBD Subcommittee - This TAC was composed of the NuStats team with GeoStats, and representatives of Caltrans, CEC and ARB. It was active during the CHTS design phase (2010) and focused on the OBD instrument parameters as well as on air quality and fuel type usage questions on the CHTS main survey.

- The TAC for Data and Model Transferability Subcommittee - This TAC consisted of Caltrans and members of the Administrative Committee. It was active in the CHTS early design phase (2010) and its primary purpose was to evaluate the feasibility of model/data transferability for MPOs/RTPAs where the CHTS alone cannot meet minimum model estimation requirements.

2.4 Survey Schedule

Figure 2.4.1 below shows the schedule by task for the CHTS. The timing of tasks is described below:

- Tasks 1 (Project Coordination) has been ongoing for the life of the project and will complete with the final delivery.

- Task 2 (Project Management) has been ongoing for the life of the project will complete with the final delivery.

- Task 3 (Develop and Finalize Survey Design) encompassed all of the activities for design of the pretest and full study.

- Task 4 (Conduct Survey Pretest) consisted of all activities involved in conducting recruitment, retrieval and preparation of the data for the pretest data file.

- Task 5 (Evaluate Survey Pretest Results) included the activities necessary to analyze the pretest data, and recommend revisions to the survey methods and materials.

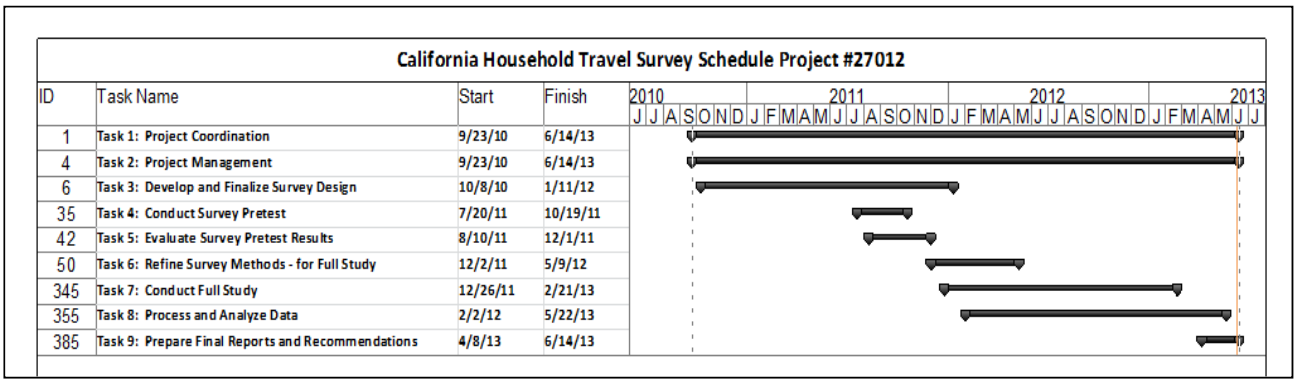
- In Task 6 (Refine Survey Methods – for Full Study) activities dedicated to this task included revision of all survey materials and programs, and the additional efforts to translate all materials and programs into Spanish. In order to maintain the project schedule, the English survey work began prior to finalizing the Spanish, which is why the finish date for Task 6 ends after the full study begins.

- Task 7 (Conduct Full Study) begins with the mailing of the first wave of advanced letters, and finishes at the conclusion of cleaning the data in preparation for building the data file.

- Task 8 (Process and Analyze Data) begins with the first retrieval data, and ends with the finalizing the analysis.

- Task 9 (Final Reports and Recommendations) will be the final task for this project.

Figure 2.4.1: Survey Schedule



3.0 Survey Design

The final goal of the CHTS full study, based on the pretest results and special requests from funding partners, was to collect the following survey samples:

- 53,483 California households, with the number of households sampled proportionate to the population in the sampling strata;
- Of these, 48,384 households were to be Non-GPS and 5,099 were to be GPS Households
- Of the GPS households, the desired distribution was:
  - ✓ 400 Wearable devices
  - ✓ 3,099 MTC Wearable devices
  - ✓ 400 Vehicle GPS devices
  - ✓ 800 Vehicle and OBD devices
  - ✓ 400 Energy Commission Vehicle GPS and OBD devices

3.1 Survey Instrument and Materials Design

The survey instruments for the CHTS were developed collaboratively with Caltrans, NuStats, and GeoStats and with input from the Steering Committee. The survey instruments were based on steering committee members' travel modeling and analytical needs.

The key data elements identified and collected were as follows:

- **Household Characteristics –** main household characteristics collected were:
  a) Physical address, including county of residence
  b) Household size
  c) Type of residence
  d) Home ownership status
  e) Number of years at current address and previous address if at current address for less than 6 years
  f) Number of cell and landline phone numbers in household
  g) Use of public transportation
  h) Bicycle availability and number of bicycles available to the household for use
  i) Plan to purchase new vehicle in the next five years
  j) Vehicle availability and number of vehicles available to the household for use
- **Person Characteristics -** Demographic information was collected for all household members to help explain the impact of household dynamics on personal travel in the region. The person-level data elements were:
  a) Name, Gender, Age and Race
  b) Relationship among household members
  c) Country of birth and year moved to US if not natural born citizen
  d) Number in household who possess driver's license

e) Employment status, location of employment, and if more than one employer, type of industry and occupation

f) If disabled type of disability and if hold disabled license plate or disabled transit registration, eligibility for transit subsidy and amount of subsidy

g) Typical work days, number of hours worked per week, availability of working flexible hours, and mode of transportation to and from work location, HOV lane availability and use

h) If any household members are of Hispanic, Latino or Spanish origin

i) Student status, grade level, location of school, home or on-line schooled, level of education completed

- **Vehicle Characteristics -** The recruitment instrument included questions about the vehicles available to the household:
  a) Year, Make, Model, Series, Body type, Transmission type, Drive/Power Train (FWD, AWD, etc.) and Number of cylinders
  b) Vehicle fuel type (hybrid, gasoline, diesel, etc.)
  c) Vehicle new or used when acquired
  d) Vehicle owned, borrowed or leased
  e) Vehicle covered by Pay-as-You-Drive insurance
  f) Vehicle driven on assigned travel day, or if not driven reason not driven
  g) Devices provided by insurance company to detect mileage driven
  h) For GPS households, information on working power outlet or cigarette lighter socket in vehicle
  i) If electric vehicle, the number of feet to nearest electric outlet and if it is 110 or 220 volt
- **Activities –** The retrieval interview collected information about each person's activities throughout their assigned travel period. These data elements included:
  a) Participation in activity/activities alone or with others and the number of others who participated
  b) Activity start time/end time
- **Trip Data –** During the retrieval interview, trip data was collected for each household member, and included the following:
  a) Number of household members who traveled
  b) Trip modes
  c) Parking type, cost (and if reimbursed by employer), duration, location, and if household members remained in the vehicle at stopping point
  d) Arrival and departure time
  e) Use of transit, if so, which transit system and route
  f) Vehicle(s) driven by each household member and if transit passes, tolled facilities or car sharing were utilized by any member of the household, and if so, the specifics of each
  g) Trip place name and address

For the CHTS full study, the following process was utilized:

- **Advanced Mailing -** Advanced letters were mailed to households approximately 1 week prior to placing recruitment calls. The purpose of the advanced letter was to notify households they had been chosen to be eligible to participate in the CHTS. By sending advanced notification, households had the chance to read about the study prior to receiving a recruitment telephone call. The advanced letters contained the Personal Identification Number (PIN) assigned to that specific household. Additionally, the advanced letter served to inform households of the available option to complete recruitment online via the CHTS website, or to call the hotline to complete via CATI. Three rounds of advanced postcards were sent in May and June 2012, however, this method was found to be less effective than advanced letters and was discontinued. An example of the advanced letter may be found in Appendix A.

- **Recruitment Interview** – Generally within one week of sending advanced letters, households would begin completing recruitment online. Once Online recruitment had begun, the recruitment interview telephone calls would begin. The recruitment interviews were conducted using CATI and Online and secured the household to participate in the CHTS. The recruitment introduction was specifically designed to obtain agreement to participate. The recruitment questionnaire collected all of the key data elements listed above. The recruitment CATI and online scripts are included in Appendix B and Appendix C, respectively.

- **Respondent Material Mailing** – The demographic information collected during recruitment was utilized to prepare personalized cover letters for the recruited households. The cover letter included the household's PIN, the assigned travel day, instructions for completing the diary, and instructions for completing the long distance log. Additionally, diaries were personalized for each member of the household. Appendix G contains an example of the materials included in the respondent mailing packet. Appendix J is an example of the long distance materials. Households participating in the GPS component of the survey were mailed the appropriate GPS equipment and instructions for the equipment, along with travel diary packet materials and a long distance log. The GPS travel diary packet materials may be found in Appendix H. The Energy Commission materials may be found in Appendix I.

- **Reminder Contact –** At the time of recruitment, respondents were given the option to receive their travel reminder via telephone call, email, or text message. The day prior to the assigned travel day (or two days prior if the day before their travel day was a holiday) each household was contacted via their requested form of contact, to remind them of their impending travel day, confirm receipt of travel materials, answer any questions the respondents may have, and provide the hotline number. If the travel packet was not received by the time of the reminder, respondents were given instructions on how to download the materials from the survey website. In the case of GPS materials not being received, the households were given the option to reschedule. Non-GPS households were only given the option to reschedule under specific circumstances. Scripts for the reminder calls, emails and text messages may be found in Appendix D.

- **Retrieval Interview** – Retrieval was completed in one of three modes: CATI, Online and Mail. If responding households had not logged onto the survey website to complete their retrieval interview the day following their assigned travel day, retrieval calls were placed to collect the travel data. The CATI and Online programs were set up to encourage respondents to answer every required question, and to terminate the retrieval interview if respondents refused. The telephone representatives were trained on refusal rebuttals to minimize terminations. The CATI program also prompted interviewers to reference the same trips made by other household members. A look-up table of frequently visited

locations aided with the retrieval process. The retrieval questionnaire utilized in the CATI interviews is found in Appendix D. The questionnaire utilized for Online retrieval is found in Appendix E. The non-GPS travel diary packet materials may be found in Appendix G. Appendix H contains the GPS travel diary packet materials.

3.2 Sample Design

3.2.1 Source of Sample and Survey Universe

An Address-based sampling frame approach was used. An Address-based sample is a random sample of all residential addresses that receive U.S. Mail delivery. Its main advantage is its reach into population groups that typically participate at lower-than-average levels, largely due to coverage bias (such as households with no phones or cell-phone only households). For efficiency of data collection, NuStats matched addresses to telephone numbers that had a listed name of the household appended to the sampled mailing addresses. This sampling frame ensured coverage of all types of households irrespective of their telephone ownership status, including households with no telephones (estimated at less than 3% of households in the U.S.).

In order to better target the hard-to-reach groups, the address-based sample were supplemented with samples drawn from the listed residential frame that included listed telephone numbers from working blocks of numbers in the United States for which the name and address associated with the telephone number were known. The "targeted" Listed Residential sample, as available from the sampling vendor, included low-income listed sample, large-household listed sample, young population sample, and Spanish-surname sample (to name a few). As expected, this sample was used to further strengthen the coverage of hard-to-reach households. The advantage of drawing sample from this frame is its efficiency in conducting the survey effort—being able to directly reach the hard-to-reach households and secure their participation in the survey in a direct and active approach. Both address and listed residential samples were procured from the sample provider – Marketing Systems Group (MSG) based in Fort Washington, PA.

The survey population was representative of all households residing in the 58 counties in California. According to 2010 Census data, the survey universe comprised 12,577,498 households. Table 3.2.3.1 provides the distribution of households by counties and by MPO/RTPA. As shown in the table, 83% resided in four MPO regions (spread over 22 counties) – 46% in SCAG, 21% in MTC, 9% in SANDAG, and 7% in SACOG. The remaining 17% households reside in 36 counties in California

3.2.2 Sampling Design and Selection Methodology

NuStats employed a stratified probability sample of households for the CHTS 2010-2012 Full Study. Stratified sampling is a type of random or probability sampling, the methods of which are well grounded in statistical theory and the theory of probability. Specifically, stratified sampling is a probability sampling method where the survey universe is divided into smaller groups and a random sample is chosen within each group (i.e., every sampling unit has some non-zero probability of being selected into the sample). This method resulted in over-sampling for some strata ensuring NuStats captured the diversity of the population according to specific factors affecting travel behavior in the study area. Thus, within strata, households were selected with equal probabilities but the combined sample (across strata) comprised an unequal probability sample of households.

To ensure geographic representation, NuStats utilized a geographic stratification scheme, which ensured adequate representation of households throughout the study area. A stratified random sample that was disproportionate to the distribution of households by county of residence was drawn.

The study area had a high concentration of hard-to-reach groups (see Tables 3.2.3.4 through 3.2.3.7 pages 23-27):

- 31% large households (i.e., 4 or more member households)
- 22% low-income households (i.e., households with annual income less than $25,000)
- 36% younger population (i.e., 25 years of age or less)
- 38% Hispanic population
- 8% zero-vehicle households.

As a result, NuStats implemented a selective oversampling strategy. Specifically, the oversampling strategy was two-fold: (1) oversample addresses from the census tracts with high concentrations of hard-to-reach groups, and (2) supplement the address-based samples with 'targeted' listed residential samples. Besides utilizing sampling-based methods, NuStats also utilized intercept-based surveying methods to recruit transit-using households for Kern County[2]. Based on Hispanic household, person age, household size data from the Census 2010 by census tract, and household income and number of household vehicle data from the American Community Survey (ACS), a five year estimate for 2005-09 which were the latest available reference data during the sampling design stage, NuStats identified census tracts with a high concentration of these hard to reach households.

As shown in the Figures 3.2.3.2 through 3.2.3.6, the census tracts were classified into four segments based on a weighted quartile distribution of hard-to-reach segments (weighted by the hard-to-reach segment counts), where each quartile included 25% of hard-to-reach segment counts. To illustrate, the top quartile in the Hispanic population distribution denoted as "Greater than 77%" in Figure 3.2.3.2 included all census tracts with more than 77% Hispanic residents at the census tract level (as identified by the 75th percentile) and represented 3,506,974 Hispanic residents that made up 25% of the Hispanic population. NuStats oversampled the hard-to-reach population segments from the "top two" quartiles with higher rate of oversampling from the topmost quartile. It is important to note that the figures presented in this section used the weighted quartile distribution to the segment count and therefore, do not directly represent a sample distribution of each target population group to the total population from 2010 Census data. The oversampling rates were adjusted across sample orders by MPOs/RTPAs depending on the incidence of completed surveys from hard-to-reach groups.

NuStats also supplemented this effort with listed samples available from our vendor for hard-to-reach groups. This included low-income listed sample, large-household listed sample, young household headed listed sample and Hispanic surname sample (to name a few). In addition to the aforementioned hard-to-reach groups, NuStats also oversampled transit-using households and zero vehicle households to ensure there was adequate representation of the travel patterns of transit users. Specifically, NuStats oversampled all households residing within 0.25 mile of the transit lines or bus stops, and 0.5 mile of the rail stations (see Figure 3.2.3.7, page 22).

Note that the geographic and socioeconomic stratifications were monitored separately. In addition, the sample performance was closely monitored to ensure that adequate representation of hard-to-reach demographic groups was realized. In cases of under-representation, the specifications of the subsequent

[2] This effort was funded by Kern County.

sample orders were adjusted to oversample these demographic groups. Subsequent sample orders were adjusted based on the following evaluation criteria:

- What was the response rate? Were as many surveys completed as expected with the amount of sample ordered?
- How much of the sample was eligible vs. ineligible?
- For the completed surveys, what were the demographic distributions of each sample type compared to the Census distributions? Did the targeted listed residential sample successfully find the hard-to-reach population groups?
- Was the progress towards the geographic and demographic stratifications goals consistent, or were some geographic/demographic segments not performing as well as others?

3.2.3 Geographic Distribution

Figure 3.2.3.1 is a map showing the thirty sampling strata in the study area and were utilized to manage the recruitment and retrieval goals for the CHTS. A sampling structure was developed to oversample under represented areas, resulting in a distribution considered by the AC to be statistically accurate at the county level. The first 2/3 of the total sample size of households was allocated based on a proportional distribution of the number of households within each county relative to the entire state. The remaining 1/3 of household samples were targeted towards the "rural" counties, which included all counties except the top ten counties with the largest number of households. Table 3.2.3.1 delineates the distribution of households that comprised the study area.

Figure 3.2.3.1: A map of 30 sampling strata (see pages 19-20 for counties included in each strata)

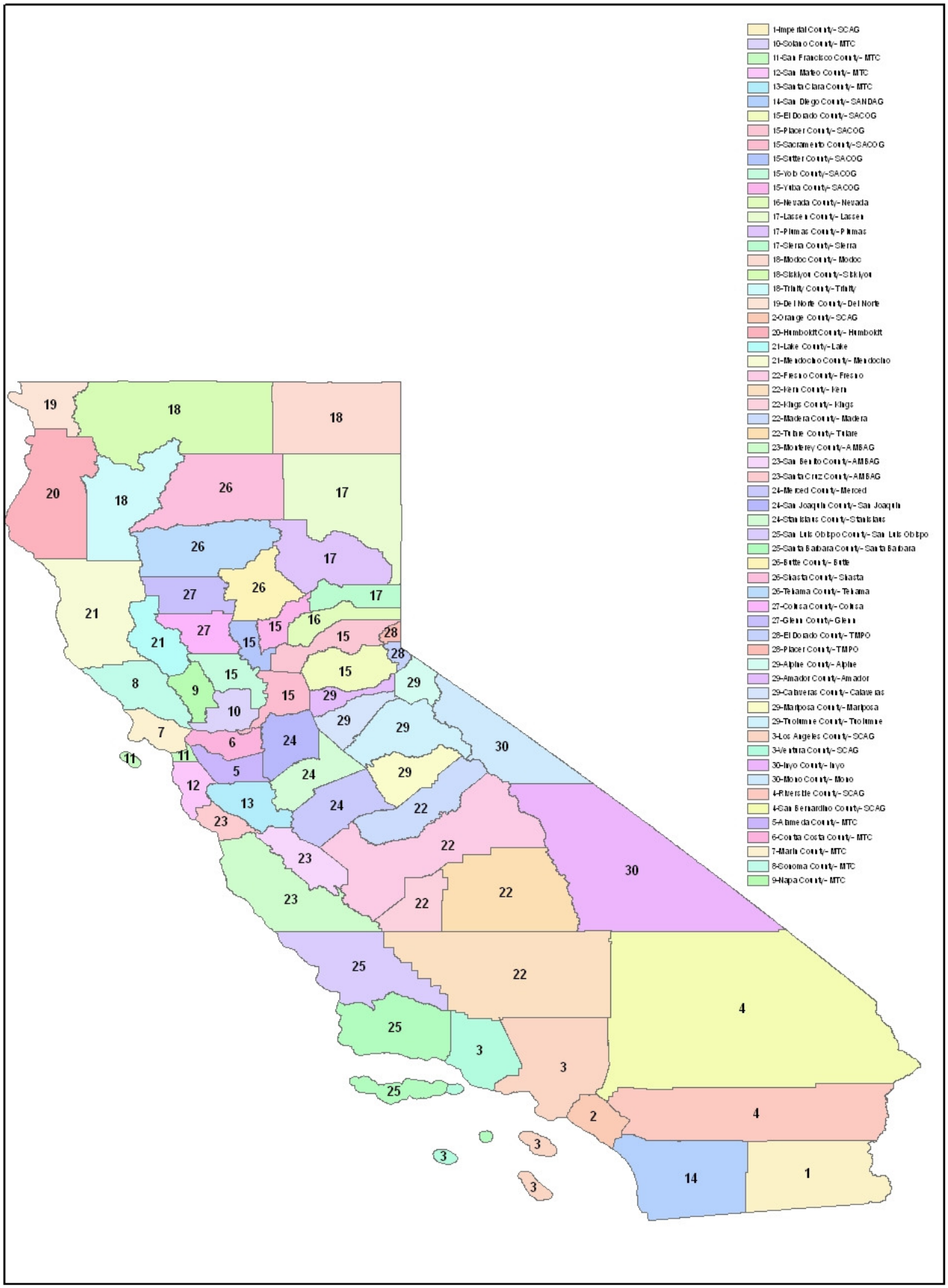


Table 3.2.3.1: Distribution of Sampled Households in the Study Area

MPO/RTPA	County	Total Households	Percent of Total Households	Total Households	Percent of Total Households
	Los Angeles	3,241,204	26%		
	Orange	992,781	8%		
	Riverside	686,260	5%		
	San Bernardino	611,618	5%		
	Ventura	266,920	2%		
SCAG	Imperial	49,126	<1%	5,847,909	46%
	Santa Clara	604,204	5%		
	Alameda	545,138	4%		
	Contra Costa	375,364	3%		
	San Francisco	345,811	3%		
	San Mateo	257,837	2%		
	Sonoma	185,825	1%		
	Solano	141,758	1%		
	Marin	103,210	1%		
MTC	Napa	48,876	<1%	2,608,023	21%
SANDAG	San Diego	1,086,865	9%	1,086,865	9%
	Sacramento	513,945	4%		
	Placer	128,160	1%		
	Yolo	70,872	1%		
	El Dorado	57,346	<1%		
	Sutter	31,437	<1%		
SACOG	Yuba	24,307	<1%	826,067	7%
Fresno	Fresno	289,391	2%	289,391	2%
Kern	Kern	254,610	2%	254,610	2%
	Monterey	125,946	1%		
	Santa Cruz	94,355	1%		
AMBAG	San Benito	16,805	<1%	237,106	2%
San Joaquin	San Joaquin	215,007	2%	215,007	2%
Stanislaus	Stanislaus	165,180	1%	165,180	1%
Santa Barbara	Santa Barbara	142,104	1%	142,104	1%
Tulare	Tulare	130,352	1%	130,352	1%
San Luis Obispo	San Luis Obispo	102,016	1%	102,016	1%
Butte	Butte	87,618	1%	87,618	1%
Merced	Merced	75,642	1%	75,642	1%
Shasta	Shasta	70,346	1%	70,346	1%
Humboldt	Humboldt	56,031	<1%	56,031	<1%
Madera	Madera	43,317	<1%	43,317	<1%
Nevada	Nevada	41,527	<1%	41,527	<1%
Kings	Kings	41,233	<1%	41,233	<1%

MPO/RTPA	County	Total Households	Percent of Total Households	Total Households	Percent of Total Households
Mendocino	Mendocino	34,945	<1%	34,945	<1%
Lake	Lake	26,548	<1%	26,548	<1%
Tehama	Tehama	23,767	<1%	23,767	<1%
Tuolumne.	Tuolumne	22,156	<1%	22,156	<1%
Siskiyou	Siskiyou	19,505	<1%	19,505	<1%
Calaveras	Calaveras	18,886	<1%	18,886	<1%
TMPO	El Dorado	12,877	<1%	17,344	<1%
	Placer	4,467	<1%		
Amador	Amador	14,569	<1%	14,569	<1%
Lassen	Lassen	10,058	<1%	10,058	<1%
Del Norte	Del Norte	9,907	<1%	9,907	<1%
Glenn	Glenn	9,800	<1%	9,800	<1%
Plumas	Plumas	8,977	<1%	8,977	<1%
Inyo	Inyo	8,049	<1%	8,049	<1%
Mariposa	Mariposa	7,693	<1%	7,693	<1%
Colusa	Colusa	7,056	<1%	7,056	<1%
Trinity	Trinity	6,083	<1%	6,083	<1%
Mono	Mono	5,768	<1%	5,768	<1%
Modoc	Modoc	4,064	<1%	4,064	<1%
Sierra	Sierra	1,482	<1%	1,482	<1%
Alpine	Alpine	497	<1%	497	<1%
		12,577,498	100%	12,577,498	100%

The sampling plan was revised on several occasions and was finalized in June 2012, although at the request of the Administrative Committee (November 14, 2012), the goals were modified to reflect the expected true goals. In Table 3.2.3.2 and Figure 3.2.3.2, an overall summary of the rebaselined sampling plans through June 2012 is presented. Table 3.2.3.3 presents the rebaselined sample distribution by the 30 sampling strata, with the modified expected goals.

Table 3.2.3.2: Summary of Sample Plans

SOURCE	NuStats									GRAND TOTAL		
	CHTS			SCAG, Energy Commission and MPO Augment			NuStats Total					
	Non-GPS	GPS	Total	Non-GPS	GPS	Total	Non-GPS	GPS	Total	Non-GPS	GPS	Total
Original Proposal ("up to 60,000)	55,000	5,000	60,000	-	-	-	55,000	5,000	60,000	55,000	5,000	60,000
Sample Plan July 2011	35,695	3,152	37,847	19,514	-	19,514	54,209	3,152	57,361	54,209	3,152	57,361
Sample Plan December 2011	29,443	2,400	31,843	12,234	3,500	15,734	41,677	5,900	47,577	46,377	5,900	52,277
Final Sample Plan June 2012	36,368	1,600	37,968	12,016	3,499	15,515	48,384	5,099	53,483	37,660	5,099	42,759

Table 3.2.3.3: Final Sample Plan Distribution by 30 sampling strata

	Strata	County	Initial 30 Sampling Strata Goals	Final Retrieved Samples
	1	Imperial	564	450
	2	Orange	3,353	2,676
	3	Los Angeles		
	3	Ventura	12,580	10,039
	4	Riverside		
SCAG	4	San Bernardino	4,192	3,345
	5	Alameda	1,730	1,380
	6	Contra Costa	1,243	992
	7	Marin	599	478
	8	Sonoma	955	762
	9	Napa	393	314
	10	Solano	770	614
	11	San Francisco	1,092	871
	12	San Mateo	1,204	960
MTC	13	Santa Clara	1,911	1,525
SANDAG	14	San Diego	2,177	1,737
	15	El Dorado		
	15	Placer		
	15	Sacramento		
	15	Sutter		
	15	Yolo		
SACOG	15	Yuba	2,889	2,305
Nevada	16	Nevada	328	262
Lassen	17	Lassen		
Plumas	17	Plumas		
Sierra	17	Sierra	574	458
Modoc	18	Modoc		
Siskiyou	18	Siskiyou		
Trinity	18	Trinity	714	570
Del Norte	19	Del Norte	309	246
Humboldt	20	Humboldt	416	332
Mendocino	21	Mendocino		
Lake	21	Lake	570	455
Fresno	22	Fresno		
Kings	22	Kings		
Madera	22	Madera		
Kern	22	Kern		
Tulare	22	Tulare	5,027	4,012
AMBAG	23	Monterey	2,558	2,041

	Strata	County	Initial 30 Sampling Strata Goals	Final Retrieved Samples
	23	Santa Cruz		
	23	San Benito		
San Joaquin	24	San Joaquin		
Stanislaus	24	Stanislaus		
Merced	24	Merced	2,169	1,731
San Luis Obispo	25	San Luis Obispo		
Santa Barbara	25	Santa Barbara	1,282	1,023
Butte	26	Butte		
Shasta	26	Shasta		
Tehama	26	Tehama	1,080	862
Glenn	27	Glenn		
Colusa	27	Colusa	486	388
	28	El Dorado		
TMPO (CA part)	28	Placer	450	359
Alpine	29	Alpine		
Amador	29	Amador		
Calaveras	29	Calaveras		
Mariposa	29	Mariposa		
Tuolumne	29	Tuolumne	1,003	801
Inyo	30	Inyo		
Mono	30	Mono	464	371
Subtotal (Including 100 Energy Commission)			**53,083**	**42,359**
Energy Commission GPS SAMPLE* **			**400**	**400**
GRAND TOTAL:			**53,483**	**42,759**

Figure 3.2.3.2 shows the overall recruitment and retrieval completes throughout the entire duration of the project. The chart is color coded to present the breakdown of CATI, Online and Mailback recruited and retrieved completed households. The red line indicates project expenses.

Figure 3.2.3.2 Recruitment and Retrieval Completes Over the Entire Duration

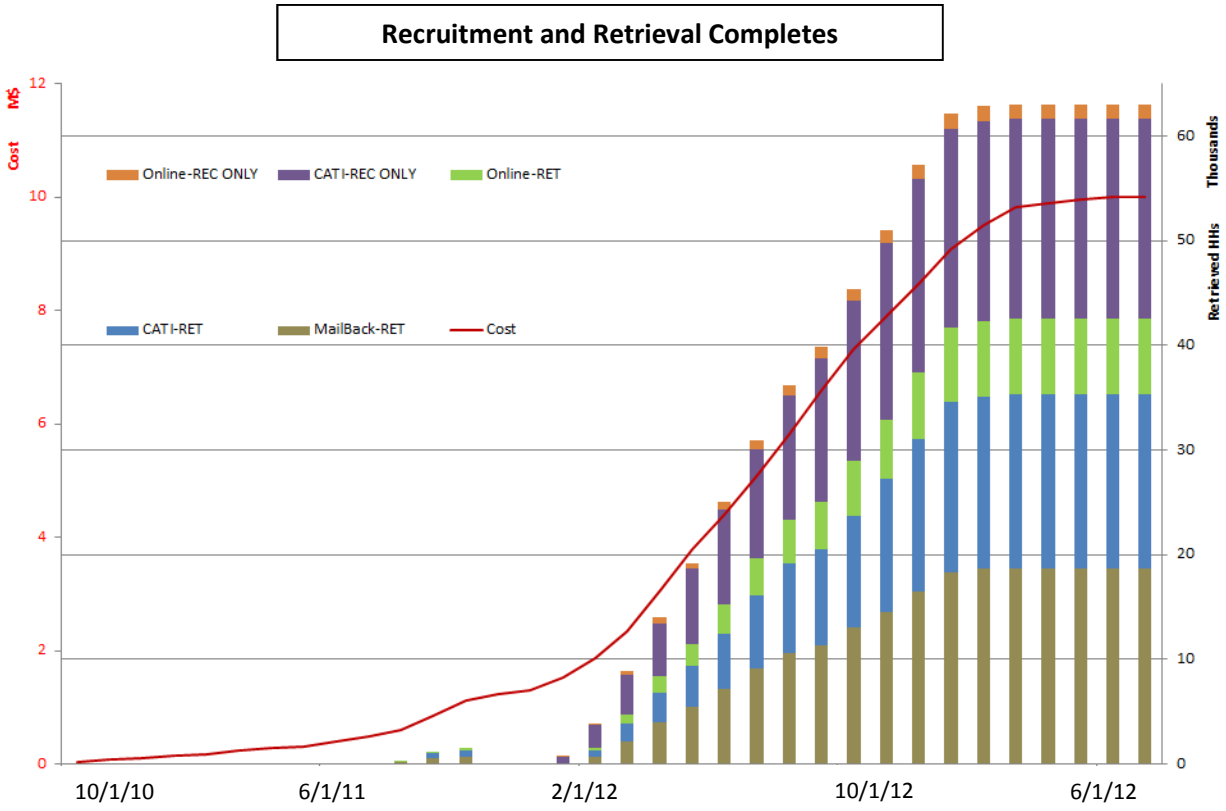


Figure 3.2.3.3 shows the density of the numbers of retrieved samples by strata ranging from 0.6%-25%. The ranges are color coded as is shown by the key at the lower right corner of the figure.

Figure 3.2.3.3: Density of Number of Samples by Strata

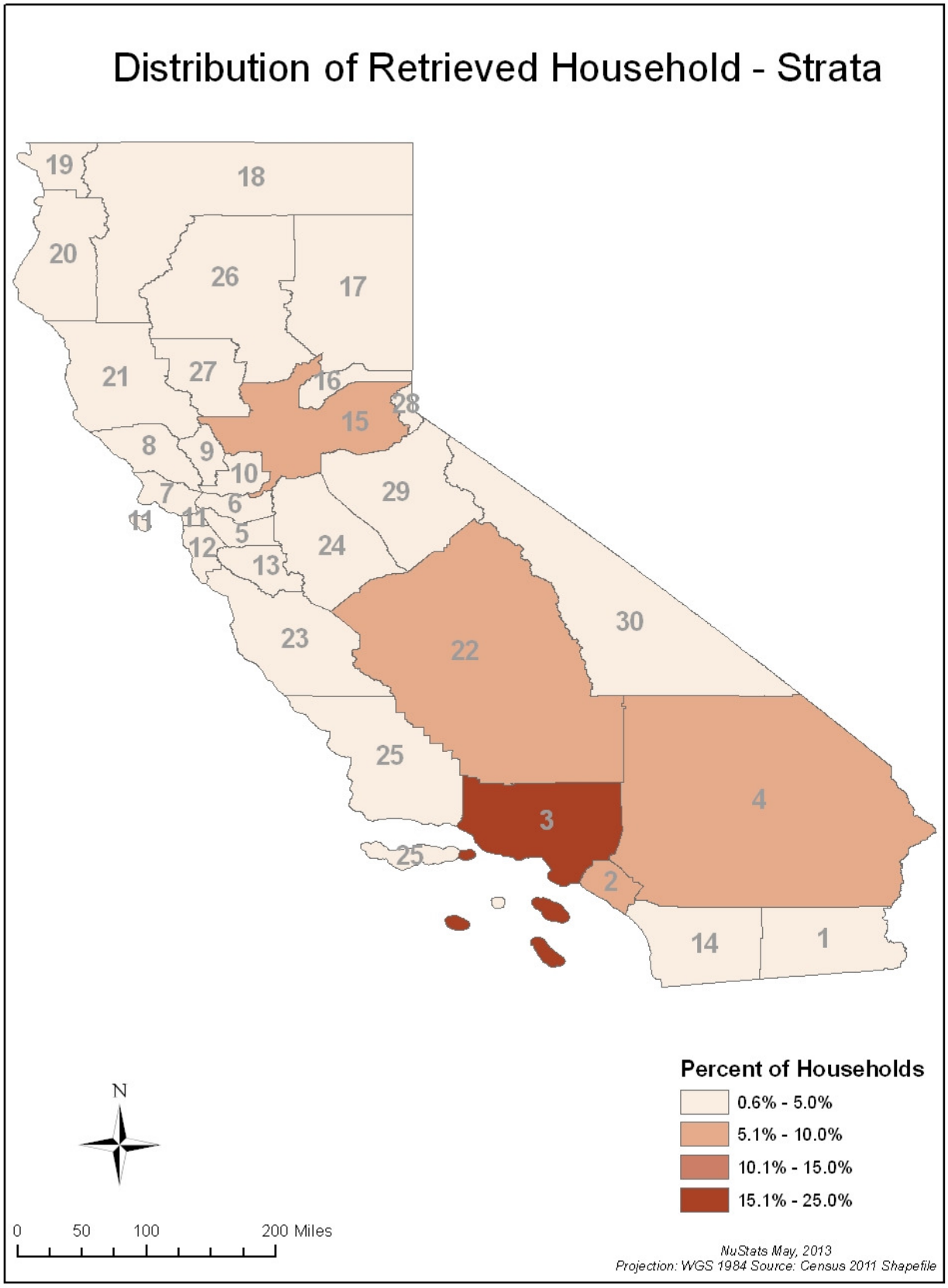


Figure 3.2.3.4: Quartile Distribution of Hispanic Population

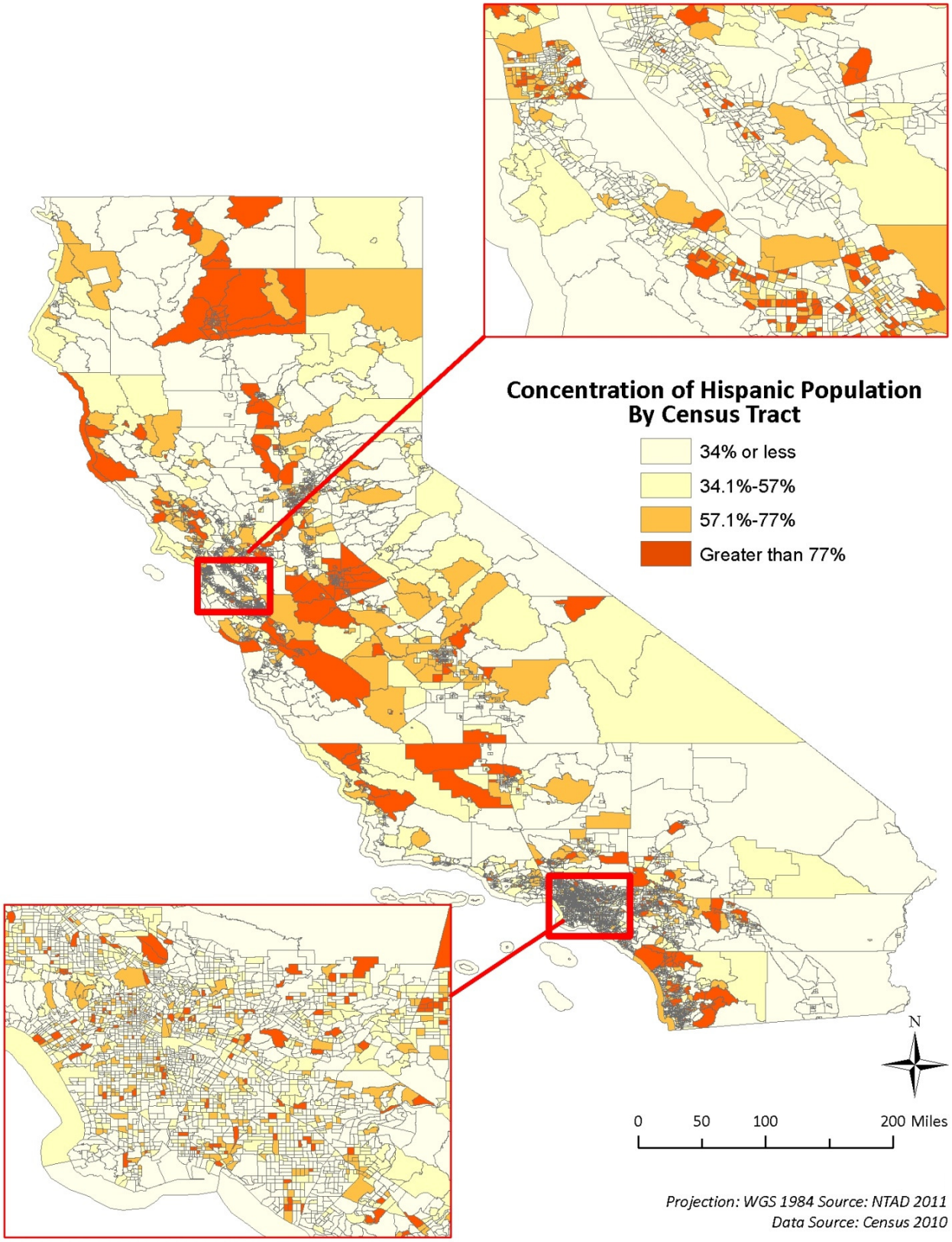


Figure 3.2.3.5: Quartile Distribution of Low Income Households (annual income less than $25,000)

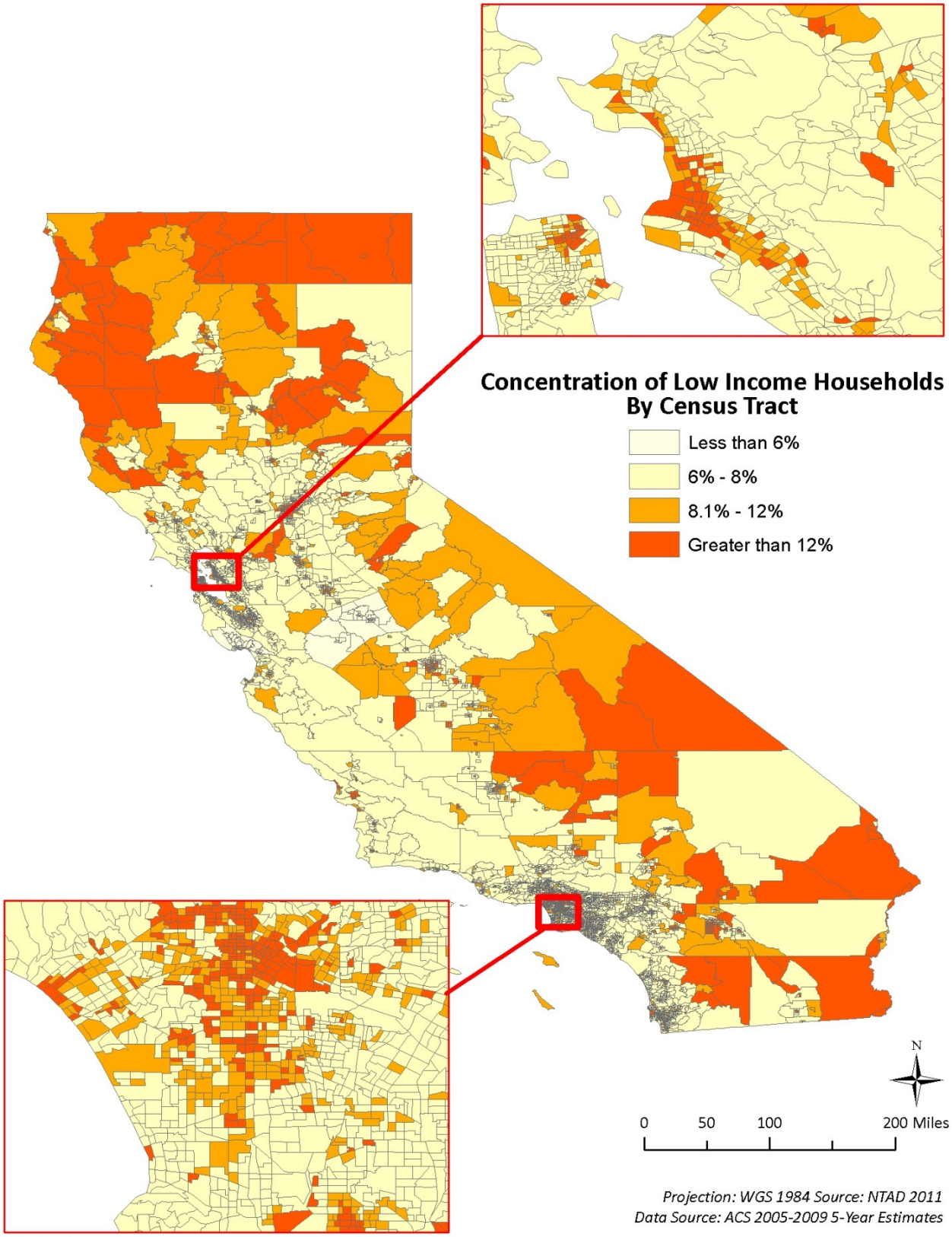


Figure 3.2.3.6: Quartile Distribution of Young Population (25 years of age or less)

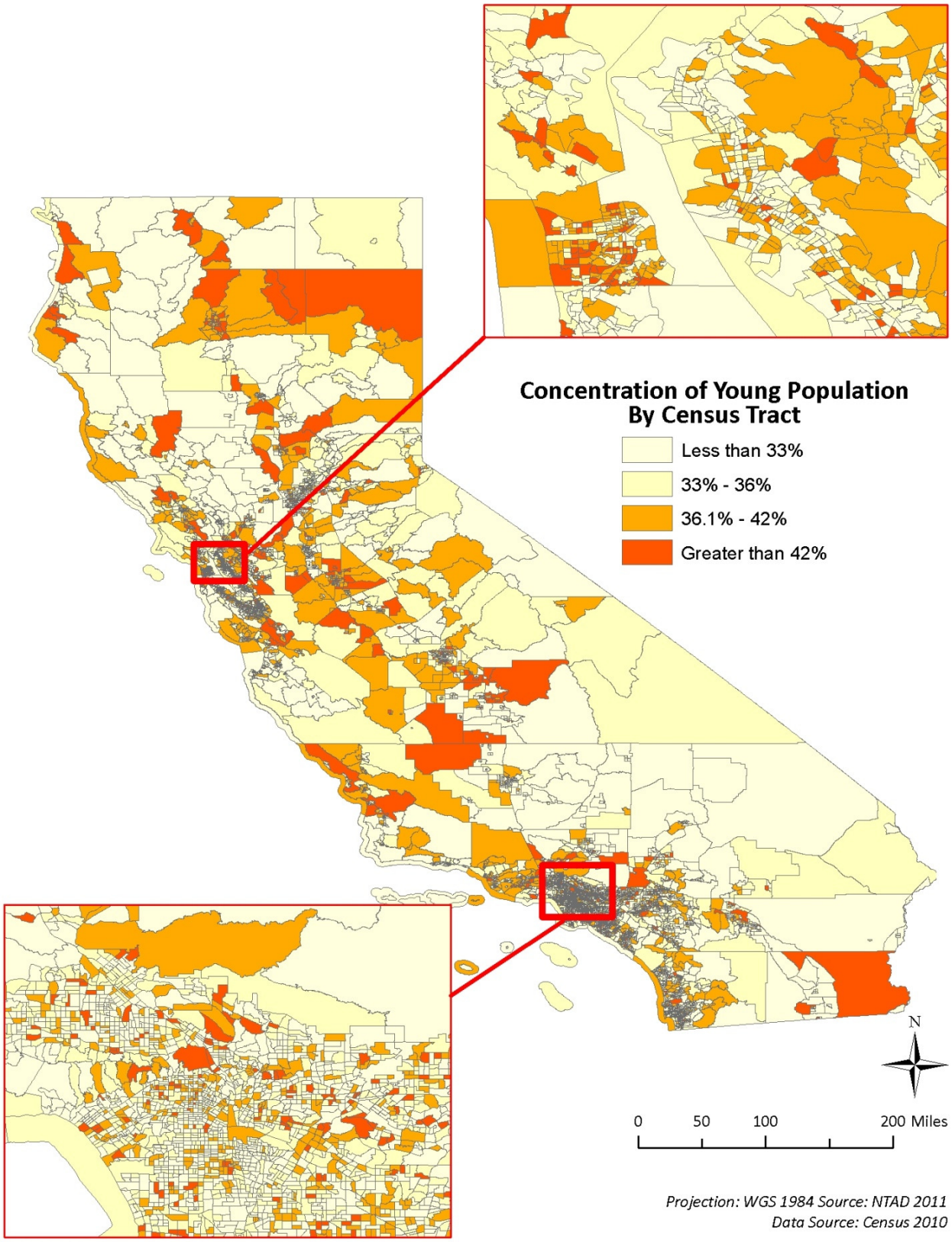


Figure 3.2.3.7: Quartile Distribution of Zero Vehicle Households

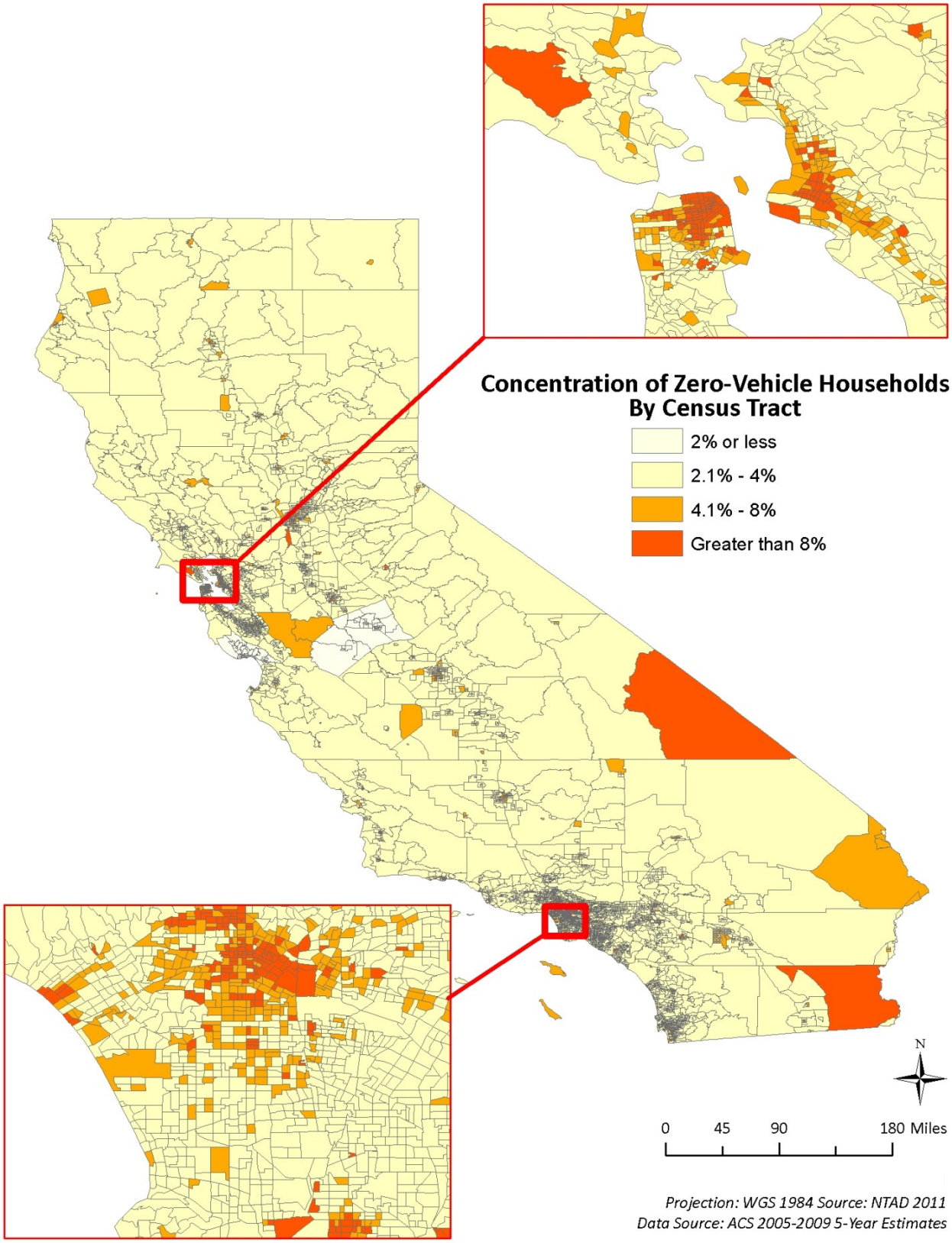


Figure 3.2.3.8: Quartile Distribution of Large Households (4 or more member households)

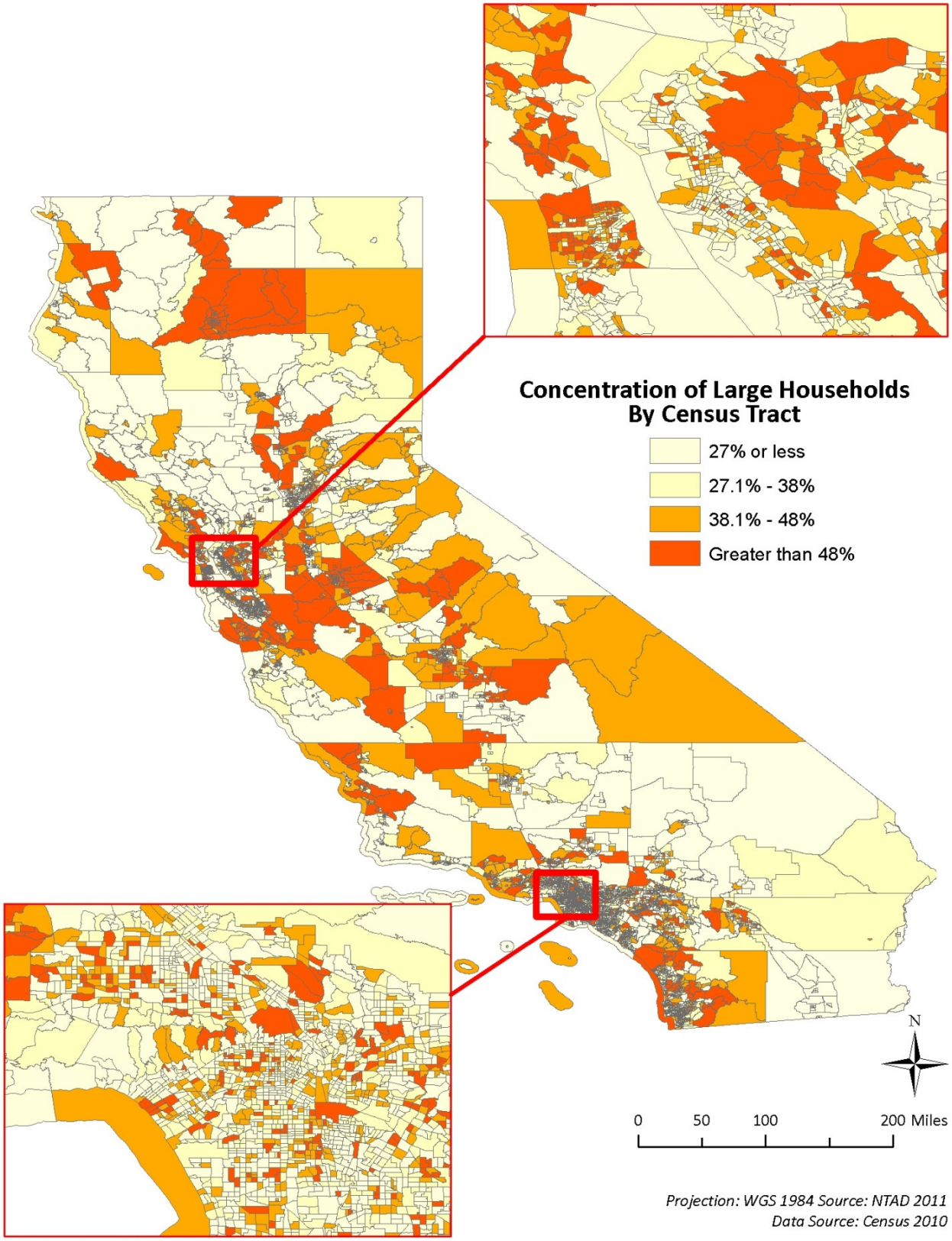
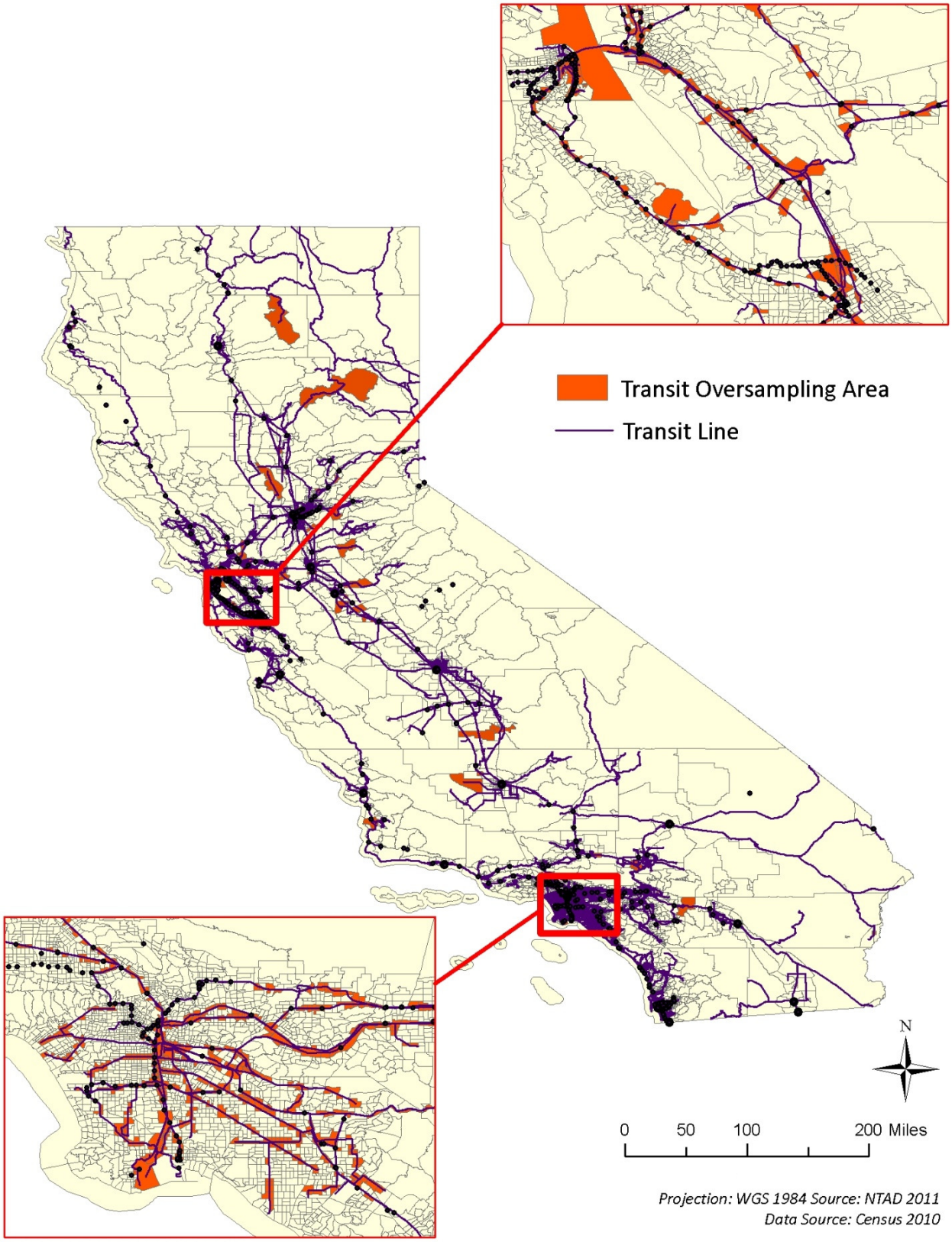


Figure 3.2.3.9: Transit Oversampling Area



NuStats also used a socioeconomic stratification to set demographic goals. Several demographic characteristics, including household size, household workers, household vehicles, household income, Hispanic status, and age of the residents in the study area were monitored. Table 3.2.3.4 provides the 2010 ACS/2010 Census distributions of these key data elements for the overall study area that were tracked in the weekly reports. The observed socioeconomic distribution of the completed surveys was monitored and compared with the 2010 ACS data and/or the 2010 Census distributions, to track the extent to which they fell within the expected ranges.

Table 3.2.3.4: Socio-Demographic Distribution for the Study Area

		Total Counts	% Counts
Household Size (Census 2010)	1	2,929,442	23.3%
	2	3,653,802	29.1%
	3	2,043,812	16.2%
	4 or more	3950442	31.4%
	Total	12,577,498	100.0%
Household Vehicle Ownership (ACS 2010 1 year)	0	969,100	7.8%
	1	3,992,884	32.2%
	2	4,644,854	37.4%
	3 or more	2,799,637	22.6%
	Total	12,406,475	100.0%
Household Workers (ACS 2010 1 year)	0	3,105,348	25.0%
	1	4,924,635	39.7%
	2	3,388,872	27.3%
	3 or more	987,620	8.0%
	Total	12,406,475	100.0%
Household Income (ACS 2010 1 year)	<$25K	2,669,373	21.5%
	$25K-$50K	2,770,966	22.3%
	$50k-$75K	2,168,573	17.5%
	$75K-$100K	1,530,962	12.3%
	$100K+	3,266,601	26.3%
	Total	12,406,475	100.0%
Hispanic Status of Residents (Census 2010)	Hispanic	14,013,719	37.6%
	Non-Hispanic	23,240,237	62.4%
	Total	37253956	100.0%
Age of Residents (Census 2010)	<25 yrs	13,217,991	35.5%
	25 – 34 yrs	5,317,877	14.3%
	35 – 44 yrs	5,182,710	13.9%
	45 – 54 yrs	5,252,371	14.1%
	55 – 64 yrs	4,036,493	10.8%
	65+ yrs	4,246,514	11.4%
	Total	37,253,956	100.0%

4.0 Survey Methods

This section describes the main survey methods. Following a brief discussion of the changes made to the main survey as a result of the CHTS pretest, the final survey design is presented in detail. Discussions of the following specific aspects of the survey methods are then presented: proxy reporting, call backs, refusals, hotline, handling non-English speaking households, interviewer training, incentives, definition of a completed household, long distance logs, respondent burden, and sample management. Survey outreach to hard to reach populations and ongoing quality control complete the survey methods.

4.1 Survey Pretest

The CHTS was a unique collaborative effort between several state agencies and all of California's Regional MPOs and RTPAs, each with varying data needs and desires. While the CHTS was always planned to include many data elements that were standard items in most travel behavior surveys, there were also many new data items that the various partner agencies and entities brought forward to be developed and tested in the CHTS pretest. Accordingly, the pretest was a complete test of all survey items and methods, with specific focus on interview length.

The CHTS pretest was conducted between August and mid-October, 2011, in English only. There were 1,568 completed households, comprising 1,357 non-GPS households and 211 GPS households (39 wearable GPS, 125 in-vehicle GPS, and 47 in-vehicle GPS and OBD households). Given the large number of questions tested, it was not surprising that the CATI interview length for both the recruitment and retrieval interviews was longer than estimated in the survey budget (22.4 minutes for recruitment as compared to 19 minutes estimated; 23.4 minutes for retrieval compared to 21 minutes estimated). To reduce the main survey length, the Pretest Peer Review Panel (a subset of the Administrative and Steering Committee members) approved the following recommendations:

- Remove items from the main survey that did not compromise the data necessary for modeling;
- Reduce the number of instances some questions were asked by asking them only once during the travel day instead of for each trip (e.g. use of toll roads);
- Expand the listed response options to reduce the need for "Other, specify" (i.e. open-ended questions).
- Move generic questions from the end of the retrieval interview to the end of the recruitment interview.
- Use targeted sampling to improve the response of under-represented populations; and,
- Enhance the survey instructions and explanations to encourage participation.

4.2 Final Survey Design

The CHTS pretest yielded many recommended revisions to the recruitment and retrieval instruments, and the changes based on the pretest were implemented in the main survey without the benefit of a second pilot test. As is discussed in the Limitations section, this meant that some changes may not have yielded the anticipated benefits. In addition, during the 12 months of main survey data collection, there were changes made to increase recruitment and retrieval rates for particular populations, to encourage online responses, and to generally raise the overall level of response. This section presents the final survey design and documents, to the extent possible, changes made.

4.2.1 Main Survey Data Collection Overview

The CHTS collected one day's travel information from a sample of household residents in all of California's 58 counties, plus portions of three adjacent counties in Nevada. The survey covered a one year period from February 1, 2012 through January 31, 2013. Travel was collected for all 366 days (2012 was a leap year) with no blackout periods for holidays, weekends or other events. The sampled households recorded their travel for a pre-assigned 24-hour period plus reported on long distance trips taken in the prior eight weeks. Households that agreed to participate in one of the three GPS samples used the GPS devices on the assigned travel day plus an additional two days for wearable GPS (3 days total), or an additional six days for in-vehicle or in-vehicle + OBD (7 days total).

Travel for all participating MPOs and RTPAs was spread across months of the year, and across all seven days of the week, with one exception: for the MTC non-core wearable GPS households, only Tuesday, Wednesday and Thursday travel was collected.

The main survey was conducted in English and in Spanish, so all survey materials including all printed materials, the CATI scripts, the online scripts, and the GPS instructions, were available in Spanish.

CATI interviews were conducted between 4 pm and 9 pm Pacific Standard Time (PST) on Mondays through Fridays, and between 2 pm and 7 pm on weekends. Starting on April 4, 2012, an earlier daytime shift was added to call between noon and 3 pm, Mondays through Thursdays.

Survey respondents were provided the option of completing the recruitment and retrieval surveys via a secure website. The online surveys followed the same general format and flow as the CATI programs used by the interviewers. The online portion was implemented using the same VOXCO software as was used for the CATI. Respondents accessed the online surveys from the public website, and gained access to the recruit and retrieval applications using a unique PIN provided in the advance letter or to recruited households during the CATI interview.

The majority of households in the main survey were recruited through CATI, but more households were retrieved by mail, as may be seen in Table 4.2.1.1. The percentage of CATI recruitment and the percentage of mail retrievals were both higher than anticipated, or budgeted, and were a complete reversal of what was observed in the pretest where 47% of retrievals were online. This shift in the main survey from online to CATI and mail had a severe impact on the data collection resources.

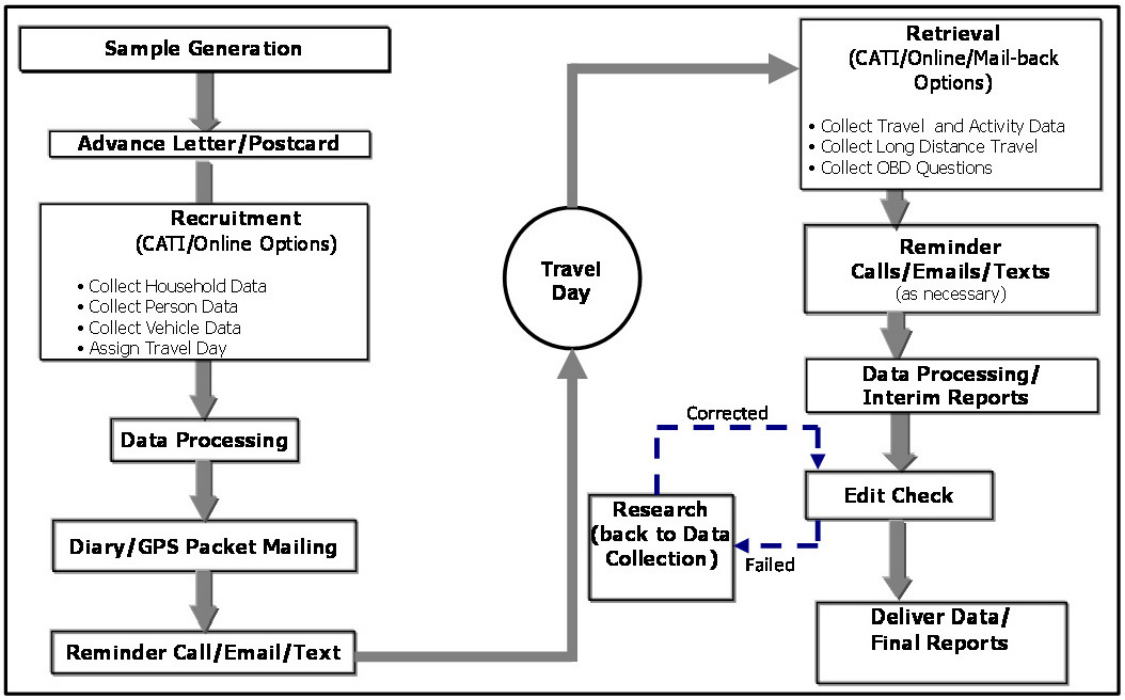
Table 4.2.1.1: Main Survey Recruitment and Retrieval Summary by Survey Mode

Survey Mode	Recruitment				Retrieval			
	Non-GPS Households	GPS Households	Total	Percent of Total	Non-GPS Households	GPS Households	Total	Percent of Total
CATI	49120	6205	55325	87.7%	16194	1117	17311	40.8%
Online	4917	2840	7757	12.3%	5655	1638	7293	17.2%
Mail					14865	2962	17827	42.0%
Total	**54,037**	**9,045**	**63,082**	**100.0%**	**36,714**	**5,717**	**42,431**	100.0%

4.2.2 Survey Processes

The main survey followed the traditional two-step process of recruitment of a household for a prospective assigned travel day, followed by a separate retrieval effort to collect the detailed travel information. Figure 4.2.2.1 shows the survey process utilized for the CHTS main survey.

Figure 4.2.2.1: CHTS Survey Process



The sequential survey processes discussed below include:

- Advance Letters
- Recruitment
- Survey Materials
- Reminder Contact
- Retrieval

Advance Letters

Advance letters provided potential participants with basic information about the survey, and were initially mailed to all sampled households in December, 2011 when recruitment started. Subsequent analyses of the effectiveness of the advance letters indicated they were less effective among matched households. This led to a change in the protocol in February 2012 so that advance letters were only sent to:

- All unmatched households;
- All households in the GPS samples, regardless of type of GPS; and,
- All households that were in any of the targeted samples, regardless of whether they were matched or unmatched households

Recruitment

There were two modes for recruitment: CATI and online. Table 4.2.2.1 shows the start and end dates of recruitment, by mode and for each language used in the main survey. The Spanish language implementation lagged the English as it was decided to wait until the English scripts were stable before undertaking translation in Spanish.

Table 4.2.2.1: Main Survey Recruitment Start and End Dates

Response Mode	START DATES		END DATE
	English	Spanish	
CATI	1/16/2012	3/22/2012	1/13/2013
Online	1/17/2012	3/22/2012	1/18/2013

Sampled households were eligible for recruitment at different points depending on whether they had received an advance letter. Households that were mailed an advance letter received an initial CATI recruitment contact within seven days from the date the letter was mailed out. The timing of the initial call was critical to increase the chances that the respondent would remember receiving a letter and for them to make the connection between the letter and the phone call. These potential respondents could call the toll-free number included in the letter to initiate the recruitment process or could complete the interview online using a PIN provided in the letter. Online completions were closely monitored and were used as indicators that letters had arrived. For households that did not receive an advance letter, recruitment calling was scheduled to begin about 12 days prior to the travel day.

To maximize response and reduce confusion among family members, during the recruitment interview, a household “reference” person was identified. This person was given the responsibility of ensuring that all members of the household completed a travel diary and, if applicable, used the GPS devices sent to them. At the end of the recruitment interview, this same person provided their contact information including a mailing address to have all the survey materials sent to them to distribute to other household members. This reference person was critical in ensuring all family members participated in the survey.

In order to ensure that the final demographic distribution was in line with the ACS data for California, "termination" algorithms were included in the CATI recruitment to randomly disqualify two groups that were disproportionately at home and reachable by telephone: the elderly and non-workers. Termination algorithms in the CATI program randomly disqualified 67% (two of every three) of elderly, where the age limit for elderly was initially set at age 75 but was lowered in early April, 2012 to 65 for both GPS and non-GPS recruitment. Half (50%) of all zero worker households were randomly disqualified.

The recruitment survey was made longer after the pretest by the decision to move some items from the end of the retrieval script to the recruitment script. The overall average time to complete the CATI recruitment interview was 26 minutes for the main survey.

In September, 2012, in an effort to reduce the recruitment interview length, Caltrans and the Administrative Committee agreed to skip the following four questions from the recruitment script for all households except those in the GPS in-vehicle and OBD households:

- How close is the nearest electrical outlet to where the vehicle is usually parked when you are at home?
- Is that a 110 or 220 volt outlet?
- Do you have Pay-As-You-Drive auto insurance for this vehicle?

- Does this vehicle have any devices provided by your insurance company to detect mileage driven?

This change was implemented in mid-September, 2012.

Survey Materials

Following recruitment, a packet of survey materials was custom assembled for each recruited household. For non-GPS households, the material contained either the English or Spanish versions of the following:

- Survey cover letter, signed by the Caltrans project manager;
- Separate travel diaries for each member of the household, with the name and PIN on each diary;
- A long-distance travel log, and,
- A postage-paid return envelope.

Recruited GPS households received a box containing all of the above, plus the relevant GPS equipment and instructions for use. Households recruited for the in-vehicle + OBD GPS group also received an additional paper questionnaire for electric only vehicle owners (Leaf and Volt).

Only 5,543 households requested at the end of the recruitment interview to receive the Spanish version of the recruitment package. This is less than 1% of the recruited households, and indicates that the majority of Hispanic households in the CHTS preferred the English versions.

Reminder Contact

Depending on the respondent's preference expressed at the end of the recruitment interview, recruited households were contacted the day prior to the household's assigned travel day by telephone, text or email. Households that received a text or email message had the opportunity to ask questions by calling the toll-free number or directly by emailing or texting the hotline team. There was a trained, dedicated team that reviewed and answered respondent's emails on a timely basis and forwarded emails that required special attention to managers.

The reminder contact served several key purposes. First, it confirmed that the travel diary (or GPS and travel diary) package was received. Second, it increased the likelihood that respondents would follow all the instructions and complete the travel diary in a timely manner. Third, it provided an opportunity to further reinforce the study's legitimacy and to answer any questions participants had. Fourth, it reminded eligible households of the incentive they would receive if they completed the retrieval interview in a timely manner. And, finally, it provided an opportunity to schedule a specific retrieval callback appointment.

Telephone reminders were done in two waves each day. Wave one took place earlier during the day and staff made as many direct contacts with respondents as possible until all households were called once. Since the goal of the call was to make a direct contact with the household, voice-mail messages were not left during the initial wave. Wave two was a second round of calls that took place later in the day, and this time voice-mail messages were left if the household was not reached.

Retrieval

There were three modes for a household to provide travel information: by CATI, online or by mailing back the completed diary and long distance logs. Table 4.2.2.2 presents the start and end dates of retrieval for CATI and online, by language. The last day for receipt of mailed back diaries was February 7, 2013.

Table 4.2.2.2: Main Survey Retrieval Start and End Dates

Response Mode	START DATES		END DATE
	English	Spanish	
CATI	2/2/2012	4/5/2012	2/14/2013
Online	2/3/2012	4/5/2012	2/14/2013
Mail			2/7/2013

The recruitment and retrieval surveys were designed to provide a consistent platform for travel behavior questions across the State. However, the two major MPOS, MTC and SCAG, each asked for slightly different approaches or questions for households in their region, and the Energy Commission had several items that were unique to their desired sample of alternative fuel vehicle owners. As noted above, the MTC requested that their funded sample of wearable GPS households have their assigned travel days restricted to Tuesdays, Wednesdays, and Thursdays only. SCAG wanted more detail about participants in each activity than was desired by the rest of the state, so questions asking for the nature of the relationship of each person who accompanied a respondent in an activity were asked only in the SCAG counties. The Energy Commission had several questions asked of GPS in-vehicle and OBD households only.

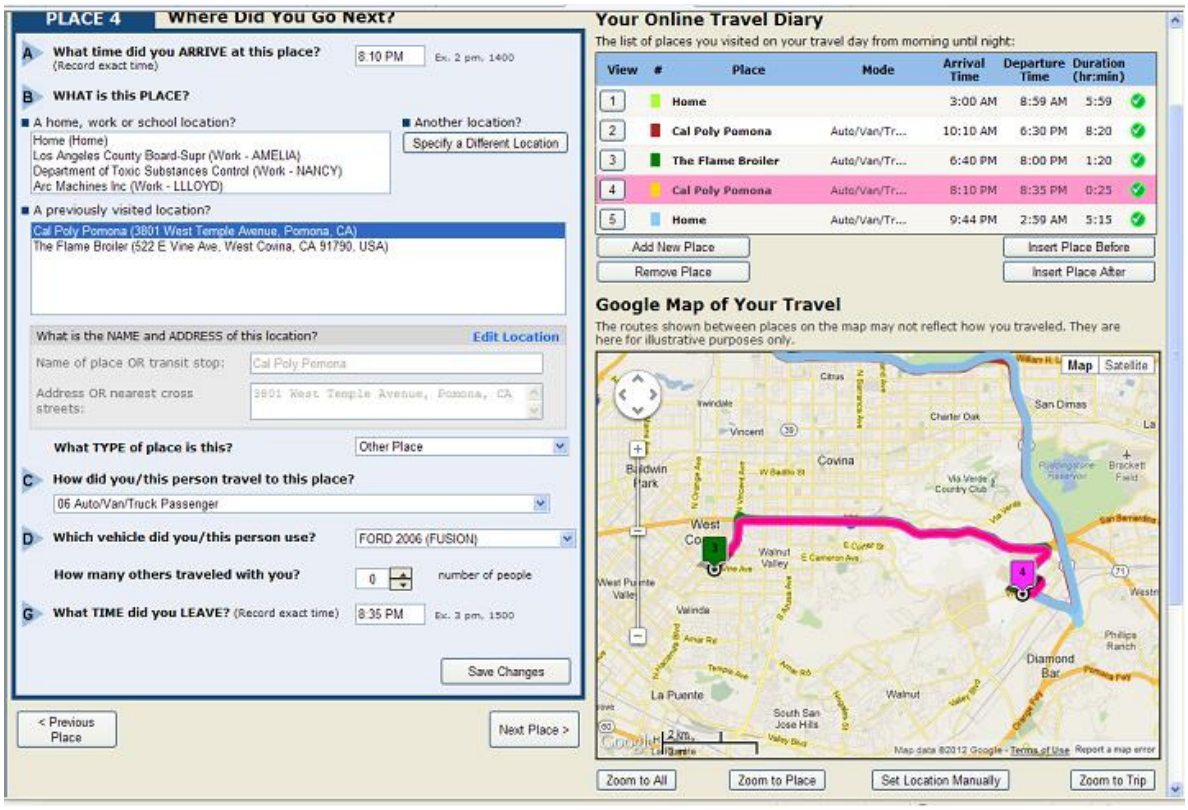
TripBuilder™

TripBuilder™ is an interactive mapping software tool which integrates an online Google map, online geocoding, and routing to effectively collect travel details using a browser. It was used in both the CATI and online retrieval portions to collect and automatically geocode locations. First, the habitual locations such as home, work, or school locations (if applicable) of all household members were collected and geocoded to x- and y-coordinates using TripBuilder™. These habitual locations were then recorded in the retrieval application, so that the households did not have to re-enter these locations. TripBuilder™ then geocoded all locations visited by household members during their assigned 24 hour travel day, and collected additional details about each location. TripBuilder™ incorporates a Google mapping interface to view and plot these locations. Locations could be found on a map using name, address, or cross streets. Several search results of the location were presented based on information of place name, address or cross street information. This allowed the interviewers or online respondents to select the most accurate location. An added feature within TripBuilder™ was the Google transit button that allowed the CATI interviewers and online respondents to use the last and new destination by transit mode to give the most logical routes taken when the travel mode was transit. In addition, TripBuilder™ featured a trip summary which allowed interviewers or online respondents to view the details of places including place name, mode, arrival and departure times. TripBuilder™ for the most part followed the format and order of the diary and long distance log materials. A tutorial video of the TripBuilder™ software was provided on the CHTS website for online respondents.

For households that completed both the recruitment and retrieval portions of the CHTS (primary completes), in the minimal number of cases for which zip codes , city names, or state abbreviations were not appended from TripBuilder™, NuStats used autocoder for reverse geocoding to retrieve these missing data elements.

An example TripBuilder™ screen appears in Figure 4.2.2.2.

Figure 4.2.2.2: Example TripBuilder™ Screen



4.2.3 Proxy Reporting

It is generally accepted best practice for travel data to be collected from the person who performed the travel in as many cases as possible. Information that is provided by anther household member is referred to as "proxy" reporting.

In the CHTS, the CATI interviewers were trained to speak to each person 16 years of age or older. Proxy reporting was permissible when:

1) The information for the missing adult existed in a completed travel log and another person was willing to read off the recorded information; or
2) The travel data could be obtained through the GPS unit.

In both situations interviewers were required to make a minimum of three call attempts within a seven-day period. Households with missing adult information were coded as Proxy Partials and follow up calls were made by the same interviewer when possible to maintain rapport and continuity with the household. At the beginning of the fourth day after the assigned travel day, if no contact had been made, the household was released for completion by proxy. This usually meant having the reference person report from memory the activities of the missing adult. In those instances when the missing travel information could no longer be obtained, the household was technically unresolved and it was coded as a Partially Completed Interview or a Partial Refusal.

4.2.4 Call Backs

Call backs were initiated in two places within the CHTS survey process. During the retrieval process, call backs were made to:

- Households that were missing key data elements, such as travel location information, and
- All households that returned their diaries by mail were automatically called back (up to a maximum of 3 times) to retrieve those data elements that were not printed on the diary or long distance travel log. Since almost half of the main survey household provided their travel information by mail, this was a major effort.

These call backs were managed by the VOXCO CATI software, which has a sophisticated sample management component that allows interviewers to schedule callbacks or types of contacts at the time requested by the respondent.

The next step in the survey process was an automated edit check system (described in Section 6.2). Households that did not pass the edit checks and needed additional corrections or follow-up were handled by the Quality Assurance research team. The research team conducted a thorough review of each record and initiated a follow-up or call back with the main respondent of the household to clarify any missing data or data discrepancy. If the research team was unable to reach the household, they left a message to call the hotline to confirm information about their reported travel. If an email address was provided, an email message was sent requesting the respondent call the research team to confirm information about their reported travel.

4.2.5 Refusals

Each respondent has a unique set of factors to consider when making the decision to participate in a survey. Some respondents are concerned with the legitimacy of the research, others want to make sure their privacy is protected, some want to make certain there is a clear benefit to participation (to themselves, their community, or society in general), and still others are concerned about the time and burden of the study. Regardless of their primary concern, all respondents are more likely to participate when contacted by a professional, persuasive, and engaging interviewer.

In addition to teaching interviewers to use the characteristics of their voices for sounding upbeat and engaging, the interviewer training focused on teaching interviewers to “read” respondents and tailor their replies to respondent questions and objections based on the undermining concerns. Remaining professional at all times as well as friendly and courteous were considered crucial elements at gaining and maintaining cooperation from respondents. Interviewers were always taught to be tactful, pleasant, sincere, and well prepared.

Interviewers were also trained to provide additional information about the study to handle a call where the respondent sounded insecure and showed a lack of understanding about the CHTS even after an explanation was given. In addition to learning best practices, interviewers were trained to leave detailed interviewer notes in the records. It was critical that interviewers document the "facts" for full understanding of the situation in case the respondent was very difficult or threatening during the call and later wanted to complain about the study or the phone call.

Refusal avoidance and refusal turn around skills were more critical during the retrieval stage. At the retrieval stage, much time and effort had been spent in recruiting the household and in mailing them materials for their participation. This is why not just one but a series of refusal conversion attempts were made, each followed by a resting period. These attempts were often successful, especially when the calls were made by seasoned interviewers that had experience working with difficult cases.

4.2.6 Hotline

NuStats maintained a toll-free hotline that provided assistance and responded to survey participant's concerns. The hotline was staffed from 9 am to 9 pm on weekdays, and from 9 am to 7 pm on weekends. During the course

of CHTS, roughly 8,500 hotline telephone calls were received, along with 3,500 emails. As can be seen from Table 4.2.6.1 below, almost half of the calls during recruitment were from households asking to be taken off the call list. During retrieval, the calls were most frequently general questions or requests to report travel.

Table 4.2.6.1: Hotline Call Summary

RECRUITMENT CALLS			RETRIEVAL CALLS		
Reason for Call	Count	% of Total	Reason for Call	Count	% of Total
Take me off your list	1732	42.0%	Take me off list	316	7.2%
General Question	955	23.2%	General Question	772	17.5%
Called to participate in survey	688	16.7%	Called to report travel	615	13.9%
Called to say they got advance letter	456	11.1%			
Validation Questions	114	2.8%	Validation Call	2	<1%
PIN number issue	50	1.2%	PIN Question	38	<1%
Needed on line help	48	1.2%	On line issue	422	9.6%
Had not received materials	10	<1%	Has not received materials-needs reschedule	28	<1%
Wanted to be re-scheduled	9	<1%	Needed to be rescheduled	136	3.1%
			Returning our call	514	11.6%
			How to fill out diaries	91	2.1%
			GPS question	185	4.2%
			Long Distance Log Questions	105	2.4%
			Has mailed completed diaries in	205	4.6%
			Household will mail in diaries	62	1.4%
			Called to correct information	21	<1%
			Incentive Questions	593	13.4%
Other	63	1.5%	Other	311	6.9%
Total Recruitment Calls	4125	100.0%	Total Retrieval Calls	4416	100.0%
Grand Total All Hotline Calls = 8,451					

4.2.7 Non-English Speaking Households

The main survey was conducted in Spanish as well as in English. NuStats provided a team of experienced bilingual interviewers who were trained to conduct interviews in Spanish as requested by respondents. Households that requested the interviews be conducted in Spanish were either routed to one of the bilingual interviewers or, if one was not available, the household was coded as requiring a Spanish call back. Interviews in Spanish tended to be longer than those in English as interviewers had to explain concepts that sometimes were harder to relate to for some of these respondents. A team of bilingual supervisors was tasked with daily monitoring duties to ensure interviewing protocols were met in Spanish just as well as they were in the main English survey.

The Hispanic surname sample that was purchased to help obtain a representative sample of Hispanic households (see Section 6.0) was coded for bilingual interviewers. The daytime shifts that were scheduled after the study began were primarily for bilingual interviewers to call this sample as previous experience indicated being able to reach a significant number of Hispanic households during the day.

Households that were monolingual in languages other than English or Spanish were coded with a "Language Barrier" call disposition, thanked and not included in the survey. There were 28,783 such households in the main survey, as may be calculated from the recruitment sample disposition table in Section 6.4. This equates to 1.4% of all sampled households. Remember that this represents all other non-English languages, which in California include Chinese, Tagalog, Vietnamese, Korean, Persian, Armenian and many more.

4.2.8 Interviewer Training

All telephone interviewers and hotline staff were rigorously trained to ensure delivery of the highest quality data. The production and quality teams worked closely with the interviewers, the project manager(s) and programming team to evaluate sample and interviewer performance, and implement changes where it was deemed necessary. These efforts resulted not only in high quality data, but also ensured all sample was adequately worked.

All CHTS team members were trained according to Marketing Research Association (MRA) standards. The rigorous training program at NuStats included not only the technical aspects such as using the CATI interviewing programs and phone system, but also how to convey the importance and legitimacy of the survey, techniques for overcoming respondent's refusals and maintaining professionalism at all times. In addition, CHTS project-specific training was provided, covering the specific details of the study such as the geography of the study area, colloquialisms, and subtle nuances about the study and/or particular region. The training program included:

- Details about the study including project purpose, objectives, and goals;
- Specific interviewing quotas (e.g., demographic items, residence location); and,
- A detailed project schedule.

Interviewers also underwent in-depth training on the CATI recruitment and retrieval programs. The training protocol covered the recruitment introductory script and each interviewer spent time familiarizing him/herself with the types of questions asked in the survey along with how to record the outcome results. Interviewers walked through each question along with choices and acceptable responses. Special attention was paid to not introduce any bias in the interviewing process, as this was a critical component of the training. Clarification of any question was discussed thoroughly with the team along with specific probing techniques particularly for open-ended questions. Bilingual interviewers were trained in English and Spanish to ensure they were familiar with both scripts.

The Interviewer Training Manual is included as Appendix J.

4.2.9 Incentives

Households participating in the CHTS survey were offered an incentive for providing complete information, which included travel and other information about all household members and vehicles. In addition, GPS households were not eligible for the incentive until all devices were used as instructed and returned to the GPS deployment team. Based on the results of the CHTS pretest, incentives in the main survey were targeted to:

- Households that used any form of GPS;
- Households that responded online. Initially, the incentive was offered to households that completed either recruitment or retrieval online. This was changed in May 2012 to only offer the online incentive to households that completed both recruitment and retrieval online.
- Young households (age <34);
- Low Income (< $25,000);
- Hispanic; and,

- Large (4+ person) households.

Table 4.2.9.1 presents the incentive structure for the non-GPS households in first phase of the main survey. An individual household was eligible to receive only one incentive, which would be the maximum amount in any single eligible category. For example, a 6-person, Hispanic and low-income household that responds online would receive a $40 incentive, the maximum incentive the household was eligible for as a large household.

The standard incentive amount used in the main survey ($20) was slightly lower than the amount in the pretest ($25); this change was made to keep the total budget for incentives within the original amount proposed. The incentive structure for non-GPS households underwent changes in May 2012; most notably, the structure was changed to require households complete both recruitment and retrieval online in order to be eligible for an incentive.

Table 4.2.9.1: Main Survey Incentive Structure for Non-GPS Households

TARGETED NON-GPS HOUSEHOLDS	Incentive Amount		Offered to What Percent of Targeted Households	
	Jan. - May 9, 2012	May 10, 2012 - Feb. 2013	Jan. - May 9, 2012	May 10, 2012 - Feb. 2013
Online Recruitment or Retrieval	$20	Same	100%	0%
Online Recruitment **and** Retrieval	$20	Same	100%	Same
Young (<34)	$20	Same	50%	Same
Low-Income (<$25K)	$20	Same	50%	25%
Hispanic	$20	Same	75%	Same
Large households (4+)	$40	$30	50%	Same

Table 4.2.9.2 shows the incentive structure for GPS Households. Note that the GPS incentive structure was per person or per vehicle, depending on the type of GPS unit. The GPS incentive structure for the main survey initially was the same as had been used in the CHTS pretest, but then was changed in May 2012 to place a maximum limit on the total incentive amount a household using wearable GPS devices could receive.

Table 4.2.9.2: Main Survey Incentive Structure for GPS Households

GPS TYPE	Incentive Amount	
	Jan to May 9, 2012	May 10, 2012 to Feb. 2013
Wearable GPS	$25/Person	$25/Person ($75 maximum per
Vehicle GPS	$25/Vehicle (3 vehicle maximum per Household)	Same
Vehicle GPS and OBD	$40/Vehicle (3 vehicle maximum per Household)	Same

The total amount of households who received incentives during the main survey and the pretest is presented in Table 4.2.9.3 below.

Table 4.2.9.3: Incentives Summary

Household Type	Incentive type	Non-GPS Households	GPS Households
Non-GPS	**Online completes but not demographic group**		
	Online REC or RET; Online REC and RET	4097	
	Not Online completes but demographic group		
	Large HH (4+)	3862	
	Hispanic HH/Young HH(<35)/Low Income *HH (<$25K)	6028	
	Subtotal	**13,987**	
GPS	Wearable GPS		3871
	Vehicle GPS		424
	GPS / OBD		1442
	Subtotal		**5737**
	MAIN STUDY TOTAL	**19,692**	
	PRETEST TOTAL		
			GRAND TOTAL

4.2.10 Definition of a Completed Household

The initial definition of what constituted a complete household for the CHTS was determined in May 2011, before the pretest. The initial definition of completeness:

1. Required all locations to be 100% geocoded
2. Specified there could be no more than 5% missing data from a record
3. Provided exceptions for households with 4+ and 5+ persons
4. Confirmed that the long distance survey was independent and did not affect the definition of completeness
5. Defined completeness for each type of GPS.

In May 2012, with the approval of Caltrans staff and the Administrative Committee, the definition was changed to:

1. Clarify the levels of location geocoding
2. Clarify that DK/RF were valid responses that were not considered missing
3. Lowered the upper age for GPS use from 75 to 65
4. Capped the GPS wearable incentives at a total of $75 per household
5. Clarified the definition of GPS completes.

The final definition of a completed household is presented in Appendix K.

4.2.11 Long Distance Logs

One of Caltrans' key requirements for the CHTS was that it collect long-distance, specifically inter-regional, trips. Even with the large sample size of the CHTS, it was doubtful that the number of long-distance trips collected during the 24-hour travel days would be statistically robust. Accordingly, NuStats had proposed to collect additional long distance trips using a retrospective long distance travel log.

In the CHTS pretest, a one-page long distance (LD) log was tested to collect all trips of 50 miles or more in one direction taken in the previous two weeks. If no one in the household had taken a long distance trip in the previous two weeks, the household was asked to report the most recent long distance trip made by any household member, whether it was two months or two years ago. The pretest results indicated the log worked in that more long distance trips were collected than those that were on the assigned travel day, but it did not yield the desired minimum of one LD trip per household. More importantly, the log itself appeared to be confusing to respondents, with too many similar-sounding items crowded into a relatively small space on the printed page.

The long distance log was extensively revised for the main survey, with the goal of focusing the questions only on the items deemed absolutely critical for long distance trip modeling. The changes included:

1. The long distance recall period was re-defined as the eight weeks prior to the assigned travel day. If there were no long distance trips made during that period, the respondent made note of this and no further questions were asked.
2. Reducing the number of questions printed on the long distance log, which included removing the type of lodging, number of stops, name and address of airport or bus/train station (if used), and access and egress modes to airport of bus/train station (basically the physical right side of the pretest version of the printed log). These questions were asked in the CATI and online retrieval scripts in the main survey, but were asked only of the most recent trip. Note that survey respondents who mailed back a completed LD log did not provide responses to those items.

These changes were reviewed and agreed upon by the Pretest Expert Peer Review Panel. Later review by various modeling experts indicated that removing the access and egress modes from all transit trips except the most recent trip left the long distance dataset limited for certain modeling purposes. This is also noted in Section 10, Survey Limitations.

Table 4.2.11.1 provides the total number of long distance trips that were reported in the CHTS, in either the diary on the assigned travel day, or in the long distance log as being made in the prior 8 weeks. The importance of the long distance log is emphasized by the finding that only 5% of the over 77,000 long distance trips in the CHTS were reported in the diaries on the assigned travel day. The retrospective long distance log was needed in order to gather sufficient trips for modeling purposes.

Table 4.2.11.1: Summary of Long Distance Trips Reported

Where Trips Reported	Households Reporting Long Distance Trips (Trip distance 50 miles or longer)		Long Distance Trips Reported (All reported)	
	Number	Percent	Number	Percent
In Diary (On Assigned Travel Day) - Only	1630	3.8%	4069	5.2%
In LD Log Only	15801	37.2%	58154	74.9%
In Both	2207	5.2%	15430	19.9%
Subtotal:	19638	46.3%	77653	100.0%
No LD Trips Reported:	22793	53.7%		
Total	42431	100.0%		

The main survey long distance log (English only) is in Appendix L.

4.2.12 Respondent Burden

Table 4.2.12.1 below presents the average length of time, in minutes, for a respondent to complete the recruitment and retrieval portions of the survey, by response mode.

Table 4.2.12.1 Average Time in Minutes to Complete the Main Survey

RESPONSE MODE	RECRUITMENT	RETRIEVAL
CATI	26	21
Online	28	30
Mail		23

4.2.13 Sample Management

Sample management concerns those aspects of data collection management involving the availability and release of households (samples) in the project database to the appropriate next step in the survey process for that household. Much of the sample involves the management efforts of the data collection team. This included looking at the characteristics of the sample and making adjustments to maximize productivity and response, including review of live/non-final sample to determine how much new sample, relatively fresh sample (only a few call attempts), and older sample was available. It also included ensuring that all callbacks, including recruitment and retrieval programs and all specialized or target sample including GPS households, were properly loaded in VOXCO and allocated to staff, including calls that may be scheduled from online recruitment mode.

NuStats staff oversaw and facilitated quota management for all modes of data collection on an on-going, real-time basis through the VOXCO Command Center program. Quotas and strata were constantly checked to ensure that they were filling proportionately. This aspect of the VOXCO interviewing software was critical in launching complex, large household studies such as the CHTS because it provided an efficient, low-risk method for

centralized, timely tracking and adjustments. When necessary, sample was assigned with priority to generate completes in lagging quota cells.

In addition to sample and quota management, the team closely tracked and managed productivity, production levels, and schedules on an hourly basis. If productivity was lagging, staff troubleshot project performance and worked quickly to identify the cause(s) and rectify the issue(s). Proper quota and production management for large studies such as the CHTS were heavily reliant on real-time, constant sample management so production task leads were tracking, coordinating, and reporting on sample performance indicators with other key project team members on a regular basis.

Recruitment Sample Protocols

For the CHTS sample was divided into individual replicates of 500 samples each. Each replicate contained a random representation of the sample universe. The value of using replicates to manage sample was in having the ability to fully work through sample within each replicate before moving on to the next one. This allowed the data collection team to maximize sample performance before releasing new sample to the mix. Some replicates were also designed to represent various household types (i.e. matched vs. unmatched or GPS vs. Non-GPS households) and they were loaded into the VOXCO system and released for dialing following a systematic advance mail out schedule. Note that the timing of the sample release was done in conjunction with when advance letters had been mailed out, for those households that received advance letters. Toward the end of the main survey, replicates were created for specific counties and system weights were applied to these replicates so that the program would release this sample at a higher rate than the rest of the sample. Among other reasons, this was done to attempt to increase representation of lagging counties.

The CHTS recruitment program contained standard call outcomes and some project specific codes as well. Interviewers were trained to follow specific protocols in coding call outcomes correctly. Each interviewer were assigned an interviewer identity number to access the program. This allowed for each call record to be tracked to the interviewer for review, feedback and coaching opportunities as needed. This was a valuable tool to identify interviewers that needed help with refusal avoidance techniques or other areas that could be identified by running interviewer performance statistics.

For the CHTS, a minimum of eight attempts to valid numbers resulting in a no contact were made before finalizing a sample record. This protocol was adjusted throughout the duration of the project, for example, to increase the level of effort in lagging areas. In some of the hard to reach areas sample was rested for a long period of time and re-attempted later in the project. For some of these cases the minimum call attempt was higher although the calls were spaced out across a longer period of time. In other areas it was necessary to maintain the number of five call attempts in order to maintain acceptable productivity levels.

One other aspect of sample management was the "rest-and-recycle" technique for non-responsive households. After eight attempts without being able to contact a household, those samples were "rested" for a period of three months (or until the end of the quarter), and then were recycled back into the active sample pool for re-calling and re-contacting.

Retrieval Sample Protocol

A key element to consider when referring to sample management and the retrieval stage was the Production Schedule. The Production Schedule contained the list of all valid travel dates for the duration of the project. This schedule dictated when sample needed to be available for reminder calls and when it needed to be available for retrieval calls.

Sample management for retrieval was an on-going and hands on task that often times required supervisory and management staff to discuss sample segments or even specific households on the best approach to finalize the household. Some of the considerations taken into account included whether the household had been called during the day of the week and time of the day when the recruitment interview took place, whether calls had been spread out across times of the day and days of the week, whether any or too many messages had been left, or whether the household needed to be finalized as non-completed and needed to be replaced.

The Strata and Quotas definition module in VOXCO allowed NuStats to manage subsets of the sample and to open or close access to any stratum or subset as needed. It also allowed NuStats to apply quotas or ceilings to control the maximum number of completed interviews by stratum, and the rate at which they were attained.

This module was used for tracking goals and in sample management by assisting in the release or withholding of specific sample segments. Many of the sample management activities already described were made possible by a specific strata definition that existed in the Quota Management module. The starting point of making this sample control tool work was to specify a set of criteria or strata, upon which sample controls or quotas were to be applied.

For the CHTS, quotas also were used to monitor household distribution across travel days to obtain a proportional distribution of days of the week and across weeks and months during the full year of data collection.

There were situations in which there was a need to regulate or balance the rate at which a group of strata were filled during the course of the project. To achieve this, a probability or weight was assigned to a lagging stratum, so that the system would increase the rate by which sample from that strata was released. This process was critical for achieving goals on time, for example when the deadline for closing out a wearable MTC scheduling date was approaching, adding a weight to the wearable MTC sample ensured more of this sample was called to increase the chances to meet the goal on time.

4.3 Survey Outreach – Hard to Reach Populations

The CHTS pretest results indicated a lower than desired response rate from Hispanic and low income populations. At the urging of representatives of the Federal Highways Administration (FHWA) and the CHTS Administrative Committee, Caltrans sought internal funding for a public outreach effort to improve representation of these groups in the CHTS main survey effort. The Division of Transportation Planning provided funding for public outreach efforts. The initial scope of work was circulated in January 2012 and the first meeting with the contractor was held in April 2012. To provide guidance to the contractor, a technical advisory committee (TAC) of the Administrative and Steering Committees, the Hard-to-Reach Populations Subcommittee, was formed and met monthly through November 2012.

Key outreach efforts conducted by the contractor were:

- Developed and provided to Caltrans Public Affairs Office lists of prominent media (print, radio and television) statewide and focusing on Southern California (developed in June 2012)
- Provided two public service announcements (PSA), in English and in Spanish, to major media outlets in Southern California. The first paid PSA ran in early October 2012 for 2 weeks in mid-October and the second ran in early December 2012. Additional PSAs were aired statewide, free of charge, until January 31, 2013.
- Provided Caltrans and SCAG-specific voice over of the MTC video (see below) explaining the survey process. The revised MTC video was released in early October and posted on the CHTS website as well as the social media sites.

- Prepared Speakers Bureau, Press and Community Influentials Kits. Contents of the kits included: a project brochure, sample news article, Frequently Asked Questions (FAQ) list, fact sheet and PowerPoint presentation, all in both English and Spanish and in print and on CD. These kits were finalized in August 2012. The Speaker's Bureau Kits and Press Release Kits were distributed to all stakeholders upon release of the video in early October 2012.

While the materials developed by the contractor were of high quality, most of the efforts occurred in the third and fourth quarter of the main survey data collection, so that any impact on participation and response rates was minimized.

In addition to the Caltrans public outreach contractor, Caltrans and individual MPOs also conducted their own outreach efforts in their region. Caltrans Public Affairs Division prepared and disseminated press releases about the CHTS. The most spectacular MPO outreach effort was a video about the CHTS survey and what it entailed for respondents created by the Bay Area Metropolitan Transportation Commission (MTC). The video was available in English in March 2012, and in Spanish in April 2012. At the date of this report, the video was available for viewing on the MTC website in English:
(http://www.mtc.ca.gov/news/press_releases/rel548.htm) and in Spanish:
(http://www.mtc.ca.gov/news/press_releases/rel548_espanol.htm).

To assist in targeting the outreach effort, NuStats provided quarterly analyses of the recruitment and retrieval rates for hard-to-reach populations, by county. In general, the hardest to reach groups continued to be Hispanic, and younger (<25) residents, as well as residents of the larger counties in the state.

4.4 Quality Control

The following quality control protocols were implemented for the CHTS data collection team:

- A comprehensive Interviewer-training (specifically focused on understanding and proper delivery of the CATI questionnaire)
- Adherence to CASRO guidelines
- Expert program design input and detailed and redundant program testing
- Dedicated, permanent team of Managers, Trainers, Supervisors and Interviewers.
- On-site and off-site monitoring of interviewers' efforts by project-specific QC leaders. Monitoring capability used with options of providing instant messaging feedback during live calls.
- On-going, constant dual data reviews being conducted by data collection leaders and by NuStats data cleaning team throughout the entire data collection period.
- Electronic tracking of interviewers' performance – dialing statistics, completed interviews, refusals, non-contacts, average interview lengths.

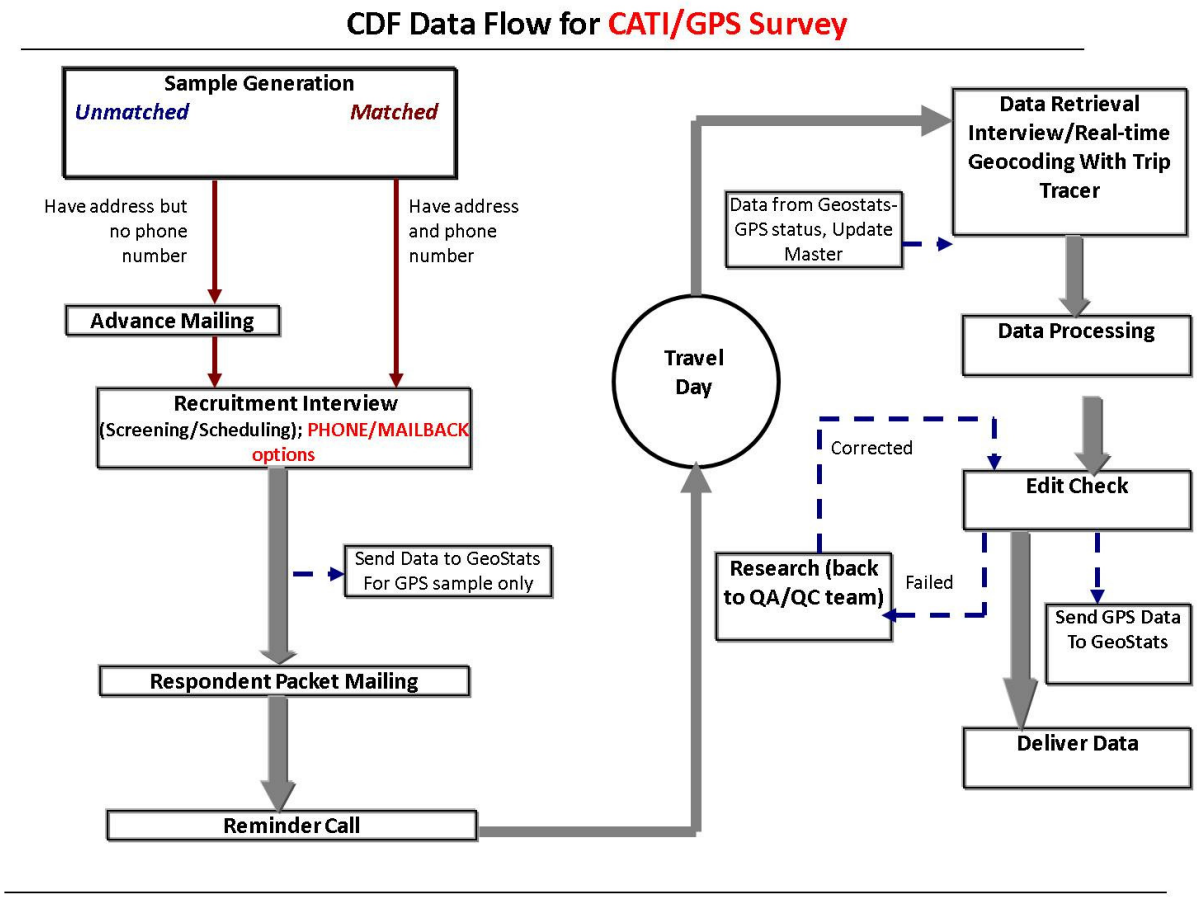
Live, full monitoring of CATI interviews led by project-dedicated Quality Control Managers and Supervisors were conducted as the cornerstone of the QC process for this study. Full monitoring sessions, where a conversation between an interviewer and a respondent is not only heard but also viewed through remote visual monitoring, were the most efficient and reliable method for ensuring that Interviewers were reading scripts verbatim as well as accurately recording all data provided by respondents. Following industry guidelines, a minimum of 10% of all CATI completes were monitored or validated. Monitoring sessions were also used to provide on-going supplementary training to interviewers as well as to validate the accuracy of the real-time entry. For each monitoring session, interviewers were evaluated on the following criteria: dialing rate, effective use of time, professionalism, gaining cooperation, disposition coding, contact procedures, reading verbatim, neutral delivery,

effective probing, pacing and focus, and accurate data entry. In addition, for retrieval the primary QC focus was on trip collection, probing for missed trips, and the accuracy of the collection of address details.

In addition, dual project data reviews were also a key part of the overall QC process. On a shift-by-shift basis, the NuStats QC team actively checked data within the dialing program for completeness on key criteria. This was followed by full-scale automated data checks by NuStats data staff to confirm that data met the required specifications. This dual system helped ensure that the NuStats QC team was able to quickly correct any potential data issues and to also administer immediate remedial training for specific Interviewers.

Figure 4.4.1 shows the full data processing effort, including the quality control measures.

Figure 4.4.1: Data Processing Flow Chart



5.0 Global Positioning System (GPS) Subsample

5.1 Overview

The purpose of the GPS component of the California Household Travel Survey (CHTS) was to collect detailed information about all trips made by the GPS subsample and to estimate levels of trip underreporting in this subsample that can be applied to the larger, non-GPS sample. The following section summarizes the GPS data collection results for the GPS / Diary Complete households (as defined by the updated GPS and diary completion rules). All households that reported travel by February 14, 2013 are included. With a target goal of obtaining 5,199 GPS complete households, it was estimated that at least 8,949 households would need to be recruited. Recruitment for the study concluded on January 18, 2013. There were 9,048 households recruited into the GPS component of the study. A split design was implemented, with some households receiving in-vehicle GPS devices and other households receiving wearable GPS devices. The GPS devices were to be used for seven days by the vehicle sample and three days by the wearable sample, with the first day coinciding with the assigned diary / travel day. A portion of the vehicle sample was also targeted to receive On-Board Diagnostic (OBD) Engine Sensors to use in tandem with the vehicle GPS devices to provide additional details about vehicle and engine activity that could be used, in turn, to estimate fuel consumption and emissions levels.

This split technology design allowed for the collection of seven days of highly accurate vehicle-based data with minimal respondent burden while limiting the burden of carrying wearable GPS devices to a three-day period. Households selected for the wearable GPS component were deployed for three days, with all household members between the ages of 16 and 75 receiving GPS equipment. Local deployment personnel shipped and received returned equipment from/to their home. As GPS devices were returned by GPS households, the data collected on the devices were downloaded and posted to the GPS Project Management Website. From there, the data were imported into the project database and processed by analysts to review and confirm trip end locations and mode assignments. A $25 incentive per instrumented vehicle or person was offered to all recruited GPS households for successful reporting of travel data, for use of all GPS devices provided, and for return of all devices. A $40 incentive per instrumented vehicle was offered to all recruited GPS/OBD households.

GeoStats, as a subcontractor to NuStats, was responsible for implementing the GPS and OBD components of this survey. A supplemental GPS data deliverable containing all GPS data collected from households that completed the study after February 14, 2013, which only supplied partially complete data or which collected GPS data, but did not report their travel, will be generated and delivered before the contract ends on June 14, 2013 as a separate data set.

5.2 Deployment Methods and Results

5.2.1 Deployment Methods

Given the size and scope of the GPS portion of this study (which was set at approximately 175 households recruited and deployed per week for one year), it was decided that three persons should be contracted to assist with equipment deployment — two for wearable deployments and one for vehicle and vehicle OBD deployments. Deployment staffing was obtained accordingly, with the recruits split between the deployment team members based on GPS type, geographic location and the availability of equipment.

Households were recruited into the travel survey at least 10 days prior to their assigned travel date. As GPS households were recruited, recruit details were pulled such as names, addresses, phone numbers, and person and vehicle rosters. This recruit information was imported into the database and the deployment zone was assigned based on the GPS type and the split between the deployment team members. This recruit information was then made available on the GPS Study Management website, where each deployment person accessed the recruit information for only their assigned shipments.

The deployment team members signed onto the password-protected website on a daily basis to review upcoming deployments. The lead time between the posting of recruited households to the website and the assigned travel date was at least seven days, allowing sufficient time to prepare the necessary documents, diaries, and equipment, and to ship them to arrive prior to the assigned travel date.

Simple printed instructions were shipped with the devices; these instructions also listed the assignment of each logger to each household vehicle or household member (for either the vehicle or wearable GPS sample) based on the logger identification number. In addition, a hotline phone number was provided to the respondent for assistance with installation and use of the devices. A sticker was affixed to each GPS device with the vehicle year and model for households recruited into the vehicle study or the first name of the household member printed on the sticker for households recruited into the wearable study. The instructions also emphasized the need to use the diaries to record travel on the assigned travel date. A return device sheet was also provided on which the household members were asked to record if they used the devices, and if not, to list the reason(s) why.

Shipping was conducted via FedEx. Participant instructions, equipment, diaries and a pre-paid return FedEx Pak were placed in a cardboard box and secured with packing material. The equipment was delivered to the household two business days prior to the assigned travel day. After the assigned GPS data collection period, households were to place all of the equipment and the return device sheet in the original box, insert that box in the FedEx Pak, and put either the package into a FedEx drop box or call 1-800-GoFedEx to schedule a pick-up at their home. Outbound and return equipment packages were tracked on the FedEx website, with tracking information loaded on the GPS Study Management website. The participants were requested to hold onto their diaries, either reporting travel over the phone, via the project website or return the diaries in the pre-paid return envelope provided with the diaries.

The deployment team was instructed to prepare and ship equipment packages for each household listed for them on the GPS Study Management website. Project management communicated with the deployment team on a regular basis to ensure that each member had sufficient equipment supplies to meet the upcoming deployment needs. The deployment team members were instructed to update the household deployment status on the website as the statuses changed. The default status for deployment when recruit information was first loaded was 'Recruit'. They would then change this status to reflect the current state of the deployment process. Below is a list of all household deployment status codes: the first four statuses reflect the natural progression of a successful deployment, whereas the final four statuses reflect GPS recruits that did not result in a useful deployment.

- Recruited
- Shipped
- Deployed
- Returned Deployed (used and returned equipment)
- Invalid Address
- Returned Refused (elected not to participate)

- Return-Delivery Exception (package unable to be delivered by FedEx)
- Not Returned / Lost

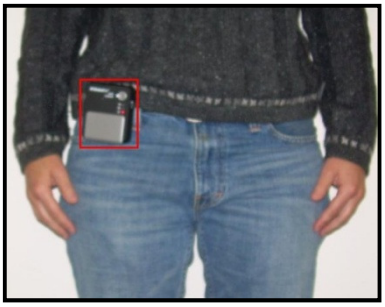
After receiving the returned equipment, the deployment staff downloaded the GPS raw data from the loggers and then cleared the device memory for redeployment. The downloaded, zipped GPS file was then posted to the project website and imported into the project database, from where all further GPS data processing occurred. Deployment personnel were also responsible for updating the person-level equipment usage status fields as reported by each household, for recording any household or person-level comments on the website, and for updating the household level control code. A 10% sample from the GPS raw data has been supplied to NuStats on a quarterly basis.

Wearable GPS Equipment

The GlobalSat GPS Data Logger is a rugged yet simple GPS data logging device (see Figure 5.2.1.1Figure). The GlobalSat device weighs 6 oz. and has dimensions of 2.75”x3.15”x.7”. It can be worn on the waist, clipped to a purse or backpack, or dropped in a suit jacket pocket.

This device can log at various frequencies, can log all valid GPS points or only those valid points for which the speed is greater than one MPH (to screen out non-movement events), and has a 100,000 GPS point storage capacity. For the purpose of this study, the logging frequency was three-second intervals with the speed screen activated. The GPS data stream elements recorded by the GlobalSat for this study included date, time, latitude, longitude, speed, heading, horizontal dilution of precision (HDOP), and number of satellites. These elements are stored in the logger in standard NMEA units and are converted into user-specified units and formats upon download. At the start of the study, 1,476 GlobalSat devices were provided to support deployment of 6,141 households over the 12-month main survey data collection period.

Figure 5.2.1.1: GlobalSat DG-100 GPS Data Logger



In-Vehicle GPS Equipment

The QStarz BT-Q1000x Travel Recorder (Figure 5.2.1.2) was used for the in-vehicle GPS component of this study. This device captures date, time, latitude, longitude, speed, and other standard GPS variables in one-second intervals, and can be configured to collect additional variables including heading, horizontal dilution of precision (HDOP), and number of satellites. This device entered the market in 2009 in and has been successfully deployed in two recent large-scale household travel surveys, and several other transportation related projects. In the California Statewide Travel Survey, this device was provided to participants with a vehicle power cable and power splitter so that participants could also charge other personal devices if needed. The power cable also has a small suction cup attached so that the participant could secure the cable and device on the dashboard near the windshield to prevent slippage. GeoStats provided 720 QStarz BT-Q1000x devices to support the deployment of 2,808 households to meet the in-vehicle (including OBD) GPS deployment goals for the study.

Figure 5.2.1.2: QStarz BT-Q1000X Travel Recorder

On-Board Diagnostic Sensor

The CarChip Fleet Pro On-Board Diagnostic Sensor (OBD) seen in Figure 5.2.1.3 was used for the in-vehicle GPS with OBD component of this study. The device parameters were limited to five and the firmware was customized to capture speed, air flow rate, throttle position, engine load and engine speed in 5-second intervals. These variables can be used to identify modal profiles (idle, cruise, acceleration and deceleration) which can, in turn, be used with existing emission rate models to forecast green house gas (GHG) emissions and fuel use. Participants were asked to insert this device into the diagnostic port in their vehicle, which is typically located under the dash on the driver side of the vehicle. Once installed, the device records data whenever the vehicle is powered on. The OBD device does not require external charging. GeoStats provided 573 CarChip Fleet Pro devices to support the deployment of 2,106 households to meet the in-vehicle GPS and OBD deployment goals for the study.

Figure 5.2.1.3: CarChip Fleet Pro On-board Diagnostic Engine Sensor

5.2.2 Deployment Results

Equipment was deployed to 8,994 households. An equipment retrieval management system was developed and used to coordinate follow up with all GPS households that did not immediately return their GPS equipment as instructed. First, a phone call was placed to the home telephone number for all households that did not return their GPS devices within one week after the last GPS travel date. When a person answered or an answering machine picked up, a message was delivered thanking the household for their participation and requesting that the GPS equipment be returned in the pre-paid FedEx envelope. A toll-free call back number was left if the household had any questions. If no person or answering machine was reached, additional calls were attempted.

If equipment still had not been placed into the FedEx system by two weeks after the last GPS travel day, a letter was sent to the home. A second equipment retrieval letter was mailed to the household if equipment was still outstanding after four weeks. During the final week of the study, phone calls were made and letters were mailed simultaneously in an attempt to retrieve as much equipment as possible. At the time of this report, 337 households across all GPS types (3.74% of total households) had not returned the GPS devices sent to them.

In addition to tracking deployments by GPS type, households were also tracked by funding source. The Core households refer to those that were funded by Caltrans and their partners and were tracked at the statewide and

county level. Two agencies provided additional funding, and specified that that funding be spent to collect additional GPS data of interest to their agency. The Metropolitan Transportation Commission (MTC), the planning organization for the nine-county San Francisco Bay area provided funding for an additional 3,099 wearable GPS households to be deployed in their region. The California Energy Commission (CEC) provided funding for in-vehicle GPS and OBD of 500 households that currently own alternative and renewable fuelled vehicles. The CEC sample was limited to households that owned one or more of the following vehicles: hybrid, clean diesel, battery electric, plug-in hybrid electric vehicle, CNG, flex-fuel (E85), and Hydrogen vehicles. The deployment outcomes by GPS Type and funding source are in Table 5.2.2.1.

Table 5.2.2.1: Deployment Statistics by GPS Household Sample Type

Sample Type	Recruited	Returned Deployed	Refused	Not Returned	Not Deployed
Core Wearable GPS	633	524	83	17	9
Core Vehicle GPS	700	563	92	38	7
Core Vehicle GPS / OBD	1,299	1,031	195	56	17
MTC Wearable GPS	5,608	4,534	848	207	19
Energy Commission Vehicle GPS / OBD	809	726	61	19	3
Total	**9,049**	**7,378**	**1,279**	**337**	**55**

5.2.3 GPS Participation Results

Once the GPS trip processing and GPS / diary matching steps are finished, complete and accurate GPS trip details are available. These details include trip start and end times, origin and destination coordinates, travel distances and paths, and average speeds for each trip detected. These GPS data sets contain data for the 8,202 persons instrumented in the 3,871 GPS/diary complete households (that received wearable GPS devices) and for 3,491 vehicles in the 1,684 GPS/diary complete households (that received vehicle GPS or GPS/OBD devices) for which data were received by February 2013. The data deliverable contains 204,634 trips covering 1,265,986 miles traveled and 2,660,505 travel minutes (44,342 hours). Table 5.2.3.1 shows the recruitment and completion statistics included in this data deliverable.

Table 5.2.3.1: Recruitment, Completion and Results by GPS Household Type

Sample Type	Recruit Total	Recruit Goal	Recruit % Complete	GPS/Diary Complete	GPS/Diary Complete	%Complete Goal
Core Vehicle GPS	700	702	100%	424	400	106%
Core Vehicle GPS / OBD	1,397	1,404	100%	902	800	113%
Core Wearable GPS	633	702	90%	420	400	105%
MTC Wearable GPS	5,608	5,439	103%	3,451	3,099	111%
Energy Commission Vehicle GPS / OBD	711	702	100%	540	500	108%
Total	**9,049**	**8,949**	**101%**	**5,737**	**5,199**	**110%**

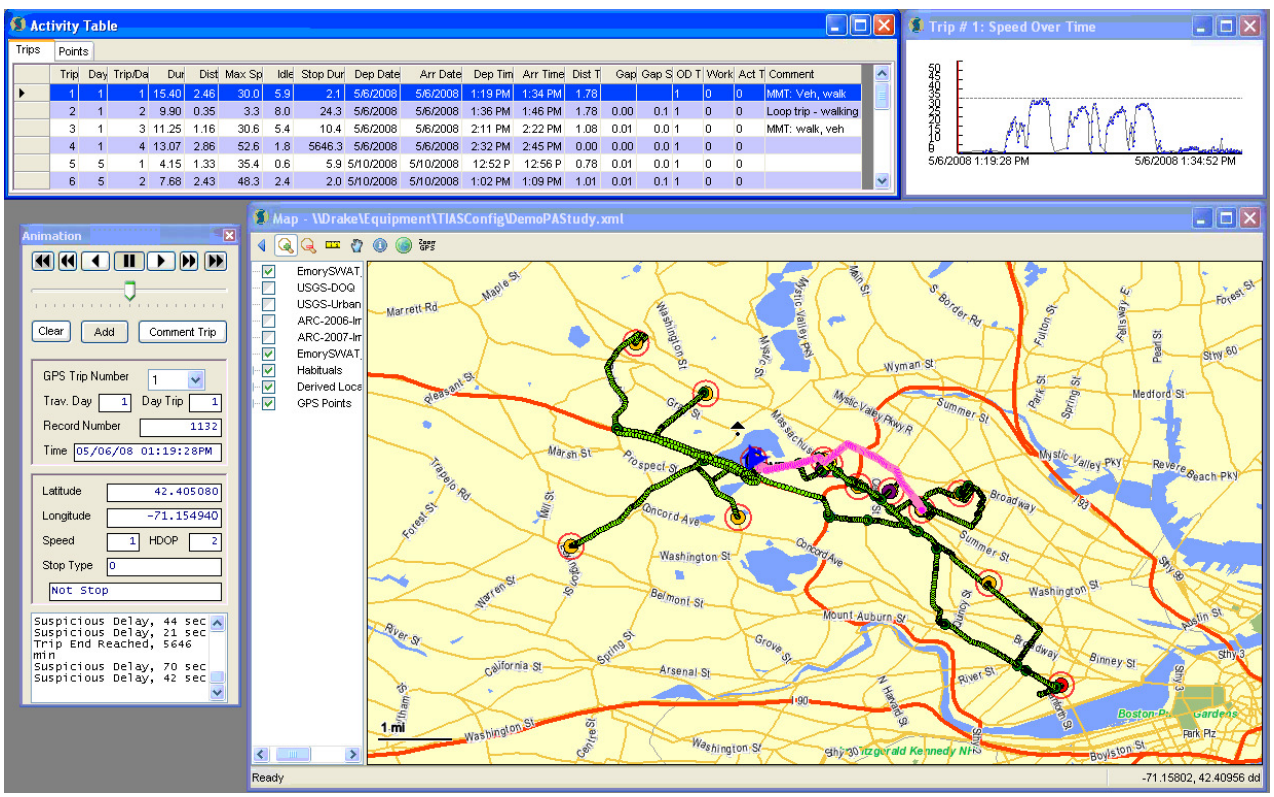
There is no disposition of all households participating in the GPS component by study type table because this report includes data for only those households which completed all portions of the study.

5.3 GPS/Diary Processing Methods and Results

As the GPS data collected by the participants were imported into the project database, the UTC (Universal Time Coordinate) date and time stamps in the GPS point data were translated to local date and time. As mentioned previously, the speed filter settings on both the in-vehicle and wearable GPS Data Loggers deployed to study participants were set to screen out all zero point speeds, with non-zero speed points recorded at a one-second frequency for in-vehicle devices and at a three-second frequency for wearable devices.

Next, each GPS file was processed using Trip Identification and Analysis System (TIAS) software to identify potential trip ends based on time intervals between consecutively logged points. For this study, all initial dwell times of 120 seconds or more were flagged as potential trip stops. The GPS trip data were then visually reviewed by analysts to screen out traffic delays and other falsely identified stops with dwell times of 120 seconds or more, as well as to add stops that had dwell times of less than 120 seconds but had clear "stop" characteristics. Examples of typical stops that would not be automatically detected by the 120 second dwell time are short drop-off/pick-ups (i.e. school, work, mail, ATM, fast food). If geocoded addresses were available from either the recruit call (i.e. habitual destinations such as home, work and school locations) or from the retrieval call (i.e. each reported destination made by each household member) then the analyst used these locations to assist in the trip end identification and/or confirmation process. Once this step was completed, the updated GPS-based trips collected were ready to be compared and matched with the diary trips reported for that same person or vehicle on the assigned travel day. Figure 5.3.1 shows an example (non-participant data) of a walk, bus, walk trip in TIAS.

Figure 5.3.1: TIAS Interface Showing Walk-Vehicle-Walk Trip

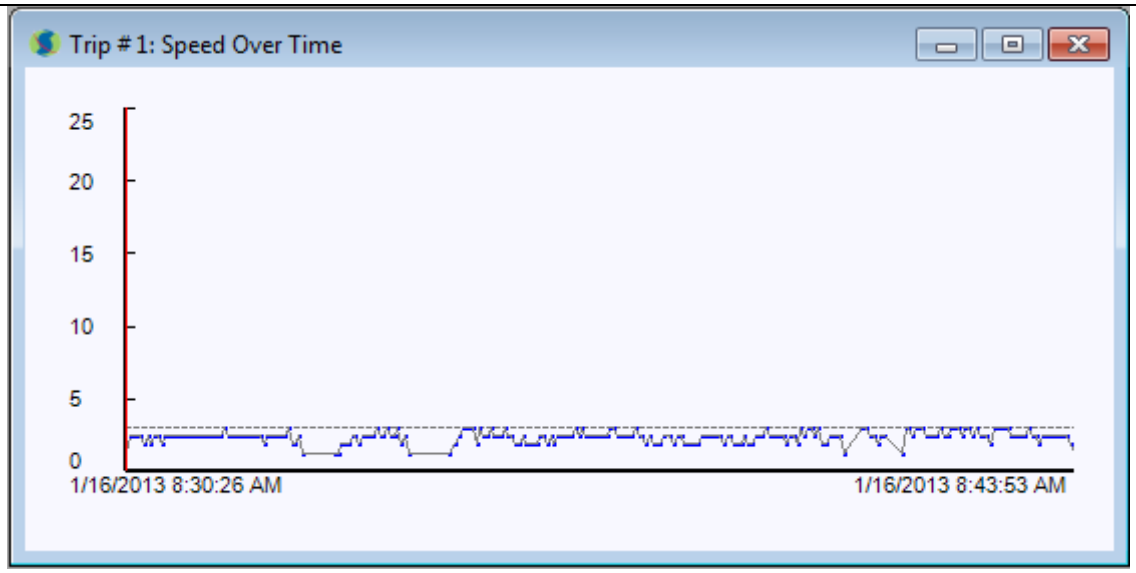


The travel modes for each activity segment were assigned using TIAS' mode assignment algorithms and update interface, and are included as part of the data delivery. TIAS assigned the travel modes based on the GPS trip's speed profile. Analysts then reviewed each trip trace to confirm or update the mode assignment. The travel

modes available for assignment in this study were walk, bicycle, auto/truck, bus/train, vanpool and other (see Figures 5.3.1 and 5.3.2).

Figure 5.3.1: Speed Profiles of Travel Modes – Walk and Personal Auto Trip

Walk Trip



Personal Auto Trip

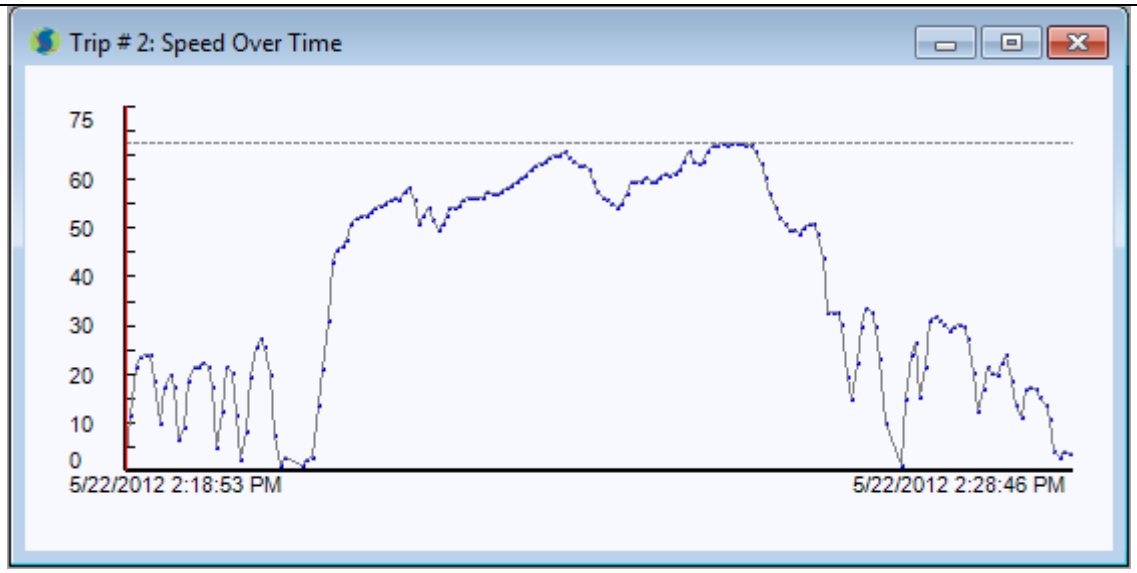
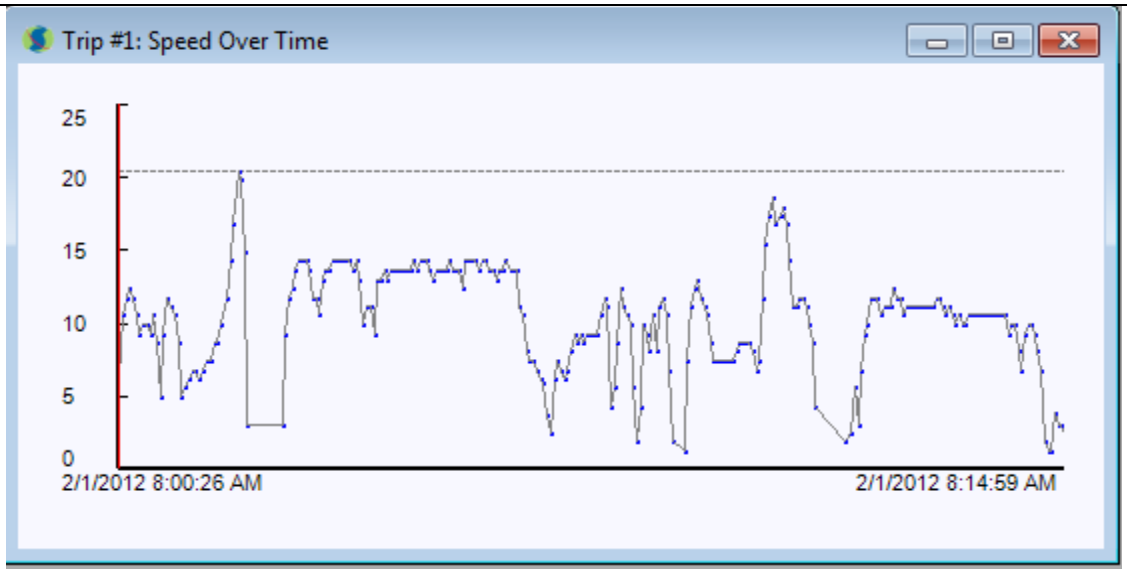
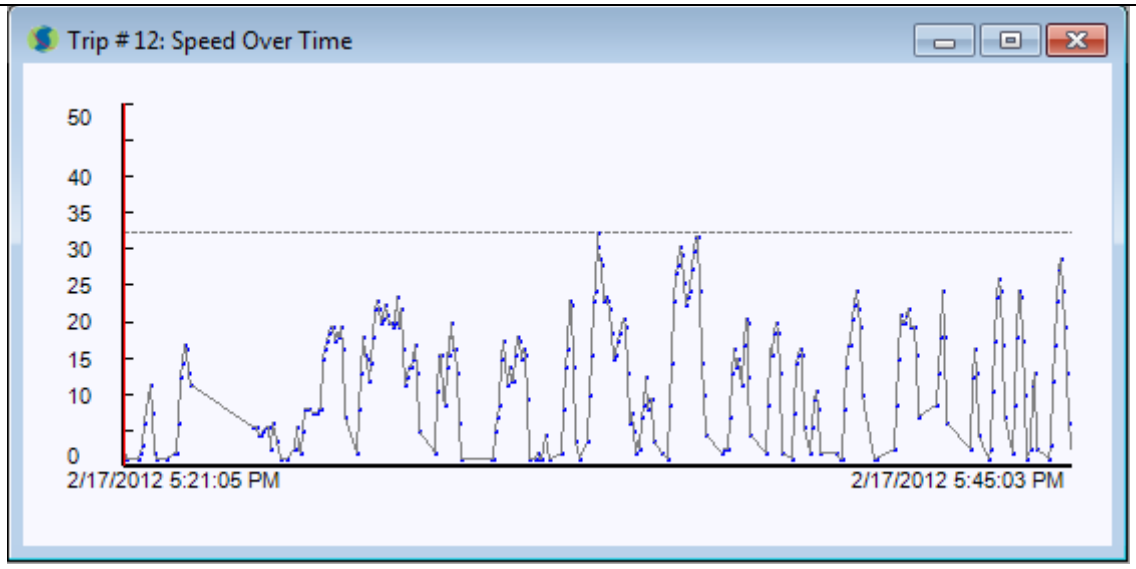


Figure 5.3.2: Speed Profiles of Travel Modes – Bicycle and Bus Trip

Bicycle Trip



Bus Trip



5.4 OBD Data Collection and Processing

Like the GPS data, the OBD data files were downloaded from the devices in the field, and then uploaded to a secure website. The files were then download and imported into the secure project database daily. GeoStats worked with Davis Instruments, the OBD device manufacturer and vendor, to customize the data recording configuration for the OBD devices used in the study. They were configured to record speed at a one-second frequency and four additional parameters at a six-second frequency. See Table 5.4.1 for the recording configuration by parameter. Davis instruments has confirmed that the device logging interval can vary depending on the vehicle response, and can be absent from some or all trip records on any given vehicle. More discussion on OBD quality checks is included later in this section.

Table 5.4.1: OBD Device Configuration Parameters

Parameter	Recording Interval	Unit System	Units	Decimals	Range
Vehicle Speed	1 sec	Metric	km/h	0	0-255
(Mass) Air Flow rate	6 sec	S. I.	kg/s	3	0-65.5
Engine Load	6 sec	N/A	%	1	0-100
Engine Speed	6 sec	U. S.	RPM	0	0-16,384
Throttle Position	6 sec	N/A	%	1	0-100

There were additional data elements queried at lower frequencies and reported as available by vehicle. The full list of other recorded variables types (which vary by vehicle) for the custom OBD configurations are listed below. These variable types and additional information about them can be found in the OBD data dictionaries, GPS/OBD and Raw OBD.

- Activity records-device activity such as plugged into vehicle, unplugged from vehicle, emissions censors checked
- Activity record readiness codes—only recorded when activity record event type is 8. The list of codes is defined in the data dictionary
- Diagnostics Trouble Codes (DTC) records
- Trip start and Trip end
- Trip duration
- Vehicle Identification Number (VIN)
- Vehicle Protocol
- Max speed
- Average speed
- Trip distance
- Hard brake, hard acceleration, extreme brake, extreme acceleration counts
- Speed records—speed record for each of the hard and extreme brake and acceleration events
- Malfunction Indicator Light (MAL)—distance with MAL on, distance since Diagnostic Trouble Codes cleared
- Fuel Type—Type of fuel, % of ethanol in fuel

The Vehicle table in the GPS/OBD deliverable contains several fields related to Vehicle Fuel Type. The 'fueltype' field contains the data records reported on the OBD device. Fuel type is not a mandated OBD parameter (not all vehicles report this value) therefore there were only 61 vehicles in the sample that returned a valid fuel type codes. Table 5.4.2 contains the list of possible fuel types collected by the OBD device.

Table 5.4.2: Fuel Type Codes from OBD Device

Fuel Type Code from OBD Device:
00 Unknown
01 Gasoline
02 Methanol
03 Ethanol
04 Diesel
05 LPG

Fuel Type Code from OBD Device:	
06	CNG
07	Propane
08	Electric
09	Bifuel running Gasoline
0A	Bifuel running Methanol
0B	Bifuel running Ethanol
0C	Bifuel running LPG
0D	Bifuel running CNG
0E	Bifuel running Prop
0F	Bifuel running Electricity
10	Bifuel mixed gas/electric
11	Hybrid gasoline
12	Hybrid Ethanol
13	Hybrid Diesel
14	Hybrid Electric
15	Hybrid Mixed fuel
16	Hybrid Regenerative

The VEHT and FUELT field records were provided by the participants during the recruitment interview. The codes and potential responses (from the recruitment script) for these items are in the Table 5.4.3 and were used to create Table 5.4.4 (Fuel Type by Vehicle Type table).

Table 5.4.3: Diary Reported Vehicle Type and Fuel Type

VEHT (vehicle type)	Response
1	Hybrid Vehicle ⍰ FUELT [PROG: SHOW ALL]
2	Gasoline Only Vehicle ⍰ FUELT=1
3	Diesel Only Vehicle ⍰ FUELT [PROG: SHOW ONLY CHOICES 2 & 5]
4	Plug In Hybrid Electric Vehicle ⍰ FUELT [PROG: SHOW ALL]
5	CNG ⍰ FUELT=4
6	Electric Only ⍰ FUELT=3
7	OTHER ⍰ FUELT [PROG: SHOW ALL]
FUELT (Fuel Type)	
1	Gasoline
2	Diesel
3	Electric/Electric Battery
4	CNG - Natural Gas
5	Biofuel, Ethanol, Biodiesel
7	OTHER, SPECIFY (O_FUELT)
8	DK
9	RF

Table 5.4.4 contains the final summary of OBD vehicles (core and Energy Commission sample) by diary reported vehicle type and / or fuel type from households which were considered complete. It includes the sample source, the recruit and complete totals, as well as the percentage of recruited and complete vehicles by fuel type.

Table 5.4.4: Fuel Type by Vehicle Type for OBD Vehicles (Core and Energy Commission add-on)

Fuel Type	VEHT	FUELT (multiple response)	Sample Source	# Vehicles Recruited	# Vehicles GPS & diary complete HHs	% Total REC by FUELT	% Total COMP by FUELT
Gasoline	2	1	Core	2251	1454	78%	76%
			DMV	730	532		
			UCD	81	74		
Hybrid Electric/Gasoline	1	1 & 3	Core	112	83	12%	12%
			DMV	319	248		
			UCD	26	24		
Flex Fuel (Ethanol/Gasoline)	7	1 & 5	Core	13	8	1%	1%
			DMV	12	9		
			UCD	0	0		
Diesel	3	2 & 5	Core	67	43	4%	4%
			DMV	89	69		
			UCD	1	1		
Primary Natural Gas	5	4	Core	1	1	1%	1%
			DMV	40	30		
			UCD	2	2		
Primary Electric	6	3	Core	4	4	4%	4%
			DMV	33	26		
			UCD	101	86		
PHEV	4	1 & 3	Core	0	0	1%	1%
			DMV	17	15		
			UCD	7	6		
Total Vehicles			**Core**	**2448**	**1592**		
			DMV	**1239**	**929**		
			UCD	**218**	**194**		
			Grand Total	**3905**	**2715**		

Table 5.4.5 includes the vehicle summary of OBD vehicles (core and Energy Commission sample) by diary reported vehicle type and / or fuel type by geographic distribution from households which were considered complete. Certain fuel types were targeted by geography. For instance, the highest density of E85 retail stores are located in the Sacramento area, therefore the portion of Energy Commission sample identified as Flex Fuel vehicles registered in the Sacramento area were targeted.

Table 5.4.5: OBD Vehicle Summary by Fuel Type and County

County	Hybrid	Gasoline	Diesel	PHEV	Natural Gas	Electric	Flex Fuel	TOTAL
ALAMEDA	25	67	4	2	0	8	1	**107**
ALPINE	0	3	0	0	0	0	0	**3**
AMADOR	0	8	0	0	0	1	0	**9**
BUTTE	2	19	1	0	0	1	0	**23**
CALAVERAS	1	8	0	0	0	1	0	**10**
COLUSA	0	1	0	0	0	0	0	**1**
CONTRA COSTA	18	63	1	0	0	7	0	**89**

County	Hybrid	Gasoline	Diesel	PHEV	Natural Gas	Electric	Flex Fuel	TOTAL
DEL NORTE	0	11	1	0	0	0	0	**12**
EL DORADO	5	42	1	0	0	0	0	**48**
FRESNO	8	55	0	0	0	0	1	**64**
GLENN	0	6	1	0	0	0	0	**7**
HUMBOLDT	1	9	1	0	0	0	0	**11**
IMPERIAL	0	9	1	0	0	0	0	**10**
INYO	0	9	0	0	0	0	0	**9**
KERN	0	51	3	0	2	1	0	**57**
KINGS	0	4	0	0	0	0	0	**4**
LAKE	3	11	3	0	0	0	0	**17**
LASSEN	0	15	1	0	0	0	0	**16**
LOS ANGELES	73	320	19	5	12	22	4	**455**
MADERA	1	19	1	0	0	0	0	**21**
MARIN	4	11	1	0	0	2	0	**18**
MARIPOSA	0	18	2	0	0	0	1	**21**
MENDOCINO	1	10	3	0	0	0	0	**14**
MERCED	0	24	0	0	0	0	0	**24**
MODOC	0	2	0	0	0	0	0	**2**
MONO	0	8	1	0	0	0	0	**9**
MONTEREY	4	15	1	0	0	0	0	**20**
NAPA	2	9	1	0	0	0	0	**12**
NEVADA	2	8	0	0	0	0	0	**10**
ORANGE	24	136	6	1	4	14	0	**185**
PLACER	4	35	5	3	0	4	0	**51**
PLUMAS	0	6	1	0	0	0	0	**7**
RIVERSIDE	11	110	7	1	7	2	0	**138**
SACRAMENTO	22	120	4	0	0	3	9	**158**
SAN BENITO	1	21	0	0	0	0	0	**22**
SAN BERNARDINO	9	99	6	0	0	0	0	**114**
SAN DIEGO	28	132	7	2	0	7	3	**179**
SAN FRANCISCO	7	18	2	0	0	1	0	**28**
SAN JOAQUIN	1	33	2	0	0	0	1	**37**
SAN LUIS OBISPO	3	28	1	0	0	1	0	**33**
SAN MATEO	17	26	1	2	1	7	0	**54**
SANTA BARBARA	0	28	1	0	0	0	0	**29**
SANTA CLARA	31	83	4	2	4	18	0	**142**
SANTA CRUZ	8	41	3	0	0	7	1	**60**
SHASTA	0	3	4	0	0	0	0	**7**
SIERRA	1	11	0	0	0	0	0	**12**
SISKIYOU	0	4	1	0	0	0	0	**5**

County	Hybrid	Gasoline	Diesel	PHEV	Natural Gas	Electric	Flex Fuel	TOTAL
SOLANO	6	23	0	0	0	1	0	**30**
SONOMA	7	27	4	1	0	1	0	**40**
STANISLAUS	2	17	0	0	0	0	0	**19**
SUTTER	0	11	0	0	0	0	0	**11**
TEHAMA	1	4	0	0	0	0	0	**5**
TRINITY	0	27	1	0	0	0	0	**28**
TULARE	3	50	2	0	0	1	1	**57**
TUOLUMNE	0	9	2	0	0	0	0	**11**
VENTURA	14	79	2	0	0	4	1	**100**
YOLO	4	32	0	0	0	2	0	**38**
YUBA	0	12	0	0	0	0	0	**12**
	354	**2060**	**113**	**19**	**30**	**116**	**23**	**2715**

To increase the number of Electric and Plug-in Hybrid Electric vehicles sampled for the study, the Energy Commission teamed with the University of California, Davis to recruit from a pool of EV and PHEV owners. Due to the newness of the technology and the lack of a combustion engine in all-electric vehicles, EVs and PHEVs do not support OBD devices. For these vehicles, GeoStats sent a paper survey (in place of an OBD device), designed by UC Davis, to EV and PHEV vehicle households to collect vehicle data. These paper surveys were collected by GeoStats, entered into the OBD database and provided as part of the OBD data deliverable.

As a quality control measure the date and timestamps present on the GPS trips were compared to the data and timestamp on the OBD trips to ensure that they were synchronized. As part of the OBD data monitoring process the data were checked to confirm that all data elements imported and were accurate. As mentioned previously, the OBD parameters and vehicle reporting can vary among vehicles depending on the make, model, and year. For example, VIN was not a mandated parameter until 2003 so only 52% of vehicles (1,411 out of 2,715) returned a valid VIN number. Likewise, some vehicles do not report one or more of the four 6-second interval parameters (i.e. Mass Air Flow Rate). To more easily identify OBD trips that had failed parameter data collection, a set of flags were created in the OBD Trips table. The OBD data dictionary contains a complete list of these flags and parameters. Beyond these quality control / monitor steps no comparison was conducted between the variables captured by GPS and OBD devices. The raw OBD data were stored and monitored, but not processed.

5.5 GPS and Diary Trip Matching Results

This data deliverable includes all 'GPS / DIARY complete' GPS households. There are a total of 3,491 GPS vehicles in the 1,866 complete vehicle and vehicle OBD GPS households and 8,202 GPS persons in the 3,871 wearable GPS households. The 3,491 GPS vehicles captured 12,380 GPS trips on the assigned travel days, compared to 11,609 reported trips for these same vehicles. The 8,202 GPS persons captured 45,986 GPS trips on their assigned travel day compared to 39,995 reported trips for these same participants. So, across all GPS samples, a total of 58,366 GPS trips were collected compared to 51,604 reported trips for the same vehicles or persons.

5.5.1 Reporting Exceptions

In some household travel surveys, work-related trips (i.e., commercial use of personal auto) and external to external trips (i.e., those that have origins and destinations outside of the planning regions) are not reported in the travel diary and not collected during the retrieval call. These were the instructions for this study as well.

Other typical unreported trip types include loop trips (i.e., those that start and end at the same location) and on-site travel (i.e. trips that are conducted on the premises of one property, like a hospital or apartment complex).

However, of the 1,120 external to external GPS trips that were detected in the GPS/CATI complete households, 1,057 of these trips were reported. Similarly, of the 3,055 work-related GPS trips found in these households, 2,066 had been reported. This left a total of 63 external-external trips and 989 work-related trips found in the GPS data that had not been reported (and were not required to be reported).

GPS trips were flagged as loop trips whenever a GPS trip was detected in which the origin and destination were the same location. According to the rules of this study, loop trips should have been reported whenever their purpose (e.g., exercise or walk the dog) was not tied to the purpose of the previous trip. This means that a loop trip made from home is a valid trip whereas a loop walk trip in a park preceded by a drive to the park for exercise purposes should not have been reported. A total of 2,637 loop trips were identified, 1,969 of which were reported by participants. Furthermore, 3,797 other non-transportation or on-site trips were found that were not required to be reported.

Even though participants in this study were instructed to report all trips except for work-related and external to external trips, it is likely that some participants also did not report loop and on-site trips as well. The remainder of the missed trip analyses will presents results that include the raw and adjusted frequencies. The adjusted frequencies removed work-related, external to external, loop and on-site travel trips if they did not have matching reported trips.

5.5.2 Matching Results - Wearable

The results of the trip matching process for the GPS sample fell into the following three categories:

100% Matched Trips. Any person instrumented with GPS that captured the same GPS trips as reported by diary were considered to be a perfect match. This category also includes no travel persons which had no GPS data collected on the travel date and no trips reported for that person on the assigned travel date. Of the 8,202 persons instrumented with GPS devices in the 3,871 GPS/diary complete households, 964 persons had no GPS data and were confirmed as no travel in the diary data (11.8% of all instrumented persons).

1. Of all trips made by the 6,241 instrumented persons, 3,050 persons had perfect matches between the diary and GPS trip data. The breakdown of this number includes the 964 persons who did not travel and 2,086 persons who made at least one trip. This represents a perfect match (or reporting rate) for 37.2% of all instrumented persons in GPS/Diary complete households and 19,266 of the 38,129 diary-reported trips (50.5%). Table 5.5.2.1 contains the trip frequency statistics for the persons included in this category.

Table 5.5.2.1: Trip Frequencies for Perfect Matches at Person Level

Trips (#)	Frequency	Frequency (%)	Cumulative (%)
0	964	31.6%	31.6%
1	11	0.4%	32.0%
2	485	15.9%	47.9%
3	254	8.3%	56.2%
4	351	11.5%	67.7%
5	249	8.2%	75.9%
6	241	7.9%	83.8%
7	148	4.9%	88.6%
8	129	4.2%	92.9%
9	72	2.4%	95.2%
10	55	1.8%	97.0%
11	34	1.1%	98.1%
12	16	0.5%	98.7%
13	16	0.5%	99.2%
14	8	0.3%	99.4%
15	5	0.2%	99.6%
16	3	0.1%	99.7%
17	3	0.1%	99.8%
18	2	0.1%	99.9%
19	1	0.0%	99.9%
21	1	0.0%	99.9%
23	1	0.0%	100.0%
25	1	0.0%	100.0%
Totals	**3,050**	**100.0%**	**100.0%**

2. **Trips reported by diary but not captured by GPS**. The second comparison identifies diary trips that had no corresponding GPS trips. During the matching process, 5,757 diary trips were identified that had no corresponding GPS trip (which represents 13.1% of all GPS trips). This typically happens when participants place the GlobalSat device in a position in which it cannot receive GPS satellite signals (such as in a purse or backpack) or forget to carry the device, or confirm that it is powered on.
3. **Trips captured by GPS but not reported by diary**. The last category in the matching process contains those cases where trips were identified within the GPS data stream but not within the diary data. These 11,725 "missed" diary trips were either single links within a trip chain, multiple links within a trip chain, or complete round-trips missing all links in a tour, based on characteristics of adjacent trips. Based on the total of 38,129 diary trips reported, the missing 11,725 diary trips reflect a 30.8% missing trip rate across the entire sample. However, when the typical reporting exceptions are excluded from this analysis, the missed trip rate falls to 21.5% for the GPS sample.

Table 5.5.2.2 shows the frequency of missing GPS and diary trip counts detected for the 5,152 persons who were not perfect matches.

Table 5.5.2.2: Trip Frequencies for Missing Trips – Wearable GPS

Missing Trips (#)	Missing GPS Frequency	Missing Diary Frequency Raw	Missing Diary Frequency Adjusted
1	845	1373	1255
2	1288	1608	1482
3	963	1437	1170
4	788	1420	1048
5	575	1050	725
6	408	930	630
7	224	700	392
8	224	496	416
9	126	459	261
10	130	320	120
11	88	253	110
12	24	240	96
13	26	221	143
14	0	210	84
15	15	120	45
16	16	64	0
17	17	102	17
18	0	72	36
19	0	57	19
20	0	60	20
21	0	42	42
22	0	22	22
23	0	46	0
24	0	48	0
25	0	0	0

Missing Trips (#)	Missing GPS Frequency	Missing Diary Frequency Raw	Missing Diary Frequency Adjusted
26	0	52	26
27	0	27	0
28	0	0	0
29	0	29	0
30	0	30	0
31	0	93	0
32	0	0	0
33	0	33	0
36	0	36	36
75	0	75	0
Totals	**5,757**	**11,725**	**8,195**

5.5.3 Matching Results – Vehicle

100% Matched Trips. Any vehicle instrumented with GPS that captured the same GPS trips as reported by diary were considered to be a perfect match. This category also includes vehicles which had no GPS data collected on the travel date and no trips reported for that vehicle on the assigned travel date. Of the 776 vehicles instrumented with GPS devices in the 424 GPS/diary complete households, 232 vehicles had no GPS data and were confirmed as no travel in the diary data (29.9% of all instrumented vehicles).

1. Of all trips made by the 776 instrumented vehicles, 481 vehicles had perfect matches between the diary and GPS trip data. The breakdown of this number includes the 232 vehicle that did not travel and 249 vehicles that made at least one trip. This represents a perfect match (or reporting rate) for 62.0% of all instrumented vehicles in GPS/Diary complete households and 1,003 of the 2,318 diary-reported trips (43.3%). Table 5.5.3.1 contains the trip frequency statistics for the vehicles included in this category.

Table 5.5.3.1: Trip Frequencies for Perfect Matches at Vehicle Level

Trips (#)	Frequency	Frequency (%)	Cumulative (%)
0	232	48.2%	48.2%
1	4	0.8%	49.1%
2	80	16.6%	65.7%
3	36	7.5%	73.2%
4	47	9.8%	83.0%
5	32	6.7%	89.6%
6	20	4.2%	93.8%
7	8	1.7%	95.4%
8	9	1.9%	97.3%
9	7	1.5%	98.8%
10	1	0.2%	99.0%
11	3	0.6%	100.0%
12	0	0.0%	100.0%
13	1	0.2%	100.0%
14	0	0.0%	100.0%
15	0	0.0%	100.0%
16	1	0.2%	100.0%
17	0	0.0%	100.0%
Totals	**481**	**100.0%**	**100.0%**

2. **Trips reported by diary but not captured by GPS**. The second comparison identifies diary trips that had no corresponding GPS trips. During the matching process, 159 diary trips were identified that had no corresponding GPS trip (which represents 5.8% of all GPS trips). This typically happens when participants place the GPS device in a position in which it cannot receive GPS satellite or forget to confirm that it is powered on.

3. **Trips captured by GPS but not reported by diary**. The last category in the matching process contains those cases where trips were identified within the GPS data stream but not within the diary data. These 567 "missed" diary trips were either single links within a trip chain, multiple links within a trip chain, or complete round-trips missing all links in a tour, based on characteristics of adjacent trips. Based on the total of 2,318 diary trips reported, the missing 567 diary trips reflect a 24.5% missing trip rate across the entire sample. However, when the typical reporting exceptions are excluded from this analysis, the missed trip rate falls to 22.1% for the GPS sample.

Table 5.5.3.2 shows the frequency of missing GPS and diary trip counts detected for all vehicles that were not perfect matches.

Table 5.5.3.2: Trip Frequencies for Missing Trips – Vehicle GPS

Missing Trips (#)	Missing GPS Frequency	Missing Diary Frequency Raw	Missing Diary Frequency Adjusted
1	44	100	94
2	34	43	45
3	24	23	26
4	24	27	21
5	15	7	6
6	0	6	6
7	1	3	3
8	0	5	5
9	0	3	2
10	0	1	1
11	1	1	1
24	0	1	0
Totals	**159**	**567**	**512**

5.5.4 Matching Results – Vehicle / OBD

100% Matched Trips. Any vehicle instrumented with GPS that captured the same GPS trips as reported by diary were considered to be a perfect match, regardless of the presence of OBD data, as defined by the data completion rules. This category also includes vehicles which had no GPS data collected on the travel date and no trips reported for that vehicle on the assigned travel date. Of the 2,715 vehicles instrumented with GPS devices in the 1,442 GPS/diary complete households, 670 vehicles had no GPS data and were confirmed as no travel in the diary data (24.7% of all instrumented GPS/OBD vehicles).

1. Of all trips made by the 2,715 instrumented vehicles, 1,504 vehicles had perfect matches between the diary and GPS trip data. The breakdown of this number includes the 670 vehicle that did not travel and 834 vehicles that made at least one trip. This represents a perfect match (or reporting rate) for 55.4% of all instrumented vehicles in GPS/Diary complete households and 3,548 of the 7,631 diary-reported trips (46.5%). Table 5.5.4.1 contains the trip frequency statistics for the vehicles included in this category.

Table 5.5.4.1: Trip Frequencies for Perfect Matches– OBD Households

Trips (#)	Frequency	Frequency (%)	Cumulative (%)
0	670	44.5%	44.6%
1	10	0.7%	45.2%
2	243	16.2%	61.4%
3	135	9.0%	70.4%
4	135	9.0%	79.3%
5	113	7.5%	86.8%
6	66	4.4%	91.2%
7	39	2.6%	93.8%
8	45	3.0%	96.8%
9	17	1.1%	97.9%
10	12	0.8%	98.7%
11	5	0.3%	99.1%
12	7	0.5%	99.5%
13	2	0.1%	99.7%
14	3	0.2%	99.9%
15	1	0.1%	99.9%
18	1	0.1%	100.0%
Totals	**1,504**	**100.0%**	**100.0%**

2. **Trips reported by diary but not captured by GPS**. The second comparison identifies diary trips that had no corresponding GPS trips. During the matching process, 478 diary trips were identified that had no corresponding GPS trip (which represents 5.5% of all GPS trips). This typically happens when participants place the GPS device in a position in which it cannot receive GPS satellite or forget to confirm that it is powered on.

3. **Trips captured by GPS but not reported by diary**. The last category in the matching process contains those cases where trips were identified within the GPS data stream but not within the diary data. These 1,582 "missed" diary trips were either single links within a trip chain, multiple links within a trip chain, or complete round-trips missing all links in a tour, based on characteristics of adjacent trips. Based on the total of 7,631 diary trips reported, the missing 1,582 diary trips reflect a 20.7% missing trip rate across the entire sample. However, when the typical reporting exceptions are excluded from this analysis, the missed trip rate falls to 18.4% for the GPS/OBD sample.

Table 5.5.4.2 shows the frequency of missing GPS and diary trip counts detected for the 1,211 GPS/OBD vehicles that were not perfect matches.

Table 5.5.4.2: Trip Frequencies for Missing Trips – Vehicle GPS (OBD)

Missing Trips (#)	Missing GPS Frequency	Missing Diary Frequency Raw	Missing Diary Frequency Adjusted
1	118	303	277
2	74	140	131
3	27	81	81
4	12	54	44
5	9	29	29
6	0	13	9
7	2	12	10
8	0	4	3
9	0	6	6
10	1	7	4
11	0	1	1
12	0	1	3
13	0	3	0
14	1	0	0
15	0	1	1
Totals	**478**	**1,582**	**1,407**

5.5.5 Matching Results – Summary Tables

Table 5.5.5.1: Perfect Match Summary

Perfect Match Summary	Perfect Matches	Perfect Match %
Wearable Persons Instrumented	8,202	
Wearable Persons (All Perfect Matches)	3,050	37.2%
Vehicles Instrumented	776	
Vehicle (All Perfect Matches)	481	62.0%
OBD Vehicles Instrumented	2,715	
OBD (All Perfect Matches)	1,504	55.4%
All Instrumented Persons / Vehicles	**11,693**	
All Perfect Matches	**5,397**	**46.2%**

No Travel Perfect Match Summary		
Wearable Persons (No GPS / No Travel)	964	31.6%
Vehicle (No GPS / No Travel)	232	48.2%
OBD (No GPS / No Travel)	670	44.6%
No GPS / No Travel Total	**1,866**	**34.6%**

Table 5.5.5.2: Missing Trip Matching Summary

Missing Trip Summary	Count	Percent
Wearable GPS Missing Trips	5,757	13.1%
Wearable Diary Missing Trips	11,725	30.8%
Wearable Adjusted Diary Missing Trips	8,195	21.5%
Vehicles GPS Missing Trips	159	5.8%
Vehicle Diary Missing Trips	567	24.5%
Vehicle Adjusted Missing Trips	512	22.1%
OBD Vehicles GPS Missing Trips	478	5.5%
OBD Vehicles Diary Missing Trips	1,582	20.7%
OBD Vehicles Adjusted Diary Missing Trips	1,407	18.4%
All GPS Missing Trips	**6,394**	**11.5%**
All Diary Missing Trips	**13,874**	**28.9%**
All Adjusted Diary Missing Trips	**10,114**	**21.0%**

Total Number of Reported and Captured Trips	Count
Wearable GPS Trips	44,092
Wearable Diary Trips	38,129
Vehicle GPS Trips	2,735
Vehicle Diary	2,318
OBD GPS Trips	8,737
OBD Diary Trips	7,631
GPS Trips	**55,564**
Diary Trips	**48,078**

5.6 Link Matching

Another task included in the GPS component of this study is link matching the GPS points confirmed as valid trips to GIS spatial layers. All GPS data collected in complete GPS households will be run though a link matching routine. This routine will compare GPS point sequences with linear spatial databases representing different elements from the study area's transportation infrastructure. Link matching results will be available in late May 2013. A description of the link matching process is below.

5.6.1 Process Description

The spatial layers used in the link-matching were developed from a number of different sources based on need and availability. In the MTC area, MTC provided road, bike, rail, and ferry databases to use in the matching. In the rest if the state, TIGER road data will be used and integrated transit networks where available. In order to improve the matching process, some road segments were "flipped" to coordinate the topologic direction and the direction of travel. This prevents the link-matching routine from matching the GPS to wrong side of a divided highway. Further, TIGER data was also adjusted when clear connectivity gaps were identified.

The algorithm used to perform the link-matching was based on the one proposed by Marshal, Hackney and Axhausen[3], with the added feature of performing shortest network paths on gaps found in the final routes. Each record in the Shapefile received a unique id in PostGIS, which matched its position in the original file; this field (uid) was used to associate the GPS points with the link features.

The transportation layer are stored and processed in WGS 84 geographic coordinates. The GPS points were matched based on the travel modes they were associated with in TIAS, only modes bound to the street network were matched (Table 5.5.1.1).

Table 5.5.1.1: List of Travel Modes included in Matching Process

Mode ID	Mode Description
1	Walk
2	Bike
3	Wheelchair / Mobility Scooter
4	Other Non Motorized
5	Auto / Van / Truck Driver
6	Auto / Van / Truck Passenger
7	Carpool / Vanpool
8	Motorcycle / Scooter / Moped
9	Taxi / Hired Car / Limo
10	Private Shuttle (Super Shuttle, Employer, Hotel)
11	Greyhound Bus
13	Other Private Transit
14	Local Bus, Rapid Bus
15	Express Bus / Commuter Bus (Golden Gate, AC Trans)
17	School Bus
18	Public Transit Shuttle
20	Dial-a-Ride / Para-transit (Access Services)
21	Amtrak Bus
22	Other Bus

Spatial operations were performed in the layer's original local projection with GPS coordinates projected on the fly. The match tolerance was set at 150 ft (approx. 50 meters). This value was selected based on the spatial resolution and detail of the street networks and also by iteratively running the matching routines and reviewing results.

The GPS points were associated with links by intersecting lines perpendicular to the points' trajectories with the route's links. Linear referencing measurements were computed by calculating the distance along the routes' individually matched segments to the point snaps. Distances were saved in meters.

[3] F. Marchal, J. Hackney, K. W. Axhausen, Efficient Map Matching of Large Global Positioning System Data Sets: Tests on Speed-Monitoring Experiment in Zürich, Transportation Research Record: Journal of the Transportation Research Board, Transportation Research Board of the National Academies, 2006.

The output of this process will be saved as the GPSLinks table. It will show the link sequence used to complete a given trip. The time stamps in this table can be used to select individual GPS points associated with the links. The GPS data dictionary provided with the data deliverable contains detailed field descriptions for the GPSLinks table.

5.7 GPS Data Deliverables

The GPS data deliverable included several Access and Excel Databases containing all data collected from complete households. Tables included as part of the GPS data deliverables are:

HOUSEHOLDS contains one record for each household deployed with GPS equipment during the study period. Summary level information is provided.

PERSONS contains one record for each person deployed with GPS equipment during the study period. Summary information for each GPS data collection day is provided. This table is available only for wearable GPS households.

VEHICLES contains one record for each vehicle deployed with GPS equipment during the study period. Summary information for each GPS data collection day is provided. This table is available only for vehicle GPS households.

GPSTRIPS contains trip-level information for each valid GPS trip detected in the GPS point data collected by the sampled households during the assigned travel day.

GPSTRIPSTAGES contains one record for each trip stage identified within a GPS trip, where a stage is defined as travel made by a given travel mode. This table is available only for wearable GPS households. This table is available only for wearable GPS households.

***GPSPOINTS** contains all valid GPS points (associated with GPS trips) collected by the sampled households during the assigned travel day.

OBDTRIPS contains trip-level information for each trip identified by the OBD engine sensor during the study period. This table is available only for vehicle GPS/OBD households.

***OBDPOINTS** contains point-level information for each trip identified by the OBD engine sensor during the study period. This table is available only for vehicle GPS/OBD households.

MISSEDTRIPANALYSIS contains a comparison of diary reported trips and GPS captured trips by persons or vehicles for complete households. This table contains only persons or vehicles whose diary data was able to be matched to GPS data, or whose diary data confirmed no travel on the travel day.

DIARYGPSTM contains all diary reported trips by persons or vehicles for all households. This table contains only persons or vehicles whose diary data was able to be matched to GPS data, or whose diary data confirmed no travel on the travel day.

TRIPS_SORTED contains an integrated record of all trips, both diary reported and GPS captured trips, by persons or vehicles for all complete households. This table contains only persons or vehicles whose diary data was able to be matched to GPS data, or whose diary data confirmed no travel on the travel day.

6.0 Assessment of Survey Quality

This section discusses the assessment of various aspects of the CHTS quality. Overall, the CHTS data meets or surpasses the usual industry standards for household travel survey data. The quality of the final main survey is demonstrated through the assessment of: Item non-response, expected value ranges and logical relationships between data elements, geographic coverage of participating households, and overall survey response rate.

6.1 Item Non-Response Analysis

One of the key indicators of survey quality is the amount of non-response to the individual items. The following is a summary of item non-response to the survey items within the final data files. The percentages indicated in each table are the proportion of responses that were "Don't Know" and/or "Refused".

Table 6.1.1 presents the two items that, at the household level, had a non-response level of 2% or greater. As may be seen, the question asking participants about their plans to purchase a new vehicle within the next 5 years had the highest item non-response, with 10.1% of all households refusing to answer this question. As is typically experienced in household travel surveys of similar magnitude, Household Income also had a comparatively high item non-response rate, of 8.6%.

Table 6.1.1: Household Item Non-Response

Household File	% Non-Response
Plans to purchase new vehicle within 5 years	10.1%
Household income	8.6%

Table 6.1.2 presents the 17 items that experienced an item non-response of 2% or greater. At the person level, the 42.5% non-response rate for the follow-up question asking whether the employer provided a transit subsidy, and what that subsidy unit is, largely reflects uncertainty or inability to answer, rather than refuse, the question. This may also be the case with the work days (what days does the person work) question (27.6%), the type of Clipper Card (14.1%), and the question asking which toll road or express lane was used (10.9%), which experienced high non-response rates. All other items are within reasonable bounds and are comparable to other studies of this type. Please refer to Table 6.1.2 for all items at the person level that experienced item non-response at 2% or greater.

Table 6.1.2: Person Item Non-Response

Person File	% Non-Response
Transit subsidy unit (per day, per week, etc.)	42.5%
Work days	27.6%
Type of Clipper Card	14.1%
Which toll road/express lane was used	10.9%
Flexible work schedule programs offered	5.6%
Disability Type	5.0%

Person File	% Non-Response
Hours worked per week	4.5%
Age	3.6%
Type of transit pass	3.4%
Vehicle driven by respondent	3.1%
Occupation	3.1%
Transit Subsidy	3.1%
Ethnicity	2.5%
Pre-school location	2.5%
Country of birth	2.3%
Industry	2.3%
Online school	2.1%

In the vehicle file, some of the items presented a high degree of refusal. These included the question asking about insurer-provided vehicle devices (40.8%), about the vehicle's power train (16.4%), and "pay as you go"/"pay as you drive" vehicle insurance (12.9%). It is likely that respondents simply did not know the answers to these questions. See Table 6.1.3 for more information on the eight vehicle data elements that experienced item non-response at 2% or greater.

Table 6.1.3: Vehicle Item Non-Response

Vehicle File	% Non-Response
Insurer-provided vehicle devices	40.8%
Vehicle Power train	16.4%
Vehicle insurance	12.9%
Vehicle Cylinders	11.9%
Reason vehicle not used on travel day	7.0%
Electrical outlet availability	6.5%
Year of vehicle	3.3%
Outlet volts	3.3%

The following is a summary of item non-response for the travel data elements asked during the retrieval interview. The data element with the highest non-response was time spent walking from parking location to destination (56.7%). See Table 6.1.4 for more information on the five place data elements that experienced item non-response at 2% or greater.

Table 6.1.4: Travel Behavior Item Non-Response

Place File	% Non-Response
Time(in minutes) walking from parking location to destination	56.7%
Parking unit	11.8%
Transit system	10.7%
Pay to park vehicle on trip	3.2%
How did you pay for parking	2.6%

In the activity data table, only the following data element had over 2% item non-response: "Did anyone else participate with you?" This question experienced a 30.9% "Don't Know" and/or "Refusal" rate.

As expected, data from the Long Distance file also had fairly low non-response. Arrival and Departure Mode experienced moderately high non-response, as shown in Table 6.1.5, below. Recall that these two questions had been removed from the printed version of the Long Distance Log for the main survey, which means that participants who responded via mail would not have even seen these items.

Table 6.1.5: Long Distance Item Non-Response

Long Distance File	% Non-Response
Arrival Mode	25.3%
Departure Mode	25.1%

6.2 Expected Value Ranges and Logical Relationships between Items

Another indicator of high data quality is that each data element contains the expected value ranges as shown in the survey recruitment and retrieval instruments. Where data elements should be skipped (i.e. a non-worker should not be asked the Occupation question), is the data for that person appropriately blank? Similarly, if there are two allowable categories for an item (i.e. Male and Female for the Gender item) does the data file contain only the appropriate choice codes? Logical relationships between items are also critical for a high quality data file. If a parent takes a child to school, does the child's place data also reflect the corresponding school trip? These quality assurance checks, and many more, were reviewed and flagged throughout data collection in NuStats' Edit Check module.

The Edit Check module is used by analysts to check data for consistency and accuracy, as well as to transform data to the final delivery format and perform summaries on the data. For the Edit Check section, there are a number of queries that are run to check for the quality of the data and update the status flags for any existing data and other queries. Table 6.2.1 details the automated edit checks performed on the main survey data file.

In addition to the automated checks shown in the table below, access/egress trips from transit, intra-household travel, and spelling/consistency of open-ended responses were manually reviewed.

Table 6.2.1: Summary of Automated Quality Assurance Checks

Error Code	Message	Treatment	FILE
1	Arrival before departure (TRIP)	Check to see if TRPDUR>0, If not there is a time error between this row and the previous row	TRIP
2	Departure before arrival (TRIP)	Check to see if ACTDUR>0, If not there is a time error between ARRIVAL and DEPARTURE	TRIP
3	First place does not start at 3am (TRIP)	Check the ARRIVAL time of PLANO=1, it should be 3:00, if not, the first trip is may be missing or there is a reporting error	TRIP
4	Last place does not end at 2:59am (TRIP)	Check the DEPART time of the last trip, it should be 259, if not there is a numbering error between trips or the last trip has a reporting error	TRIP
6	Need location information	Look for shared trips, look in RET data	TRIP
7	Day Time Totals <> 1439 (TRIP)	One of the TRPDUR/ACTDUR's is false	TRIP
8	Need reason for no travel/filled in and should not be (PER)	Check NOGO/O_NOGO	PER
10	HHSIZ (HH) not equal to person count (PER)	Check PER data to see if everyone is a valid person then modify HHSIZ	HH/PER
11	HHVEH (HH) not equal to vehicle count (VEH)	Check VEH data to see if vehicle is a valid vehicle , then modify HHVEH	HH
11	VEHOP (HH) not equal to vehicle count (VEH)	Check VEH data to see if vehicle is a valid vehicle , then modify HHVEH	HH
12	HHWRK (HH) not equal to workers count (PER)	Check PER data to see if everyone AGE>15 has a valid EMPLY code, then modify HHWRK	HH/PER
14	HTRIPS (HH) does not match number of household trips (TRIP)	Make sure only valid HH members AGE>15 have trip data	HH/TRIP
15	INCOM is missing or is out of range (HH)	Check INCOM, look in REC data	HH
18	RESTY missing or is out of range (Including RESTO)	Check RESTY and O_RESTY, look in REC data	HH
20	HHSTU does not match number of Household students	RERUN PRECLEAN	HH
21	TRIP - Person without Driver's License Driving	Check Person Roster	PER
22	TRIP - Person Making Trips not in PER file (PER/TRIP)	Check Trip file or Person Roster for inconsistency	TRIP
28	TRIP-person traveling together (TRIP)	Manually review intra-household travel	TRIP
29	AGE and/or GENDER is missing or out of range (PER)	Check AGE and GENDER, one could be missing, RET (add per) and REC data	PER
36	PROXY or INTRV missing	Check PROXY and PER (add per) can also check RET look for interviewed item	PER
37	PERSON not in HH file	There is no HH in the HH table corresponding to this PERSON, check REC and RET or send to RESEARCH	HH/PER
40	Work marked as "home" (WLOC) but WADD<>HHADDR (PER/HH), IF NOT CHECK, if WADDR is Missing from PER file.	Check if WLOC is not home	PER
41	Work trip address does not match WADDR (PER/TRIP)	Check WLOC, maybe 2 works	PER/TRIP
45	SCHOL is missing	Check PER school data, update from RET (add per) or send to research	PER
45	SCHOL is not null	Check PER school data, update from RET (add per) or send to research	PER
46	SNAME, SADDR is missing when SLOC is not home or vice versa	Check PER school data, update from RET (add per) or send to research	RES
47	School trip address does not match SADDR (PER/TRIP)	The school may be in the file twice as 2 different locnos or there are 2 schools.	PER/TRIP

Error Code	Message	Treatment	FILE
50	Trip duration (TRPDU) is out of range or does not agree with PLANO (TRIP)	Check Arrival time of current place and departure time of previous place, PLANO=1 should have a null TRPDUR	TRIP
54	PTRIPS (PER) does not match number of person trips (TRIP)	RERUN PRECLEAN	PER/TRIP
55	Home trip does not match HHADDR (HH/TRIP)	Re-pull Location , check TRIP and LOCNO of PTYPE=1	HH/TRIP
58	Invalid mode	PLANO 1 should not have a mode, there should be a MODE for all other PLANO's	TRIP
62	Number of household members traveling together is larger than household size	Check HHMEM in TRIP it is too large	TRIP
65	ACTIVITY DURATION =0	Activity does not have a duration. Check times and activities. Send to research.	TRIP
68	LOOPTRIP	Confirm valid loop trip (ie. Walking Dog), else, send to research.	TRIP
71	Wrong geocoding for work location-geocoded to the city	Need to collect addr or cross street	PER
73	Wrong geocoding school loc - geocoded to the city	Need to collect addr or cross street or SNAME with at least one street	PER
78	VEH YEAR is missing or is out of range (VEH)	Check rec data	VEH
94	PER - Employment Verification (EMPLY) - Part 1	Check REC and RET PER tables	PER
96	PER - WORKER (WLOC, OCCUP, INDUS) - Part 3	Check REC and RET PER tables	PER
116	PER - AGEB is NOT NULL	Update AGEB to NULL	PER
117	PER - DISAB is null or DTYPE,DSLIC,TWEXT is null	Check REC and RET PER tables	PER
120	PER - WKSTAT is null	Check Work Status	PER
121	PER - WKSTAT is not null	Check Work Status	PER
128	TRIP - PARTY is >0 and HHMEM is null	Review TRIP	TRIP
129	TRIP - PER1 is null and HHMEM > 0	Review TRIP	TRIP
136	PER-OCCUP Contains Will Provide	Check RET PER	PER
138	PER - School-aged person not a student	Obtain school information, or reason not in school	PER
139	TRIP - Auto passenger riding alone	Include driver in PARTY or change to driver	TRIP
140	PER - Person under 14 years old is INTRV=1.	Change PROXY to 2 and get the proxy person # from tb_personextended table	PER
152	Update PTYPE to 1	Check If PNAME = Home and PTYPE<>1.	TRIP
153	Look for home xy-coordinates in trip table or geocode haddr	Invalid home address. Locate and geocode home addr, else, send to research	HH/TRIP
154	Transit Trip - Missing Access and/or Egress Trip.	Flagged for Research	RES
155	Out of area household - Need Out of Area Addr and needs to be geocoded	Flagged for Research	RES
156	Speed is too fast(Place is wrongly geocoded or mode is wrong or travel time is wrong)	Review locations, times, and travel mode, else, send for research.	TRIP
157	O_NOGO is missing	Check O_NOGO	PER/TRIP
160	ROUTE missing	Flagged for Research	TRIP

Error Code	Message	Treatment	FILE
163	ACTIVITY STARTS BEFORE ARRIVAL TIME	Review Trip table and times, else, send for research.	ACTIVITY
164	ACTIVITY ENDS AFTER DEPARTURE TIME	Review Trip table and times, else, send for research.	ACTIVITY

6.3 Geographic Coverage

Another indicator of high survey quality is the achievement of a final dataset that is representative of the full diversity of the surveyed population, including both the socio-demographic profile of residents of the state, as well as the full geographic coverage of residential addresses. Table 6.3.7 presents the geographic distribution of total households by County and MPO/RTPA, their percentage of all total households in California total, and the geographic distribution and percentage of the final unweighted data file. Overall, the survey achieved a fairly equal geographic distribution as compared with the 2005-2009 ACS. The largest discrepancies were in the SCAG region for the Los Angeles/Ventura strata, in which there were 6% fewer completed households in the final data than the overall percentage of statewide households in that strata, and in SANDAG, with 5% fewer households in the final dataset than expected. As previously noted in section 3.2.3, the larger MPOs were underrepresented in the final data set by design, as the determination had been made to oversample the rural areas.

Table 6.3.7: Geographic Distribution by Strata and MPO/RTPA

MPO/RTPA	Strata/ County	Total Households	Percent of Total Households	Final Data File (Unweighted)	Percent of Final Data File
SCAG	Imperial	49,126	<1%	481	1%
	Los Angeles Ventura	3,508,124	28%	9,430	22%
	Orange	992,781	8%	2,401	6%
	Riverside San Bernardino	1,297,878	5%	3,404	8%
MTC	Santa Clara	604,204	5%	2,136	5%
	Alameda	545,138	4%	1,700	4%
	Contra Costa	375,364	3%	1,389	3%
	San Francisco	345,811	3%	1,076	3%
	San Mateo	257,837	2%	1,142	3%
	Sonoma	185,825	1%	870	2%
	Solano	141,758	1%	628	1%
	Marin	103,210	1%	461	1%
	Napa	48,876	<1%	317	1%
SANDAG	San Diego	1,086,865	9%	1,689	4%
SACOG	Sacramento Placer Yolo	826,067	7%	2,038	5%

MPO/RTPA	Strata/ County	Total Households	Percent of Total Households	Final Data File (Unweighted)	Percent of Final Data File
	El Dorado				
	Sutter				
	Yuba				
Fresno	Fresno				
Kern	Kern				
Madera	Madera				
Kings	Kings				
Tulare	Tulare	758,903	6%	4,062	10%
	Monterey				
	Santa Cruz				
AMBAG	San Benito	237,106	2%	1,964	5%
San Joaquin	San Joaquin				
Stanislaus	Stanislaus				
Merced	Merced	455,829	4%	1,656	4%
Santa Barbara	Santa Barbara				
San Luis Obispo	San Luis Obispo	244,120	2%	1,282	3%
Butte	Butte				
Shasta	Shasta				
Tehama	Tehama	181,731	1%	786	2%
Humboldt	Humboldt	56,031	<1%	321	1%
Nevada	Nevada	41,527	<1%	188	<1%
Mendocino	Mendocino				
Lake	Lake	61,493	<1%	357	1%
Calaveras	Calaveras				
Amador	Amador				
Mariposa	Mariposa				
Tuolumne.	Tuolumne				
Alpine	Alpine	63,801	<1%	720	2%
	El Dorado				
TMPO	Placer	17,344	<1%	299	1%
Siskiyou	Siskiyou				
Trinity	Trinity				
Modoc	Modoc	29,652	<1%	499	1%
Lassen	Lassen				
Plumas	Plumas				
Sierra	Sierra	20,517	<1%	361	1%
Del Norte	Del Norte	9,907	<1%	189	<1%

MPO/RTPA	Strata/ County	Total Households	Percent of Total Households	Final Data File (Unweighted)	Percent of Final Data File
Glenn	Glenn				
Colusa	Colusa	16,856	<1%	289	1%
Mono	Mono				
Inyo	Inyo	13,817	<1%	296	1%
		12,577,498	100%	42,431	100%

6.4 Response Rate Summary

The quality of a survey is also measured by the response rate, which can be measured simply as the number of households sampled divided by the number of completes or by using one of the statistically accepted formulas. This report presents the Council of American Survey Research Organization's (CASRO's) calculation of response rate, which includes all eligible and assumed eligible sampled households in the denominator. This calculation yields a more precise view of the overall percent of households from the original sample that end up completing the survey.[4]

6.4.1 Total Sample Size

To understand the response rate, it is first necessary to understand the total sample size. A total sample of 2,120,720 households was used for the main survey effort. Given that California has roughly 12 million households, this means that approximately one out of every six households in the state was contacted to participate in the CHTS. Of the sample households, 2,098,697 were pulled from multi–sampling frames and 22,023 sampled households that were unused in the pretest were recycled into the main survey. Table 6.4.1 summarizes the used sample count by sampling frame and sample type.

[4] For more information on response rate calculation visit http://www.quantitativeskills.com/sisa/calculations/resprhlp.htm

Table 6.4.1: Summary of Used Sample Count by Sample Type

Sampling Frame	Specific Sample Type	Total Counts Used for Full Study	Drawn for Full study	Recycled From Pilot
Address–based Sampling Frame	ABS Matched	452,276	430,260	22,016
	ABS Unmatched	585,520	585,513	7
Listed RDD Sampling Frame	Listed General	444,066	444,066	0
	Targeted Hispanic Surname	106,338	106,338	0
	Targeted Low Income Household (<25K)	80,552	80,552	0
	Targeted Young Household (Age<25)	61,517	61,517	0
	Targeted Large Household (HHSIZ>3)	156,046	156,046	0
	Listed Household From Transit Oversampling Area	62,782	62,782	0
	Listed Household From Zero Vehicle Household	46,788	46,788	0
Non–probability Sampling	Energy Commission Database of Alternative Fuel Vehicle Owners	121,021	121,021	0
	Kern County Transit Intercept Sample	3,000	3,000	0
	UC Davis Sample of Alternative Fuel Vehicle Owners	814	814	0
Total		2,120,720	2,098,697	22,023

The CHTS was conducted utilizing a two–stage interview approach; recruitment from contacted samples and retrieval of travel information from all household members of the recruited households. The interviews were conducted separately and call outcomes and response rates were separately monitored and analyzed. Table 6.4.2 shows the results of sample disposition in the recruitment stage. The percentages are based on the total for each sample type. For eligible, completed households, there was a slightly higher recruitment rate within the sample of listed households (3.5%) than among the address-based sample (2.7%). The Energy Commission's targeted samples were not very productive, as they yielded less than 1% recruited households. The Kern County Transit Intercept sample, on the other hand, had a remarkable 14.8% recruitment rate.

Table 6.4.2: Sample Disposition for Recruitment by Sampling Type

Sample Type	Category	Dispositions	Count	% of Total Sample Type
Address-based Sample	**Eligible**	Complete	27,917	2.7%
		Partial complete	5314	0.5%
		Final refusal	43,720	4.2%
		Subtotal	**76,951**	**7.4%**
	Ineligible	Language barrier*	10510	1.0%
		Disconnect	6,003	0.6%
		Business/government	1,492	0.1%
		Invalid phone number –fax/modem	2,837	0.3%
		Not qualified/terminated from qualification question/over quota	15307	1.5%
		Subtotal	**36,149**	**3.5%**

Sample Type	Category	Dispositions	Count	% of Total Sample Type
	Unknown	Answering machine	52,537	5.1%
		Busy line	1806	0.2%
		Call back	23619	2.3%
		No answer/left message	54,336	5.2%
		Soft refusal to participate	52,157	5.0%
		Hang up	64,166	6.2%
		Unmatched sample contacted via mail and no response	581231	56.0%
		Not connected	93732	9.0%
		Other	1,112	0.1%
		Subtotal	**924,696**	**89.1%**
		Total	**1,037,796**	**100.0%**
Listed	**Eligible**	Complete	33,731	3.5%
		Partial complete	9530	1.0%
		Final refusal	35,208	3.7%
		Sub total	**78,469**	**8.2%**
	Ineligible	Language barrier*	18196	1.9%
		Disconnect	13,932	1.5%
		Business/government	3,679	0.4%
		Invalid phone number –fax/modem	4,468	0.5%
		Not qualified/terminated from qualification question/over quota	22294	2.3%
		Subtotal	**62,569**	**6.5%**
	Unknown	Answering machine	99,186	10.4%
		Busy line	3103	0.3%
		Call back	56030	5.8%
		No answer/left message	115,917	12.1%
		Soft refusal to participate	101,678	10.6%
		Hang up	122,943	12.8%
		Unmatched sample contacted via mail and no response	0	0.0%
		Not connected	315,687	32.9%
		Other	2,507	0.3%
		Subtotal	**817,051**	**85.3%**
		Total	**958,089**	**100.0%**
Energy Commission and UC Davis Alternative Fuel Vehicle Owner Samples	**Eligible**	Complete	985	0.8%
		Partial complete	307	0.3%
		Final refusal	534	0.4%
		Subtotal	**1,826**	**1.5%**
	Ineligible	Language barrier*	70	0.1%
		Disconnect	169	0.1%
		Business/government	60	0.0%
		Invalid phone number –fax/modem	68	0.1%
		Not qualified/terminated from qualification question/over quota	678	0.6%
		Subtotal	**1,045**	**0.9%**

Sample Type	Category	Dispositions	Count	% of Total Sample Type
	Unknown	Answering machine	1,122	0.9%
		Busy line	19	0.0%
		Call back	886	0.7%
		No answer/left message	1,241	1.0%
		Soft refusal to participate	2,198	1.8%
		Hang up	1,437	1.2%
		Unmatched sample contacted via mail and no response	111343	91.4%
		Not connected	627	0.5%
		Other	91	0.1%
		Subtotal	**118,964**	**97.6%**
		Total	**121,835**	**100.0%**
Kern County Transit Intercept Sample	**Eligible**	Complete	443	14.8%
		Partial complete	28	0.9%
		Final refusal	135	4.5%
		Subtotal	**606**	**20.2%**
	Ineligible	Language barrier*	7	0.2%
		Disconnect	289	9.6%
		Business/government	11	0.4%
		Invalid phone number –fax/modem	5	0.2%
		Not qualified/terminated from qualification question/over quota	13	0.4%
		Subtotal	**325**	**10.8%**
	Unknown	Answering machine	164	5.5%
		Busy line	1	0.0%
		Call back	29	1.0%
		No answer/left message	60	2.0%
		Soft refusal to participate	99	3.3%
		Hang up	106	3.5%
		Not contacted (No contact info)	1598	53.3%
		Not connected	11	0.4%
		Other	1	0.0%
		Subtotal	**2,069**	**69.0%**
		Total	**3,000**	**100.0%**

*Language barrier refers to a language other than English or Spanish.

6.4.2 CASRO Response Rate

Using the CASRO response rate calculation, which takes into account ineligible sample and call outcome unknown sample, the CHTS main survey had a recruit response rate of 4.9%. This is in line with other household surveys that report CASRO rates. However, the main survey CASRO response rate is lower than the CHTS pretest CASRO response rate of 5.6%. This most likely reflects the larger size of the main CHTS survey. Overall retrieval rate was 67.3%.

6.4.3 Simple Response Rate

For purposes of comparison of recruitment and retrieval rates by sample type and by geography, the simple response rate calculations are presented. Recruitment rates and response rates by sample type are shown in Table 6.4.3. As is frequently seen in household travel surveys, the ABS Unmatched sample resulted in the lowest response rate (0.4%) as compared with other sample types. Since there was no telephone number associated with the household, these households would have had to self-recruit online. The next lowest response rate was for the Energy Commission's sample of alternative fuel vehicle owners (0.6%).

Table 6.4.3: Recruitment Rates and Response Rates by Sample Type

Sample Type	Specific Sample Type	Sampled HH (A)	Recruited HH (B)	Recruitment Rate (B)/(A)	Retrieved HH (C)	Retrieval Rate (C)/(B)	Response Rate (C)/(A)
Address–based sample	ABS Matched	452,276	24,926	5.5%	16,774	67.3%	3.7%
	ABS Unmatched	585,520	2,996	0.5%	2,458	82.0%	0.4%
Listed RDD sample	Listed General	444,066	13,782	3.1%	9,489	68.9%	2.1%
	Targeted Hispanic Surname	106,338	3,085	2.9%	1,722	55.8%	1.6%
	Targeted Low Income Household (<25K)	80,552	2,861	3.6%	1,757	61.4%	2.2%
	Targeted Young Household (Age<25)	61,517	2,224	3.6%	1,325	59.6%	2.2%
	Targeted Large Household (HHSIZ>3)	156,046	7,461	4.8%	5,036	67.5%	3.2%
	Listed Household From Transit Oversampling Area	62,782	2,589	4.1%	1,713	66.2%	2.7%
	Listed Household From Zero Vehicle Household	46,788	1,730	3.7%	1,118	64.6%	2.4%
Non–probability samples	Energy Commission Database of Alternative Fuel Vehicle Owners	121,021	873	0.7%	707	81.0%	0.6%
	Kern County Transit Intercept Sample	3,000	443	14.8%	230	51.9%	7.7%
	UC Davis Sample of Alternative Fuel Vehicle Owners	814	112	13.8%	102	91.1%	12.5%
	Total	**2,120,720**	**63,082**	**3.0%**	**42,431**	**67.3%**	**2.0%**

Table 6.4.4 presents the recruitment rate and response rate by each of the 30 sampling strata for the Address-based (ABS) sample. Humboldt County had the highest response rate (4.5%), while two strata in the SCAG region had the lowest response rates (1.4 and 1.5).

Table 6.4.4: Recruitment Rates and Response Rates by 30 Sampling Strata for ABS Sample

Sampling Strata	MPO/ STRATA	Sampled HH (A)	Recruited HH (B)	Recruitment Rate (B)/(A)	Retrieved HH (C)	Retrieval Rate (C)/(B)	Response Rate (C)/(A)
1	SCAG	25,424	775	3.0%	481	62.1%	1.9%
2		160,208	3,464	2.2%	2,401	69.3%	1.5%
3							
3		654,423	14,688	2.2%	9,430	64.2%	1.4%
4							
4		178,269	5,368	3.0%	3,404	63.4%	1.9%
5	MTC	60,352	2,341	3.9%	1,700	72.6%	2.8%
6		56,319	1,949	3.5%	1,389	71.3%	2.5%
7		16,863	617	3.7%	461	74.7%	2.7%
8		28,506	1,207	4.2%	870	72.1%	3.1%
9		15,145	496	3.3%	317	63.9%	2.1%
10		28,639	905	3.2%	628	69.4%	2.2%
11		44,580	1,460	3.3%	1,076	73.7%	2.4%
12		47,952	1,588	3.3%	1,142	71.9%	2.4%
13		75,150	2,917	3.9%	2,136	73.2%	2.8%
14	SANDAG	81,672	2,437	3.0%	1,689	69.3%	2.1%
15	SACOG	79,296	2,693	3.4%	2,038	75.7%	2.6%
16	Nevada	7,763	269	3.5%	188	69.9%	2.4%
17	Lassen						
17	Plumas						
17	Sierra	10,646	491	4.6%	361	73.5%	3.4%
18	Modoc						
18	Siskiyou						
18	Trinity	11,696	689	5.9%	499	72.4%	4.3%
19	Del Norte	4,582	266	5.8%	189	71.1%	4.1%
20	Humboldt	7,182	399	5.6%	321	80.5%	4.5%
21	Lake						
21	Mendocino	12,367	557	4.5%	357	64.1%	2.9%
22	Fresno						
22	Kern						
22	Kings						
22	Madera						
22	Tulare	182,635	6,499	3.6%	4,062	62.5%	2.2%
23	AMBAG						
23							
23		79,784	2,768	3.5%	1,964	71.0%	2.5%
24	Merced						
24	San Joaquin						
24	Stanislaus	82,687	2,517	3.0%	1,656	65.8%	2.0%
25	San Luis Obispo	60,457	1,846	3.1%	1,282	69.4%	2.1%

Sampling Strata	MPO/ STRATA	Sampled HH (A)	Recruited HH (B)	Recruitment Rate (B)/(A)	Retrieved HH (C)	Retrieval Rate (C)/(B)	Response Rate (C)/(A)
25	Santa Barbara						
26	Butte						
26	Shasta						
26	Tehama	24,182	1,126	4.7%	786	69.8%	3.3%
27	Colusa						
27	Glenn	10,805	432	4.0%	289	66.9%	2.7%
28	TMPO						
28	TMPO	11,432	405	3.5%	299	73.8%	2.6%
29	Alpine						
29	Amador						
29	Calaveras						
29	Mariposa						
29	Tuolumne	22,654	1,032	4.6%	720	69.8%	3.2%
30	Inyo						
30	Mono	7,905	406	5.1%	296	72.9%	3.7%
Unknown		31,145	475	1.5%	0	0.0%	0.0%
Total		2,120,720	63,082	3.0%	42,431	67.3%	2.0%

7.0 Survey Data Weighting and Expansion

From a finite population sampling theory perspective, analytic weights are needed to develop estimates of population parameters and, more generally, to draw inferences about the sampled population. Without the use of analytic weights, population estimates are subject to biases of unknown (and possibly large) magnitude. Consequently, analytic weights are crucial to obtain survey estimates with minimal bias.

The weighting approach utilized in this study accounts for the biases associated with sampling and robustness of the data collected. Specifically, the components of the analytic weights generated from method are as follows:

- Sampling weights
- Raking adjustment

Analytic weights are computed at the household and person levels. These weights adjust the relative importance of responses to reflect the different probabilities of selection by respondents, and align the sample distributions to population distributions. This section discusses the components of the household weight and person weight in detail.

7.1 Household Weight

7.1.1 Sampling Weight

The sampling weight reflects the probability of selection of a telephone number or an address from the sampling frame. Considering the dual-sampling frame employed in this study, separate sampling weights are calculated for samples from the listed residential sampling frame and those from the address-based sampling frame. Sample orders were occurred in several waves. As sampling frame gets updated frequently, sample universe continued to be changed whenever sample were drawn. Therefore, sampling weights were calculated for each sample order. Specifically, the sampling weight for a sampling unit *j* in the sampling frame (denoted as $W_{j,SampFr}$) from each sample draw, is simply the reciprocal of the selection probability of the sampling unit.

$$W_{j,SampFr} = \frac{1}{\text{Prob}_{j,SampFr}}$$

Where:

The sampling unit *j* is a landline residential phone number in the listed residential frame or an address in the address-based sampling frame.

Sampling frame $SampFr$ is listed residential sampling frame or address-based sampling frame.

The sampling weights help adjust for oversampling of specific geographies or demographic groups of interest for which we had implemented controls to ensure adequate observations in these groups. To illustrate, the sampling weight associated with an address-based sample is simply computed as the number of addresses (universe) in the address-based frame divided by number of sample pieces ordered from the frame for the study area for each sample order. For this study, samples (i.e. addresses) was drawn by county for CHTS, except TMPO where samples were drawn from the census tracts within the MPO area(see the list of census tracts in Appendix Q) from address-based sampling frame, sampling weights will be computed by county except TMPO for the samples drawn from the address-based sampling frame. Samples (i.e. residential land line phone) were also drawn from

the listed sampling frame. The listed sample was divided evenly among six targeted groups including: Hispanic surnames, low income households with annual income less than $25,000, young households with all members aged 25 or younger, large households with 4 or more persons, transit oversample, zero-vehicle household. Sampling weights were computed separately for samples drawn from each of the six targeted sampling groups. It is important to note that samples from four of the targeted listed sampling groups – (Hispanic surnames, low income households with annual income less than $25,000, young households with all members aged 25 or younger, and large households with 4 or more persons) were drawn across the state, while samples from transit oversample or zero-vehicle household sampling groups were drawn from the targeted census tracts Zero-vehicle household census statistics were available from the 2005-2009 ACS 5-year estimate data at the 2000 census tract level (see the list of 2010 and 2000 census tracts in Appendix Q) when the sampling plan was designed.

Exclusion of Samples from Non–probability Sampling Frame

In CHTS, three other non–sampling methodologies were implemented in order to capture certain population of the interest: Energy Commission samples were drawn from two sources – 2009 database from the Department of Motor Vehicles (DMV), vehicle owner database from University of California at Davis and intercept sample for Kern County transit users. These non-probability based samples were assigned with the base sampling weight of 1 and included in the next step of raking procedure.

7.1.2 Raking Adjustment

Raking improves the reliability of survey estimates; hence, a raking adjustment was used to align the weighted sample with population statistics from the latest available census data - 2011 American Community Survey (ACS) 1-year estimates or 2007-2011 5-year estimates, depending on selected raking control variables and base-geography. In particular, the aforementioned weights were adjusted so that the sums of the adjusted weights are equal to known population totals for certain subgroups of the population, defined by demographic characteristics and geographic variables. Variables and variable categories used for raking at the household level are as follows:

- Household size (1, 2, 3, 4 or more) – State-wide distribution
- Household income (Less than $24,999, $25,000 – $49,999, $50,000 - $74,999, $75,000-$99,999, $100,000-$149,999, $150,000 or above) – State-wide distribution
- Total number of workers in the household (0, 1, 2, 3 or more) – State-wide distribution
- Total number of vehicles in the household (0, 1, 2, 3 or more) – State-wide distribution
- County of Residence – by County
- These variables were chosen as raking variables due to significant differences in coverage by categories of these variables. Therefore, it is reasonable to expect that maximum bias reduction would be achieved using these variables. It is important to note that the missing values in the raking variables were imputed to calculate the raking adjustments using the well-known hot deck method, in which a missing value is imputed using the data from other observations in the same dataset. Missing income was imputed before the household level raking procedure using a mean of household income for combination of OWN (home ownership), HHSIZ (household size) and HHVEH (number of household vehicles) variables. A mean of each combination was calculated and applied to the refused income values for the relevant category.
- The raking procedure was based on an iterative proportional fitting procedure, and involves simultaneous ratio adjustments to two or more marginal distributions of population counts. The raking procedure was performed in a sequence of adjustments. First, base weights (sampling weights) were

adjusted to one marginal distribution and then to the second marginal distribution, and so on. One sequence of adjustments to the marginal distributions was known as a cycle or iteration. The procedure was repeated until convergence was achieved.

- Note that state-wide marginal control total data were obtained from 2011 ACS 1-year estimates while county of residence data were obtained from 2007-2011 ACS 5-year estimates due to small counties where data are not available from 1-year or 3-year estimates.
- Following the raking procedure, inordinately large weights, a by-product of raking, ought to be capped in order to prevent samples with extremely large weight from skewing other variables that are not controlled by the weighting process and travel pattern. There were no "very large" weights exceeding a maximum of five times the mean weight observed after the household level raking procedure, so capping was not necessary.

Table 7.1.2.1 shows the survey and population distributions by demographic and geographic raking variables for the study area. A comparison of the unweighted distribution and the weighted distribution of these raking variables indicates that the raking procedure has aligned the sample statistics to the population statistics.

Table 7.1.2.1: Raking Adjustment at Household Level

Key variables	Unweighted		Weighted		ACS 2011 1 year		Difference (% points) Weighted-ACS
Household Size							
1	9140	21.5%	10379	24.5%	3050172	24.5%	0.0%
2	16319	38.5%	12744	30.0%	3745136	30.0%	0.0%
3	6821	16.1%	6939	16.4%	2039065	16.4%	0.0%
4 or more	10151	23.9%	12368	29.2%	3634370	29.2%	0.0%
Total	**42431**	**100.0%**	**42431**	**100.0%**	**12468743**	**100.0%**	**0.0%**
Income*							
Less than $24999	6431	16.58%	8544	21.83%	2764797	22.17%	-0.34%
$25000 – $49999	7923	20.43%	9370	23.94%	2759357	22.13%	1.81%
$50000 - $74999	6903	17.80%	6204	15.85%	2112377	16.94%	-1.09%
$75000-$99999	5870	15.13%	5017	12.82%	1488173	11.94%	0.88%
$100000-$149999	6470	16.68%	4659	11.90%	1768081	14.18%	-2.28%
$150000 or above	5192	13.39%	5344	13.65%	1575958	12.64%	1.01%
Total	**38789**	**100.00%**	**39138**	**100.00%**	**12468743**	**100.00%**	**0.00%**
Number of Household Vehicles							
0	2459	5.8%	3402	8.0%	999,638	8.0%	0.0%
1	12678	29.9%	13886	32.7%	4,080,664	32.7%	0.0%
2	18657	44.0%	15788	37.2%	4,639,481	37.2%	0.0%
3 or more	8637	20.4%	9355	22.1%	2,748,960	22.1%	0.0%
Total	**42431**	**100.0%**	**42431**	**100.0%**	**12468743**	**100.0%**	**0.0%**
Number of Household Workers							

Key variables	Unweighted		Weighted		ACS 2011 1 year		Difference (% points) Weighted-ACS
0	9120	21.5%	10809	25.5%	3175985	25.5%	0.0%
1	17915	42.2%	16894	39.8%	4964467	39.8%	0.0%
2	12818	30.2%	11527	27.2%	3387597	27.2%	0.0%
3 or more	2578	6.1%	3201	7.5%	940694	7.5%	0.0%
Total	**42431**	**100.0%**	**42431**	**100.0%**	**12468743**	**100.0%**	**0.0%**
Household Counts by County							
Alameda	1700	4.0%	1830	4.3%	536160	4.3%	0.0%
Alpine	21	0.1%	1	0.0%	357	0.0%	0.0%
Amador	182	0.4%	49	0.1%	14283	0.1%	0.0%
Butte	360	0.9%	291	0.7%	85219	0.7%	0.0%
Calaveras	176	0.4%	64	0.2%	18865	0.2%	0.0%
Colusa	107	0.3%	24	0.1%	6989	0.1%	0.0%
Contra Costa	1389	3.3%	1266	3.0%	370925	3.0%	0.0%
Del Norte	189	0.5%	34	0.1%	9818	0.1%	0.0%
El Dorado	412	1.0%	235	0.6%	68812	0.6%	0.0%
Fresno	1115	2.6%	974	2.3%	285338	2.3%	0.0%
Glenn	182	0.4%	32	0.1%	9483	0.1%	0.0%
Humboldt	321	0.8%	183	0.4%	53724	0.4%	0.0%
Imperial	481	1.1%	164	0.4%	48117	0.4%	0.0%
Inyo	189	0.5%	27	0.1%	7910	0.1%	0.0%
Kern	1544	3.6%	857	2.0%	250999	2.0%	0.0%
Kings	293	0.7%	139	0.3%	40716	0.3%	0.0%
Lake	182	0.4%	88	0.2%	25654	0.2%	0.0%
Lassen	152	0.4%	34	0.1%	10097	0.1%	0.0%
Los Angeles	8219	19.4%	10984	25.9%	3218518	25.9%	0.0%
Madera	311	0.7%	143	0.3%	42032	0.3%	0.0%
Marin	461	1.1%	351	0.8%	102832	0.8%	0.0%
Mariposa	148	0.4%	26	0.1%	7607	0.1%	0.0%
Mendocino	175	0.4%	116	0.3%	34102	0.3%	0.0%
Merced	474	1.1%	253	0.6%	74079	0.6%	0.0%
Modoc	111	0.3%	13	0.0%	3947	0.0%	0.0%
Mono	107	0.3%	18	0.0%	5416	0.0%	0.0%
Monterey	1022	2.4%	427	1.0%	125217	1.0%	0.0%
Napa	317	0.8%	169	0.4%	49640	0.4%	0.0%
Nevada	188	0.4%	142	0.3%	41561	0.3%	0.0%
Orange	2401	5.7%	3369	7.9%	987164	7.9%	0.0%

Key variables	Unweighted		Weighted		ACS 2011 1 year		Difference (% points) Weighted-ACS
Placer	481	1.1%	446	1.1%	130736	1.1%	0.0%
Plumas	150	0.4%	32	0.1%	9434	0.1%	0.0%
Riverside	1701	4.0%	2296	5.4%	672896	5.4%	0.0%
Sacramento	825	1.9%	1744	4.1%	510976	4.1%	0.0%
San Benito	268	0.6%	57	0.1%	16785	0.1%	0.0%
San Bernardino	1703	4.0%	2044	4.8%	598822	4.8%	0.0%
San Diego	1689	4.0%	3631	8.6%	1064048	8.6%	0.0%
San Francisco	1076	2.5%	1155	2.7%	338366	2.7%	0.0%
San Joaquin	630	1.5%	727	1.7%	212902	1.7%	0.0%
San Luis Obispo	847	2.0%	348	0.8%	101993	0.8%	0.0%
San Mateo	1142	2.7%	875	2.1%	256423	2.1%	0.0%
Santa Barbara	435	1.0%	483	1.1%	141635	1.1%	0.0%
Santa Clara	2136	5.0%	2047	4.8%	599652	4.8%	0.0%
Santa Cruz	674	1.6%	320	0.8%	93834	0.8%	0.0%
Shasta	250	0.6%	236	0.6%	69147	0.6%	0.0%
Sierra	59	0.1%	5	0.0%	1328	0.0%	0.0%
Siskiyou	212	0.5%	67	0.2%	19782	0.2%	0.0%
Solano	628	1.5%	475	1.1%	139312	1.1%	0.0%
Sonoma	870	2.1%	629	1.5%	184170	1.5%	0.0%
Stanislaus	552	1.3%	563	1.3%	164933	1.3%	0.0%
Sutter	168	0.4%	108	0.3%	31668	0.3%	0.0%
Tehama	176	0.4%	81	0.2%	23810	0.2%	0.0%
Trinity	176	0.4%	20	0.1%	5731	0.1%	0.0%
Tulare	799	1.9%	438	1.0%	128324	1.0%	0.0%
Tuolumne	193	0.5%	76	0.2%	22157	0.2%	0.0%
Ventura	1211	2.9%	904	2.1%	264982	2.1%	0.0%
Yolo	246	0.6%	238	0.6%	69860	0.6%	0.0%
Yuba	205	0.5%	82	0.2%	23885	0.2%	0.0%
Total	**42431**	**100.0%**	**42431**	**100.0%**	**12433172**	**100.0%**	**0.0%**

*The weighted survey data distribution for household income uses unimputed value and excludes the refusals.

7.1.3 Final Expanded Household Weight

The final analytic weight is simply the product of sampling weight and raking adjustment. Following the computation of this weight, an expansion procedure was undertaken to get the final 'expanded' analytic weight so that the weighted survey dataset can provide estimates for the total population in the study area. The expansion process simply takes the weighted total number of households and multiplies each household by a factor that, when applied, expands the data to represent the universe of households in the study area of State of

California. The 2011 ACS 1-year estimate was used to get the total household counts in the state of California. To derive the expansion factor, a simple division was used: Expansion Factor = N(Universe)/N(Surveyed. This translates to a survey universe of 12,433,172 households.

The final expanded household weight was appended to the Household and Vehicle data files.

7.2 Person Weight

Person weight is a product of the final household weight and the person level raking weight. Person data weighted by "final household weight" was raked to align it to population statistics from the 2011 ACS 1-year estimates except population counts by county, which was pulled from 2007-2011 ACS 5-year estimates. Variables used for raking at the person level are as follows:

- Hispanic Status (Hispanic, Non-Hispanic) – State-wide distribution.
- Ethnicity (White, African American, Asian, Other) – State-wide distribution.
- Age (less than 20 years, 20 –34 years, 35 – 54 years, 55 – 64 years, 65 years or older) – State-wide distribution.
- Employment Status (Part-time or full-time Employed, Not-employed) – State-wide distribution.
- County of Residence (Three smallest counties- Alpine, Amador and Calaveras) were grouped due to difficulty of convergence by small sample size) – by County

Before the raking procedure, any missing data for Hispanic status/race or age were imputed using hot–deck imputation method which is the most commonly used method for missing data imputation. With this method, a missing value is imputed from randomly selected similar records. To select similar records, other reference demographic variables known to have a strong correlation with the imputing variable are used to compute mean or mode – a statistical term for the number that appears most often – to replace missing value. Imputation of these variables was carried out as follows:

- Hispanic status/race is a categorical variable. Hence, mode (a statistical term meaning the value that appears most often) was calculated and applied for missing value. For race, mode by household income category was computed and applied to race refusal records in the same household income category. For Hispanic status, mode of Hispanic status by combination of household income and race was computed and applied to missing or refusal values of the same household income and age group.
- Age is a scale variable. Hence, mean age for combination of education level, work status, and student status was computed and applied to age refusals. If education level was refused or missing, a mean age of relevant work status and student status category was applied. If all the variables used for imputation are refusals, and the overall average age was applied.

Following the raking procedure, any very large weights were capped to equal a maximum of five times the mean weight. Table 7.2.1 shows the survey and population distribution by the aforementioned raking variables.

Table 7.2.1: Survey and Population Distribution by Raking Variables

Key variables	Unweighted		Weighted		ACS 2011 1 year		Difference (% points) Weighted-ACS
Hispanic Status							
Hispanic	27692	25.7%	39154	36.5%	14359500	38.1%	-1.56%
Non-Hispanic	80267	74.3%	67995	63.5%	23332412	61.9%	1.56%
Total	**107959**	**100.0%**	**107149**	**100.0%**	**37691912**	**100.0%**	**0.00%**
Age							
less than 20 years	24170	23.0%	28108	26.7%	9,873,223	26.2%	0.55%
20 – 34 years	12163	11.6%	21414	20.4%	7,866,957	20.9%	-0.49%
35 – 54 years	29175	27.7%	27008	25.7%	9,913,281	26.3%	-0.60%
55 – 64 years	21985	20.9%	11249	10.7%	4,011,905	10.6%	0.06%
65 years or older	17696	16.8%	17305	16.5%	6,026,546	16.0%	0.48%
Total	**105189**	**100.0%**	**105084**	**100.0%**	**37691912**	**100.0%**	**0.00%**
Race							
White	74882	70.5%	65088	61.8%	23698393	62.9%	-1.05%
Black or African American	3356	3.2%	6403	6.1%	2253905	6.0%	0.10%
American Indian or Alaska Native	5573	5.2%	848	0.8%	289597	0.8%	0.04%
Asian	6564	6.2%	14054	13.3%	4970627	13.2%	0.16%
OTHER	15866	14.9%	18889	17.9%	6479390	17.2%	0.75%
Total	**106241**	**100.0%**	**105282**	**100.0%**	**37691912**	**100.0%**	**0.00%**
Employment Status							
Yes	51838	47.6%	46502	42.8%	16047067	42.6%	0.20%
No	57027	52.4%	62216	57.2%	21644845	57.4%	-0.20%
Total	**108865**	**100.0%**	**108718**	**100.0%**	**37691912**	**100.0%**	**0.00%**
Population by County							
Alameda	4191	3.8%	4443	4.1%	1494876	4.0%	0.03%
Alpine	56	0.1%	3	0.0%	1167	0.0%	0.00%
Amador	373	0.3%	103	0.1%	38244	0.1%	-0.01%
Butte	853	0.8%	655	0.6%	219309	0.6%	0.01%
Calaveras	372	0.3%	149	0.1%	45794	0.1%	0.01%
Colusa	248	0.2%	63	0.1%	21297	0.1%	0.00%
Contra Costa	3490	3.2%	3100	2.8%	1037817	2.8%	0.03%
Del Norte	458	0.4%	85	0.1%	28561	0.1%	0.00%
El Dorado	975	0.9%	535	0.5%	179878	0.5%	0.00%
Fresno	3016	2.8%	2662	2.4%	920623	2.5%	-0.05%
Glenn	455	0.4%	84	0.1%	28027	0.1%	0.00%
Humboldt	740	0.7%	399	0.4%	133585	0.4%	0.00%
Imperial	1439	1.3%	511	0.5%	171343	0.5%	0.00%

Key variables	Unweighted		Weighted		ACS 2011 1 year		Difference (% points) Weighted-ACS
Inyo	431	0.4%	55	0.1%	18457	0.0%	0.00%
Kern	4096	3.8%	2458	2.3%	829254	2.2%	0.01%
Kings	833	0.8%	455	0.4%	152335	0.4%	0.00%
Lake	384	0.4%	192	0.2%	64392	0.2%	0.00%
Lassen	339	0.3%	105	0.1%	35001	0.1%	0.00%
Los Angeles	21184	19.4%	29068	26.6%	9787747	26.5%	0.16%
Madera	860	0.8%	443	0.4%	149611	0.4%	0.00%
Marin	1062	1.0%	739	0.7%	250666	0.7%	0.00%
Mariposa	324	0.3%	55	0.1%	18290	0.0%	0.00%
Mendocino	418	0.4%	261	0.2%	87525	0.2%	0.00%
Merced	1327	1.2%	748	0.7%	253606	0.7%	0.00%
Modoc	254	0.2%	29	0.0%	9587	0.0%	0.00%
Mono	262	0.2%	42	0.0%	14016	0.0%	0.00%
Monterey	2573	2.4%	1203	1.1%	411385	1.1%	-0.01%
Napa	763	0.7%	385	0.4%	135377	0.4%	-0.01%
Nevada	431	0.4%	294	0.3%	98392	0.3%	0.00%
Orange	6357	5.8%	8838	8.1%	2989948	8.1%	0.01%
Placer	1166	1.1%	1016	0.9%	343554	0.9%	0.00%
Plumas	333	0.3%	60	0.1%	20192	0.1%	0.00%
Riverside	4920	4.5%	6394	5.9%	2154844	5.8%	0.03%
Sacramento	2151	2.0%	3970	3.6%	1408480	3.8%	-0.17%
San Benito	726	0.7%	164	0.2%	54873	0.1%	0.00%
San Bernardino	4882	4.5%	6025	5.5%	2023452	5.5%	0.05%
San Diego	4606	4.2%	8779	8.0%	3060849	8.3%	-0.23%
San Francisco	2249	2.1%	2379	2.2%	797983	2.2%	0.02%
San Joaquin	1717	1.6%	2013	1.8%	680277	1.8%	0.01%
San Luis Obispo	1900	1.7%	797	0.7%	267871	0.7%	0.01%
San Mateo	2801	2.6%	2126	1.9%	711622	1.9%	0.02%
Santa Barbara	1046	1.0%	1203	1.1%	419793	1.1%	-0.03%
Santa Clara	5868	5.4%	5261	4.8%	1762754	4.8%	0.05%
Santa Cruz	1571	1.4%	775	0.7%	259402	0.7%	0.01%
Shasta	589	0.5%	529	0.5%	177231	0.5%	0.01%
Sierra	120	0.1%	10	0.0%	3277	0.0%	0.00%
Siskiyou	472	0.4%	133	0.1%	44687	0.1%	0.00%
Solano	1575	1.4%	1213	1.1%	411620	1.1%	0.00%
Sonoma	2031	1.9%	1429	1.3%	478551	1.3%	0.02%
Stanislaus	1540	1.4%	1522	1.4%	512469	1.4%	0.01%

Key variables	Unweighted		Weighted		ACS 2011 1 year		Difference (% points) Weighted-ACS
Sutter	411	0.4%	281	0.3%	94192	0.3%	0.00%
Tehama	438	0.4%	188	0.2%	62985	0.2%	0.00%
Trinity	381	0.3%	41	0.0%	13711	0.0%	0.00%
Tulare	2186	2.0%	1298	1.2%	436234	1.2%	0.01%
Tuolumne	419	0.4%	166	0.2%	55736	0.2%	0.00%
Ventura	3343	3.1%	2371	2.2%	815745	2.2%	-0.03%
Yolo	616	0.6%	594	0.5%	198889	0.5%	0.01%
Yuba	492	0.5%	212	0.2%	71817	0.2%	0.00%
Total	**109113**	**100.0%**	**109113**	**100.0%**	**36969200**	**100.0%**	**0.00%**

7.2.1 Final Expanded Person Weight

Following computation of "final person weight", weights were then expanded to reflect the total 36,969,200 persons residing in the State of California. The final expanded person weight was appended to Person, Place and Activity data files.

7.3 GPS Trip Correction Factors

In a household travel survey, accuracy of the reported trips is as important as the coverage of survey samples within the survey universe. Unfortunately, misreporting of travel behaviors occur due to honest mistakes, privacy concerns, nonchalance, and other factors (Zmud, 2003). Advances in global positioning systems (GPS) have made it a feasible and affordable technology for collecting more reliable travel behavior information, in a passive way and with higher accuracy. In the California Household Travel Survey (CHTS), final overall sample size covers non-GPS households and GPS-enabled households. Even though GPS households only occupy 12% of the total samples, general misreporting patterns and trip correction factors can be identified through comparing the trips of households recorded passively by vehicle-mounted/Wearable GPS devices and the corresponding trips recorded actively by members in the same households via other approaches (e.g. travel diaries and computer-assisted telephone interviewing CATI). Applying trip correction factors to non-GPS household trips significantly improves overall survey accuracy. In this study, the trip correction process was conducted in three steps:

- Initial analysis on misreporting/over-reporting trips
- Identifying the key factors (trip characteristics or demographic characteristics of households/persons) that would significantly impact the misreporting or over-reporting rate through descriptive statistics and ANOVA analysis
- Creating trip correction factors through logistic regression analysis for each groups of trips with different characteristics defined by the key factors

7.3.1 Initial Trip Matching Analysis

GeoStats conducted the initial trip match analysis by comparing the sample GPS-identified trips and the sample diary-recorded trips. This analysis isolated three types of trips:

- Matched trip (M) – trips that were found in both the sample GPS trip table and the sample diary trip table

- Underestimated trip (U) – trips that were found in the sample GPS trip table but not in the sample diary trip table
- Overestimated trip (O) – trips that were found in the sample diary trip table but not in the sample GPS/OBD trip table

For example, if a non-stop trip starting at home and ending at work was not only identified from the respondent's GPS traces but also recorded in his/her diary, this trip is labeled as a matched trip; if the GPS traces revealed that the respondent stopped at a gas station along his/her way to work but his/her diary-recorded a home to work trip, the GPS trip from home to gas station and the GPS trip from gas station to work would be identified as two underestimated trips because they did occur but not recorded in the diary, while the home to work trip would be labeled as an overestimated trip in the diary. Table 7.3.1.1 gives a summary of the three types of trips in the sample.

Table 7.3.1.1: Distribution of Trips of Different Match Types

MATCH TYPE	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Overestimated Trip	4,218	5.2%	4,218	5.2%
Matched Trip	63,672	78.3%	67,890	83.5%
Underestimated Trip	13,399	16.5%	81,289	100.0%

Matched trips (63,672) and underestimated trips (13,399) are trips that really occurred (Real Trips), while the overestimated trips did not really occur (Unreal Trips) but were recorded in the diary by mistake. Trips recorded in diaries consist of matched trips (63,672) and overestimated trips (4,218). The diary-recorded trips (67,890=63,672+4,218) are the base upon which trip correction factors would apply since 88% of respondents in this survey who filled out their diaries without GPS/OBD devices installed on their vehicles. Among diary-recorded trips, around 5.2% are the overestimated trips which need to be corrected down. At the same time, diary-recorded trips need to be corrected up to compensate the 16.5% underestimated trips. Table 7.3.1.2 presents an initial estimate of the total trip correction factor to explain how these data would be used to perform trip correction in two steps.

Table 7.3.1.2: Distribution of Trips of Different Match Types

TRIP	Overestimated (964 Trips)	Matched (15,500 Trips)	Underestimated (2,967 Trips)	Sum
Diary-recorded Trips	x	x		67,890
Real Trips		x	x	77,071
Trip Correction Factor	=(Number of Real Trips) / (Number of Diary-recorded Trips) = (M+U)/(M+O) =1.135			
Corrected Trips	=(Diary-recorded Trips)*(Trip Correction Factor)=67,890*1.135=77,071			

The trip correction factor 1.135 in Table 7.3.1.2 is the average trip correction for all the diary-recorded trips from the GPS sample. However, it is not wise to apply a single trip correction factor on the total number of trips because trip misreporting/over-reporting rates change significantly under different environments. The following

sections will present the procedure and results of identifying the key factors that would impact trip misreporting/over-reporting rates significantly and creating trip correction factors under conditions defined by the key factors.

7.3.2 Identification of Key Trip and Demographic Factors

All of the trip characteristics and household/person demographic information available have been considered as potential factors that would impact trip misreporting/over-reporting rates. After several rounds of screening by descriptive correlation analysis and ANOVA, the following variables have been identified as the key factors due to their significant correlation with the trip match type (matched, overestimated, and underestimated):

- Trip Travel Time: the time between the respondent leaving the origin and arriving the destination of a trip
- Minimum Dwelling Time: the minimum between the dwelling times of the respondent at the origin and at the destination
- Education Level of the Respondent
- Person Number of Trips: number of trips made by a respondent during the survey time period

Table 7.3.2.1 shows all of the key factors' value ranges, F statistics from one-way ANOVA analysis against trip match type, and the P value of the F test. All of the P values indicate a significant correlation between the factors with trip match type at a 99% confidence level. However, the characteristics of the trips themselves – trip travel time and minimum dwelling time – show much higher F statistics with trip match types than the person demographic factors, the education level of a respondent, and the number of trips made by him/her. This means trip characteristics would dominate in explaining why a trip would be misreported or over-reported. Among all of the factors, the minimum dwelling time of the respondent at the origin or destination played the most important role in his or her view to decide whether or not a trip is important enough to be logged in diaries. For example, a trip with a short stop at a gas station is easily ignored by the respondents no matter how long they spend at the other end of the trip.

Table 7.3.2.1: Key Trip and Demographic Factors

VARIABLES	Value Range	F Statistics	P value
Minimum Dwelling Time	< 10 mins > 10 mins and < 20 mins > 20 mins and < 30 mins > 30 mins	1470.86	<.0001
Trip Travel Time	< 10 mins > 10 mins and < 20 mins > 20 mins and < 30 mins > 30 mins	1159.15	<.0001
Person Number of Trips	<= 5 trips > 5 trips	74.30	<.0001
Education Level of Respondents	< High School Undergraduate Graduate	67.42	<.0001

A unique trip correction factor is applied to each group of trips defined by any combination of the key factors. These trip correction factors are created automatically from a logistic regression analysis which models the logit odd ratio of the probability of a diary-recorded trip being underestimated or overestimated over being matched with GPS-identified trips, i.e.

$$\ln\left(\frac{P_i}{P_m}\right) = intercept + \sum_{j=1}^{n} \beta_j x_i$$

Where:

P_i = Probability of not finding match in GPS-identified trips (i = underestimated or overestimated);

P_m = Probability of finding match in GPS-identified trips

X_j = Independent variable j (j = travel time, dwelling time, education level, person trips)

β_j = Coefficient of Independent variable j (j = travel time, dwelling time, education level, person trips)

Two models were built – the "Overestimated Trip" model estimated the probability of a diary trip being overestimated over finding its match in GPS trips, while the "Underestimated Trip" model predicted the probability of a diary trip being underestimated over finding its match in GPS trips. Trip correction factors can be easily computed from the modeling results following a similar procedure shown in Table 7.3.2.1 as follows:

$$\mathbf{F} = \frac{M+U}{M+O} = \frac{1+U/M}{1+O/M} = \frac{1+P_u/P_m}{1+P_o/P_m}$$

Table 7.3.3.1 gives the estimates of the coefficients of logistic models and the hypothesis test whether or not these coefficients are significantly different from zero. All of the key factors are significant enough to be retained in the models at a 95% confidence level.

7.3.3 Summary

The following conclusions have been drawn based on the logistic regression analysis results in Table 7.3.3.1.

- The probability of a diary trip being underestimated increases with the decrease in its travel time and the minimum dwelling time at the origin and destination. On the contrary, the trend of overestimated probability goes in the opposite direction. This may indicate that trips with short travel time and dwelling time are easier ignored by respondents.
- Both the underestimated and overestimated probabilities of a diary trip decrease with the increase in the education level of the respondent. This may indicate that respondents with higher education levels are more capable of and are more reliable in filling out the travel diary correctly.

- Both the underestimated and overestimated probabilities of a diary trip decrease with the increase in the number of trips made by the respondent. It may be because the proportion of ignored trips becomes less with the increase in the total number of trips made by a person.

Each trip in the final delivery dataset will be attached with a trip correction factor, variable named as "TCF". "TripCorrectedWeight" is a final trip weight which is an outcome of [TCF]*[PERWGT] (trip correction factor * person level weight).

Table 7.3.3.1: Estimate of Coefficients of Logistic Models

Parameter		Model Type	Estimate	Wald Chi-Square	Pr > ChiSq
Intercept		Overestimated Trip	-4.2696	1112.7153	<.0001
traveltime	10to20mins	Overestimated Trip	1.9753	259.1221	<.0001
traveltime	20to30mins	Overestimated Trip	2.468	339.933	<.0001
traveltime	>30mins	Overestimated Trip	3.4279	793.6214	<.0001
minDuration	10to20mins	Overestimated Trip	0.2424	4.3751	0.0365
minDuration	20to30mins	Overestimated Trip	0.2502	3.0996	0.0783
minDuration	>30mins	Overestimated Trip	-0.1057	1.6212	0.2029
educa	Undergraduate	Overestimated Trip	-0.4181	25.7287	<.0001
educa	Graduate	Overestimated Trip	-0.5934	45.3166	<.0001
ptrips	>5	Overestimated Trip	-0.0463	0.3998	0.5272
Intercept		Underestimated Trip	-0.0684	2.486	0.1149
traveltime	10to20mins	Underestimated Trip	-0.4413	56.2228	<.0001
traveltime	20to30mins	Underestimated Trip	-0.7042	51.3444	<.0001
traveltime	>30mins	Underestimated Trip	-0.2614	8.9541	0.0028
minDuration	10to20mins	Underestimated Trip	-1.1506	244.3857	<.0001
minDuration	20to30mins	Underestimated Trip	-1.374	175.501	<.0001
minDuration	>30mins	Underestimated Trip	-2.3931	1014.0271	<.0001
educa	Undergraduate	Underestimated Trip	-0.3671	51.6509	<.0001
educa	Graduate	Underestimated Trip	-0.5317	94.0688	<.0001
ptrips	>5	Underestimated Trip	-0.927	438.0132	<.0001

8.0 Statewide Survey Results

The chapter contains the summary tables for weighted and expanded data and is based on unlinked trips. The results represent all households in the dataset, as discussed in the data expansion section of Chapter 6). To run results by specific strata, MPO or county refer to Chapter 7 or the Data User's Guide (Appendix P) on how to select these subsets of households. Survey results were weighted by four weight factors – own/rent status by vehicle availability, households by county distribution, household size and income. All trip-level results presented in this section and throughout the main report are based on unlinked trips. Table 8.0.1 summarizes the recruitment and retrieval, by sampling strata, for the CHTS.

Table 8.0.1: 30 Sampling Strata Table

	County	30 Sampling Strata Goals	Recruit Goal	Recruited HH	% of REC goal	Retrieve Goal	Retrieved HH (Primary Completes)	% of RET goal	% of 30 Sampling Strata Goals	% of Secondary* + Primary Completes 30 SS Goals
SCAG	Imperial	564	692	775	112%	450	481	107%	85%	137%
	Orange	3,353	4,117	3,469	84%	2,676	2,359	88%	70%	103%
	Los Angeles	12,580	15,445	14,676	95%	10,039	9,293	93%	74%	117%
	Ventura									
	Riverside	4,192	5,146	5,395	105%	3,345	3,359	100%	80%	129%
	San Bernardino									
MTC	Alameda	1,730	2,123	2,309	109%	1,380	1,660	120%	96%	133%
	Contra Costa	1,243	1,526	1,952	128%	992	1361	137%	109%	157%
	Marin	599	735	593	81%	478	454	95%	76%	99%
	Sonoma	955	1,172	1,216	104%	762	858	113%	90%	127%
	Napa	393	483	496	103%	314	315	100%	80%	126%
	Solano	770	945	906	96%	614	624	102%	81%	118%
	San Francisco	1,092	1,340	1,464	109%	871	1067	123%	98%	134%
	San Mateo	1,204	1,477	1,590	108%	960	1117	116%	93%	132%
	Santa Clara	1,911	2,346	2,933	125%	1,525	2,078	136%	109%	153%
SANDAG	San Diego	2,177	2,672	2,453	92%	1,737	1,648	95%	76%	113%
SACOG	El Dorado	2,889	3,546	2,902	82%	2,305	1,933	84%	67%	100%
	Placer									
	Sacramento									
	Sutter									
	Yolo									
	Yuba									
Nevada	Nevada	328	403	263	65%	262	185	71%	56%	80%
Lassen	Lassen	574	705	491	70%	458	360	79%	63%	86%
Plumas	Plumas									
Sierra	Sierra									
Modoc	Modoc	714	877	670	76%	570	499	88%	70%	94%
Siskiyou	Siskiyou									
Trinity	Trinity									
Del Norte	Del Norte	309	378	260	69%	246	188	76%	61%	84%

	County	30 Sampling Strata Goals	Recruit Goal	Recruited HH	% of REC goal	Retrieve Goal	Retrieved HH (Primary Completes)	% of RET goal	% of 30 Sampling Strata Goals	% of Secondary* + Primary Completes 30 SS Goals
Humboldt	Humboldt	416	511	398	78%	332	319	96%	77%	96%
Mendocino	Mendocino	570	700	518	74%	455	351	77%	62%	91%
Lake	Lake									
Fresno	Fresno	5,027	6,172	6,345	103%	4,012	4,046	101%	80%	126%
Kings	Kings									
Madera	Madera									
Kern	Kern									
Tulare	Tulare									
AMBAG	Monterey	2,558	3,140	2,774	88%	2,041	1,945	95%	76%	108%
	Santa Cruz									
	San Benito									
San Joaquin	San Joaquin	2,169	2,663	2,521	95%	1,731	1,644	95%	76%	116%
Stanislaus	Stanislaus									
Merced	Merced									
San Luis Obispo	San Luis Obispo	1,282	1,574	1,852	118%	1,023	1,277	125%	100%	144%
Santa Barbara	Santa Barbara									
Butte	Butte	1,080	1,326	1,098	83%	862	778	90%	72%	102%
Shasta	Shasta									
Tehama	Tehama									
Glenn	Glenn	486	597	419	70%	388	289	74%	59%	86%
Colusa	Colusa									
TMPO (CA part)	El Dorado	450	552	259	47%	359	299	83%	66%	58%
	Placer									
Alpine	Alpine	1,003	1,232	974	79%	801	716	89%	71%	97%
Amador	Amador									
Calaveras	Calaveras									
Mariposa	Mariposa									
Tuolumne	Tuolumne									
Inyo	Inyo	464	571	396	69%	371	296	80%	64%	85%
Mono	Mono									
Subtotal (Including 100 Energy Commission)		**53,083**	**65,166**	**62,367**	96%	**42,359**	**41,799**	99%	79%	117%
Energy Commission GPS SAMPLE		**400**	**702**	**711**	101%	**404**	**632**	156%	158%	178%
GRAND TOTAL:		**53,483**	**65,868**	**63,078**	96%	**42,763**	**42,431**	99%	79%	118%

*Secondary completes include retrieval partial completes (secondary I) and recruit only completes (secondary II).

Due to the lower than expected retrieval of respondents reporting travel Online, an analysis was performed to see the breakdown of households specifically by: Income, Hispanic/Latino, Household Size, Sample Type and Race. The results amongst those households who reported income showed the $100,000 or more household income group with 40.3% choosing to report travel via diary mailback, and 30.4% via Online. The group who

reported household income as less than $25,000 had the smallest percentage who reported travel via diary mailback at 5.9%, and the highest percentage (23.4%) who reported travel via CATI (see Table 8.0.2).

Table 8.0.2: Household Income By Retrieval Mode

Household Income	CATI		MAIL		ONLINE		Total	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Less than $25,000	4074	23.4%	409	5.9%	1970	10.8%	6453	15.2%
$25,000 to $50,000	3905	22.5%	882	12.8%	3165	17.3%	7952	18.7%
$50,000 to $75,000	2599	14.9%	1131	16.4%	3186	17.4%	6916	16.2%
$75,000 to $100,000	1921	11.0%	1137	16.5%	2825	15.5%	5883	13.8%
$100,000 or more	3368	19.4%	2781	40.3%	5550	30.4%	11699	27.5%
DK/RF	1518	8.7%	555	8.0%	1584	8.7%	3657	8.6%
Total	17385	100.0%	6895	100.0%	18280	100.0%	42560	100.0%

The percentage of respondents who reported they were of Hispanic or Latino ethnicity, chose to report travel primarily via CATI (36.9%), and were least likely to report travel by diary mailback (16.6%) as may be seen in Table 8.0.3.

Table 8.0.3: Hispanic Status By Retrieval Mode (Person, excluding dk/rf)

Hispanic Status	CATI		MAIL		ONLINE		Retrieved	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
YES	16302	36.9%	2976	16.6%	8344	18.6%	27622	25.9%
NO	27867	63.1%	14922	83.4%	36408	81.4%	79197	74.1%
Total	44169	100.0%	17898	100.0%	44752	100.0%	106819	100.0%

When looking at household size, two person households were most likely to report travel via Online (42.1%), while three person households were the least likely to report travel via CATI (15.7%). The results of retrieval mode by household size may be seen in Table 8.0.4.

Table 8.0.4: Household Size By Retrieval Mode

Household Size	CATI		MAIL		ONLINE		TOTAL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
1 person	4138	23.8%	1304	18.9%	3592	19.6%	9034	21.2%
2 persons	6212	35.7%	2441	35.4%	7695	42.1%	16348	38.4%
3 persons	2736	15.7%	1149	16.7%	2971	16.3%	6856	16.1%
4+ persons	4299	24.7%	2001	29.0%	4022	22.0%	10322	24.3%
Total	17385	100.0%	6895	100.0%	18280	100.0%	42560	100.0%

Table 8.0.5 presents the multiple sample types analyzed, along with the results of each. The largest group who retrieved overall was the matched address based sample type.

Table 8.0.5: Entry Mode Retrievals by Sample type

Sample Type	CATI		MAIL		ONLINE		TOTAL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
ABS matched	6594	37.9%	2470	35.8%	7735	42.3%	16799	39.5%
ABS unmatched	447	2.6%	901	13.1%	1117	6.1%	2465	5.8%
Listed general	4517	26.0%	1151	16.7%	3863	21.1%	9531	22.4%
Hispanic surnames	1008	5.8%	207	3.0%	515	2.8%	1730	4.1%
Low HHI(HHI<25K)	1064	6.1%	134	1.9%	566	3.1%	1764	4.1%
Young HHS(AGE<=25)	557	3.2%	279	4.0%	498	2.7%	1334	3.1%
Large HHS(4+ people)	1647	9.5%	1009	14.6%	2403	13.1%	5059	11.9%
Transit oversample	735	4.2%	294	4.3%	688	3.8%	1717	4.0%
Volunteer	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Zero Vehicle	490	2.8%	173	2.5%	459	2.5%	1122	2.6%
Energy Commission sample	166	1.0%	210	3.0%	331	1.8%	707	1.7%
Kern County Transit OB sample	151	0.9%	10	0.1%	69	0.4%	230	0.5%
UC DAVIS	9	0.1%	57	0.8%	36	0.2%	102	0.2%
Total	17385	100.0%	6895	100.0%	18280	100.0%	42560	100.0%

Of the respondents who reported their ethnicity, the largest group who also reported travel was the White ethnic group. The White ethnic group also comprised the largest group who reported travel via Online with 72.3% of the Online respondents belonging in this category. The complete breakdown of retrieval mode by race may be seen in Table 8.0.6.

Table 8.0.6: Race by Retrieval Mode (Person, excluding dk/rf)

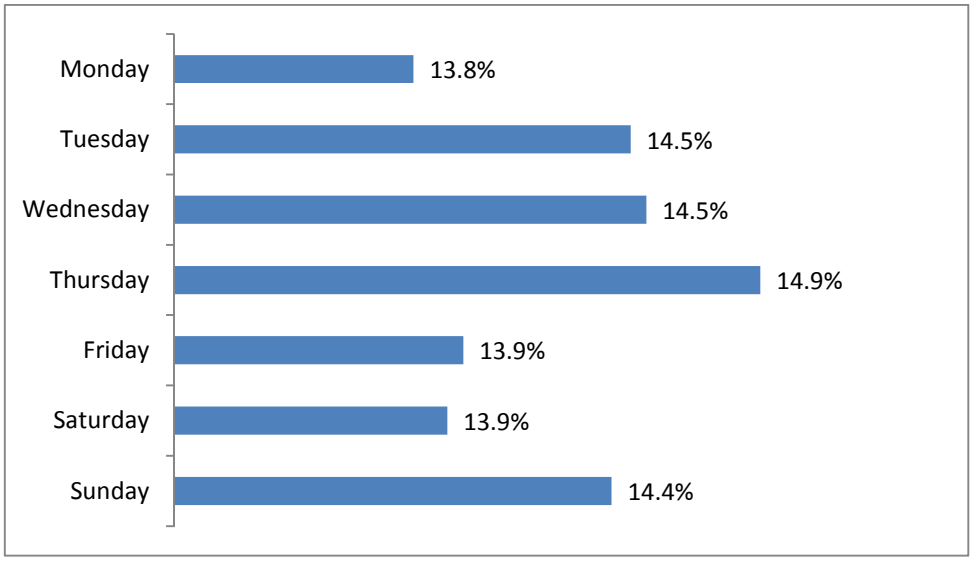
Ethnicity	CATI		MAIL		ONLINE		TOTAL	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
White	26795	61.3%	12742	72.3%	32517	73.4%	72054	68.2%
African American	1864	4.3%	364	2.1%	1083	2.4%	3311	3.1%
American Indian or Alaska Native	441	1.0%	78	0.4%	287	0.6%	806	0.8%
Asian	1906	4.4%	1755	10.0%	2535	5.7%	6196	5.9%
Native Hawaiian or Pacific Islander	143	0.3%	74	0.4%	154	0.3%	371	0.4%
Other	12542	28.7%	2622	14.9%	7725	17.4%	22889	21.7%
Total	43691	100.0%	17635	100.0%	44301	100.0%	105627	100.0%

8.1 Respondent/Household Summary- Statewide

This section provides a summary of the participating households. Included are summaries of different household and person characteristics for the total State. Statewide average household size for the CHTS was 2.57.

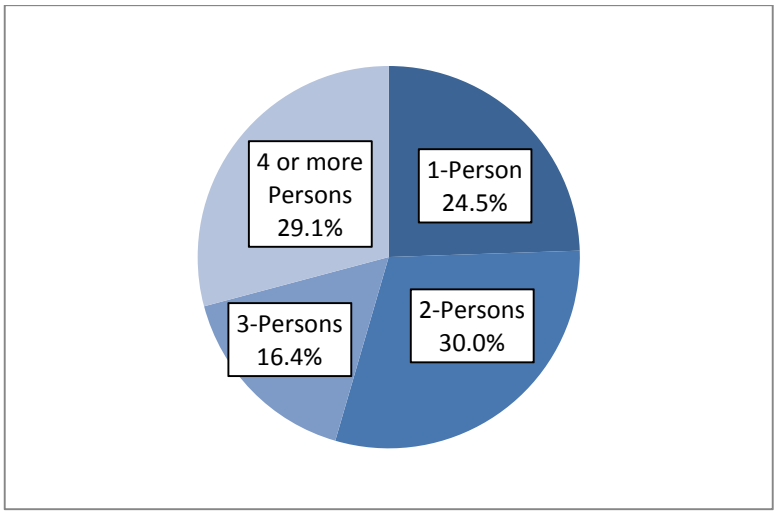
As may be seen in Figure 8.1.1, the two most popular travel days were Thursday and Wednesday (14.9% and 14.5% respectively), and the least popular travel day being Monday with 13.8%.

Figure 8.1.1: Distribution of Households by Day of Week



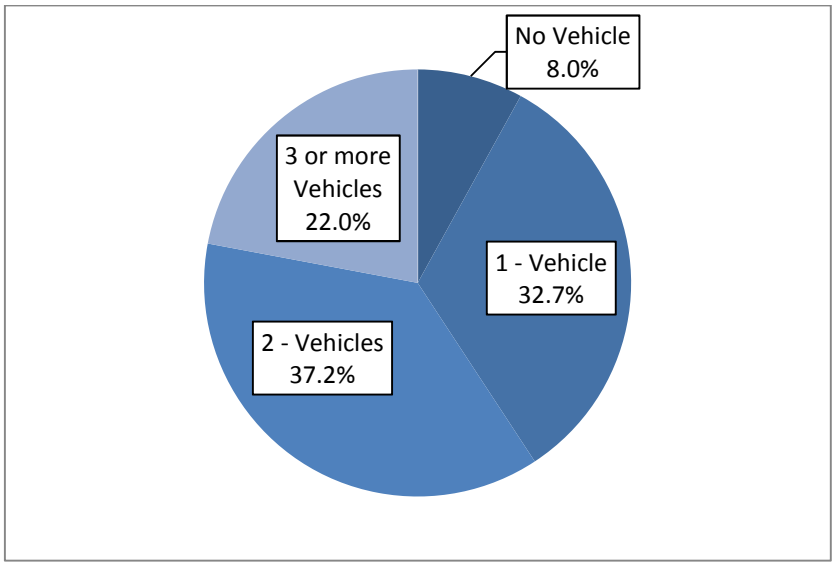
Overall, 30% of households reported having two household members and just over 29% live in a large household of four or more persons. The results are presented in Figure 8.1.2 which provides a visual view of the percentages of household size.

Figure 8.1.2: Household Size (Weighted)



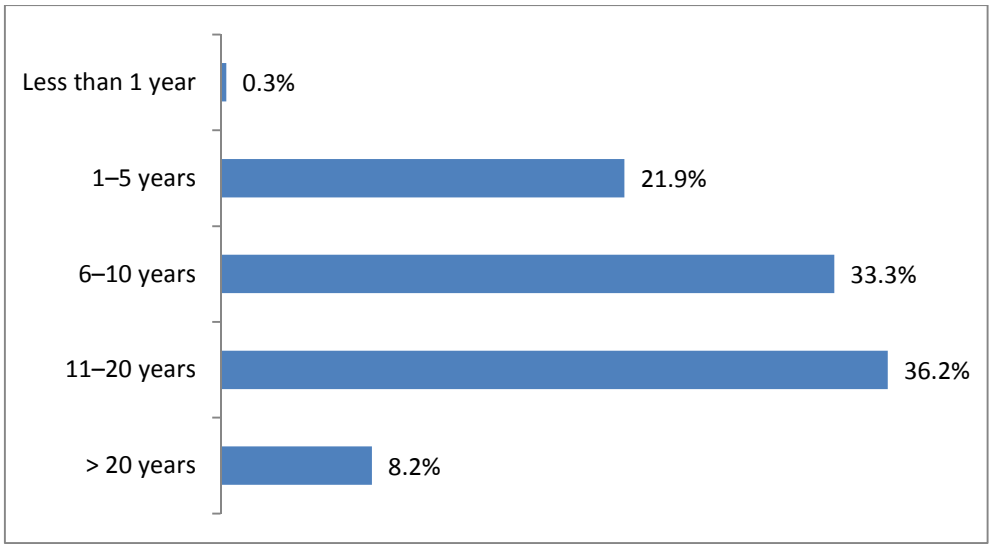
Over 37% of household reported having two vehicles, nearly 33% had at-least one vehicle, and 8% of households reported not owning a vehicle. Overall, the statewide average number of household vehicles for the CHTS was 1.8. Figure 8.1.3 provides a view of the percentages of the number of household vehicles.

Figure 8.1.3: Number of Household Vehicles (Weighted)



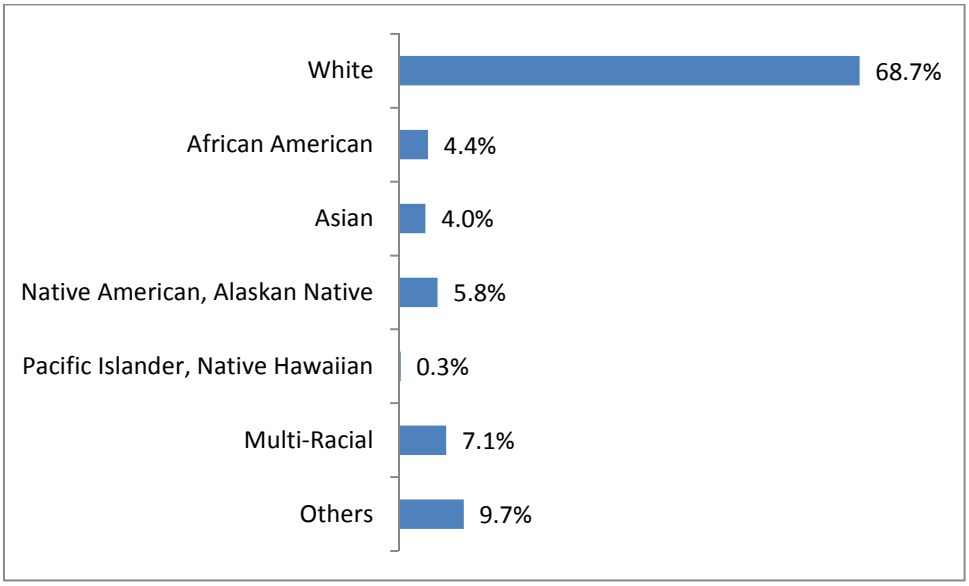
When looking at vehicle age, 33.3% of the vehicles were in the range of 6–10 years old, while 0.3% of vehicles were less than 1 year old. Figure 8.1.4 shows the distribution of the weighted age of vehicle groups.

Figure 8.1.4: Distribution of Vehicle Age (Weighted)



Regarding ethnicity of the participating households, 68.7% were White, 4.4% were African American, 4% Asians, 7.1% indicated Multi-racial, while 16% belonged to other ethnicities. The survey respondents' reported household ethnicity distribution is illustrated in Figure 8.1.5.

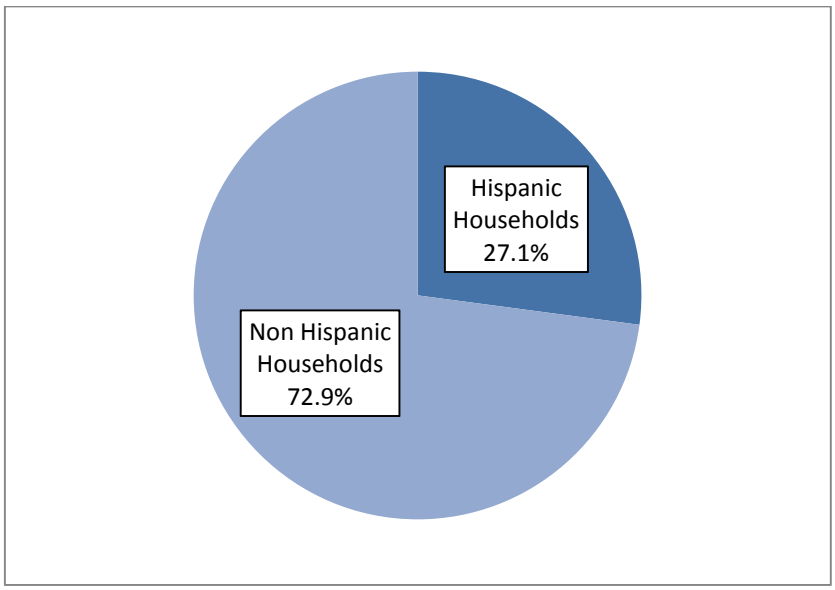
Figure 8.1.5: Ethnicity distribution (Weighted)



* Excludes DK/RF and Computed based on Respondent Relations Self/ Respondent

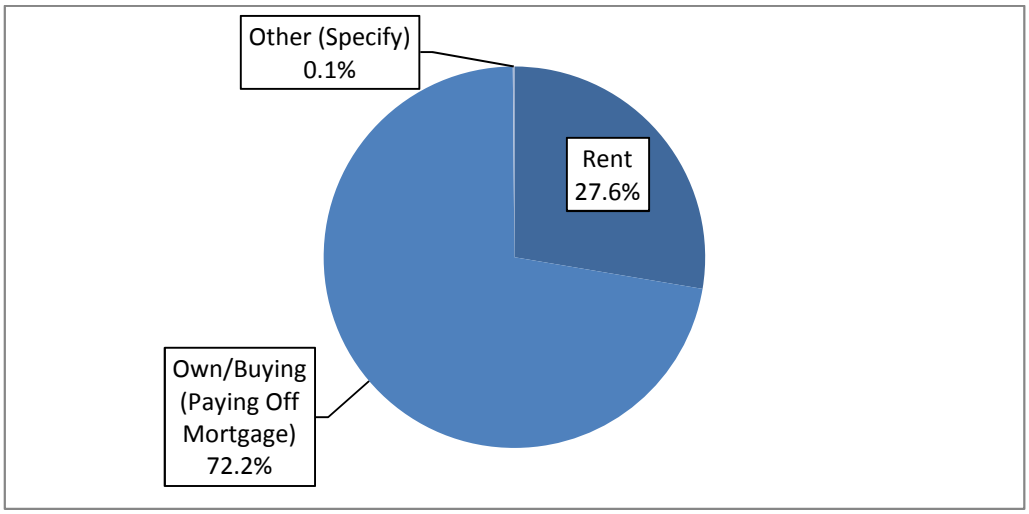
Overall participation by Hispanic or Latino households in the CHTS was 27.1%. Percent distribution is illustrated in Figure 8.1.6.

Figure 8.1.6: Proportion of Hispanic Household (Weighted)



Overall, 72.2% of households reported owning their homes, while 27.6% reported they were renters. The distribution is shown in Figure 8.1.7.

Figure 8.1.7: Ownership of Household Residence (Weighted)



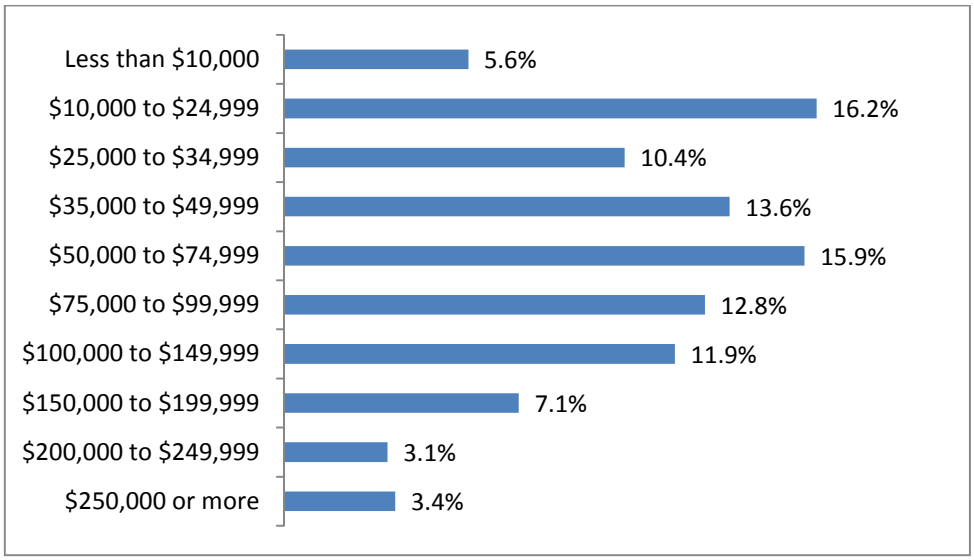
The majority of households (97.1%) reported they had landline telephones. A much smaller percentage (2.9%) reported they do not have a landline telephone. Table 8.1.1 shows the distribution of landlines in households.

Table 8.1.1: Landlines in Household (Weighted)

Landlines in Household	Frequency	Percent
Yes	41049	97.1%
No	1243	2.9%
Total	42292	100.0%

In looking at overall household annual income distribution, a total of 21.8% of the CHTS households reported income in the range of less than $25,000, of these, 5.6% reported income as less than $10,000. The income range of $10,000 to $24,000 is the highest with 16.2% In the range of $25,000 to $ 35,000, 10.4% of the households reported income falling within that range; 13.6% of the households reported income in the range $35,000 to $49,000; and 15.9% of the households reported income in the range of $50,000 to $75,000. In summary, 45.8% of the CHTS households reported their annual income as less than $50,000, and 54.2% of the households reported income above $50,000. Household income distribution is illustrated in Figure 8.1.8.

Figure 8.1.8: Illustrates Household Income* (Weighted)



*Income distribution excludes DK/RF

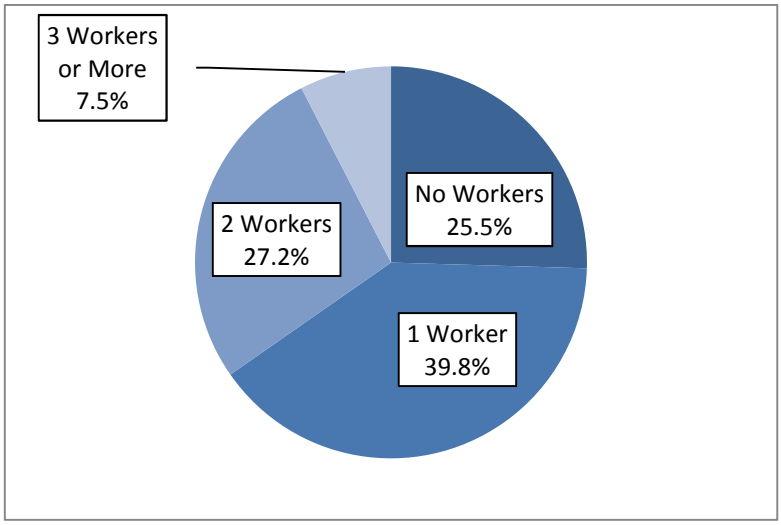
Table 8.1.2 provides the distribution of the reported number of students. Over half (64.1%) of the CHTS households reported no students, 16.5% reported having one student in the household, 12.7% reported two students in the household, and 6.7% reported more than three students in the household.

Table 8.1.2: Household Number of Students (Weighted)

Number of Students	Frequency	Percent
No Students	25348	59.7%
1 Student	7269	17.1%
2 Students	6254	14.7%
3 Students	2513	5.9%
4 Students or more	1046	2.5%
Total	42431	100.0%

Overall 39.8% of households reported having one worker, 27.2% reported having two workers, and 25.5% reported having no workers in the household, while 7.5% had more than three workers. This distribution is illustrated in Figure 8.1.9.

Figure 8.1.9: Number of Household Workers (Weighted)



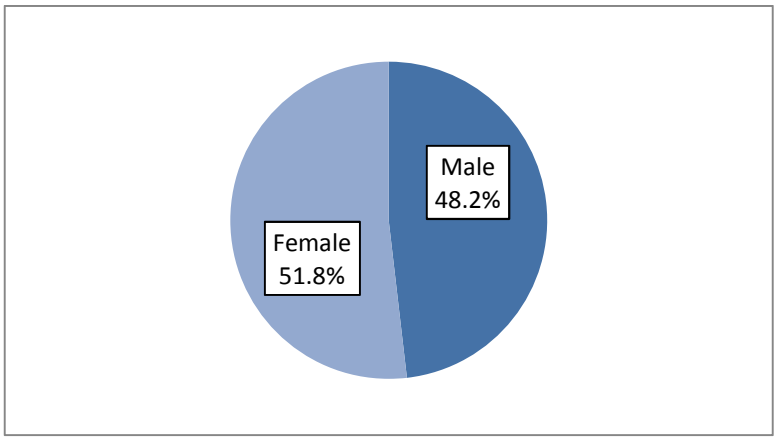
The majority of households (45.2%) reported having two licensed drivers in the household, 30.9% reported having only one licensed driver, 19.1% reported having three or more licensed drivers, and 4.9% reported having no licensed drivers. Table 8.1.3 provides the distribution of licensed drivers.

Table 8.1.3: Number of Licensed Drivers in Household (Weighted)

Number of Household License Holders	Frequency	Percent
No License	2084	4.9%
1 License	13098	30.9%
2 Licenses	19165	45.2%
3 Licenses	5877	13.9%
4 Licenses or more	2206	5.2%
Total	42431	100.0%

Among survey respondents, 51.8% were female; the remaining 48.2% were male. Figure 8.1.10 shows the distribution.

Figure 8.1.10: Gender Participation (Weighted)



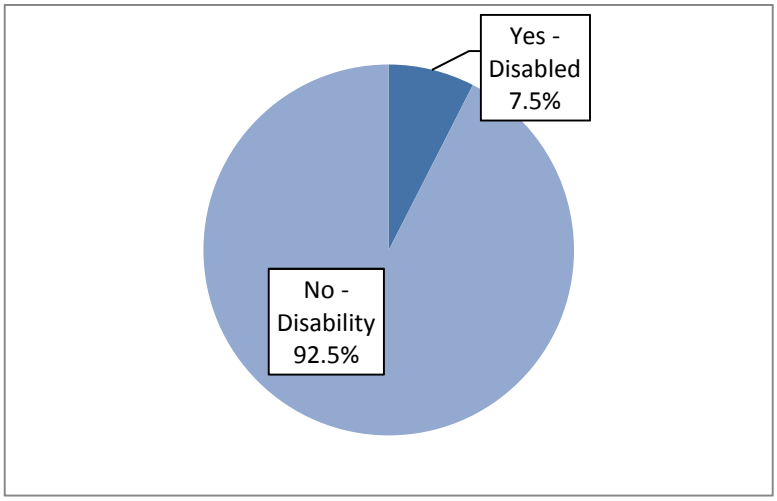
The largest percentage of CHTS respondents was represented by the age group of between 25 and 54 years (working age group) at 38.5%. The next largest group was those younger than 18 years of age - 24.2%. 16.5% of the CHTS respondents were 65 years of age or older, while 10.2% of respondents were between the ages of 18 and 24. Table 8.1.4 shows respondent age distribution.

Table 8.1.4: Respondent Age Distribution (Weighted)

Age Distribution	Frequency	Percent
<18 years	25432	24.2%
18–24 years	10669	10.2%
25–54 years	40429	38.5%
55–64 years	11249	10.7%
65+ years	17305	16.5%
Total	105084	100.0%

Among the survey respondents 7.5% reported having a disability. Respondent disability status is shown in Figure 8.1.11.

Figure 8.1.11: Distribution of Respondent Disability Status (Weighted)



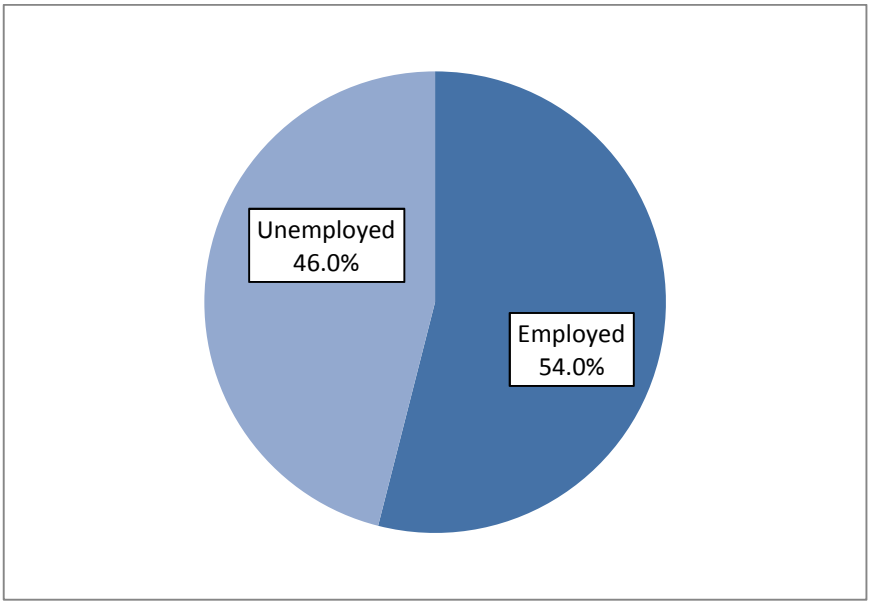
Overall, 83.2% of the CHTS respondents reported having a valid driver's license. Table 8.1.5 shows this distribution.

Table 8.1.5: Respondents with Valid Driver's License (Weighted)

Valid Driver's License	Frequency	Percent
Yes	71729	83.2%
No	14453	16.8%
Total	86161	100.0%

While looking at employment status, 54% of respondents reported being employed. Figure 8.1.12 illustrates the distribution of employment status.

Figure 8.1.12: Employment Status (Weighted)



Of the CHTS respondents who reported no employment, 37.9% were retired, 19.8% were students, while 13.3% are unemployed but looking for work. Unemployment status is shown in Table 8.1.6.

Table 8.1.6: Respondent Unemployment Status, if Does Not Work (Weighted)

Unemployment Status	Frequency	Percent
Retired	15108	37.9%
Homemaker	6181	15.5%
Unemployed but Looking for Work	5285	13.3%
Unemployed, Not Seeking Employment	768	1.9%
Student (Part-time or Full-time)	7904	19.8%
Other (Specify)	4589	11.5%
Total	39429	100.0%

Amongst those who reported they are employed, the average number of jobs per employed respondent is 1. The majority of respondents (92.9%) had one job, while 6.3% had two jobs and 0.8% had three or more jobs. Table 8.1.7 provides the number of reported jobs.

Table 8.1.7: Respondent Number of Jobs (Weighted)

Number of Jobs	Frequency	Percent
1	43008	93.0%
2	2886	6.2%
3	289	0.6%
4+	81	0.2%
Total	46264	100.0%
Average	1.5	

8.2 Travel Behavior

The previous section provided a summary of the demographic characteristics for the participating households. The variations among participating households based on the county of residence suggest that travel behavior also varies throughout the region. The purpose of this section is to review the travel behavior reported by the 42,431 participating households, in order to document the extent to which travel behavior varies. Included are summaries of trip rates by different household and person characteristics for the total State. The results include GPS trip correction factors and are weighted.

Overall, the average household trips per household reported was 9.2 and the average person trips per person was 3.3.

For households of four or more people with at least 1 worker, the average trip rate is highest among all respondents with 17.4 trips per household; three person households with at least 1 worker reported a trip rate of 10.0; two person households with at least 1 worker reported a trip rate of 6.1, single person households with at least 1 worker reported a trip rate of 3.7; while households with no workers reported the fewest trips in general. Table 8.2.1 shows the average trips by household size and employment status.

Table 8.2.1: Average Household Trips by Household Size and Employment Status [Weighted]

Average Trips			
Household Size	At least 1 worker Household	Non -worker Household	Total
1-Person	3.7	3.0	3.3
2-Persons	6.1	4.9	5.7
3--Persons	10.0	7.8	9.7
4 or more Persons	17.4	15.2	17.3
Total	10.6	4.8	9.2

The more vehicles a household owns the higher the trip rate in general. The trip rate of households with two vehicles is highest among all households, overall. Large households with zero household vehicles show the highest trip rate of 22.2 trips on average. The average household trips by household size and number of household vehicles are presented in Table 8.2.2.

Table 8.2.2: Average Household Trips by Household Size and Number of Household Vehicles [Weighted]

Average Trips					
Household Vehicle	1 – Person Household	2 - Persons Household	3- Persons Household	4 or more Persons Household	Total
No Vehicle	4.2	8.2	14.8	22.2	7.5
1 – Vehicle	3.1	5.9	11.2	19.7	7.3
2 – Vehicles	3.4	5.5	9.6	17.6	11.5
3 or more Vehicles	2.8	5.2	8.7	15.6	9.3
Total	3.3	5.7	9.7	17.3	9.2

Overall, households with a higher household income reported a higher trip rate. The trip rate of households reporting income of between $150,000 and $199,999 is highest among all groups at 11.1while 1 – person households, that reported household income of between $200,000 and $249,999 show the smallest trip rate at 3.0. The average household trips by household size and household income are shown in Table 8.2.3.

Table 8.2.3: Average Household Trips by Household Size and Household Income [Weighted]

Average Trips					
Household Income	1 – Person Household	2 - Persons Household	3- Persons Household	4 or more Persons Household	Total
Less than $10,000	3.5	6.0	11.6	19.0	8.8
$10,000 to $24,999	3.2	5.9	19.0	3.2	8.6
$25,000 to $34,999	3.1	5.2	9.5	18.4	8.6
$35,000 to $49,999	3.4	5.5	9.2	17.8	8.6
$50,000 to $74,999	3.2	5.8	9.1	16.6	8.6
$75,000 to $99,999	3.7	5.9	9.6	16.3	9.6
$100,000 to $149,999	3.6	5.8	9.9	17.0	10.5
$150,000 to $199,999	17.0	3.4	10.3	16.9	11.1
$200,000 to $249,999	3.0	5.8	10.3	16.9	10.9
$250,000 or more	4.9	5.7	10.0	16.4	10.8
Total	7.5	7.3	11.5	9.3	9.2

The age group that reported the highest overall trip rate (4.3) is the age 35-54 group, while those in the age 65 or older group reported the least trips (2.9). The average trip rate per person by age group is presented in Table 8.2.4.

Table 8.2.4: Average Trips per Person by Age Group [Weighted]

Age	Person*	Trip Count	Trip Rate
0-19	27975	92897	3.3
20-24	7910	25545	3.2
25-34	13325	49568	3.7
35-54	26932	116221	4.3
55-64	11236	41844	3.7
65 or older	17295	49483	2.9
Don't know/refused	4000	13389	3.3
Total	108673	388947	3.6

*440 respondents (weighted) who did not complete retrieval were excluded.

Generally, women reported they made more trips than men. The average trip rate for women is 3.7, which is higher than the male trip rate of 3.4. Table 8.2.5 presents the summary.

Table 8.2.5: Average Trips per Person by Gender [Weighted]

Age	Person*	Trip Count	Trip Rate
Male	52089	179519	3.4
Female	56169	207990	3.7
DK/RF	415	1439	3.5
Total	108673	388947	3.6

*440 respondents (weighted) who did not complete retrieval were excluded.

When looking at trip rates by age and gender, of those who responded, women in the 35–54 age group reported the highest trip rate of 4.6, while women in the age 65 or older group show the smallest trip rate, 2.7. The average trips per person by age and gender are presented in Table 8.2.6.

Table 8.2.6: Average Trips per Person by Age and Gender [Weighted]

Gender	Age	Person*	Trip Count	Trip Rate
Male	0-19	14360	47514	3.3
	20-24	4023	11953	3.0
	25-34	6335	21156	3.3
	35-54	12699	51055	4.0
	55-64	5320	19640	3.7
	65 or older	7791	23521	3.0
	Don't know/refused	1561	4678	3.0
	Total	52089	179519	3.4
Female	0-19	13549	45199	3.3
	20-24	3878	13564	3.5
	25-34	6988	28409	4.1
	35-54	14200	64982	4.6
	55-64	5911	22183	3.8
	65 or older	9502	25957	2.7
	Don't know/refused	2140	7697	3.6
	Total	56169	207990	3.7
Gender Refused	0-19	65	183	2.8
	20-24	10	29	3.0
	25-34	2	3	1.7
	35-54	33	184	5.6
	55-64	5	21	4.3
	65 or older	2	5	2.6
	Don't know/refused	299	1014	3.4
	Total	415	1439	3.5

*440 respondents (weighted) who did not complete retrieval were excluded.

Those who were younger than age 15 and not eligible for a driver's license reported the lowest trip rate (2.7). Licensed drivers reported the highest trip rate of 3.8 over those who do not own a driver license (3.1), as may be seen in Table 8.2.7.

Table 8.2.7: Average trips per driver vs. non driver [Weighted]

Driver Status	Person	Trip Count	Trip Rate
Licensed Drivers	71457	269123	3.8
No Licensed Drivers	14356	44526	3.1
Age15 or younger (not eligible for drive license)	306	835	2.7
Don't know/Refused	22554	74463	3.3
Total	108673	388947	3.6

8.3 Trip Characteristics

This section presents the characteristics of the trips themselves. Data includes: the main reason for travel, mode of travel, and travel and activity times. In addition, details specific to transit-using households and those reporting non-motorized travel are presented. The results include GPS trip correction factors and are weighted.

Respondents were asked to record up to three activities they participated in at each trip destination. Aside from activities at home/work/school that initiated the trips, routine shopping (9.4%), social/visit friends/relatives (4.8%), and eat meal restaurant/diner (4.4%) were the main other activities. Table 8.3.1 presents the results of the trip distribution by activity.

Table 8.3.1: Trip Distribution by Activity [weighted, multiple responses]

Activity	Trip Counts	Percent
Personal activities (sleeping, personal care, leisure, chores)	103407	26.6%
Preparing meals/eating	34371	8.8%
Hosting visitors/entertaining guests	2100	0.5%
Exercise (with or without equipment)/playing sports	1899	0.5%
Study / schoolwork	6187	1.6%
Work for pay at home using telecommunications equipment	1847	0.5%
Using computer/telephone/cell or smart phone or other communications device for personal activities	11983	3.1%
All other activities at my home	17593	4.5%
Work/job duties	25798	6.6%
Training	236	0.1%
Meals at work	4694	1.2%

Activity	Trip Counts	Percent
Work-sponsored social activities (holiday or birthday celebrations, etc)	90	0.0%
Non-work related activities (social clubs, etc)	313	0.1%
Exercise/sports	306	0.1%
Volunteer work/activities	504	0.1%
All other work-related activities at my work	949	0.2%
In school/classroom/laboratory	14298	3.7%
Meals at school/college	2977	0.8%
After school or non-class-related sports/physical activity	987	0.3%
All other after school or non-class related activities (library, band rehearsal, clubs, etc)	1521	0.4%
Change type of transportation/transfer (walk to bus, walk to/from parked car)	34816	9.0%
Pickup/drop off passenger(s)	34474	8.9%
Drive through meals (snacks, coffee, etc.)	5819	1.5%
Drive through other (ATM, bank)	1582	0.4%
Work-related (meeting, sales call, delivery)	7999	2.1%
Service private vehicle (gas, oil, lube, repairs)	5476	1.4%
Routine shopping (groceries, clothing, convenience store, hh maintenance)	36466	9.4%
Shopping for major purchases or specialty items (appliance, electronics, new vehicle, major hh repairs)	2749	0.7%
Household errands (bank, dry cleaning, etc.)	9512	2.4%
Personal business (visit government office, attorney, accountant)	6338	1.6%
Eat meal at restaurant/diner	17307	4.4%
Health care (doctor, dentist, eye care, chiropractor, veterinarian)	5510	1.4%
Civic/religious activities	7667	2.0%
Outdoor exercise (playing sports/jogging, bicycling, walking, walking the dog, etc.)	10052	2.6%
Indoor exercise (gym, yoga, etc.)	4895	1.3%
Entertainment (movies, watch sports, etc)	6349	1.6%
Social/visit friends/relatives	18765	4.8%
Other (specify)	3226	0.8%
Loop trip	13631	3.5%
Don't know/refused	201	0.1%
Total	388940	100.0%

8.3.1 Mode Choice

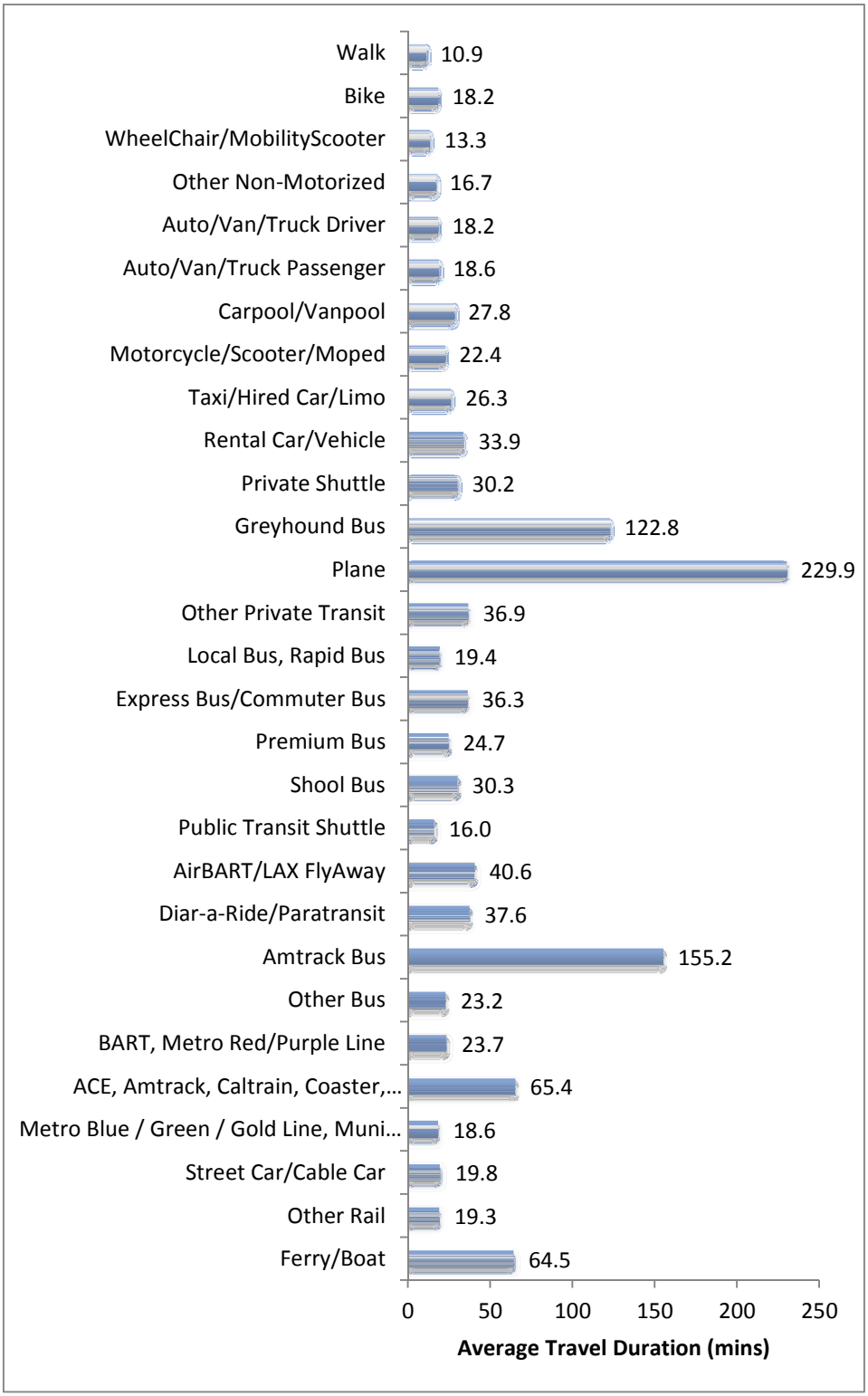
Respondents were asked to record the mode of travel they used to make each trip. The distribution of trips by mode collected from the survey is shown in Table 8.3.1.1. As indicated, auto was the dominant mode throughout the region, accounting for about 76% of all trips (49.6% as drivers and 26.4% as passengers). Approximately 18% of trips were made by non-motorized modes, and about 3% of reported trips were made by public transit. Around 0.6% of trips were made by school bus. The distribution by travel mode is detailed in Table 8.3.1.1.

Table 8.3.1.1: Trip Distribution by Travel Mode

Mode	frequency	Percent
Walk	62,879	16.2%
Bike	5,943	1.5%
WheelChair/Mobility Scooter	372	0.1%
Other Non-Motorized	550	0.1%
Auto/Van/Truck Driver	192,818	49.6%
Auto/Van/Truck Passenger	102,598	26.4%
Carpool/Vanpool	2,199	0.6%
Motorcycle/Scooter/Moped	873	0.2%
Taxi/Hired Car/Limo	421	0.1%
Rental Car/Vehicle	607	0.2%
Private Shuttle	604	0.2%
Greyhound Bus	7	< 0.1%
Plane	382	0.1%
Other Private Transit	326	< 0.1%
Local Bus, Rapid Bus	10,581	2.7%
Express Bus/Commuter Bus	339	< 0.1%
Premium Bus	225	< 0.1%
School Bus	2,400	0.6%
Public Transit Shuttle	279	< 0.1%
AirBART/LAX FlyAway	12	< 0.1%
Dial-a-Ride/Paratransit	258	< 0.1%
Amtrack Bus	20	< 0.1%
Other Bus	123	< 0.1%
BART, Metro Red/Purple Line	1,834	0.5%
ACE, Amtrack, Caltrain, Coaster, Metrolink	468	0.1%
Metro Blue / Green / Gold Line, Muni Metro, Sacramento Light Rail, San Diego Sprinter / Trolley / Orange/Blue/Green, VTA Light Rail	1,511	0.4%
Street Car/Cable Car	100	< 0.1%
Other Rail	160	< 0.1%
Ferry/Boat	56	< 0.1%
Total	388,947	100.0%

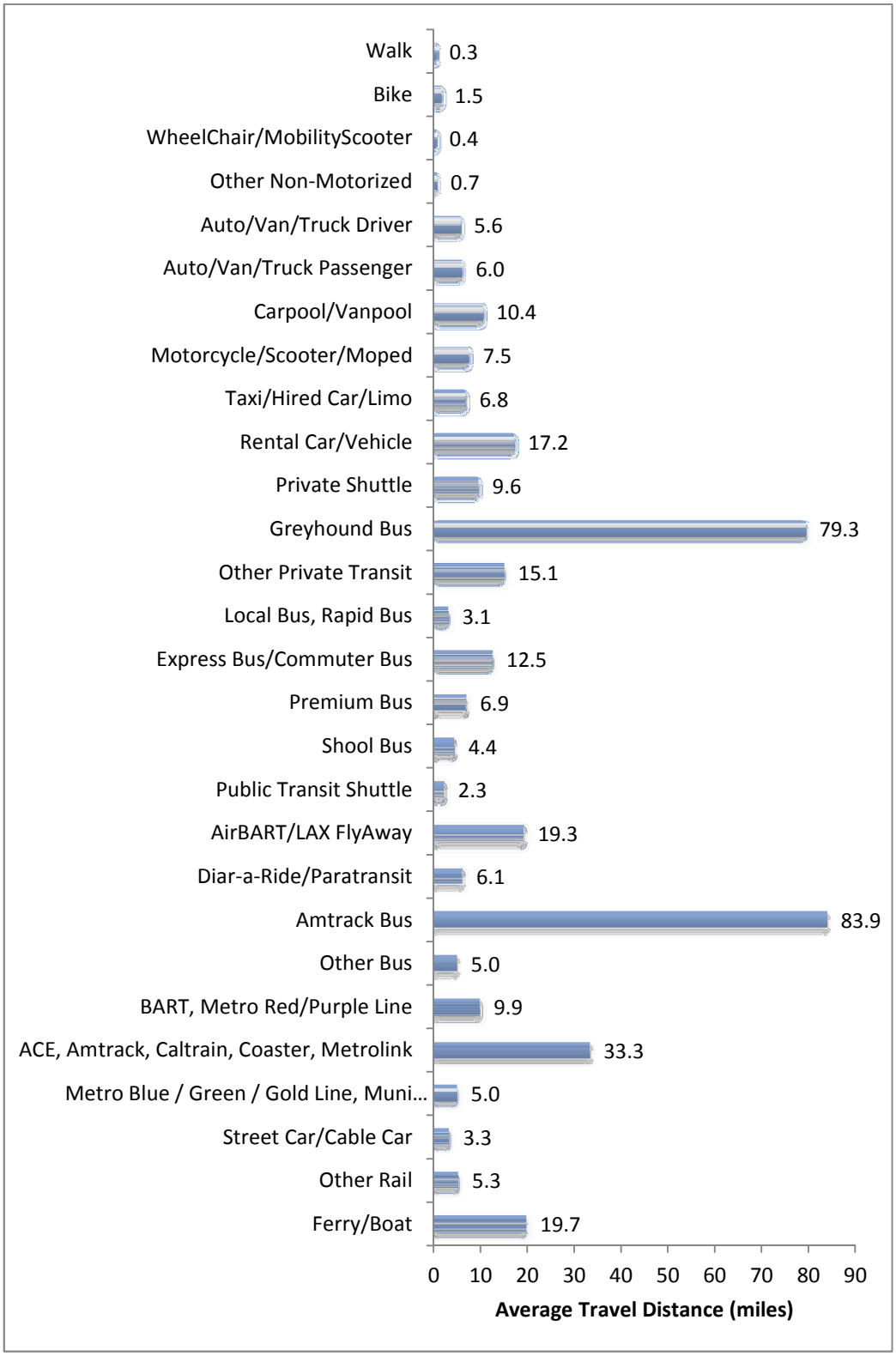
Trip duration varied by mode. Overall, walk trips were the shortest, taking 10.9 minutes on average, while plane trips took the longest at 229.9 minutes. Figure 8.3.1.1 is based on the linked trips, which included access and egress travel by other modes for most transit modes.

Figure 8.3.1.1: Average Travel Duration by Mode



Looking at travel distance by travel mode in Figure 8.3.1.2, walking trips were the shortest with the average trip length of 0.3 miles. The longest trips were made by plane – 1432.9 miles on average, which was not shown because the extremely great value would shadow all other modes in the graph.

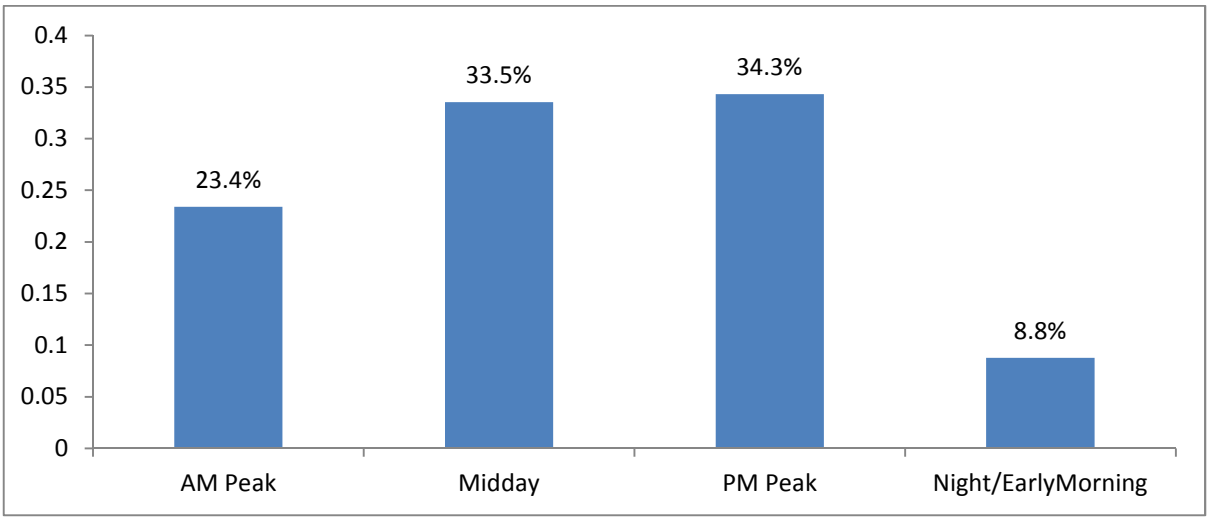
Figure 8.3.1.2: Average Travel Distance by Mode



8.3.2 Travel Times

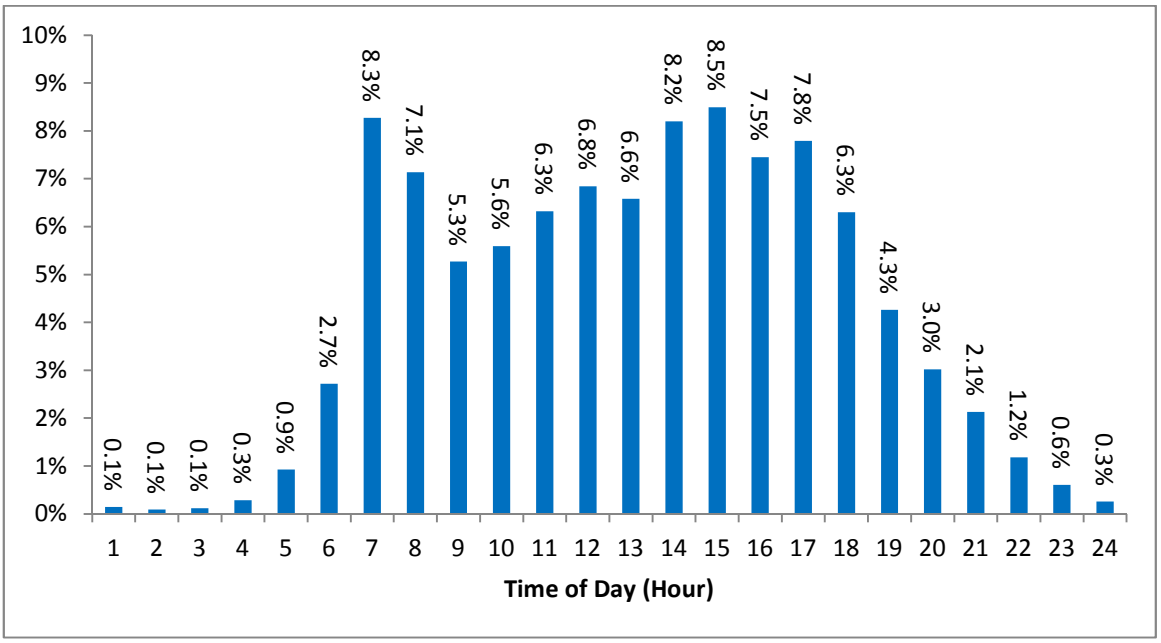
Departure times can be grouped into time slots, representing travel in the morning peak (6 am to 10 am), midday (10 am to 3 pm), afternoon peak (3 pm to 8 pm), night and early morning (8 pm to 6 am). Figure 8.3.2.1 is a distribution of trips based on these travel time categories. Approximately one third of all travel (33.5%) occurred between the mid–day hours of 10 a.m. to 2:59 p.m., while 34.3% of all travel occurred between PM peak hours of 3 pm to 7:59 pm.

Figure 8.3.2.1: Trip Distribution by Time of Day Based on Departure Hours



In examining hourly trip distribution, the highest peak times of travel were 7 am to 8 am (8.3%) and 3 pm to 4 pm (8.5%). These results are shown in Figure 8.3.2.2 utilizing a 24 hour time of day.

Figure 8.3.2.2: Hourly Trip Distribution by Departure Hours



8.4 Activity-Based Survey Results

For each place visited, up-to-three activities were collected. On average, two activities were reported for each place. In detail, the average number of activities reported for the place type of Home was 1.9, the highest overall. The results of the average number of activities by place are illustrated in Table 8.4.1.

Table 8.4.1: Average Number of Activities by Place Type (Home, Work, School and Other)

Place Type	Average Number of Activities	Counts of Trip Places
Home	1.9	190431
Work	1.6	28817
School	1.7	19130
Other	1.1	237061
Total	1.5	475438

The average travel duration reported for the Entertainment (movies, watch sports, etc) category was 27.9 minutes, which was the longest travel duration. Respondents reported 24.4 minutes average travel duration for the Social/visit friends/relatives category, which was the second longest travel duration. Overall, the average travel duration was 17.8 minutes. Table 8.4.3 presents the average travel duration by activity.

Table 8.4.3: Average Travel Duration by Activity [weighted, multiple responded activities]

Activity at Visited Place	Mean	N
Personal activities (sleeping, personal care, leisure, chores)	18.8	108298
Preparing meals/eating	17.6	34922
Hosting visitors/entertaining guests	16.6	2119
Exercise (with or without equipment)/playing sports	17.6	1907
Study / schoolwork	15.7	6280
Work for pay at home using telecommunications equipment	15.1	1875
Using computer/telephone/cell or smart phone or other communications device for personal activities	17.0	12114
All other activities at my home	17.0	17834
Work/job duties	21.5	27880
Training	24.0	239
Meals at work	23.6	4796
Work-sponsored social activities (holiday or birthday celebrations, etc)	19.0	90
Non-work related activities (social clubs, etc)	18.7	323

Activity at Visited Place	Mean	N
Exercise/sports	22.3	309
Volunteer work/activities	16.2	507
All other work-related activities at my work	23.7	960
In school/classroom/laboratory	14.5	15514
Meals at school/college	14.0	3057
After school or non-class-related sports/physical activity	13.3	996
All other after school or non-class related activities (library, band rehearsal, clubs, etc)	16.0	1551
Change type of transportation/transfer (walk to bus, walk to/from parked car)	17.1	34880
Pickup/drop off passenger(s)	13.9	34513
Drive through meals (snacks, coffee, etc.)	13.6	5823
Drive through other (ATM, bank)	10.8	1585
Work-related (meeting, sales call, delivery)	22.4	8135
Service private vehicle (gas, oil, lube, repairs)	17.5	5483
Routine shopping (groceries, clothing, convenience store, hh maintenance)	13.5	36556
Shopping for major purchases or specialty items (appliance, electronics, new vehicle, major hh repairs)	17.2	2751
Household errands (bank, dry cleaning, etc.)	12.9	9537
Personal business (visit government office, attorney, accountant)	20.2	6379
Eat meal at restaurant/diner	18.8	17363
Health care (doctor, dentist, eye care, chiropractor, veterinarian)	20.7	5543
Civic/religious activities	16.3	7708
Outdoor exercise (playing sports/jogging, bicycling, walking, walking the dog, etc.)	20.0	10135
Indoor exercise (gym, yoga, etc.)	15.2	4920
Entertainment (movies, watch sports, etc)	27.9	6394
Social/visit friends/relatives	24.4	19046
Other (specify)	25.6	3279
Loop trip	17.7	13635
Don't know/refused	14.8	202
Total	17.8	475441

The overall average number of people participated in an activity together was 1.4. The highest average amongst the groups of people who participated in an activity together was Civic/religious category at 2.5. The average number of people participating in an activity together was 2 or more for the following activities: After school or non-class-related sports/physical activity; Hosting visitors/entertaining guests; Training; Work-sponsored social

activities (holiday or birthday celebrations, etc). Table 8.4.4 presents the average number of people who participated in an activity together, by activity.

Table 8.4.4: Average Number of People who Participated in an Activity Together, by Activity [weighted, multiple responded activities]

Activity at Visited Place	Mean	N
Personal activities (sleeping, personal care, leisure, chores)	1.2	108298
Preparing meals/eating	1.4	34922
Hosting visitors/entertaining guests	2.2	2119
Exercise (with or without equipment)/playing sports	1.2	1907
Study / schoolwork	1.1	6280
Work for pay at home using telecommunications equipment	1.1	1875
Using computer/telephone/cell or smart phone or other communications device for personal activities	1.1	12114
All other activities at my home	1.2	17834
Work/job duties	1.5	27880
Training	2.0	239
Meals at work	1.1	4796
Work-sponsored social activities (holiday or birthday celebrations, etc)	2.1	90
Non-work related activities (social clubs, etc)	1.5	323
Exercise/sports	1.4	309
Volunteer work/activities	1.7	507
All other work-related activities at my work	1.4	960
In school/classroom/laboratory	1.9	15514
Meals at school/college	1.7	3057
After school or non-class-related sports/physical activity	2.0	996
All other after school or non-class related activities (library, band rehearsal, clubs, etc)	1.9	1551
Change type of transportation/transfer (walk to bus, walk to/from parked car)	1.2	34880
Pickup/drop off passenger(s)	1.4	34513
Drive through meals (snacks, coffee, etc.)	1.3	5823
Drive through other (ATM, bank)	1.2	1585
Work-related (meeting, sales call, delivery)	1.3	8135
Service private vehicle (gas, oil, lube, repairs)	1.3	5483
Routine shopping (groceries, clothing, convenience store, hh maintenance)	1.3	36556

Activity at Visited Place	Mean	N
Shopping for major purchases or specialty items (appliance, electronics, new vehicle, major hh repairs)	1.3	2751
Household errands (bank, dry cleaning, etc.)	1.2	9537
Personal business (visit government office, attorney, accountant)	1.2	6379
Eat meal at restaurant/diner	1.6	17363
Health care (doctor, dentist, eye care, chiropractor, veterinarian)	1.3	5543
Civic/religious activities	2.5	7708
Outdoor exercise (playing sports/jogging, bicycling, walking, walking the dog, etc.)	1.7	10135
Indoor exercise (gym, yoga, etc.)	1.5	4920
Entertainment (movies, watch sports, etc)	1.7	6394
Social/visit friends/relatives	1.7	19046
Other (specify)	1.4	3279
Loop trip	1.5	13635
Don't know/refused	1.1	202
Total	1.4	475441

8.5 Long Distance Survey Results

This section summarizes findings from the long distance trips collected from the long distance travel log only. A total of 68,193 long distance trips were collected from 18,012 households, which is 42% of all households that completed both recruitment and retrieval successfully. In this section, findings are based on unweighted data.

The straight-line distances between geocoded origin and destination were computed to determine approximate travel distance. By trip purpose, combined business and pleasure trips show the longest average travel at 485.7 miles, followed by vacation/sightseeing trips (479.2 miles). Table 8.5.1 provides further details on the average trip distance by trip purpose.

Table 8.5.1: Average Distance, and by Trip Purpose [unweighted]

Long Distance Trip Purpose	Average Number of Miles	Frequency of Trips
Going to work	171.3	2815
Business (work-related meeting/convention/seminar	502.3	6193
Combined business and pleasure	485.7	1125
School -related activity	299.3	927
Visit friends/family/relatives	340.9	13067
Medical	87.8	1870
Vacation/sightseeing	479.2	7666

Long Distance Trip Purpose	Average Number of Miles	Frequency of Trips
Outdoor recreation (sports, fishing, hunting, camping, boating, etc)	135.8	2763
Entertainment (theater, concert, sports event, gambling, etc)	141.1	2919
Personal Business (e.g. shopping)	133.3	2781
Drive someone else	105.5	1216
Return home	323.5	23223
Other (specify)	199.6	755
Don't know	435.6	198
Refuse	183.5	85
Total	***321.9***	***67603***

The long distance log collected the travel mode used for the longest distance for each long distance trip. Looking into travel distance by travel mode, airplane trips show the longest average travel distance at 1614.0 miles, followed by Greyhound bus (434.8 miles). A summary of average distance by travel mode is found in Table 8.5.2.

Table 8.5.2: Average Distance and by Travel Mode (multiple responses) [unweighted]

Long distance Mode	Average Number of Miles	Frequency of Trips
Walk	140.8	40
Bike	75.9	72
Wheelchair / Mobility Scooter	87.8	5
Other Non-Motorized (please specify)	228.2	4
Auto / Van / Truck Driver	125.8	47031
Auto / Van / Truck Passenger	137.5	7363
Carpool / Vanpool	137.9	499
Motorcycle / Scooter / Moped	137.3	291
Taxi / Hired Car / Limo	416.1	166
Rental Car/Vehicle	248.0	967
Private shuttle (SuperShuttle, employer, hotel, etc.)	162.6	171
Greyhound Bus	434.8	157
Plane	1614.0	8502
Other Private Transit (please specify)	285.7	234
Local Bus, Rapid Bus	73.4	88
Express Bus / Commuter Bus (AC Transbay, Golden Gate Transit, etc)	57.2	113
Premium Bus (Metro Orange / Silver Line)	72.1	24
School Bus	96.9	98
Public Transit Shuttle (DASH, Emery Go Round, etc.)	70.0	13
AirBART / LAX FlyAway	17.5	7

Long distance Mode	Average Number of Miles	Frequency of Trips
Dial-a-Ride / Paratransit (Access Services, etc.)	41.2	15
Amtrak Bus	199.9	82
Other Bus (write code and specify)	210.1	105
BART, Metro Red / Purple Line	205.9	104
ACE, Amtrak, Caltrain, Coaster, Metrolink	203.4	715
Metro Blue / Green / Gold Line, Muni Metro, Sacramento Light Rail, San Diego Sprinter / Trolley / Orange/Blue/Green, VTA	53.5	31
Street Car / Cable Car		0
Other Rail (please specify)	343.8	50
Ferry / Boat	616.1	118
DK/RF	255.6	67
Total	***321.5***	***67132***

*50 miles or longer long distance trips reported to be made by AirBART/LAX FlyAway were reclassified to the trips made by airline after reviewing origin and destination location. AirBart.Lax FlyAway is more likely to be used as an access or an egress mode to/from an airport.

On average, approximately three persons traveled together on long distance trips. Long distance trips made by auto/van/truck passenger travel mode averaged 3 persons. Long distance trips by airplane averaged 2 persons. Table 8.5.3 presents the average number of travelers by travel mode.

Table 8.5.3: Average Number of Travelers by Travel Mode (multiple responses) [unweighted]

	Average Number of Travelers	Frequency of Trips
Walk	2.0	41
Bike	2.6	68
Wheelchair / Mobility Scooter	2.6	5
Other Non-Motorized	2.0	5
Auto / Van / Truck Driver	2.1	47155
Auto / Van / Truck Passenger	2.9	7415
Carpool / Vanpool	4.2	499
Motorcycle / Scooter / Moped	1.9	286
Taxi / Hired Car / Limo	2.9	162
Rental Car/Vehicle	2.6	965
Private shuttle (SuperShuttle, employer, hotel, etc.)	6.4	169
Greyhound Bus	3.5	155
Plane	1.9	8415
Other Private Transit (please specify)	8.9	227
Local Bus, Rapid Bus	2.2	93
Express Bus / Commuter Bus (AC Transbay, Golden Gate Transit, etc)	2.1	105
Premium Bus (Metro Orange / Silver Line)	6.8	23
School Bus	15.6	101
Public Transit Shuttle (DASH, Emery Go Round, etc.)	1.1	13

	Average Number of Travelers	Frequency of Trips
AirBART / LAX FlyAway	3.7	31
Dial-a-Ride / Paratransit (Access Services, etc.)	5.3	15
Amtrak Bus	1.6	81
Other Bus	8.3	98
BART, Metro Red / Purple Line	2.0	103
ACE, Amtrak, Caltrain, Coaster, Metrolink	1.7	708
Metro Blue / Green / Gold Line, Muni Metro, Sacramento Light Rail, San Diego Sprinter / Trolley / Orange/Blue/Green, VTA	1.9	31
Street Car / Cable Car		0
Other Rail	3.1	50
Ferry / Boat	2.6	113
DK/RF	2.2	50.0
Total	***2.3***	***67175***

Excluding "returning home" trips, 96.9% of trip destinations were within the United States. Mexico is ranked as the second most popular long distance trip destination with a 0.7% share, followed by Canada with 0.4% of trips having ended in Canada. The top 10 destinations by country are ranked in Table 8.5.4.

Table 8.5.4: Top 10 Destination Countries [unweighted]

Destination Countries	Percent
United states	96.9%
Mexico	0.7%
Canada	0.4%
United kingdom	0.2%
Italy	0.1%
France	0.1%
Germany	0.1%
Japan	0.1%
China	0.1%
India	0.1%
Other counties	1.1%
Total	100.0%

Excluding "returning home" trips, 79.2% of trip destinations were within the state of California. Looking at destination cities in detail, 4.6% of trips were destined for San Francisco, followed by Los Angeles (4.2%) and Sacramento (2.9%). Table 8.5.5 gives a summary of the results for the top 50 destination cities.

Table 8.5.5: Top 50 Destination Cities [unweighted]

Destination Cities	Percent	Destination Cities	Percent
San Francisco	4.6%	Irvine	0.4%
Los Angeles	4.2%	Chico	0.4%
Sacramento	2.9%	Ventura	0.4%
San Diego	2.7%	New York	0.4%
San Jose	1.9%	Santa Clara	0.4%
Las Vegas	1.7%	Santa Ana	0.4%
Reno	1.4%	Truckee	0.4%
Fresno	1.3%	Carlsbad	0.4%
Oakland	1.1%	Palo Alto	0.4%
Anaheim	0.9%	Seattle	0.4%
Bakersfield	0.9%	Yosemite National Park	0.4%
Santa Rosa	0.8%	Portland	0.4%
Santa Barbara	0.8%	Riverside	0.3%
Redding	0.7%	Pasadena	0.3%
Santa Cruz	0.7%	Palm Desert	0.3%
Stockton	0.7%	Roseville	0.3%
Monterey	0.6%	Temecula	0.3%
Long Beach	0.6%	Lancaster	0.3%
Modesto	0.5%	Phoenix	0.3%
Palm Springs	0.5%	Salinas	0.3%
Berkeley	0.5%	Santa Maria	0.3%
South Lake Tahoe	0.5%	Newport Beach	0.3%
San Luis Obispo	0.5%	Santa Monica	0.3%
Napa	0.5%	Ontario	0.3%
Davis	0.5%	Santa Clarita	0.3%

For those who reported traveling via airplane, rail or bus for their long distance trip, access mode to the departure airport or station was asked. The most popular mode of access for departing trips (all trips excluding returning home trips) was auto driver (34.5%) or passenger (27.7%). Taxis followed with 6.3% of the share. Access mode to the departure airport or station is presented in Table 8.5.6.

Table 8.5.6: Access Mode to the Departure Airport/Station (Base=Outbound Trips Made by bus/rail/airplane)

Departure Mode	Count	Column N %
Walk	49.0	3.9%
Bike	2.0	.2%
Auto / Van / Truck Driver	436.0	34.5%
Auto / Van / Truck Passenger	350.0	27.7%
Carpool / Vanpool	3.0	.2%
Taxi / Hired Car / Limo	80.0	6.3%
Rental Car/Vehicle	16.0	1.3%
Private shuttle (SuperShuttle, employer, hotel, etc.)	23.0	1.8%
Greyhound Bus	5.0	.4%
Plane	19.0	1.5%
Other Private Transit	5.0	.4%
Local Bus, Rapid Bus	26.0	2.1%
Express Bus / Commuter Bus (AC Transbay, Golden Gate Transit, etc)	5.0	.4%
Premium Bus (Metro Orange / Silver Line)	3.0	.2%
Public Transit Shuttle (DASH, Emery Go Round, etc.)	5.0	.4%
AirBART / LAX FlyAway	7.0	.6%
Amtrak Bus	3.0	.2%
Other Bus (write code and specify)	6.0	.5%
BART, Metro Red / Purple Line	15.0	1.2%
ACE, Amtrak, Caltrain, Coaster, Metrolink	5.0	.4%
Metro Blue / Green / Gold Line, Muni Metro, Sacramento Light Rail, San Diego Sprinter / Trolley / Orange/Blue/Green, VTA	2.0	.2%
Other Rail	3.0	.2%
Don't Know/Refused	196.0	15.5%

For trips made by airplane, bus or rail for the return home, auto driver (21.5%) or passenger (17.2%) were again the most likely means of transportation used to access the departure airport or bus/rail station. Taxis followed with 4.5% of the share. Table 8.5.7 details the egress mode to the arrival airport or station.

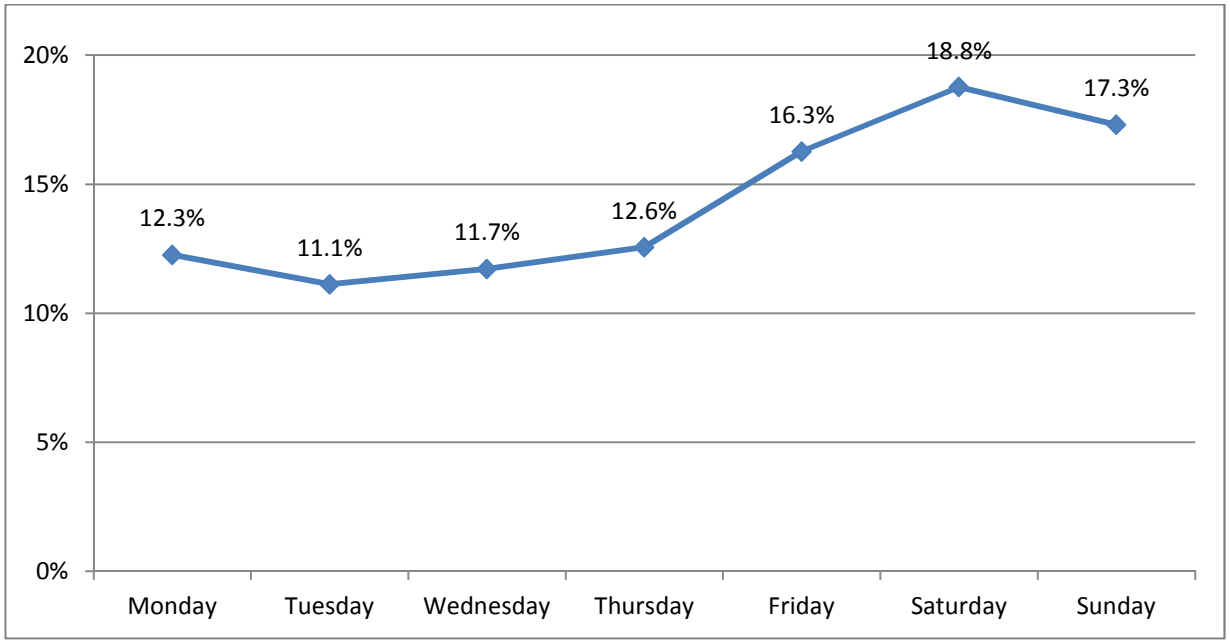
Table 8.5.7: Egress Mode to the Arrival Airport/Station (Base=Returning Home Trips Made by bus/rail/airplane)

Arrival Mode	Count	Column N %
Walk	7	1.2%
Wheelchair / Mobility Scooter	1	.2%
Other Non-Motorized (please specify)	1	0.2%
Auto / Van / Truck Driver	130	21.5%
Auto / Van / Truck Passenger	104	17.2%
Carpool / Vanpool	2	0.3%

Arrival Mode	Count	Column N %
Taxi / Hired Car / Limo	27	4.5%
Rental Car/Vehicle	10	1.7%
Private shuttle (SuperShuttle, employer, hotel, etc.)	9	1.5%
Plane	14	2.3%
Other Private Transit (please specify)	2	.3%
Local Bus, Rapid Bus	2	0.3%
Express Bus / Commuter Bus (AC Transbay, Golden Gate Transit, etc)	1	.2%
Public Transit Shuttle (DASH, Emery Go Round, etc.)	1	.2%
AirBART / LAX FlyAway	4	.7%
Other Bus (write code and specify)	2	.3%
BART, Metro Red / Purple Line	10	1.7%
ACE, Amtrak, Caltrain, Coaster, Metrolink	3	.5%
Metro Blue / Green / Gold Line, Muni Metro, Sacramento Light Rail, San Diego Sprinter / Trolley / Orange/Blue/Green, VTA	1	0.2%
Other Rail (please specify)	2	.3%
DK/RF	274	45.3%
Total	605	100.0%

When looking at the days of the week reported for long distance trips, the majority of participants reported they traveled on Saturday (18.8%) and Sunday (17.3%). Tuesday and Wednesday were reported as the least popular days for long distance travel with 11.1% and 11.7%, respectively. Figure 8.5.1 presents the distribution of long distance trips by day of week.

Figure 8.5.1: Distribution of Long Distance Trips by Day of the Week



9.0 Statistical Reliability Estimates

Any estimate or statistic from a sample survey will always come with a certain amount of error – the difference between the true value of the population and the estimated value from the sample survey. Such error can be dissected into two major types of errors – the systematic error and the random error. The systematical error could be caused purely by mistakes, or by inappropriate sampling designs which do not reveal the impact of some hidden factors. Even if the sampling strategies are thoughtfully designed to avoid this type of error, in reality, there is non-response bias due to non-response for the study from certain populations. In the CHTS, NuStats minimized this type of error by implementing a stratified sampling design and by oversampling for hard-to-reach populations identified at the beginning of the survey. Additional efforts to minimize these errors were to develop analytic weights for the surveyed households and to apply trip correction factors and trip weights to correct misreported trips and then to project trips to the total population. The random error is produced from randomness of occurrence of events (e.g. travel trips) and the random selection of survey samples. In order to measure underlying sampling error and predict how reliable the estimates from the survey data are, the margin of error (MOE) can be used. MOE is a measure of the precision of the sample estimates of the population value. Table 9.0.1 shows the margin of random errors (MOE) of different estimates at 90% and 95% confidence levels in this survey. For example, the average number of trips made by each household per day is 9.17, and the MOE at 90% confidence level is 0.07. This means if the survey were conducted repeatedly for 100 times, for 90 of the 100 times, we would obtain the average number of trips per household within the range of (9.17+0.07=) 9.24 and (9.17-0.07=) 9.10. In another word, there is a 90% probability that this range would include the true value of the population. The smaller margin of error indicates more reliable estimates from the sampled survey. The margin of error at both 90% and 95% for all listed trip statistics is within the range of 0.02-0.20 except trip rate of zero vehicle household (0.34).

Table 9.0.1: Summary of Trip Rate by Key Demographics

Variable	Trips per household/person per day	90% MOE	95% MOE
Household	9.2	0.07	0.08
Person	3.6	0.02	0.02
Household size			
1	3.3	0.07	0.08
2	5.7	0.07	0.08
3	9.7	0.14	0.17
4+	17.3	0.18	0.21
Household vehicles			
0	7.5	0.34	0.41
1	7.3	0.11	0.14
2	11.5	0.11	0.13
3+	9.3	0.16	0.19
Household employee			
0	5.7	0.11	0.14
1	8.4	0.11	0.13
2	10.8	0.13	0.15

Variable	Trips per household/person per day	90% MOE	95% MOE
3+	18.4	0.3	0.36
Income Level			
Less than $24,999	8.6	0.20	0.24
$25,000 - $49,999	8.6	0.16	0.19
$50,000 - $74,999	9.0	0.16	0.20
$75,000 - $99,999	10.5	0.18	0.22
$100,000 - $149,999	11.0	0.18	0.21
$150,000 or above	8.6	0.20	0.24
Gender			
Male	3.4	0.02	0.03
Female	3.7	0.02	0.03
Age			
Less than 20 years	3.3	0.03	0.03
20 - 34 years	3.5	0.05	0.06
35 - 54 years	4.3	0.04	0.04
55 - 64 years	3.7	0.04	0.05
65 years or older	2.9	0.04	0.05
Hispanic or Latino			
Yes	3.5	0.03	0.04
No	3.6	0.02	0.02
Race			
White	3.6	0.02	0.02
Black or African American	3.5	0.11	0.13
American Indian or Alaska Native	3.7	0.08	0.09
Asian	3.5	0.07	0.08
Native Hawaiian or Pacific Islander	3.4	0.3	0.36
Employment			
Yes	4.0	0.02	0.03
No	3.2	0.03	0.04
Driver License			
Yes	3.8	0.02	0.02
No	3.1	0.08	0.09

10.0 Limitations of the Survey

As with any survey dataset, there are limitations on its use. End users must understand the methods used to collect the data, the accuracy when analyzing at the subsample level, and various biases. Each of these affects the reliability level when generalizing to their desired population. These limitations are described below.

Under-Representation of Cell Phone Only Households

Surveys are prone to non–response errors because certain types of households selected in a sample do not participate in surveys. The main sampling frame for the CHTS was address-based, which yielded household addresses for which either a telephone number was attached (matched) or address for which there was no telephone number associated (unmatched). These latter households are predominately cell-phone-only households. A 2011 study by the National Center for Health Statistics[5] showed that the percentage of wireless only households was significantly increasing among younger, poorer and more mobile households; they estimated 18% of California households were cell phone only.

As may be seen from Table 10.1, unmatched households were sampled at a higher rate (28%), but they were a far lower percentage of recruited households (4.7%). Recall that unmatched households were sent an advance letter that contained a PIN directing them to recruit online, and a telephone number for them to recruit by telephone. This was the only contact with these households. The CHTS is not the only survey that has an under-representation of cell phone only households; this is an issue for survey research firms nationwide. Some of the suggested remedies include using smart phone applications as another response mode, and being more active in the use of social media to promote the survey.

Table 10.1: Recruitment and Response Rate by Sample Type

Sample Type	Sample Used in Main Survey		Recruited Households			Retrieved Households		
	Number (A)	% of Total	Number (B)	% of Total	Recruitment Rate (B)/(A)	Number (C)	% of Total	Retrieval Rate (C')/(B)
ABS Matched/ Listed	1,410,365	66.5%	58658	93.0%	4.2%	38934	91.8%	66.4%
Unmatched	585520	27.6%	2996	4.7%	0.5%	2458	5.8%	82.0%
Energy Commission Samples	121835	5.7%	985	1.6%	0.8%	809	1.9%	82.1%
Kern County Transit Intercept	1353	0.1%	443	0.7%	32.7%	230	0.5%	51.9%
Total	2,119,073	100.0%	63082	100.0%	3.0%	42431	100.0%	67.3%

Language Limitations

The main survey was conducted in Spanish which, as discussed in Section 4.0, involved translating all of the survey printed materials (diary and GPS) as well as the CATI and online scripts into Spanish. As it turned out, only

[5] Accessed May 22, 2013: http://www.cdc.gov/nchs/data/nhis/earlyrelease/wireless201112.htm

5,543 households requested at the end of the recruitment interview to receive the Spanish version of the recruitment package. This was less than 1% of the recruited households, and indicated that the majority of Hispanic households that participated in the CHTS preferred the English versions.

At the same time, 1.4% of all sampled households were unable to be recruited due to the use of languages other than English or Spanish. In California, there are many areas with linguistically isolated households speaking a variety of languages such as Chinese, Tagalog, Vietnamese, Korean, Persian, Armenian and many more. While the percentage speaking any one of these languages was much lower than 1.4% on a statewide basis, there may have been local areas in which the percentage of a language was much higher.

From a statewide survey resource allocation point of view, the time and effort involved in translating materials into a language that was likely to be used by a small fraction of households was greater than the benefit in additional households. However, it must be acknowledged that there may have been certain geographies in the state in which the lack of materials in a key language may have served as a limitation to participation.

Limitation in Long Distance Data

To increase the use of the long distance log, with the concurrence of Caltrans and the Expert Pretest Review Panel, the long distance logs were extensively reformatted after the pretest, as was discussed in Section 4.0. Specifically, the questions asking for how participants travelled to the departure/arrival airport or station (mode of access and egress) for long distance trips made by transit, and the name of the airport, bus or train station, were removed from the printed log for the main survey. These questions continued to be asked for the most recent long distance trip only in the CATI and online scripts.

In August, 2012 the concern was raised that the removal of the access and egress information from being collected on every long distance trip involving transit use would severely limit the use of the data for certain travel demand models. The consensus was it was too late to make the changes to the scripts and printed materials necessary to collect the access and egress information on all long distance trips at that point in the main survey data collection. The absence of the access and egress data is noted by a DK in the dataset and, for those modelers seeking this information, remains a limitation.

Caution in Using Weights and Trip Correction Factor

The final weights were developed at the county level, but demographic controls were balanced at the statewide level only. Also trip correction factors for the CHTS were developed at the statewide level only. Users of the CHTS final data are cautioned in applying these weights to lower level geographies, such as sampling strata, counties or MPO.

Process for Performing OBD Weighting

Sampling weights for the CHTS were computed to address sampling bias and non-response bias. More detail with regard to the weighting procedure may be found in Section 7.0. Sampling weights were computed based on the randomly drawn sample. Taking the base weights of these sampling weights, the sampling weights were then balanced with the control totals of key demographic variables from either the general population Energy Commission OBD GPS samples (drawn from the Energy Commission database of alternative fuel vehicle owners) or the UC Davis database of alternative fuel vehicle owners. The sample pulled from these databases was not pulled in a random draw. Additionally, overlap between these two databases and the ABS sampling frame or listed sampling frame is unknown. Also, this sample was not drawn randomly by geography. Therefore, there was no adjustment made at the sample unit level for Energy Commission GPS sample. However, Energy Commission GPS samples were included in the raking procedure to control representation of survey sample to the general population. All survey complete samples, including Energy Commission GPS sample, were controlled under key demographic variables from the latest general population data.

11.0 Recommendations for Future Survey Improvement

In a large, complex, and lengthy effort such as the CHTS, there were a number of lessons learned and recommendations for future survey improvement. This section presents the collective lessons learned and recommendations for the next California statewide travel survey.

Survey Administration and Governance: To conduct the CHTS, transportation planning and environmental agencies around the state came together to pool their resources to develop a common survey that could be used for many purposes. Having a single, common survey meant that a single contractor would be responsible for data collection, which ensured that the survey methods were consistent, as were the resulting data and data elements. A single, statewide effort also allowed participating agencies to share and build staff experience and expertise and share the costs of survey development, which is one of the more costly aspects of conducting a survey.

From a governance and process point of view, there were many aspects that worked well, such as:

- The committee structure developed to support the CHTS --having an Administrative Committee as well as the larger Steering Committee ensured decisions were discussed and made by the appropriate and informed group.
- The use of expert advisors to provide technical guidance in the development of the survey design as part of the request for proposal, and throughout the survey process;
- The use of a facilitator for the Administrative and Steering Committee meetings -- helped to streamline meetings, and to ensure there was opportunity for everyone to have a voice in the project.

There were some aspects of the CHTS survey administration that did not work as well as they could have, and recommendations for future studies include:

Recommendation 1: Ensure that the contracting process allows for flexibility and change, especially in large, complex surveys or surveys that span a long period.

Recommendation 2. Extend the survey timeline to: a) add more time for coordination and decision making when there are many partner agencies, and b) add more time between the pretest and the main survey to permit thorough review and changes to be made and re-tested, if needed.

Public Outreach: The need for public outreach and awareness of the survey effort cannot be overemphasized. Travel behavior surveys ask questions that are considered intrusive by many potential respondents, and having a level of awareness that the survey is a legitimate effort can only assist in increasing the response rate. This is especially true for groups that are typically under-represented, including travelers that are young, Hispanic, and/or low-income.

Recommendation 3: Incorporate a comprehensive outreach program into the survey design and process early on, whether the outreach is to be conducted by the sponsoring agency(cies) or by the survey contractor.

The outreach effort, whether executed by sponsoring agency staff or by the contractor, should be part of the survey design planning. If agency public relations staff are to execute the outreach, these staff should be part of the survey design team and play an active role in the survey from the beginning of the design discussions through to the end of data collection. **If** the public outreach effort execution is going to be the responsibility of the survey contractor, this should be spelled out in the RFP, an appropriate level of the survey budget should be applied to this effort, and the outreach effort and execution activities and timeline should be part of the survey contract.

Data Collection Techniques: Household travel surveys appear to be at a significant crossroads in terms of collecting primary data through surveys and increasing the use of secondary data "big data." There are likely to be many changes to the need for different types of information, and the methods to collect it.

Recommendation 4: Incorporate new data collection practices and methods, such as smart phones, enhanced and customized online surveys, expanded OBD devices, as well as the use of secondary data such as cell phone traces, to increase survey response modes and reduce respondent burden.

Recommendation 5: Recognize the need to continue to provide incentives, regardless of continued concern over the use of "tax payer" monies, but incorporate newer options such as digital currency or customized electronic gift cards.

Recommendation 6: Work to keep the respondent burden to a reasonable level even if it means collecting some data elements, such as the long distance trips, in a separate, follow-on survey.

The CHTS was a long and complex survey both to administer and for the respondents. There can be no question that the response rate and the number of completed households would have been higher with fewer questions.

Periodic or Continuous Surveys: It is a major undertaking for multiple agencies to pool their resources and come to consensus on a larger statewide travel survey. Planning for the CHTS started in 2008, two years before the RFP was issued, and the survey funding remained in motion even after data collection began. Rather than expending staff resources and saving up monetary resources for a once in a decade effort, it would smooth out the effort and require less funding at any given time if the California statewide travel survey was on a continuous or more frequent cycle. The cost per year is lower, and there is the distinct advantage that staff will have time to build up their survey skills. An alternative to a continuous survey is to conduct smaller surveys on a periodic schedule, perhaps every two to three years.

Recommendation 7: Consider conducting the California statewide travel survey on a continuous or more frequent cycle, rather than once every ten years.

Public Use Data: Over the past several years, there has been increased scrutiny of households travel behavior surveys in terms of the use of personally identifiable information and privacy issues. Most frequently at issue is access to the detailed personally identifiable information (PII) that is collected about each household, person and trip. When the CHTS was being planned, in 2008 and 2009, these issues were just coming to the forefront. But the time this report was written in 2013, the need for security around PII was high, and there were real concerns over how much of the collected data could be made available to research organizations other than those that had participated in the study.

Recommendation 8: Plan the data sharing protocols for different levels of users in advance.

The desired data sharing protocols should be determined in advance of data collection, and the respondent consent statement should reflect the desired data sharing.

GPS Subsample

In the technical proposal for this study, NuStats offered an alternate solution in addition to the method of GPS data collection that was ultimately used in the study. This alternate solution suggested the use of GPS-only passive data collection with no paper diary, then a prompted recall interview in order to gather the uncollected diary data. NuStats has since found that in order for the prompted recall to be successful, the respondent still requires some sort of memory jogger in place of the travel diary.

A solution to this need for memory joggers would be to put more effort into developing trip detection algorithms such as the one used in this study, so that prompted recall is not necessary. These algorithms are becoming more and more sophisticated and can impute not only trip origin and destination points from raw GPS data; they can also impute trip mode and purpose. Used in conjunction with rich georeferenced road & path, land use, and recruit information databases, trip detection tools can produce highly accurate results and do not require significant supplementation by trip diaries.

The less preferred way of reducing the amount of prompted recall required in a GPS survey is to have an active device which requires some sort of respondent input while traveling. Active devices have been shown to affect a respondent's ability to capture a complete set of data as they come with a larger burden. Current active GPS devices call for the respondent to answer specific questions about each trip during the travel period and/or start and stop the device when beginning and ending travel. However, there are GPS devices available that can passively collect GPS data and also have the option to record time-and geographically-tagged voice notes. A quick recording of the respondent saying "home", "work", "school", or any other relevant information when a stop is made can be converted from voice to text and documented at that geographic location in the data file. These devices are comparable in price to completely passive ones and offer a hybrid approach that is minimally burdensome on the respondent and can still provide some mode/purpose data.

Another suggestion for future studies not listed in the technical proposal, but that has since the beginning of the Caltrans survey become an increasingly attractive option, would be to use passive smartphone GPS data collection applications which transmit GPS location traces wirelessly to the data servers. Offering respondents the option to use their personal smartphone in travel surveys not only reduces the amount of money spent on device purchase and shipping, but also provides respondents with a familiar, fatigue-free medium for data collection. In addition, smartphones' wireless data transmission capability offers the surveyor freedom to conduct long-term studies as device memory is not a limitation, and also decreases the amount of time that must be invested in data uploading. There is no potential for unreturned devices with surveys done on personal smartphones, and a respondent's data usage is more than compensated for with the incentive. These applications can also retrieve information from wireless and Bluetooth OBD sensors. More work must be done to adapt applications such as these to all smartphone models and operating systems, but the flexibility and potential provided by this technology is extremely great.