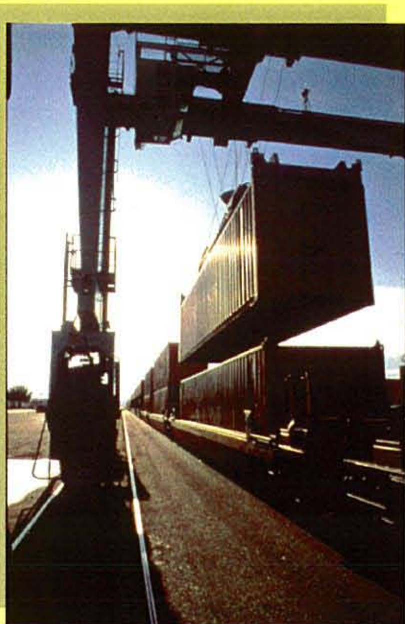

Truck Trip Generation at Intermodal Freight Facilities in the Delaware Valley Region

Delaware Valley Regional Planning Commission

June 2000

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Delaware Valley Regional Planning Commission
The Bourse Building
111 South Independence Mall East
Philadelphia, PA 19106 - 2515

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ACKNOWLEDGMENT
This study was prepared with the cooperation of and in close coordination with members of the Delaware Valley Goods Movement Task Force. The DVGMTF seeks to improve communication among, and data and technology sharing between, different freight interests in the region. The DVGMTF also acts as a freight community advocate in influencing the allocation of TEA-21 and other transportation improvement funds to optimize commodity flows in the Delaware Valley.

The facility and truck trip generation data used in this work were obtained with their assistance. As a condition of their participation and use of their data, DVRPC pledged not to divulge performance characteristics of individual facilities or publish data which would compromise the proprietary nature of their operations.

We are grateful to those who helped. Without it this report would not have been possible.

Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty and intercity agency that provides continuing, comprehensive and coordinated planning to shape a vision for the future growth of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties, as well as the City of Philadelphia, in Pennsylvania; and Burlington, Camden, Gloucester and Mercer counties in New Jersey. DVRPC provides technical assistance and services; conducts high priority studies that respond to the requests and demands of member state and local governments; fosters cooperation among various constituents to forge a consensus on diverse regional issues; determines and meets the needs of the private sector; and practices public outreach efforts to promote two-way communication and public awareness of regional issues and the Commission.

Our logo is adapted from the official DVRPC seal, and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole, while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. The authors, however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

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EXECUTIVE SUMMARY

This report summarizes a data collection and statistical analysis effort conducted in close association with members of the Delaware Valley Goods Movement Task Force (DVGMTF). Using current performance data, supplied by intermodal facility owners / operators, Delaware Valley Regional Planning Commission (DVRPC) staff determined a set of regression and trip rate equations which provide a means for estimating daily truck trips generated by intermodal port and rail terminals in the region.

Estimates of truck trip generation from the trip rates may be applied locally:

1. in forecasting truck traffic at new or expanded intermodal port or rail / truck terminal facilities to judge access / parking requirements;
2. for estimating truck traffic at an existing facility, and/or;
3. as activity indicators for establishing needs and/or prioritizing highway improvements within intermodal freight centers in the region.

Previous planning activities related to the latter two items, performed for the DVGMTF and the Federal Highway Administration, have indicated a need for truck trip estimates. The need for better truck trip generation information is also recognized at the national level to better understand and plan for freight movement.

In summary of the statistical analyses, the following trip rate equations may be used to estimate total daily trucks trips (in plus out) generated in the Delaware Valley. A discussion of accuracy is provided in the report.

ALL FACILITIES: (Ports & Rail Terminals)	Total Truck Trips / Day = 3.08 x Total Acreage of the Terminal
PORTS:	Total Truck Trips / Day = 1.90 x Ship Arrivals / Yr
RAIL TERMINALS:	Total Truck Trips / Day = (1.87 x Terminal Acreage) + (0.00517 x Rail Cars / Yr)

In addition to distributing this report to the local freight community, it will be made available to the Institute of Transportation Engineers (ITE) and the Transportation Research Board (TRB). The ITE maintains trip generation statistics for a wide variety of land use types and functions as a clearinghouse for this information. The TRB is presently conducting a synthesis effort aimed at truck trip generation. The product of their efforts will include an inventory of available research materials and recent survey data as a central reference for truck trip generation information — to better serve national goods movement planning needs. □

PART I

BACKGROUND

Through the Intermodal Management System (IMS), the Delaware Valley Regional Planning Commission (DVRPC) is establishing a means for identifying and evaluating components of the transportation network that expedite the transfer of people and goods between modes of travel. This work is consistent with the multi-modal focus of federal transportation legislation (namely, *ISTEA* and the subsequent *TEA-21*) and significant amounts of professional research which recommends that greater attention be paid to the connections between transportation modes as a means of facilitating trips which increasingly require more than one mode to reach their final destination.

The Delaware Valley is a vital international freight gateway, and presents a rich environment for examining intermodal freight facilities from the perspective of a metropolitan planning organization (MPO). The region contains the world's largest fresh water maritime complex that handles several signature cargoes, is uniquely served by three of the large, Class I interstate railroads (and many complementary shortline railroads), and demonstrates consistent growth in both the domestic and international sectors of air cargo at the Philadelphia International Airport. Due to the convergence of these individual modes, the region possesses a full array of intermodal freight facilities which can handle virtually any type of cargo in state-of-the-art terminals.

In order to better understand and plan for the intermodal freight system in the region, DVRPC undertook the study of truck trip generation at intermodal freight facilities (port facilities and rail / truck terminals). The need for the information emanated from two earlier efforts and proves very timely in light of national initiatives currently being conducted.

In support of planning work conducted in 1996 for the Delaware Valley Goods Movement Task Force (DVGMTF, whose members are representatives from the local freight community), DVRPC staff developed a candidate capital highway improvement program related to intermodal freight facilities in the region. Missing from the program was a common and measurable activity indicator which could act as a gauge on the benefit of the improvement, and/or serve in prioritizing the projects.

Later that same year, DVRPC was called upon to provide its input to a Federal Highway Administration (FHWA) project to delineate National Highway System[1] (NHS) connector highways[2]. Connectors are short extensions of the NHS which provide for the local access function between line-haul highways and entry points at important intermodal facilities[3]. As a result, connectors ensure that the NHS is continuous from origin to destination.

To efficiently meet the needs of shippers and freight carriers the connector links need to be clearly marked, offer satisfactory pavement conditions, and provide proper roadway geometry and adequate capacity for trucks. Designation as a connector highway affords the full prominence of the NHS to the segment. As such, improvements to the connectors are eligible for federal-aid through the NHS funding program[4].

In 2000, the FHWA completed and reported on a nationwide inventory and assessment of conditions along connector highways serving major intermodal freight terminals. Some key findings of that work are listed below.

- The distribution of the NHS connector mileage to/from intermodal freight facilities is: airports (18%), pipeline terminals (10%), port facilities (43%) and rail terminals (29%).

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[1] National Highway System (NHS) routes aim to enhance personal mobility, serve commerce, support economic growth and increase the Nation's competitiveness.

[2] The connector designation effort was undertaken separately for the Commonwealth of Pennsylvania. The State of New Jersey considered the connector system integral with its design of the NHS, when the NHS was originally developed in 1993.

[3] NHS connectors comprise about 1,200 miles of the 161,000 total NHS mileage.

[4] In order to be considered, activity levels at the terminal facility must be measured in units which would convert to at least 100 trucks per day / per direction operating along the connector (i.e., large single-unit or combination vehicles transporting freight between the primary highway and the intermodal facility).

- Pavement conditions are rated poor or very poor for 15 percent of connector mileage serving ports, and 12 percent of the mileage serving rail terminals — about twice the rate for the connector mileage serving airports or pipeline facilities, or that experienced along the entire NHS.

- Physical and geometric problems (e.g., inadequate travelway or shoulder width, tight turning radii, drainage problems) exist along 30 percent of the connector mileage serving both ports and rail terminals, while 20 percent of the mileage serving airports and pipeline terminals contain these problems.

- Operational problems (e.g., conflicts with on-street parking, lack of turn lanes or traffic signals, traffic congestion along the connector or at the facility's gate) are encountered along approximately five percent of the entire NHS connectors' mileage, but are twice as likely to be found along the highways serving ports and rail terminals than those serving airports or pipelines.

From the foregoing, it is clear that connector routes serving port facilities and rail terminals are the most needy facilities within the national network. Conditions found in local freight centers provide some insight to the problems. Generally, low overall traffic volumes travel the highways in the immediate vicinity of rail / truck terminals and port facilities, which in the Delaware Valley tend to be located within the aged and densely developed river corridor. In contrast, the volume of heavy-duty trucks traveling within the traffic stream is usually high. The size (maneuverability) and weight (wear) characteristics associated with these truck movements inordinately stress the roadway environment (design) in which they travel.

Clearly, some measure of vehicular demand should be taken into account when identifying improvements to rectify system deficiencies. In the absence of actual truck count data, the use of surrogate truck trip generation data provides a means for estimating commercial vehicular activity near intermodal facilities.

A popular and highly regarded resource in the subject of trip generation — *Trip*

Generation[5] — summarizes trip generation information and data for approximately 100 land uses. The book is customarily used by traffic engineers and transportation planners to assess the impact of new development. Trip rates and equations in the manual address total vehicles generated, while cursory descriptions pertaining to vehicle mix / classification are provided only on a limited basis.

A companion report, *Trip Generation Handbook*[6], contains a special appendix dedicated to truck trip generation. In it, reference documents are identified and key information summarized, including trip generation data. Conversely, that article cautions the use of its contents for a variety of reasons, including: inconsistent definition of trucks, inconsistent definition of truck trips and age of the truck trip generation data contained in the reference materials.

Recognizing the crucial importance of freight movement in the national economy and an absence of reliable information to completely understand and plan for its travel needs, the National Academies' Transportation Research Board is preparing a synthesis of practices and research concerning truck trip generation[7]. The work will identify available trip generation resources and data. Ultimately, the TRB effort seeks to standardize data collection efforts, and serve as a guide for truck trip generation information, and further study requirements. The project began in February 2000 and is scheduled for completion in February 2001.

Given the current state of affairs concerning goods movement planning and truck trip generation, regionally and nationally, the need exists to investigate the truck trip generating characteristics of intermodal freight facilities.

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[5] Trip Generation, 6th Edition, Institute of Transportation Engineers, Washington, D.C., 1997.

[6] Trip Generation Handbook - An ITE Proposed Recommended Practice, Appendix A, Institute of Transportation Engineers, Washington, D.C., October 1998.

[7] NCHRP Project 20-5, Topic 31-09.

SCOPE OF WORK

Activities undertaken to establish the truck trip generation formulae / rates for intermodal facilities in the region included:

1. Coordinate with DVRPC's Manager of Urban Goods Program to determine which of the region's intermodal freight, manufacturing and/or industrial uses should be considered in the work.
2. Design a survey which seeks current facility information (use, size, current commodity types and activity levels, modes available, etc.) and truck trip generation data (trucks per day, vehicle classification, etc.) in a uniform manner.
3. Coordinate and meet with key members of the DVGMTF to explain the effort, review the draft survey instrument and seek their assistance in completing the survey / providing the input data.
4. Conduct statistical analyses (simple and multiple regression techniques) with available data.
5. Summarize the study findings in a final report. □

PART II

METHODOLOGY

Initially, a broad definition for potential truck generators was assumed (i.e., industrial, manufacturing and intermodal). The list was too large to manage in the context of this work. The set of facilities, was subsequently narrowed to include only strictly defined intermodal freight facilities — those places where goods are exchanged between transportation modes without value being added.

Within the region 45 ports, rail terminals, pipelines and airports were identified and initially considered. That list was ultimately winnowed to exclude pipelines and airports. Most pipeline locations in the region are associated with refineries; as such value is added at the "terminal", and then the product is shipped. At one intermodal pipeline location (Hog Island in Tinicum Township, Delaware County, PA), material is transferred via pipeline or ship (not trucks), and therefore is not relevant to this investigation.

At the Philadelphia International Airport relevant performance data were not available on a freight only basis, and the myriad number of carriers in "Cargo City" (which shares internal roadways with the airport) would make the data collection effort untenable. As such, it was judged that further pursuit of airport-based truck trip generation data would not be productive toward the completion of the overall project.

Twenty nine (29) intermodal port and rail / truck terminal facilities in the region were subsequently identified, and their owners / operators contacted to participate in the study. Those that agreed to assist were sent a copy of the study's data collection form (Figure 1). The form requests current information, as follows:

- facility attributes - acreage, building size, number of employees, number of operating days, etc.;
- truck trips generated and classification - single unit or combination vehicles per specified time period (able to be converted to truck trips per day using number of operating days);

Figure 1 Data Collection Form

Below is a list of the fields of data the DVRPC is attempting to collect. Please fill in only the categories that apply to your facility. The ultimate goal is to find a measure to predict the number of trucks per day. Please include the units of measure for each entry. Your input is greatly appreciated and will be kept confidential.

Facility / Operator: Contact Person:

A. FACILITY ATTRIBUTES

acres	________
square feet of building space	________
square feet of warehouse space	________
# of ship berths	________
# of employees	________
# of days of operation **per year**	________
hours of operation	________
seasonal variation (yes or no)	________

B. TRUCK ACTIVITY (note: 1 truck* in and 1 truck* out = 2 total truck* trips) CIRCLE ONE / CIRCLE ONE

# of single unit	________one-way, total / day, week, month, year
# of combination	________one-way, total / day, week, month, year
total (single unit + combos)	________one-way, total / day, week, month, year

**Note: trucks have 5 or more tires*

C. TRANSPORTATION ACTIVITY

# of ships	________/ day, week, month, year
# of barges	________/ day, week, month, year
# of rail cars	________/ day, week, month, year
tons by pipeline	________/ day, week, month, year
# of flights	________/ day, week, month, year

D. COMMODITY ACTIVITY

General	
# of TEUs	________/ day, week, month, year
# of lifts	________/ day, week, month, year
tons of project cargo	________/ day, week, month, year
tons of break – bulk cargo	________/ day, week, month, year
Bulk	
# of tons	________/ day, week, month, year
# of revenue tons	________/ day, week, month, year
# of autos	________/ day, week, month, year

If you have any questions, feel free to contact Chris Bauer at (215) 238 – 2881. Please fax your completed sheet to (215) 592 – 9125 to the attention of Christian Bauer. Please return this fax as soon as possible. Thank you very much for your time.

Delaware Valley Regional Planning Commission
The Bourse Building, 8th Floor
111 S. Independence Mall East
Philadelphia, PA 19106

- interconnecting mode(s) and activity levels - ship arrivals, rail car arrivals, etc. per specified time period, and;
- commodity activity - 20 foot equivalent units (TEUs), number of lifts, tonnage, etc. per specified time period.

Within the survey, trucks are defined as any vehicle that has six or more tires in contact with the roadway. Differentiation was requested in the survey as to whether the truck was a single unit or a combination vehicle. From the survey responses and follow-up conversations, it was determined that almost all of the trucks generated at the facilities were heavy duty trucks and the majority of those were tractor trailers (with fourteen to eighteen tires in contact with the roadway). It should also be noted that the survey effort strived to define "trucks trips" consistently — equal to a truck entering the facility or exiting the facility. Therefore, a truck that entered a facility, loaded cargo, and then exited, was equal to two total truck trips. This point of clarification is important for obvious reasons. It also keeps the data reporting in perspective with truck volume warrants of NHS connectors (i.e., 100 trucks per day in each direction or 200 total truck trips), and with the methodologies of *Trip Generation*.

Once received the completed data collection form was reviewed. Follow-up phone calls were made within a day or two of receipt — to thank the participant, and clarify any questions about the completed survey form. After the quality check, the data were entered into a spreadsheet for the subsequent analyses. It should be noted that the truck counts provided by the operators were representative of 1998 or 1999.

Ultimately data were returned from 19 of these intermodal freight facilities (9 ports - 7 in Pennsylvania and 2 in New Jersey, and 10 rail / truck terminals - all in Pennsylvania) for use in the statistical analyses.

FREIGHT FACILITIES INVENTORY

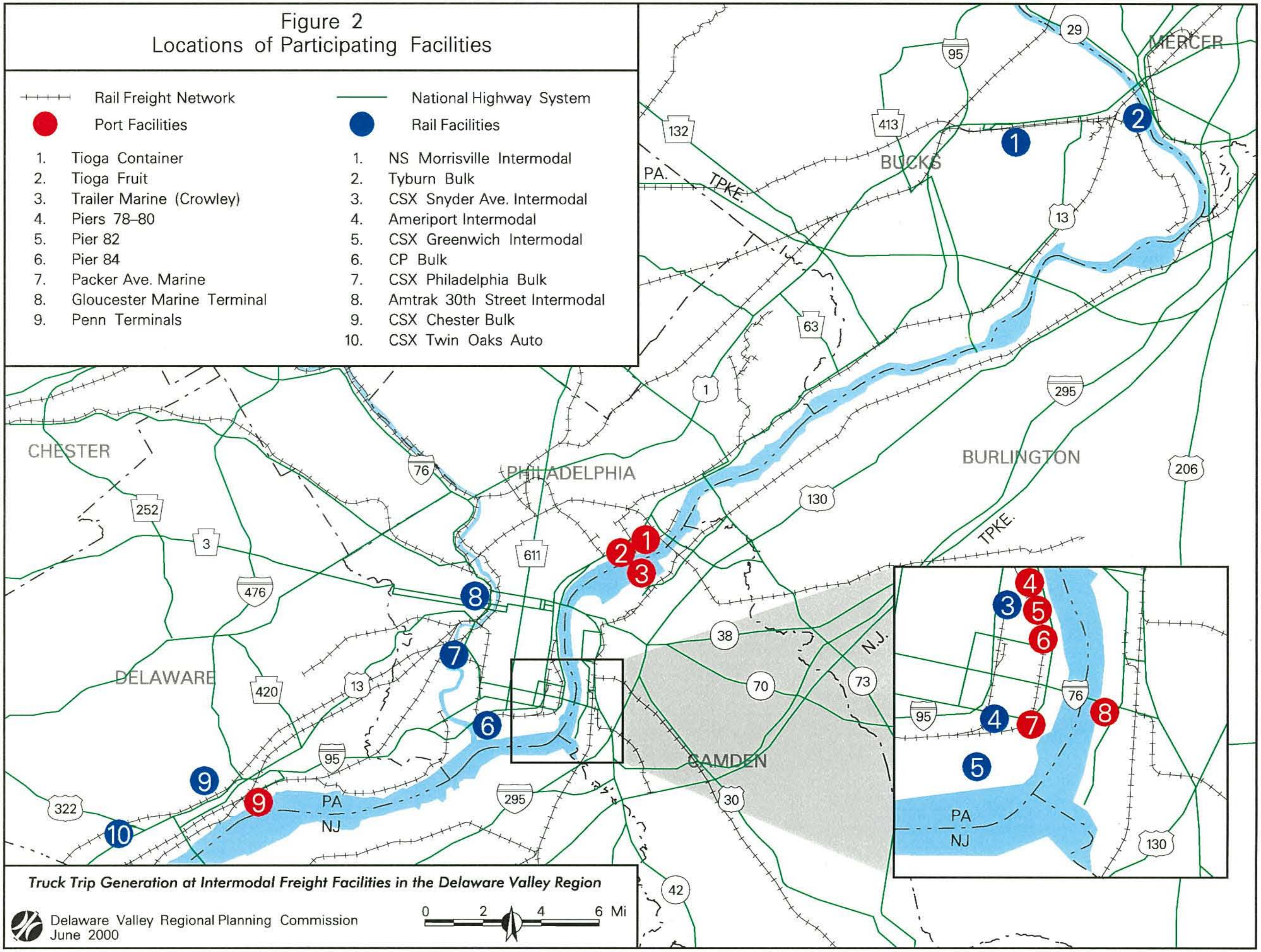
Table 1 summarizes the characteristics of the intermodal facilities which responded to the survey effort, and which were subsequently utilized in the statistical analyses. Figure 2 illustrates the locations of the facilities, which are located along or near the Delaware River.

Table 1 Intermodal Freight Facilities' Characteristics

Facility	Primary Form of Cargo	Modes Accommodated	Served by NHS or Connector?
Pennsylvania Ports			
Tioga Container	containers	ship, truck, rail	yes
Tioga Fruit	break-bulk	ship, truck, rail	yes
Pier 78-80	break-bulk	ship, truck, rail	yes
Pier 82	break-bulk	ship, truck, rail	yes
Pier 84	break-bulk	ship, truck, rail	yes
Packer Ave. Marine	containers, break-bulk	ship, truck, rail	yes
Penn Terminals	break-bulk, autos, containers	ship, truck, rail	yes
New Jersey Ports			
Trailer Marine (Crowley)	trailers, autos	barge, truck	yes
Gloucester Marine	containers, break-bulk	ship, truck, rail	yes
Rail Terminals (All Pennsylvania)			
NS Morrisville Intermodal	containers / trailers	rail, truck	yes
Tyburn Bulk	bulk	rail, truck	no
CSX Snyder Ave. Intermodal	containers / trailers	rail, truck	yes
Ameriport Intermodal	containers / trailers	rail, truck	yes
CSX Greenwich Intermodal	containers / trailers	rail, truck	yes
CP Bulk	bulk	rail, truck	no
CSX Philadelphia Bulk	bulk	rail, truck	yes
Amtrak 30th Street Intermodal	trailers	rail, truck	no
CSX Chester Bulk	bulk	rail, truck	no
CSX Twin Oaks Auto	autos	rail, truck	yes

It should be noted that not all of the requested data items were provided by each facility. As might be expected, different activity indicators apply for ports versus rail terminals. Further, whether due to the sensitivity of the information or the time necessary to assemble the response, not all data items were consistently provided within a particular category of intermodal facility. In those instances where individual performance characteristics were not supplied by more than two facilities — the

Figure 2
Locations of Participating Facilities



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information was examined, but not used in the formal statistical work or published herein in order to preserve confidentiality of specific operators. Table 2 summarizes the reportable physical and operating attributes of the data set.

Table 2 Intermodal Freight Facilities' Physical and Operating Attributes

Attribute[8]	Facility Type and (Number of Observations)	Range	Median	Average
Acres	ports (9)	13 to 150	50	63
	rail / truck terminals (10)	3 to 125	40	42
Sq. Ft. of Office Building Space	port (1) and rail / truck terminals (6)	750 to 17,200	4,500	7,536
Sq. Ft. of Warehouse Building Space	ports (9)	12,000 to 1,600,000	460,000	524,788
Employees	ports (3)	90 to 250	140	160
	rail / truck terminals (7)	5 to 60	11	21
Ships Per Year	ports (8)	17 to 261	111	110
Rail Cars Per Year	ports (6)	281 to 16,143	644	3,372
	rail / truck terminals (8)	300 to 41,600	7,500	10,329
Twenty-Foot Equivalent Units (TEUs) Per Year	ports (3)	47,027 to 146,847	83,200	92,358
Break-Bulk Tons Per Year	ports (5)	2,600 to 621,745	170,630	219,806
Bulk Tons Per Year	rail / truck terminals (3)	71,250 to 228,000	100,000	133,083
Revenue Tons Per Year	rail / truck terminals (4)	34,000 to 228,000	100,000	108,313
Autos Per Year	ports (4)	40 to 15,600	1,244	5,121
Total Trucks Per Day (in plus out)	ports (9)	15 to 475	240	228
	rail / truck terminals (10)	10 to 600	120	170

[8] Reported attributes with fewer than three observations have been excluded from the table to preserve confidentiality of the operator.

STATISTICAL ANALYSES

After establishing data availability, the work focus shifted — to determining the independent variable(s), within the data set, which is most accurate for use in estimating total daily truck trip ends (the dependent variable) oriented to intermodal freight facilities[9]. To accomplish this goal simple and multiple regression techniques were applied to the data in order to find the best activity indicators for ports, rail terminals, and all facilities combined utilizing a statistical software package[10].

Regression models study the linear relationship between a dependent variable (in this case, total truck trips per day) and one or more independent variables. The most common type of regression is the least squares method, wherein the graphical distances between the actual values of the dependent variable and statistically predicted values, along a best-fit straight line, is minimized.

Regression findings are described by an equation similar to that shown below.

$$\textit{Total Truck Trips per day} = a+b_1x_1+b_2x_2+\ldots+b_yx_y$$

Where:
a is a constant;
b is the regression coefficient for *y* number of independent variables, and;
x is the value of the independent variable (e.g., acres, employees, etc.).

The plot of the equation yields a straight line that, in this case, estimates total truck trips (in plus out) per day. Within the limited sample size, DVRPC analysts used the survey returns to determine a simple regression model to predict total truck trips per day for all facilities and for ports and rail terminals individually, and a multiple regression model for ports and rail terminals[11]. After the independent variables were

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[9] It should be emphasized that usable responses were provided by 19 port and rail facilities from a "universe" of 29 similar facilities within the region. Therefore, data from this study are applicable only to port and/or rail / truck terminal facilities within the Delaware Valley.

[10] The NCSS 2000 software package was used for this work.

[11] Multiple regression was not performed for all facilities since no two independent variables were consistently provided for all facility types.

determined and the regression equations completed, the constant, *a*, was set to zero in the procedure — and the regression analyses were completed again. Setting *a* equal to zero eliminated situations where the regression line predicted a negative value for truck trips per day, and yielded simplified trip rates.

A constraint was identified in developing the trip generation "model". As described in the previous section, a significant portion of facility performance data is considered proprietary in nature. Operators (particularly those in the private sector) were reluctant to disclose sensitive data (despite the pledge of confidentiality). As such, important activity indicators like TEUs, break-bulk tons, bulk tons, lifts and revenue tons were only provided for a few facilities. Therefore, the ideal goal of determining the most accurate independent variable was tempered to find an accurate measure that was also possible to obtain or derive.

Twenty two (22) regression tests were completed using every possible independent variable received from the survey returns. Certain results were eliminated from full consideration due to the small sample size of the independent variable. Examples include break-bulk and bulk tonnage, and lifts per year. Employment could not be used because the data were not universally provided and/or consistently defined through the survey effort. For example, some facilities have operators and laborers / stevedores as regular full-time employees. Others have only full-time operators and bring laborers in only on an as-needed basis.

Ultimately what is reported are the findings of the analyses of the independent variables which had the greatest response rate and provided the highest quality (these included total acreage of the terminals, ship arrivals per year and rail car arrivals per year). In statistics the coefficient of determination (R^2) indicates which independent variable(s) best predicts the actual data. Typically, the closer R^2 is to the value 1.0, the better. Also note that all regression analyses were performed using a 95 percent confidence interval.

For each analysis that follows, provided are: the equation of the actual regression line; discussion of the regression line's "goodness-of-fit", and; simplified trip rates (shown in a box).

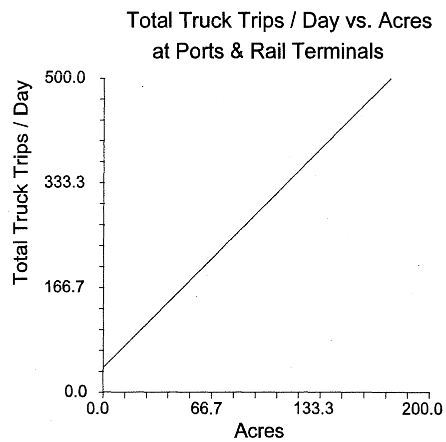
Simple Regression:

The first step was to screen the data using scatter plots, box plots, and the NCSS data screening function for the presence of outliers (i.e, atypical observations or data points). Next, a simple regression was run for each possible independent variable which remained. The following equations, graphs and trip rates were derived through inspection of each of these regressions, and represent the best indicators according to the analysis.

ALL FACILITIES

This analysis began using data from all 19 locations. One was eliminated after it was identified as an outlier. The regression equation using total acreage of the terminal as the independent variable was:

TOTAL TRUCK TRIPS / DAY = (2.62 X ACRES) + 40



The adjusted R^2 value was 0.56, with a standard error of approximately +/- 37 truck trips. In essence, this means that 56 percent of the time, this equation using total acreage accurately predicts total truck trips per day to within 37 truck trips (or 18.5 trips by direction). The regression line is shown to the right of this text[12]. The trip rate formula for all facilities, using acres as the independent variable, is:

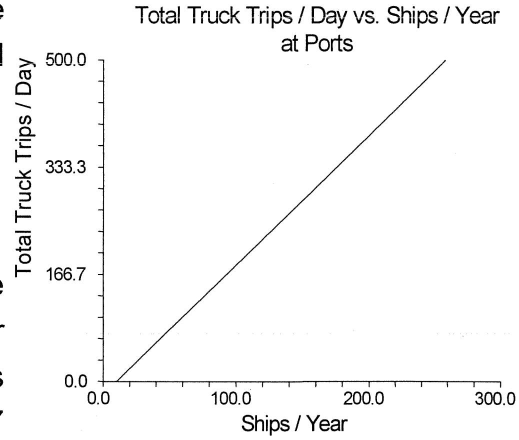
TOTAL TRUCK TRIPS / DAY = 3.08 X TOTAL ACREAGE OF THE TERMINAL

While acreage is a readily available independent variable (because it can be derived using an aerial photograph), this rate should be used carefully, and only for gross approximations of daily truck trip generations at an intermodal freight facility.

[12] In order to keep the individual facility data confidential, scatter plots of the actual data points are not shown on the regression line graphic(s).

PORTS

This analysis included eight facilities, there were no outliers, and the regression equation produced was:



TOTAL TRUCK TRIPS / DAY = (2.02 X SHIP ARRIVALS / YR) - 20

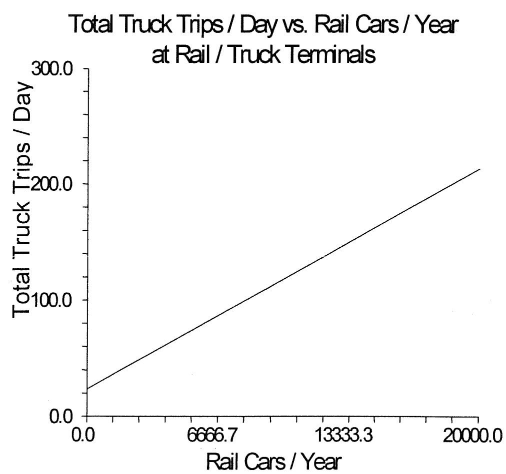
The adjusted R^2 value was 0.80, and the standard error was +/- 54 truck trips. In other words, 80 percent of the time, annual ship arrivals predict total daily truck trips within 54 trips (or 27 by direction). The regression line is shown to the right of this text. The trip rate derived using annual ship arrivals to predict daily truck trips is:

TOTAL TRUCK TRIPS / DAY = 1.90 X SHIP ARRIVALS / YR

It was determined through the research work for this study, that annual ship arrivals is available for port facilities in the region through the Maritime Exchange for the Delaware River and Bay.

RAIL TERMINALS

The analysis started with data associated with eight rail / truck terminal facilities. Data associated with one facility was subsequently eliminated as an outlier. The regression equation generated was:



TOTAL TRUCK TRIPS / DAY = (0.0095 X RAIL CARS / YR) + 24

The adjusted R^2 value was 0.50, and the standard error was +/- 31 truck trips. That is, 50 percent of the time the independent variable — the annual number of rail cars arriving at the terminal — predicts total daily truck trips within 31 trips (or 15.5 trips by direction). The trip rate equation derived using rail cars per year is:

TOTAL TRUCK TRIPS / DAY = 0.0114 X RAIL CARS / YEAR

Values for annual rail car arrivals is generally available to members of the planning community from the operators.

Multiple Regression:

The next step in the analyses examined whether a combination of two or more independent variables would yield refined predictions for truck trip generations at ports and rail terminals. An "all possible regression" was completed for ports and then rail terminals.

In an all possible regression, the software evaluates all the input variables, and combinations thereof, to determine which combination best describes the data. Whereas simple regression plots a line in two dimensions, multiple regression plots a line in three or more dimensions. As such, the equations emanating from the multiple regression analysis are not depicted in graphs. Again, after the best independent variables were identified, the regression analyses were run again with the constant (*a*) set equal to zero to establish trip rates.

PORTS

The first all possible regression was prepared for ports, with the four most widely reported variables used in the analyses (acreage of the terminal, ship arrivals per year, number of berths and square feet of warehouse space). The output ranks the combinations of three variables, two variables, and one variable equations. The output reinforced the fact that annual ship arrivals was the best variable to use in a simple regression. Second, the best model cited for a two variable multiple regression used annual ship arrivals and total terminal acreage. Since both of these data items are readily available, and the results of the additional analyses were only marginally better, it was judged not to report the detailed findings of the three and four variable multiple regression analyses.

The resulting multiple regression which estimated total truck trips per day versus ships arriving per year and site acreage is described by the following equation[13]:

TOTAL TRUCK TRIPS / DAY = [(-2.15 X TOTAL TERMINAL ACREAGE) + (3.18 X SHIP ARRIVALS / YR)] - 35

This regression included nine facilities, and there were no outliers. The adjusted R^2 value was 0.83 and the standard error was 51. As such, it can be said that 83 percent of the time this equation will predict total daily truck trips within +/- 51 trips (or 25.5 trucks per direction). The multiple variable trip rate model utilizing annual ship arrivals and total acreage at a port facility is:

TOTAL TRUCK TRIPS / DAY = (-1.95 X TERMINAL ACREAGE) + (2.87 X SHIPS ARRIVALS / YR)

Considering that the results obtained from using the one variable model (ship arrivals per year) are nearly equal to and reliable as the two variable model — it is more expedient to use the one variable model (ship arrivals per year) for daily truck trip estimates.

RAIL TERMINALS

The second “all possible regression” was performed for rail terminals using the three most widely reported independent variables: acreage, rail cars arriving to the terminal per year and the number of employees. Again the output confirmed that railcars per year was the best single variable to use in a simple regression. The best two variables for a multiple regression were total acreage and annual rail car arrivals.

The multiple regression predicting total daily truck trips versus acreage and annual rail

[13] It is noted that when truck trips are regressed against terminal acreage and annual ship arrivals the parameter guiding acreage becomes negative.

car arrivals yielded the following equation:

TOTAL TRUCKS / DAY = [(2 X TOTAL TERMINAL ACREAGE) + (0.0053 X RAIL CARS / YR)] - 9

This regression included eight facilities and there were no outliers. The adjusted R^2 value was 0.99, with standard error of +/- 5 total truck trips, or 2.5 by direction. Since this two variable model is much more accurate than the single variable model[14], it is advised to use this model when annual rail car arrivals and terminal acreage are both attainable for rail / truck terminals. The multiple variable truck trip rate model utilizing annual rail car arrivals and total acreage at a rail terminal is:

TOTAL TRUCK TRIPS / DAY = (1.87 X TERMINAL ACREAGE) + (0.00517 X RAIL CARS / YR)

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[14] The R^2 value for the single variable model was 0.50 with an error of +/- 31 trucks.

PART III

CONCLUSIONS / RECOMMENDATIONS

The study of truck trip generation characteristics at intermodal freight facilities was undertaken to support the planning needs of the goods movement community serving the Delaware Valley region. As part of the study research, it was learned that truck trip generation studies are a timely issue, and that this study's findings may also benefit a wider, national audience. At the conclusion of the work, two major findings were determined.

First, the response to requests for data by facility operators was highly varied. Most rail terminal and port facility representatives who were contacted, were very cooperative in providing current physical characteristics, activity indicators, and truck count data upon which to build truck trip generation relationships. However, not all of the requested data was provided in sufficient quantity. Ultimately, therefore, the result of the analytical work was limited by the quantity and quality of the submitted information.

Second, the analytical work yielded a set of quantitative tools (i.e., truck trip generation equations and rates), which according to statistical indicators, produce reasonable estimates of total daily truck trips generated by intermodal rail and port facilities in the Delaware Valley.

The findings produced in this report can be utilized in several ways.

First, the trip generation rates can be used by planners in situations where estimates for truck trips are desired. The rates may be applied:

1. in forecasting truck traffic at new or expanded intermodal port or rail / truck terminal facilities to judge access / parking requirements, and/or
2. for estimating truck traffic at an existing facility.

In that latter matter, a preliminary evaluation using the trip generation rates suggests the Novolog port facility in Falls Township, Bucks County generates approximately 210 total truck trips per day (105 in, and 105 out). The estimate results from using ships per year (according to available records) and the trip rates established in this study. This indicates that South Pennsylvania Avenue, linking Novolog and US 1, may be a candidate NHS connector route and eligible for National Highway System funding.

Second, truck trip estimates emanating from the rates can also serve as activity indicators for assessing conditions, establishing needs, and/or prioritizing highway improvements within intermodal freight centers in the region. As such, the membership of the Delaware Valley Goods Movement Task Force should receive copies of this report and be appraised of its content and applications.

Finally, this report will be distributed within the national freight community, to the Institute of Transportation Engineers and to the Transportation Research Board to contribute toward similar truck trip generation study efforts being conducted on a national level. □

DELAWARE VALLEY REGIONAL PLANNING COMMISSION

Publication Abstract

Title: Truck Trip Generation at Intermodal Freight Facilities in the Delaware Valley Region	Date Published: June 2000
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Geographic Area Covered: the nine county Philadelphia metropolitan area, including: Burlington, Camden, Gloucester and Mercer counties in New Jersey, and; Bucks, Chester, Delaware, Montgomery and Philadelphia counties in Pennsylvania

Key Words: Management Systems, goods movement, intermodal freight facilities, rail / truck terminals, ports, truck trip generation, regression analyses, trip rates

ABSTRACT

A synthesis effort to inventory truck trip generation studies is currently being conducted on a national level to standardize data collection efforts and serve as an endorsed source for truck trip generation information. The need stems from a recognition of the crucial importance that freight movement plays in the national economy and the absence of reliable information to understand and plan for its travel needs. Locally, recent efforts to assist the Delaware Valley Goods Movement Task Force and related goods movement network planning have also indicated a need for estimating truck travel demands.

In this study, DVRPC has gathered data, performed statistical analyses, and identified formulae and rates for estimating daily truck trips at port and rail terminal facilities in the region using data supplied by facility owners / operators. The findings and results of the work will be put into practice within DVRPC's Urban Goods Movement Planning Program, and this report will be distributed to the local freight community and to those conducting national-level truck trip generation studies to assist in meeting their needs.

The work was conducted through DVRPC's Intermodal Management System (IMS) Planning Program. The IMS was one of the six management systems created by ISTEA in 1991, and is carried on through the auspices of the region's current long range plan.

For More Information Contact:

Delaware Valley Regional Planning Commission
Transportation Planning Division
The Bourse Building, 8th Floor
111 South Independence Mall East
Philadelphia, PA 19106-2515
Phone: 215.592.1800 Fax: 215.592.9125 website: http://www.dvrpc.org

Staff contacts:	Direct phone:	E-mail:
Ted Dahlburg, Mgr. of Urban Goods Program	215.238.2844	tdahlburg@dvrpc.org
Christian Bauer, Project Planner	215.238.2881	cbauer@dvrpc.org
Jerry Coyne, Project Manager	215.238.2850	jcoyne@dvrpc.org