HIGH-CUBE WAREHOUSE
VEHICLE TRIP GENERATION ANALYSIS

PREPARED FOR

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

AND

NATIONAL ASSOCIATION OF INDUSTRIAL AND OFFICE PROPERTIES

PREPARED BY

INSTITUTE OF TRANSPORTATION ENGINEERS

WASHINGTON, DC

OCTOBER 2016

ACKNOWLEDGEMENT AND DISCLAIMER

This report was prepared as a result of work sponsored, paid for, in whole or in part, by the South Coast Air Quality Management District (SCAQMD) and NAIOP (National Association of Industrial and Office Properties (NAIOP). The report is the product of a collaborative process by which ITE, SCAQMD, and NAIOP embarked upon an effort to better understand vehicle trip generation rates at high-cube warehouse facilities.

The NAIOP Inland Empire and Southern California Chapters provided direct input for various items of the report, including a suggested high-cube warehouse classification system.

EXECUTIVE SUMMARY

Purpose – South Coast Air Quality Management District (SCAQMD) and NAIOP (National Association of Industrial and Office Properties) provided funding to the Institute of Transportation Engineers (ITE) to help in the establishment of national guidance for the estimation of vehicle trip generation at what are commonly called high-cube warehouse distribution centers (HCW).

Definition of High-Cube Warehouse – A high-cube warehouse is a building that typically has at least 200,000 gross square feet of floor area, has a ceiling height of 24 feet or more, and is used primarily for the storage and/or consolidation of manufactured goods (and to a lesser extent, raw materials) prior to their distribution to retail locations or other warehouses. A typical HCW has a high level of on-site automation and logistics management. The automation and logistics enable highly-efficient processing of goods through the HCW. For the purpose of this trip generation analysis, HCWs are grouped into five types: fulfillment center, parcel hub, cold storage facility, transload facility, and short-term storage facility.

Data Sources – The analysis contained herein is based on data from 15 separate data sources, including recent data collected under the sponsorship of SCAQMD and NAIOP. The database includes trip generation information from 107 individual sites.

Findings – The HCW market continues to evolve as individual tenants/owners implement different e-commerce business plans. For example, some deliver goods to the customer within two days and others deliver orders to the nearest store for customer pick-up. As business plans and technology continue to evolve, these should continue to be monitored. Although the tenant or its planned operations are often unknown at the time of site development review, for the purpose of estimating vehicle trip generation, it may be as important to know the tenant as much as other facility factors.

For transload, short-term storage, and cold storage HCWs, the proportionate mix of types of vehicles (i.e., cars versus trucks) accessing the site is very consistent, both daily and during the AM and PM peak hours.

For a cold storage HCW, the currently available data demonstrates a useable, direct correlation between building size and vehicle trip generation.

The single data points for fulfillment centers and parcel hubs indicate that they have significantly different vehicle trip generation characteristics compared to other HCWs. However, there are insufficient data from which to derive useable trip generation rates.

For transload and short-term storage HCW sites, additional data sites and additional information on past sites are needed in order to derive useable trip generation rates.

Recommendations (Action Plan) – A strategically-developed data collection program is needed that targets each type of HCW individually. The strategy should include a prioritized plan for collecting additional data at five classifications of HCWs that are representative of the types of facilities expected to be commonly developed in coming years. The data should be collected at mature facilities, each of which clearly fits within one HCW classification, during periods of typical levels of activity based on the types of facilities and businesses served.

All future data collection should seek to acquire an enhanced set of site descriptive information that will enable development of better predictive models than are currently available.

STUDY PURPOSE AND PROCESS

South Coast Air Quality Management District (SCAQMD) and NAIOP (National Association of Industrial and Office Properties) provided funding to the Institute of Transportation Engineers (ITE) to help in the establishment of consensus-based national guidance for the estimation of trip generation at what are commonly called high-cube warehouses (HCW). This report documents the results of that effort to develop a credible and defensible procedure for collecting and analyzing site trip generation data for use in transportation impact analyses (TIA) and air quality/vehicular emissions analyses (AQA[1]) for HCW-type facilities.

ITE convened a meeting of practitioner-based experts at ITE Headquarters on April 1, 2015. The meeting participants are listed in Table 1. At the meeting's conclusion, several individuals were tasked with development of specific products, including the following:

- An overall work plan for this report and for subsequent data collection and analysis
- A clear and consistent definition of HCW for this report and for future studies and analysis
- A vehicle classification scheme that satisfies ultimate data requirements for TIA and AQA and complies with reasonable data collection capabilities and budgets

ITE staff assumed responsibility for compilation and analysis of existing HCW trip generation data.

The full expert panel provided comments and suggestions on each interim product that eventually became part of this complete report. Nevertheless, responsibility for content completeness and data analysis accuracy rests with ITE staff.

Table 1. Expert Panel for High-Cube Warehouse Trip Generation Study

Mr. Brian Bochner	Texas A&M Transportation Institute, College Station, Texas
Mr. Paul Basha	City of Scottsdale, Arizona
Mr. Milton Carrasco	Transoft Solutions, Inc., Richmond, British Columbia
Dr. Kelly Clifton	Portland State University, Portland, Oregon
Mr. Henry Hogo (for Mr. Barry Wallerstein)	South Coast Air Quality Management District, Diamond Bar, California
Mr. Kim Snyder	Prologis, Cerritos, California
Ms. Cecilia Ho	Federal Highway Administration, Washington, DC
Mr. Ian Macmillan	South Coast Air Quality Management District, Diamond Bar, California
Mr. Thomas Phelan	VHB, Newark, New Jersey
Mr. Jeremy Raw	Federal Highway Administration, Washington, DC
Mr. Erik Ruehr	VRPA Technologies, San Diego, California
Mr. Frank Sherkow	Southstar Engineering and Consulting, Inc., Yachats, Oregon
Mr. Joe Zietsman	Texas A&M Transportation Institute, College Station, Texas
Mr. Tom Brahms	Institute of Transportation Engineers, Washington, DC
Mr. Kevin Hooper	Institute of Transportation Engineers, Washington, DC
Ms. Lisa Tierney	Institute of Transportation Engineers, Washington, DC

[1] In California, when a new warehouse project is proposed, it undergoes environmental review pursuant to the California Environmental Quality Act (CEQA). Air quality analyses conducted pursuant to CEQA typically compare project emissions against local air district thresholds to determine the potential significance of the project's air quality impacts. These emission estimates rely on trip generation rates to determine the volume of cars and trucks that could visit the proposed project site.

HIGH-CUBE WAREHOUSE DEFINITION

A high-cube warehouse (HCW) is a building that typically has at least 200,000 gross square feet of floor area, has a ceiling height of 24 feet or more, and is used primarily for the storage and/or consolidation of manufactured goods (and to a lesser extent, raw materials) prior to their distribution to retail locations or other warehouses. A typical HCW has a high level of on-site automation and logistics management. The automation and logistics enable highly-efficient processing of goods through the HCW.[2]

A classification scheme for different types of HCWs is presented in Table 2 along with their distinctive characteristics. The characteristics of a typical standard warehouse are provided for comparative purposes. The five types of HCW are the following:

- Transload – usually pallet loads or larger handling products of manufacturers, wholesalers/distributors, or retailers with little or no storage durations
- Short-Term Storage – products held on-site for a short time
- Cold Storage – HCW with permanent cold storage in at least part of the building
- Fulfillment Center – storage and direct distribution of e-commerce product to end users
- Parcel Hub – transload function for a parcel delivery company

[2] High-cube warehouses are classified as Land Use Code 152 in ITE *Trip Generation Manual*, 9th Edition. The definition provided in *Trip Generation Manual* for HCW is as follows:

> "High-cube warehouses/distribution centers are used for the storage of materials, goods and merchandise prior to their distribution to retail outlets, distribution centers or warehouses. These facilities are typically characterized by ceiling heights of at least 24 feet with small employment counts due to a high level of mechanization. High-cube warehouses/distribution centers generally consist of large steel or masonry shell buildings and may be occupied by or multiple tenants. A small ancillary office use component may be included and some limited assembly and repackaging may occur within these facilities.
>
> "High-cube warehouses/distribution centers may be located in industrial parks or be free-standing. Intermodal truck terminal (Land Use 030), industrial park (Land Use 130), manufacturing (Land Use 140) and warehousing (Land Use 150) are related uses."

When the 10th edition of *Trip Generation Manual* is developed, the findings and recommendations of this report will be reflected in an updated definition for high-cube warehouses.

Table 2. High-Cube Warehouse Classifications

	Standard Warehouse/ Storage	Transload Facility	Short-Term Storage	Cold Storage	Fulfillment Center	Parcel Hub
Description and Key Warehouse Functions						
Typical Functions	Products stored on-site typically for more than one month	Focus on consolidation and distribution of pallet loads (or larger) of manufacturers, wholesalers, or retailers; little storage duration; high throughput and high-efficiency	Focus on warehousing/ distribution with distribution space operated at high efficiency; often with custom/special features built into structure for movement of large volumes of freight	Temperature-controlled for frozen food or other perishable products stored in any type of HCW; building built with substantial insulation, including foundation, walls, and roof[3]	Storage and direct distribution of e-commerce product to end users; smaller packages and quantities than for other types of HCW; often multiple mezzanine levels for product storage and picking	Regional and local freight-forwarder facility for time-sensitive shipments via air freight and ground (e.g., UPS, FedEx, USPS); site often includes truck maintenance, wash, or fueling facilities
Break-Bulk or Assembly	Can include break-bulk and assembly activities	Very limited pick-and-pack area within facility	May or may not include break-bulk, repack or assembly activities	Limited or no break-bulk, repack or assembly activities	Pick-and-pack area comprises majority of space	Limited or no break-bulk, repack or assembly activities
Place in Supply Chain		Usually for final distribution to retail stores but can be for manufacturer to wholesale distribution		Typically, late in the supply chain for final distribution to retail stores or local, smaller distribution centers	Typically, freight for final consumption (business-to-business and consumers)	Can be situated at multiple points in the supply chain (intermediate or final delivery)

[3] Cold storage products (e.g., flowers and other perishables) that are not frozen must be shipped within hours or a few days. Cold storage products that are frozen may take a long time to ship. Products in these facilities may be treated more like typical HCW products.

	Standard Warehouse/ Storage	Transload Facility	Short-Term Storage	Cold Storage	Fulfillment Center	Parcel Hub
Location	Typically in an industrial area within urban area or urban periphery	Typically in an area with convenient freeway access; often in rural or urban periphery area	Typically in an area with convenient freeway access	Depends on supply and demand markets	Often near a parcel hub or USPS facility, due to time sensitivity of freight	Typically in close proximity to airport; often stand-alone
Overall Site Layout						
Employee Parking		Smaller employee parking ratio (per facility square foot) than fulfillment center or parcel hub	Smaller employee parking ratio (per facility square foot) than fulfillment center or parcel hub		Larger parking supply ratio than for all other HCW types	Larger employee parking ratios; truck drivers often based at facility (i.e., parking may be for both site employees and drivers)
Truck & Trailer Parking	Limited truck parking area; increases with distance to major distribution hub	Large, open trailer parking area surrounding facility; produces high land to building ratio	Ratio of truck parking spaces to docks can vary between 0.5:1 and 1.5:1, with 1:1 being very common	Can vary with whether products are frozen or perishable[4]	Significantly higher truck parking ratios than for other HCWs	Very high truck parking ratios to dock positions, often 2:1 or more
Loading Dock Location	Either on one side or on two adjacent sides	Minimum of two sides (adjacent or opposite); can be on four sides	On either one or two sides			Usually on both long sides of building; can be on four sides
Building Dimensions						
Length vs. Depth		Typical length vs. depth ranges between 3:1 and 2:1; shallower than Standard	Typical length vs. depth is 2:1; shallower than Standard			Typical configuration is cross-dock; building typically more shallow (150-300 feet across) than other HCWs

[4] Cold storage product handling must be done quickly. Any product stored in a trailer on the site requires either an idling truck or an external power supply to maintain the temperature within the required ranges.

	Standard Warehouse/ Storage	Transload Facility	Short-Term Storage	Cold Storage	Fulfillment Center	Parcel Hub
Ceiling Height	Typically between 28 and 40 feet	Typically, lower than for other HCW	Typically between 28 and 34 feet, with some facilities in excess of 40 feet	Typically higher (70-100 feet) to maximize efficiency of refrigeration; frozen food tends to have a higher ceiling than produce handling	Often as high as 40 feet in order to accommodate up to three levels of interior mezzanines	Typically not as tall as other HCW; commonly between 18 and 20 feet range; racking not usually provided (i.e. floor-stack only)
Number of Docks	Low number of dock positions to overall facility, 1:20,000 square feet or lower	Typical dock-high loading door ratio is 1:10,000 square feet; common range between 1:5,000 & 1:15,000 square feet	Typically, 1:10,000 square feet or lower			
Automation						
Material Handling Systems	Little or no automation; mechanization limited to pallet jacks and forklifts	Very highly-mechanized material handling systems	Very highly-mechanized material handling systems; high ratio of material handling equipment to overall floor area	Very high clear height requires sophisticated material handling equipment	High levels of automation in material handling equipment	High levels of automation in material handling equipment
Conveying Systems	Little or no automation	Usually automated mechanized conveying	Usually limited automated conveying	Very high clear height requires a sophisticated conveyance system	High levels of automation in conveying systems	High levels of automation in conveying systems
Warehouse Mgmt Systems (WMS)		Some facilities use ASRS (Automated Storage and Retrieval Systems)			High levels of automation; some use of ASRS	High levels of automation

Table 2. Additional Descriptive Features

Typical Floor Area Ratios range between 35 and 60 percent. Standard, Fulfillment Center, and Parcel Hub sites tend to have higher values than Transload and Short-Term Storage HCW.

Office/Employee Welfare[5] Space is highly variable and is insignificant within overall building square footage. Common values are between 3,000 and 5,000 square feet for Cold Storage and between 5,000 and 10,000 square feet for Transload Facility, Fulfillment Center, and Parcel Hub.

Movement of Goods in Trucks – For a Transload site, typical truck movements are comprised of full load, large trailers, both inbound and outbound. For some “last mile” or local distribution centers, long-haul trucks or international containers can arrive loaded and depart empty, while local delivery trucks arrive empty and depart loaded. For national and regional distribution centers, trucks can come in loaded and re-load with different product mix and depart loaded.

Hours of Operation and Peak Periods – Peak truck movement activity is often outside the peak commuting period on the adjacent street system. HCW operations are often 24 hours per day, every day of the year. For a Standard site, there is a greater likelihood that the site peak period of traffic operations may coincide with or be near the street peak period.

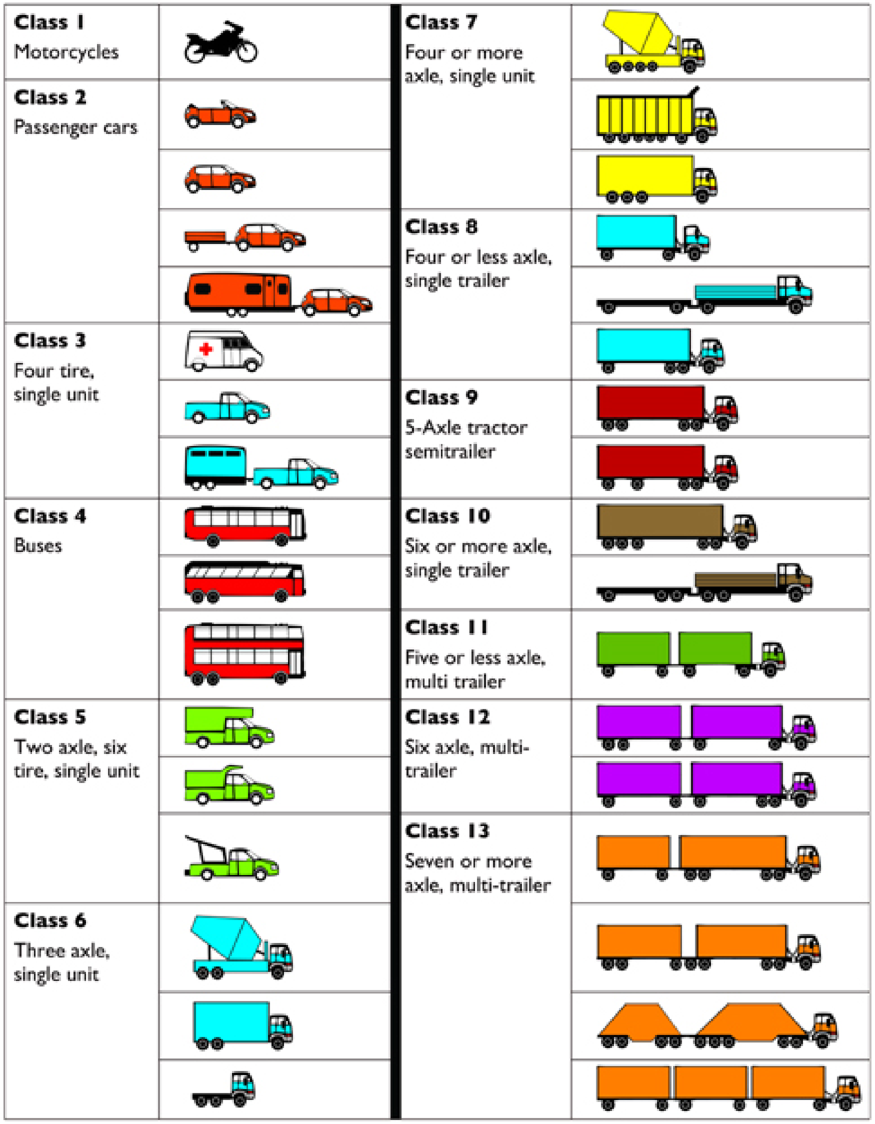
Truck Sizes – Truck size can vary significantly between similar sites. Sizes and types are a function of the origins and destinations of the goods processed at the facility (i.e., location in the supply chain). Local deliveries to business/residential customers are commonly made with smaller trucks (except warehouses that, for example, deliver bulky items to a home improvement store). Longer distance travel or deliveries at early stages in the supply chain are typically with larger trailers. For Cold Storage and Fulfillment Center, the outbound trucks are often smaller because of cargo weight and last-mile distribution needs. Intermediate hubs accommodate large trucks on both the inbound and outbound side (e.g., FedEx Ground). "Final delivery" hubs have small trucks on the outbound side (e.g., FedEx Overnight).

[5] Employee welfare area includes restrooms, locker rooms, and break rooms.

VEHICLE CLASSIFICATION FOR WAREHOUSE TRIP GENERATION DATA

The preferred vehicle classification scheme should satisfy both the ultimate needs for TIA and AQA analysis and comply with reasonable data collection capabilities and budgets. FHWA maintains a 13-category classification system for motorized vehicles (presented in Figure 1 and maintained at the following website: http://www.fhwa.dot.gov/policyinformation/tmguide/tmg_2013/vehicle-types.cfm).

Figure 1. FHWA Vehicle Classification Types



The vehicle types that enter and exit a HCW site can be separated to correspond to individual "markets:"

- Vehicles used for employee and facility service access (i.e., for goods and services consumed on site)
- Vehicles used for local delivery access (e.g., wholesale and retail delivery for consumption in the local metropolitan area)
- Vehicles used for high-volume transfer (e.g., long-distance freight, relay distribution to other distribution or warehouse facilities)

A simple and straightforward correlation between "markets" and the 13 FHWA classifications is as follows:

1. Facility Access: includes Classes 2 and 3 (passenger cars and light trucks), and Classes 1 and 4 (motorcycles and buses) if observed
2. Local Goods Movement: includes Classes 5 through 7 (two-, three-, and four-axle single-unit trucks)
3. Long Distance Goods Movement: includes Classes 8 through 13 (multi-unit trucks)

A significant limitation to this classification scheme is the growing disconnect between truck size and trip length over time. They do not correlate as well for many carriers as they did in the past. There is a wide range of practices in deliveries and many prominent retail chains currently use trucks in Classes 8 and 9, for example, for local deliveries. In other words, a Class 8-13 vehicle is not necessarily a long-distance truck trip.

The primary advantage of mapping these vehicle types to the FHWA classification scheme is that commercially available automated monitoring equipment is generally capable of reporting the FHWA vehicle classes without specialized data interpretation.

Encouraging agencies to develop local counts of these facilities will also be more successful if the agencies can use standard automated counters without specialized software, even at the expense of occasional misclassification relative to "ideal" categories for a warehouse trip generation study. Video detection could make more information available, but at greater expense for data processing.

It is also important to recognize that counting equipment manufacturers (and often representatives of a public agency) are able to reprogram automated counters to use an alternate classification scheme. For example, if there is a specific axle configuration commonly used for domestic container freight versus international container freight at a particular data collection site, it may be feasible to detect. Such schemes are relatively easy to share among agencies using the same types of equipment.

As noted above, the observed physical vehicle type based on a FHWA class may not provide sufficient information on its own to identify the "purpose" of the truck trip. The classification scheme may need to be adjusted to reflect the specific trip-making to and from a subject warehouse site. The following are examples of refinements that could be necessary given the particular characteristics of a warehouse site:

1. Even in a standard traffic monitoring application, the distinction between a passenger car (Class 2) and a light truck (Class 3: pickups, large SUVs, vans) has limited benefit and is difficult to establish decisively. For the warehouse trip generation application, the merging of these classes should improve overall accuracy.
2. Local goods movement may also include Class 3 vehicles (specifically two-axle vans). If separate driveways are used for goods movement and general facility access, the Class 3 vehicles in the goods movement driveway can be considered local goods movement vehicles.
3. It is sometimes difficult for automated equipment to distinguish between a Class 4 vehicle (bus) and a Class 5/6 truck. In the rare circumstance where a bus enters or exits a warehouse site driveway, a manual count or simple reference to a published transit service schedule may be necessary.
4. Class 5 vehicles include "dualie" pickups which may operate as personal vehicles for facility access or as larger panel trucks often used for local goods delivery. The presence of and use of separate driveways for goods movement and general facility access may be the only means to distinguish between the two types of uses.

DATA NEEDS FOR TIA AND AQA

Typical data requirements for TIA and AQA are listed in Table 3. Some measures are used to classify a building type. Some measures can be used as independent variables with a direct relationship to the quantity of vehicle trips generated by a site (by vehicle type).

Table 3. Data Needs for HCW Trip Generation Analysis

Vehicle Trip Data	TIA	AQA
Vehicle Trips by Vehicle Classification		
• 2 classifications – car, truck	√	
• 4 classifications – personal passenger vehicle, parcel delivery, single unit truck, tractor-trailer combination	*[6]	√
Vehicle Trips by Time-of-Day (by vehicle classification)		
• Directional 15-minute volumes on a weekday (typically Tuesday, Wednesday, or Thursday)		
o AM peak hour for generator	√	
o AM peak hour for adjacent street	√	
o PM peak hour for generator	√	
o PM peak hour for adjacent street	√	
• Non-directional 24-hour volume on a weekday		√
Vehicle Trips by Driveway (if employees and freight delivery use separate driveways)	√	√
Vehicle Trips within Context of Seasonal Variations		
• Daily Variations	√	√
• Monthly Variations		√
• Highest Day of Year		√
Independent Variable Data		
Building Size		
Building GSF[7] (total, office, retail, manufacturing/enhancements, storage/distribution)	√	√
Building Volume (cubic feet)	√	√
Building Shape (length-to-depth ratio)		√
Number of High-Loading docks	√	√
Building Function		
Cold Storage Provided	√	√
NAICS Industrial Code	√	√
Employees	√	√
Commodity type (retail, manufacturing, other)	√	√
Where in Supply Chain (parts, manufacturer/assembly, wholesale/distributor, retailer)		√
Site Size		
Site acres	√	√
Floor area ratio (FAR)	√	√
Parking spaces (employee/visitor, truck/trailer)	√	√
Site Context		
Area type (urban, suburban, rural)	√	√
Distance to port (seaport, intermodal center, regional air cargo)	√	√

[6] Some TIA may require truck classification information.
[7] GSF is gross square footage of the building.

ASSEMBLY AND CLASSIFICATION OF CURRENTLY AVAILABLE DATA

Data from the following studies were compiled and analyzed for possible use in the trip generation analysis for the High-Cube Warehouse study:

- Warehouse Truck Trip Study, Data Results and Usage, South Coast Air Quality Management District, Diamond Bar, CA 2014
- Trip Generation Analysis for High-Cube Warehouse Distribution Center, prepared for NAIOP by Kunzman Associates, Laguna Hills, CA 2011
- Trip Generation Characteristics of Discount/Home Improvement Superstores, Major Distribution Centers, and Small Box Stores, prepared for Florida Department of Transportation by Wilbur Smith Associates 2011
- Western Riverside County Warehouse/Distribution Center Trip Generation Study, prepared for NAIOP by Crain & Associates, Los Angeles, CA 2008
- Westside Industrial Park Warehouse Trip Generation, prepared for Premier Airport Park by King Engineering Associates, Jacksonville, FL 2008
- Trip Generation Study, Existing High-Cube Warehouse Facilities, Visalia CA, prepared for The Allen group by Peters Engineering Group, Clovis CA 2008
- Large-Scale Retail Distribution Centers, prepared for Walmart Sores, Inc. by Kimley-Horn and Associates, Tampa, FL 2007
- Trip Generation Study, High-Cube Warehouse Buildings, Fresno, California, prepared for Diversified Development Group by Peters Engineering Group, Clovis CA 2007
- Trip Generation Study, High Cube Warehouse, prepared by Schoor Depalma, Manalapan, NJ 2006
- San Bernardino/Riverside County Warehouse/Distribution Center Vehicle Trip Generation Study, prepared for NAIOP by Crain & Associates, Los Angeles, CA 2005
- Truck Trip Generation Study, prepared for City of Fontana (CA) by Transportation Engineering and Planning, Inc. 2003
- Trip Generation Analysis for High-Cube Warehouses, prepared for City of Livermore, CA by Fehr & Peers Associates, Lafayette, CA 1989

The data also includes site trip generation data provided by Texas A&M Transportation Institute (2008-2009), Randall Parker (2007), and Washington State Department of Transportation (2002).

The data were reviewed for their applicability and only acceptable sites with appropriate data are used in the analysis presented in the following section of this report. Some of the purported high-cube warehouses are instead standard storage warehouses or multi-building industrial parks. Some of the high-cube warehouse data for individual sites could not be used due to unexplained data characteristics (e.g., a significant imbalance in inbound and outbound daily vehicle trips).

The final current database of HCW sites contains 107 data records with varying degrees of vehicle classification data and of daily and peak hour traffic counts.

HIGH-CUBE WAREHOUSE TRIP GENERATION DATA ANALYSIS[8]

Classification of Individual Data Records

Each record in the database of HCW sites was classified as one of five building types, defined earlier in this report. The criteria used to classify the sites represent information that is likely to be available at the time of site development review.

The database includes one fulfillment center, one parcel hub, and nine HCWs with a significant cold storage component[9]. The remaining 95 HCWs were separated into transload and short-term storage HCW based on two building configuration criteria:

- A transload building is assumed to have a length-to-depth ratio of at least 2:1 and has loading docks on at least two sides (either opposite or adjacent); there are 56 transload data points
- The remaining HCW sites (i.e., those that are not considered transload, cold storage, fulfillment center, or parcel hub) are classified as short-term storage HCWs; they total 39 sites

Building configuration is known at the time of site development review but has the limitation of not necessarily being indicative of the function of the HCW activities. If additional characteristics can be identified that (1) are predictive of the HCW function and (2) are available at the time of site development review, the database can be reexamined and potentially reclassified and reanalyzed.

Key Findings – Cars vs. Total Vehicles

There is a significant correlation between the number of cars that enter and exit a HCW site and the total number of vehicles that enter and exit a HCW site.

Table 4 lists the weighted averages for cars as a percentage of the total site-generated traffic at the five types of HCW. At short-term storage, transload, and cold storage HCWs, nearly 68 percent of the total daily site-generated vehicle trips are cars. During the AM peak hour, the measured percentage of cars is markedly similar (69 percent) to the daily (68 percent). During the PM peak hour, the measured percentage of cars is significantly higher (78 percent) than the daily value. The higher car percentage (and therefore, the lower truck percentage) is likely due to truck operations avoiding the afternoon peak period.

The fulfillment center has a significantly higher percentage of cars during the AM and PM peak hours and daily (due largely to the significantly higher number of employees at a fulfillment center compared to the other types of HCWs). The parcel hub has a significantly lower percentage of cars (and therefore a higher percentage of trucks) during the AM and PM peak hours and daily.

Table 4. Weighted Averages for Percentage of Total Daily Vehicles that are Cars, by Type of HCW

Type of High-Cube Warehouse	Cars as Percentage of Total Vehicles		
	Daily	AM Peak Hour	PM Peak Hour
Short-Term Storage, Transload & Cold Storage (100)	67.8%	69.2%	78.3%
Fulfillment Center (1)	91.2	97.2	98.2
Parcel Hub (1)	62.3	50.3	70.7

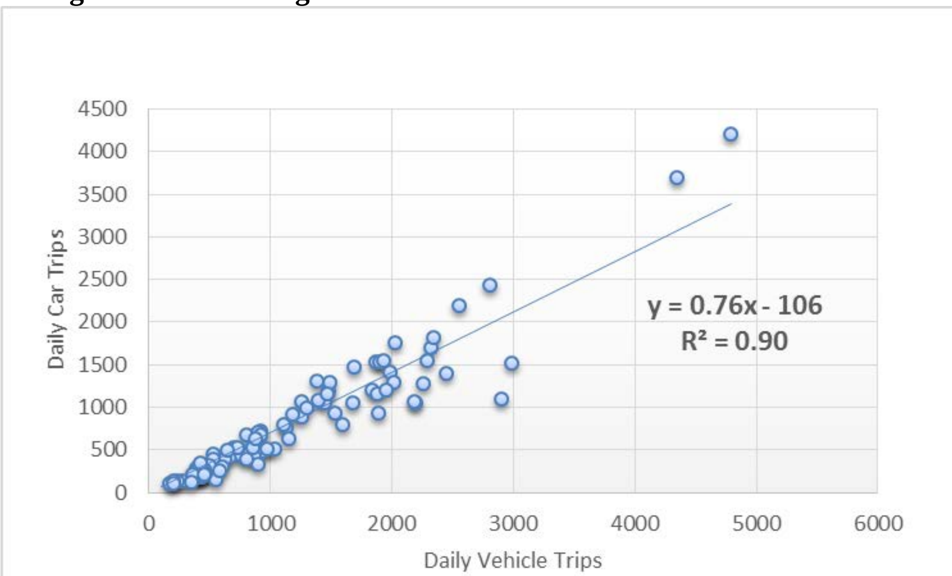
Note: The values in parentheses represent the number of data collection sites for HCW type.

[8] This section presents key analysis findings. Appendix A presents additional analyses of the HCW data.

[9] Sites were classified as cold storage either through self-categorization by data submitter (e.g., Walmart), by type of tenant (e.g., Ralphs, Publix), or by online site description (e.g., Americold, Millard Refrigeration Services).

Figure 2 is a plot of daily car trips versus daily vehicle trips generated at transload, short-term storage, and cold storage HCWs. The plot demonstrates strong correlation between the two trip-making characteristics of HCW sites. The data yields a linear fitted curve equation with an R^2 value of 0.90. The correlation between the daily truck trips and daily vehicle trips is not as strong and yields a linear fitted curve equation R^2 value that is less than the ITE acceptability threshold of 0.50.

Figure 2. Correlation between Daily Cars and Total Daily Traffic at Transload, Short-Term Storage and Cold Storage HCW Sites



Key Findings – Daily Trip Generation

Table 5 compares daily trip rates for the five different types of HCWs. The table includes weighted average rates for all vehicles, cars, trucks, and 5-or-more-axle trucks. The table also includes the weighted average rate for daily vehicle trips contained in ITE *Trip Generation Manual* 9th Edition, for high-cube warehouses (land use code 152). The single fulfillment center count was taken during a holiday shopping season when activity would be expected to be higher than an annual average.

Table 5. Weighted Average Rates for Daily Trips at High-Cube Warehouses

Type of High-Cube Warehouse	Weighted Average for Daily Trips per 1,000 GSF[10]			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
Transload & Short-Term Storage (91)	1.432	1.000	0.454	0.233
Cold Storage (9)	2.115	1.282	0.836	0.749
Fulfillment Center (1)	8.178	7.461	0.717	0.242
Parcel Hub (1)	10.638	6.631	4.007	0.982
ITE *Trip Generation Manual* – 9th Edition	1.68	--	--	--

Note: The values in parentheses represent the number of data collection sites for HCW type.

[10] The weighted average rates for cars and trucks may not sum to match the "all vehicle" rates because some data sources collected total vehicle trips and did not separate cars and trucks.

Fulfillment Center and Parcel Hub

Based on data from single data points, it is likely that vehicle trip generation rates for fulfillment centers and parcel hubs are significantly different from those at other HCW sites.

The single fulfillment center has a substantially higher vehicle trip generation rate than transload, short-term storage, and cold storage HCW sites. The higher rate is due both to a higher number of passenger cars (i.e., employees) entering and exiting the site and to the count being conducted in December during the holiday shopping season.

The single parcel hub HCW has a rate that is higher than even the fulfillment center for all vehicles. The rate for trucks (both total and 5+ axle) is substantially higher than for the other HCW types.

Cold Storage

For the relatively small number of data points in the HCW database that are classified as cold storage facilities, there is a strong correlation between vehicle trips and building gross square footage.

Figure 3 is a plot of daily total vehicle trips versus building gross square footage at all cold storage facilities in the database. The data yields a linear fitted curve equation with an R^2 value of 0.69. As recommended in ITE *Trip Generation Handbook* 3rd Edition, the fitted curve should be considered acceptable only within the building site size range in the dataset[11]. The weighted average rate (shown above in Table 5) is 2.115 total vehicles per 1,000 GSF for a cold storage HCW site.

Figure 3. Correlation between Daily Total Vehicles and Cold Storage GSF (All Sites)

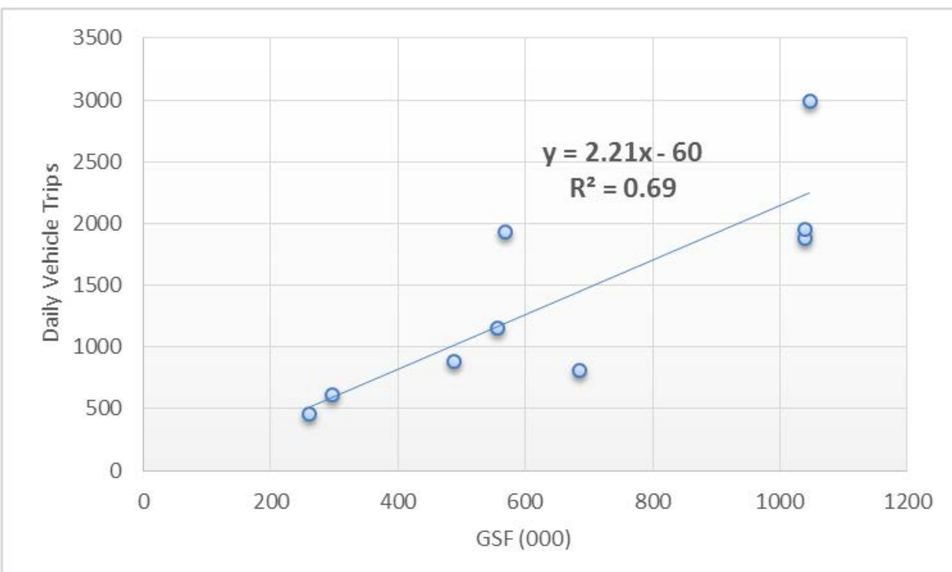
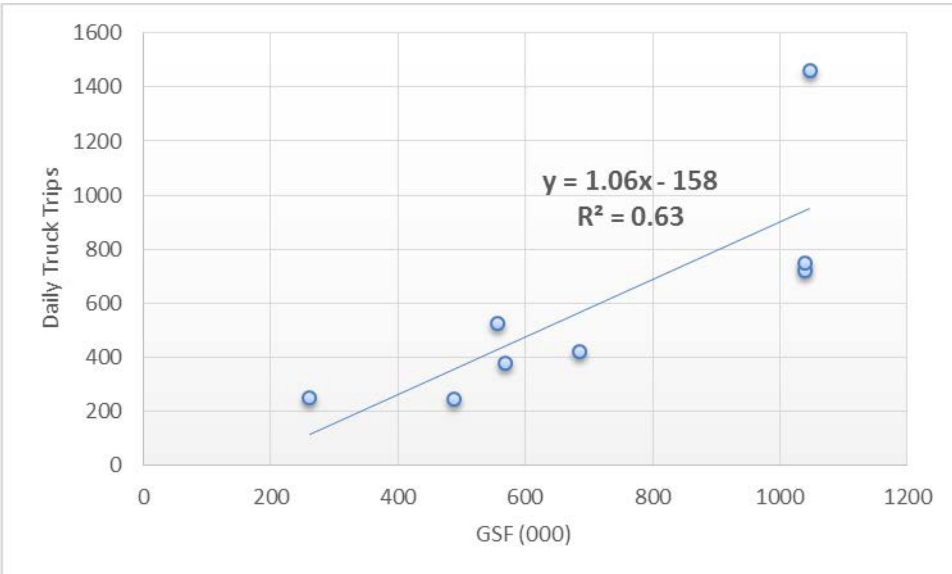


Figure 4 presents the data plot for daily trucks. The plot includes a fitted curve equation with an acceptable R^2 value. The weighted average rate for daily trucks at a cold storage HCW is 0.836 trucks per 1,000 GSF.

[11] The best correlation is found for sites with gross square footage of 500,000 or less, with greater data scatter for larger buildings. Nevertheless, there are several sites with gross square footage of more than 500,000 that have daily vehicle trip generation rates that mirror the small sites.

Figure 4. Correlation between Daily Trucks and Cold Storage GSF (SCAQMD & NAIOP Sites)



Transload and Short-Term Storage

It would be expected that a transload site could generate a different number of vehicle trips than a short-term storage HCW. But, as currently classified in this report, the sites that fall into the two categories show very little difference between the two. Therefore, the two types are analyzed together in this report. If an appropriate building characteristic can be identified at the time of site development review, the sites in the database can be re-examined and potentially reclassified and the trip-generating characteristics reanalyzed.

For this combination of HCW types, the relationship between building gross square footage and vehicle trips does not produce an acceptable level of correlation to develop a fitted curve equation. Figure 5 presents a plot of daily vehicle trips against building square footage.

The weighted average rate for transload and short-term storage HCW sites is 1.432 daily vehicle trips per 1,000 GSF (listed earlier in Table 5). As a point of comparison, this rate is lower than the weighted average rate of 1.68 provided in ITE *Trip Generation Manual* 9th Edition, for the High-Cube Warehouse land use.

The transload and short-term storage HCW dataset is much larger than the other HCW datasets. This larger dataset exhibits much greater scatter than the smaller datasets. This circumstance suggests that more data for the other HCW facility types are necessary to determine if the small dataset high correlations are accurate and justified.

Figure 5. Daily Vehicle Trips at Transload and Short-Term Storage HCW

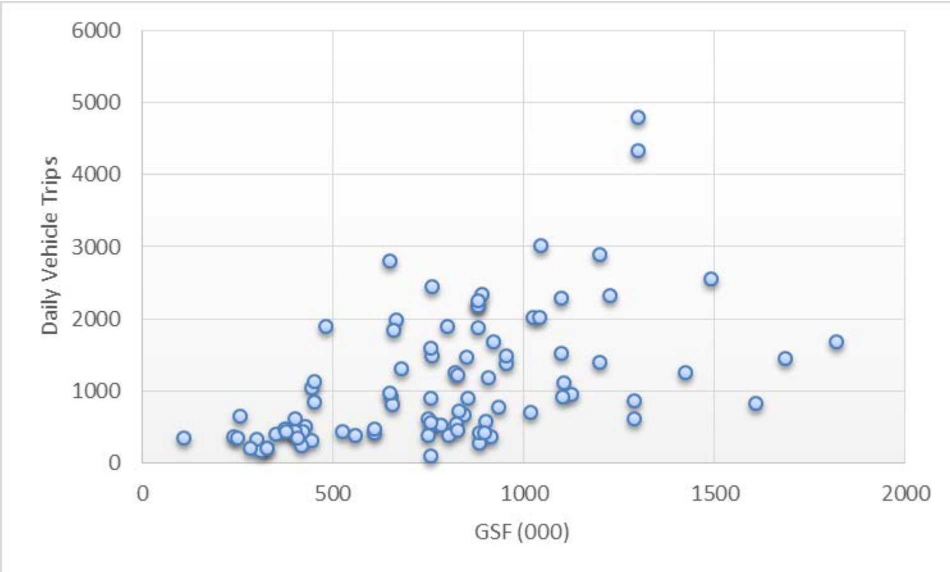
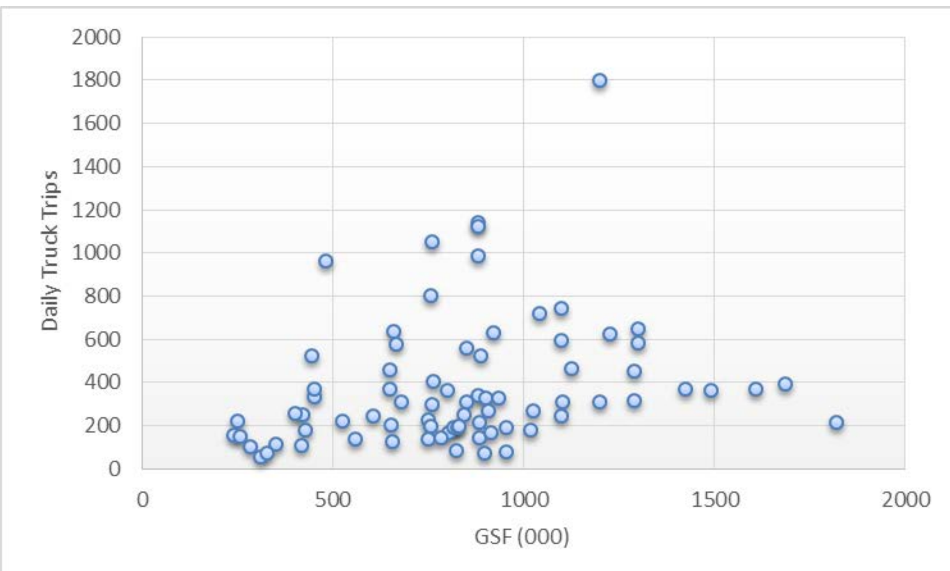


Figure 6 presents a plot of daily truck trips against building square footage at transload and short-term storage HCW. For trucks, the weighted average rate is 0.454 trucks per 1,000 GSF.

Figure 6. Daily Truck Trips at Transload and Short-Term Storage HCW



Key Findings – Peak Hour Trip Generation

Tables 6 and 7 list the weighted average rates for the AM and PM peak hours, respectively, for the five types of HCWs. The tables also include the weighted average rate for peak hour vehicle trips contained in ITE *Trip Generation Manual* 9th Edition, for high-cube warehouse (land use code 152).

Table 6. Weighted Average Rates for AM Peak Hour Trips at High-Cube Warehouses

Type of High-Cube Warehouse	Weighted Average for AM Peak Hour Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
Transload & Short-Term Storage (94)	0.082	0.057	0.024	0.015
Cold Storage (9)	0.103	0.061	0.038	0.027
Fulfillment Center (1)	0.841	0.818	0.023	0.009
Parcel Hub (1)	0.851	0.428	0.423	0.041
ITE *Trip Generation Manual* – 9th Edition	0.11	--	--	--

Note: The values in parentheses represent the number of data collection sites for HCW type.

Table 7. Weighted Average Rates for PM Peak Hour Trips at High-Cube Warehouses

Type of High-Cube Warehouse	Weighted Average for PM Peak Hour Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
Transload & Short-Term Storage (95)	0.108	0.086	0.023	0.010
Cold Storage (9)	0.129	0.087	0.042	0.031
Fulfillment Center (1)	1.979	1.944	0.035	0.013
Parcel Hub (1)	0.803	0.568	0.235	0.009
ITE *Trip Generation Manual* – 9th Edition	0.12	--	--	--

Note: The values in parentheses represent the number of data collection sites for HCW type.

Fulfillment Center

The single surveyed fulfillment center HCW has a significantly higher rate for passenger cars during both the AM and PM peak hours (as is the case for daily trips at the fulfillment center). The single fulfillment center count was taken during the December holiday shopping season.

The single surveyed parcel hub HCW has significantly higher rates for both cars and trucks during both the AM and PM peak hours (as is the case for daily trips at the fulfillment center).

Cold Storage

For cold storage HCW, fitted curve equations can be developed for estimating total vehicles during the AM and PM peak hours. The equations are:

- AM peak hour: $y = 0.17x – 40$ ($R^2 = 0.82$)
- PM peak hour: $y = 0.17x – 35$ ($R^2 = 0.83$)

The cold storage HCW weighted average rates during the AM and PM peak hours are, respectively, 0.103 and 0.129 total vehicle trips per 1,000 GSF. Both rates are close to the ITE *Trip Generation Manual* 9th Edition rate for all high-cube warehouses (land use code 152).

Transload and Short-Term Storage

Data plots for the AM and PM peak hours (not presented in this report) are comparable to the daily plot in terms of data scatter and little correlation. The weighted average rates for the AM and PM peak hours are:

- 0.082 total vehicles per 1,000 GSF during the AM peak hour
- 0.108 total vehicles per 1,000 GSF during the PM peak hour

As points of comparison, these rates are lower than the AM and PM weighted average rates of 0.11 and 0.12, respectively, provided in ITE *Trip Generation Manual* 9th Edition for the High-Cube Warehouse land use.

The weighted average rates for truck trips at transload and short-term storage HCWs during the AM and PM peak hours are:

- 0.024 trucks per 1,000 GSF during the AM peak hour
- 0.023 trucks per 1,000 GSF during the PM peak hour

RECOMMENDATIONS

The preceding analysis of available HCW trip generation data identified significant weaknesses in the ability to forecast vehicle trips with confidence. The following recommendations present a plan of action for quantifying necessary vehicle trip estimates to an acceptable level of precision for all types of HCWs.

Fulfillment Center HCW

The single available data point indicates that the trip generation characteristics (total vehicle trips and trips by vehicle type) for a fulfillment center HCW are significantly different from those for all other types of HCWs. A targeted data collection effort should be undertaken (as described below) to achieve a total of at least six sites. Included should be circulation of a Call for Data by ITE that specifically requests data for fulfillment centers. If future analysis reveals an unacceptable level of stability in the trip generation relationships, data should be collected at additional sites.

Parcel Hub HCW

The single available data point indicates that the trip generation characteristics (total vehicle trips and trips by vehicle type) for a parcel hub HCW are significantly different from those for all other types of HCWs. It is recommended that ITE circulate a Call for Data that specifically requests data for parcel hubs. A targeted data collection effort should be undertaken (as described below) to achieve a total of at least six sites. If future analysis reveals an unacceptable level of stability in the trip generation relationships, data should be collected at additional sites.

Cold Storage HCW

The limited data available for cold storage facilities produce acceptable levels of statistical precision for the estimation of vehicle trips. However, vehicle trip generation rates based on recently collected data are higher than those derived from data collected at least 10 years ago. It is recommended that (1) further investigation be made into the existing data and (2) additional data be collected.

The cold storage sites in the database are classified as such based on the interpretation of the data submitter. Confirmation of the applicability of the cold storage classification can be completed through determination of the proportion of the HCW building space devoted to cold storage. This information will also help in the development of a clear definition of cold storage facilities and their characteristics.

If some of the cold storage sites are reclassified, a targeted data collection effort should be undertaken (as described below) to achieve a total of at least six sites. Included should be circulation of a Call for Data by ITE that specifically requests data for cold storage facilities. If future analysis reveals an unacceptable level of stability in the trip generation relationships, data should be collected at additional sites.

Transload and Short-Term Storage HCW

The current database of sites for this subset of HCW types has been separated in accordance with building and dock configurations specified earlier in this report. To use a metaphor, it is possible that instead of separating the sites into apples and oranges, the sites have been separated into two sets that each contain both apples and oranges. The result is a pair of databases that (1) are not significantly different from each other in terms of trip generation and (2) do not yield satisfactory levels of correlation between building gross square footage and vehicle trips. It is possible that a more accurate allocation of the available data points between the two types of HCWs could produce better predictive relationships.

It is recommended that an analysis and evaluation of potential stratifications be undertaken and an appropriate set of data (along with a weighted average rate) be selected for use as interim rates until further study is complete (as described below).

Overall

It is recommended that a targeted data collection plan be undertaken in an attempt to further define and identify relationships between potential independent variables and vehicle trips generated at each type of HCW. A six-step process is presented below.

Step 1: Select 15 Sites[12] with Similar Characteristics for Data Collection and Further Analysis

- For each site, compile the data specified earlier in Table 3
- If the Table 3 data are available for the sites at which SCAQMD or NAIOP collected data, these sites and their data can be considered part of the initial 15
- Limit sites to one or two metropolitan regions. Preference should be given to a region with an existing freight model that disaggregates truck trips and commodity flow to the county or traffic analysis zone level, for cross-referencing purposes.

Step 2: Collect Data at the Initial 15 Sites

- Collect the vehicle volume data specified in Table 8

Step 3: Analyze Complete Data for Consistency and Correlation with One or More Independent Variables

- If consistency and correlations are found, skip to Step 5

Step 4: Identify 15 Additional Sites and Undertake Data Collection

- Summarize and analyze results, assessing consistency
- The results will set an approximate expectation for future data. They may be described statistically and/or in other clear terms.
- If variability is still considered significantly high by ITE standards, assess probable causes, further partition data into more subgroups, and reanalyze data. Use results to determine how to classify warehouse types for future data collection.

Step 5: Identify 15 Sites and Collect Data for Next Priority HCW Classification

- 15-30 sites (including usable existing data) in at least two metropolitan regions (may be selected to reflect funding sources)
- 3 year-long counts
- Compare year-long counts from second HCW type with those from first HCW type to determine if additional year-long counts are needed to show variability in different types of HCWs

[12] For a database with substantial uniformity in the characteristics that influence trip generation, a relatively small number of sites can produce predictive relationships with excellent statistical reliability (for example, perhaps the cold storage facilities). However, for sites with substantial variability, a database total of approximately 30 sites is typically recommended based on the central limit theorem. The theorem states that the sampling distribution of the means will approach that of a normal distribution with that quantity of data points even if the population being sampled is not normally distributed.

Step 6: Summarize and analyze data for each type of HCW, developing rates and equations where correlation is suitable. Identify patterns, trends, and other findings relevant to estimating HCW trip generation for use in TIAs and AQAs. Assess how many HCW types are needed/justified.

Table 8. Minimum Data Collection for Each HCW Type

• 15 sites including those for which there are usable existing data
• One or two metropolitan regions – preference should be for a region with an existing freight model that disaggregates truck trips and commodity flow to the county or TAZ level, for cross-referencing purposes
• Similar site characteristics (to minimize variability of results (desirably most common in metro region where data to be collected)
• 1-2 NAICS industrial codes – we may need to loosen this requirement in order to find 15 acceptable sites in a single metropolitan area; we may need to use data from sites in multiple metropolitan areas; should be used in site selection process, not as a prescriptive requirement
• Year-long count at 3 sites
• All counts by video; all files to be retained for possible future use; examine via simultaneous video and tube counts what the discrepancy rates might be for purpose classification based physical vehicle types and standard FHWA classes versus actually seeing the trucks on video
• All counts to follow ITE site trip generation count procedures with counts being made directionally by vehicle classification and recorded by driveway, by direction, and by 15 minute period so they can be checked (and reconstructed if necessary)

APPENDIX A. SUPPLEMENTAL DETAILED DATA ANALYSIS

Data Analysis Process

The database of 106 HCWs with vehicle trip generation data consists of one fulfillment center, one parcel hub, nine cold storage, 56 transload, and 39 short-term storage.

For each data record, a range of traffic count data is available.

- For many records, a daily count is provided. For many records, AM and PM peak hour traffic counts are provided.
- For some data records, the count data is reported simply as total vehicles. In some records, the vehicle counts are classified as cars or trucks. In some records, the vehicle counts are classified as cars and trucks, disaggregated by number of axles.

The data were disaggregated and aggregated in a variety of ways to help determine the effects of certain potential variables on vehicle trip generation.

- The entire database for each facility type
- Only the recent SCAQMD-sponsored data collection sites
- Only the recent NAIOP-sponsored data collection sites
- The combination of the recent SCAQMD- and NAIOP-sponsored data collection sites
- All data except for the recent SCAQMD- and NAIOP-sponsored data collection sites
- Sites with at least 500,000 gross square footage
- Sites with at least 800,000 gross square footage
- Sites with at least 1 million gross square footage
- Sites with data collected prior to 2007
- Sites with data collected after 2006
- Sites with data collected prior to 2010
- Sites with data collected after 2009
- Only California sites
- Only sites with close proximity to major port facilities

The vehicle count data were analyzed separately for the fulfillment center, parcel hub, cold storage, transload, and short-term storage HCWs.

- The results for fulfillment center, parcel hub, and cold storage are distinctly different from each other and are addressed separately below
- The results for transload and short-term storage HCWs are not substantially different from each other and are treated in combination below

The database enabled the compilation of over 1,500 subsets of HCW trip generation data that reflect:

- 7 different combinations of building types,
- 6 different sets for individual vehicle classifications or combinations,
- 13 different subsets of the database, and
- 3 different time periods (daily, AM, PM)

Weighted averages of vehicles per 1,000 gross square feet in the building were computed for each subset. Data plots with best fit linear curves were prepared for each subset. Examination of the data yields very few definitive relationships between site characteristics and vehicle trip generation. Key findings from these analyses are presented below.

Cars vs. Total Vehicles

Table A1 presents the weighted averages for cars, trucks, and 5+ axle trucks as a percentage of total daily vehicles measured at HCW sites. Separate calculations are presented for the entire database and for13 different subsets. When the complete set is included, the overall average is approximately 68 percent cars and 32 percent trucks of the total daily vehicles. There is minimal variation between the most recent data sources (SCAQMD and NAIOP) or between different building sizes. However, the more recent average data (post-2006 and post-2009) has a higher proportion of cars than does the older data collection sites.

Table A1. Weighted Averages for Percentage of Total Daily Vehicles for Cars and Trucks

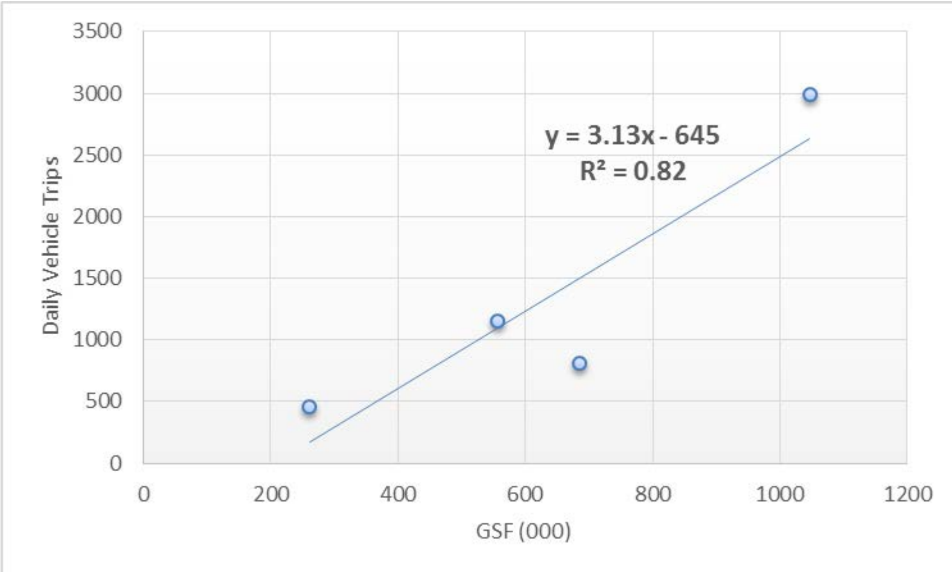
Data Site Subset	Percentage of Total Daily Vehicles		
	Cars	Trucks	5+ Axle Trucks
All	67.8%	32.2%	19.4%
SCAQMD	69.0	31.0	17.7
NAIOP	68.6	31.4	21.8
SCAQMD & NAIOP	68.8	31.2	19.0
Non-SCAQMD or NAIOP	66.6	33.4	---
More than 500,000 GSF	68.7	31.3	19.2
More than 800,000 GSF	69.4	30.6	18.5
More than 1,000,000 GSF	70.3	29.7	21.2
Pre-2007	62.1	37.9	---
Post-2006	70.1	29.9	19.5
Pre-2010	60.9	39.1	28.2
Post-2009	70.7	29.3	19.0
California Only	67.6	32.4	18.9

Cold Storage HCW

If the cold storage HCW data are restricted to only include data collected under sponsorship of SCAQMD and NAIOP within the past eight years, the correlation between daily total vehicles and site gross square footage can be improved beyond the full dataset correlation. Figure A1 presents the data plot and associated fitted curve[13]. As recommended in ITE *Trip Generation Handbook* 3rd Edition, the fitted curve should be considered acceptable only within the building site size range in the dataset.

[13] Granted, the improved correlation in Figure A3 is due in part to requiring correlation to only four data points.

Figure A1. Correlation between Daily Total Vehicles and Cold Storage GSF (SCAQMD & NAIOP Sites)



Correlation is also exhibited for cars, trucks, and 5+ axle trucks for daily traffic generated at cold storage facilities. Figures A2, A3, and A4 present the data plots for cars, trucks, and 5+ axle trucks, respectively. As recommended in ITE *Trip Generation Handbook* 3rd Edition, the fitted curves should be considered acceptable only within the building site size range in the dataset.

Figure A2. Correlation between Daily Cars and Cold Storage GSF (SCAQMD & NAIOP Sites)

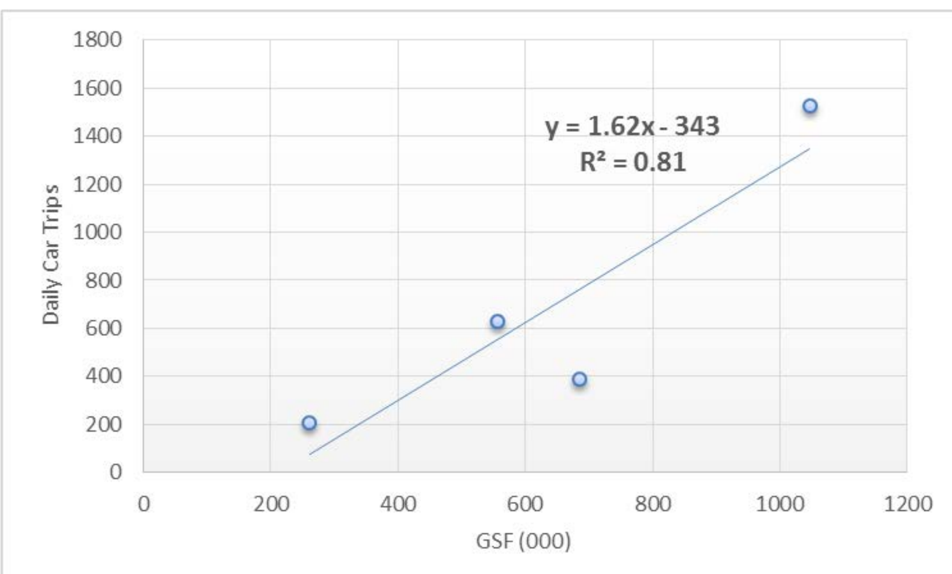


Figure A3. Correlation between Daily Trucks and Cold Storage GSF (SCAQMD & NAIOP Sites)

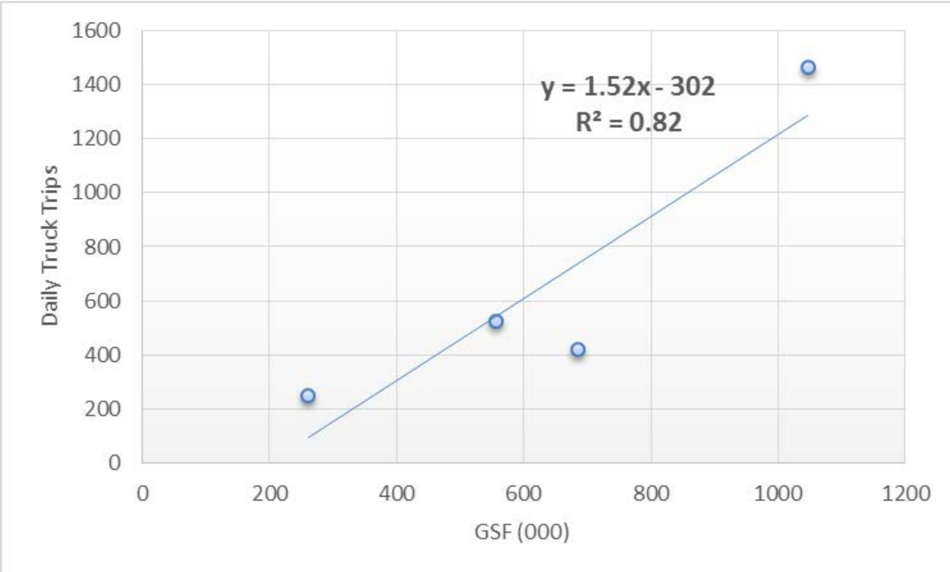


Figure A4. Correlation between Daily 5+ Axle Trucks and Cold Storage GSF (SCAQMD & NAIOP Sites)

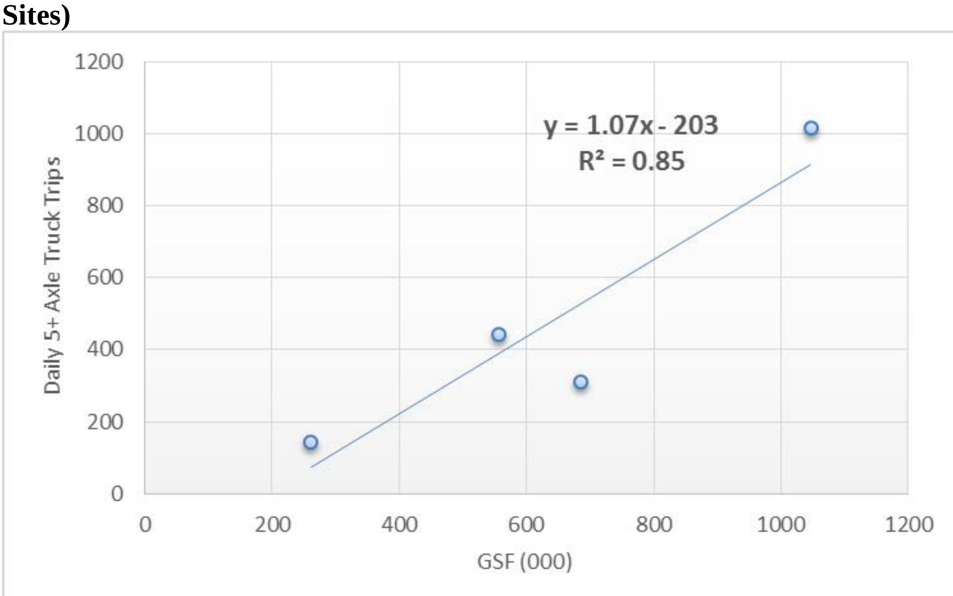


Table A2 presents the weighted average rates for all vehicles, cars, trucks, and 5+ axle trucks per 1,000 GSF at cold storage sites. Separate calculations are presented for the complete database plus 13 different subsets. When the complete set is included, the overall weighted average rate for all vehicles is 2.12. The rate is nearly identical whether calculated with only the SCAQMD and NAIOP data or with the other data points in the complete dataset.

Another observation from the table is that newer data (post-2006 and post-2009) have higher rates than do the older data, sometimes substantially higher. The newer and older datasets are comprised of relatively small numbers of data points, 6 and 3, respectively. Additional data points would be helpful to derive a more reliable estimate of cold storage HCW trip generation.

Table A2. Weighted Average Rates for Daily Trips at Cold Storage Facilities

Data Site Subset (Cold Storage)	Weighted Average for Daily Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
All (9)	2.115	1.282	0.836	0.749 (4)
SCAQMD (3)	2.466	1.265	1.201	0.858
NAIOP (1)	1.179	0.564	0.615	0.455
SCAQMD & NAIOP (4)	2.120	1.077	1.043	0.749
Non-SCAQMD or NAIOP (5)	2.111	1.449	0.667	---
More than 500,000 GSF (5)	2.009	1.121	0.888	0.772
More than 800,000 GSF (3)	2.179	1.242	0.938	0.968
More than 1,000,000 GSF (3)	2.179	1.242	0.938	0.968
Pre-2007 (3)	1.868	1.134	0.706	---
Post-2006 (6)	2.278	1.368	0.910	0.749
Pre-2010 (3)	1.868	1.134	0.706	---
Post-2009 (6)	2.278	1.368	0.910	0.749
California Only (5)	2.114	1.077	1.043	0.749
Port Only (5)	2.114	1.077	1.043	0.749

Note: The values in parentheses represent the number of data collection sites for that particular subset of cold storage sites.

Tables A3 and A4 repeat the information presented in Table A2, but for the AM and PM peak hours, respectively.

Table A3. Weighted Average Rates for AM Peak Hour Trips at Cold Storage Facilities

Data Site Subset (Cold Storage)	Weighted Average for AM Peak Hour Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
All (9)	0.103	0.061	0.038	0.027
SCAQMD (3)	0.124	0.070	0.054	0.026
NAIOP (1)	0.071	0.039	0.032	0.029
SCAQMD & NAIOP (4)	0.110	0.062	0.048	0.027
Non-SCAQMD or NAIOP (5)	0.098	0.061	0.030	---
More than 500,000 GSF (5)	0.092	0.054	0.038	0.028
More than 800,000 GSF (3)	0.099	0.058	0.041	0.030
More than 1,000,000 GSF (3)	0.099	0.058	0.041	0.030
Pre-2007 (3)	0.084	0.046	0.025	---
Post-2006 (6)	0.115	0.070	0.045	0.027
Pre-2010 (3)	0.084	0.046	0.025	---
Post-2009 (6)	0.115	0.070	0.045	0.027
California Only (5)	0.116	0.062	0.048	0.027
Port Only (5)	0.116	0.062	0.048	0.027

Note: The values in parentheses represent the number of data collection sites for that particular subset of cold storage sites.

Table A4. Weighted Average Rates for PM Peak Hour Trips at Cold Storage Facilities

Data Site Subset (Cold Storage)	Weighted Average for PM Peak Hour Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
All (9)	0.117	0.080	0.037	0.029
SCAQMD (3)	0.129	0.087	0.042	0.031
NAIOP (1)	0.089	0.050	0.039	0.026
SCAQMD & NAIOP (4)	0.118	0.077	0.041	0.029
Non-SCAQMD or NAIOP (5)	0.117	0.083	0,034	---
More than 500,000 GSF (5)	0.106	0.069	0.037	0.029
More than 800,000 GSF (3)	0.116	0.079	0.037	0.029
More than 1,000,000 GSF (3)	0.116	0.079	0.037	0.029
Pre-2007 (3)	0.097	0.058	0.037	---
Post-2006 (6)	0.131	0.093	0.038	0.029
Pre-2010 (3)	0.097	0.058	0.037	---
Post-2009 (6)	0.131	0.093	0.038	0.029
California Only (5)	0.117	0.077	0.041	0.029
Port Only (5)	0.117	0.077	0.041	0.029

Note: Values in parentheses represent the number of data collection sites for that particular subset.

Transload and Short-Term Storage HCW

Weighted average rates for daily trips at transload and short-term storage HCWs are listed in Table A5 for four vehicle classifications (all vehicles, car, truck, and 5+ axle truck) and for the complete database plus 13 subsets. One observation about the data is that the more recent data sites have, on average, lower daily trip generation rates (for all vehicle types) than the older sites[14]. This relationship is also found for the AM and PM peak hours presented in Tables A6 and A7.

Table A5. Weighted Average Rates for Daily Trips at Transload and Short-Term Storage HCW

Data Site Subset (Transload & Short-Term Storage)	Weighted Average for Daily Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
All	1.432	1.000	0.454	0.233
SCAQMD	1.412	1.006	0.406	0.217
NAIOP	1.069	0.749	0.339	0.276
SCAQMD & NAIOP	1.275	0.901	0.374	0.221
Non-SCAQMD or NAIOP	1.701	1.183	0.603	---
More than 500,000 GSF	1.433	1.008	0.431	0.223
More than 800,000 GSF	1.417	0.978	0.405	0.200
More than 1,000,000 GSF	1.493	1.044	0.392	0.257
Pre-2007	1.653	1.203	0.732	---
Post-2006	1.397	0.994	0.402	0.233
Pre-2010	1.621	1.097	0.708	0.614
Post-2009	1.347	0.970	0.377	0.221
California Only	1.226	0.871	0.388	0.221
Port Only	1.258	0.871	0.388	0.221
ITE *Trip Generation Manual* – 9th Edition	1.68	--	--	--

[14] A decline in HCW auto traffic is likely because of a reduction in employee density as HCWs have become more automated. The reduction in truck trips does not have a clear explanation. Continued data collection is recommended to enable the development of current trip generation rates that do not need to rely on older data.

Tables A6 and A7 list the weighted average rates for the AM and PM peak hours, respectively.

Table A6. Weighted Average Rates for AM Peak Hour Trips at Transload and Short-Term Storage HCW

Data Site Subset (Transload & Short-Term Storage)	Weighted Average for AM Peak Hour Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
All	0.082	0.057	0.024	0.015
SCAQMD	0.073	0.049	0.024	0.013
NAIOP	0.060	0.040	0.019	0.016
SCAQMD & NAIOP	0.068	0.046	0.022	0.014
Non-SCAQMD or NAIOP	0.100	0.075	0.028	0.022
More than 500,000 GSF	0.078	0.055	0.023	0.014
More than 800,000 GSF	0.074	0.050	0.022	0.014
More than 1,000,000 GSF	0.078	0.049	0.025	0.022
Pre-2007	0.110	0.087	0.032	0.016
Post-2006	0.079	0.057	0.022	0.015
Pre-2010	0.101	0.073	0.032	0.022
Post-2009	0.072	0.051	0.021	0.014
California Only	0.067	0.045	0.023	0.014
Port Only	0.071	0.046	0.023	0.014
ITE *Trip Generation Manual* – 9th Edition	0.11			

Table A7. Weighted Average Rates for PM Peak Hour Trips at Transload and Short-Term Storage HCW

Data Site Subset (Transload & Short-Term Storage)	Weighted Average for PM Peak Hour Trips per 1,000 GSF			
	All Vehicles	Cars	Trucks	5+ Axle Trucks
All	0.108	0.086	0.023	0.010
SCAQMD	0.081	0.060	0.021	0.010
NAIOP	0.091	0.075	0.016	0.010
SCAQMD & NAIOP	0.085	0.066	0.019	0.010
Non-SCAQMD or NAIOP	0.135	0.117	0.028	0.015
More than 500,000 GSF	0.108	0.087	0.022	0.010
More than 800,000 GSF	0.110	0.087	0.022	0.009
More than 1,000,000 GSF	0.120	0.097	0.019	0.010
Pre-2007	0.145	0.133	0.031	0.012
Post-2006	0.107	0.086	0.020	0.010
Pre-2010	0.141	0.122	0.031	0.015
Post-2009	0.091	0.072	0.019	0.010
California Only	0.082	0.063	0.019	0.010
Port Only	0.086	0.065	0.019	0.010
ITE *Trip Generation Manual* – 9th Edition	0.12			

Tables A5, A6, and A7 also include the ITE *Trip Generation Manual* 9th Edition, weighted average rate for high-cube warehouses (land use code 152). The data analyzed in this report generally produce lower rates than contained in *Trip Generation Manual*.