Training Series #2 – 3: Trip Generation

By Jinghua Xu, Ph.D, PE

Fehr & Peers

10/18/2016

Today's Training Topics

- Understanding Trip Generation
- Basic Vehicle Trip Generation
- Mixed-Use Trip Generation
- Examples

Understanding Trip Generation

- Level of activity per unit at start/end of a trip
- Type (person, vehicle, auto, truck)
- Purpose (work, shop, school)
- Land use (house, room, employee, ksf)
- Time of day (daily, peak hour)
- Directional
  - Production and Attraction
  - Inbound and Outbound
  - Internal
  - Primary, Pass by, Diverted

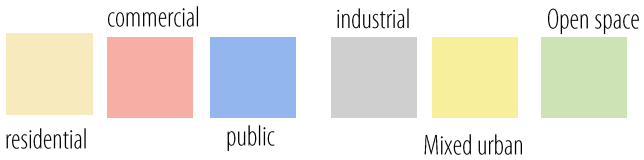
Socio-Economic Data

"SED"

Land use developments

- office
- shopping
- schools
- houses

generate different types of activity quantity and purposes based on what and where they are



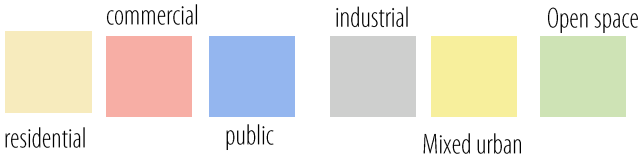
Highway and Transit Network

"The network"

Transportation system

- roadways
- transit stops and routes
- walkways and bikeways
- freight, toll, air/seaports

supply different accessibility, mobility, cost, and time options based on travel mode



Travel surveys and data

CHTS, NHTS, Census

"Data"

- household survey
- transit on-board survey
- vehicle counts & riders
- origin-destination

provide insight into decisions, preferences, and quantities of person, household, and vehicle travel

Trip Generation

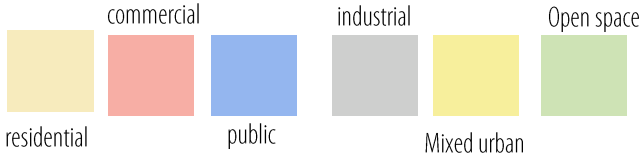
"How much"

How people make decisions…

Land Use and activity

- **live**
- **work**
- **play**
- **shop**

decisions based on multiple factors, so we try to understand what they did and how they made the decision to forecast implications of near term or long term changes.



Trip Purpose

"Why"

How people make decisions…

Land use accessibility

When doing activities, first people evaluate what they want to do: the purpose of the trip (work, shop, drop-off kids, visit friends, etc.)

They consider the development around them that would meet their needs, then select a location

How people make decisions…

Demographics influencing choice

Two people with different demographics make trips at varying rates and for different reasons.

Accessibility to activity generators also influences the trip rate.

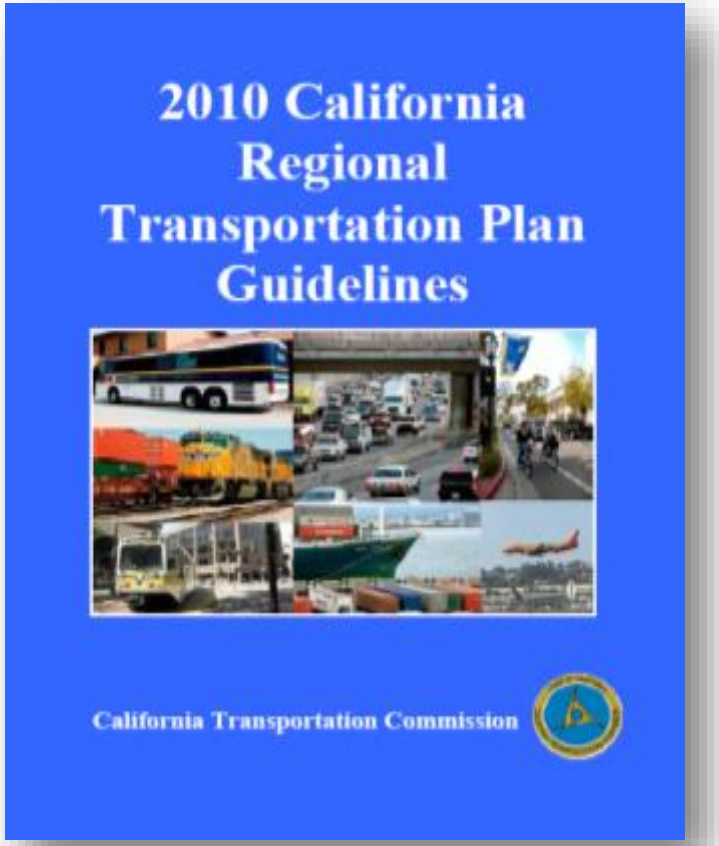
Productions & Attractions

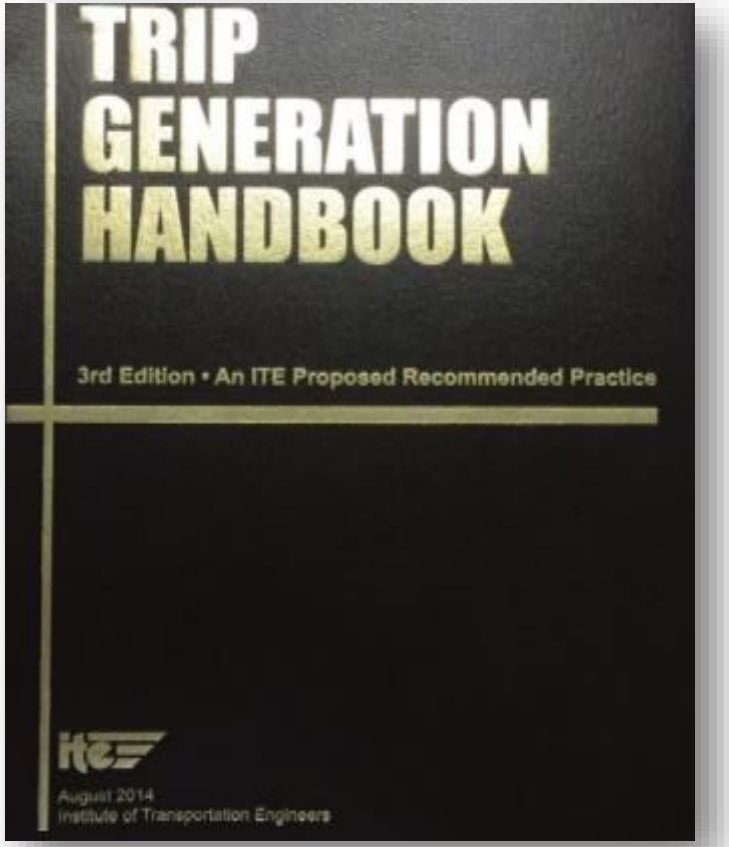
"Ps and As"

How people make decisions…

conducted in the travel model simultaneously for all the people in the study area

Basic Vehicle Trip Generation





Basic Vehicle Trip Generation

- ITE Trip Generation
  - Data assembled from more than 4,800 individual studies in United States and Canada since the 1960s
  - Mainly collected at suburban locations
    - With limited transit service
    - Without nearby pedestrian amenities
    - Without travel demand management (TDM) programs
  - Data received on “voluntary” basis

Basic Vehicle Trip Generation

- Cautions to use ITE Trip Generation
  - Data compiled over five decades
  - Various geographical locations in the United States and Canada
    - Select the land use code that most closely fits intended use of the proposed development
  - Various times of the year
    - Select appropriate time period
  - Various durations of data collection

Basic Vehicle Trip Generation

- When to collect data for local study
  - ITE land use category is not available
  - Inadequate number of studies exist in ITE data
  - Size of site is outside range of ITE data points
  - To establish local trip generation rate
  - To validate *Trip Generation* data for local application
  - To supplement national database

Basic Vehicle Trip Generation

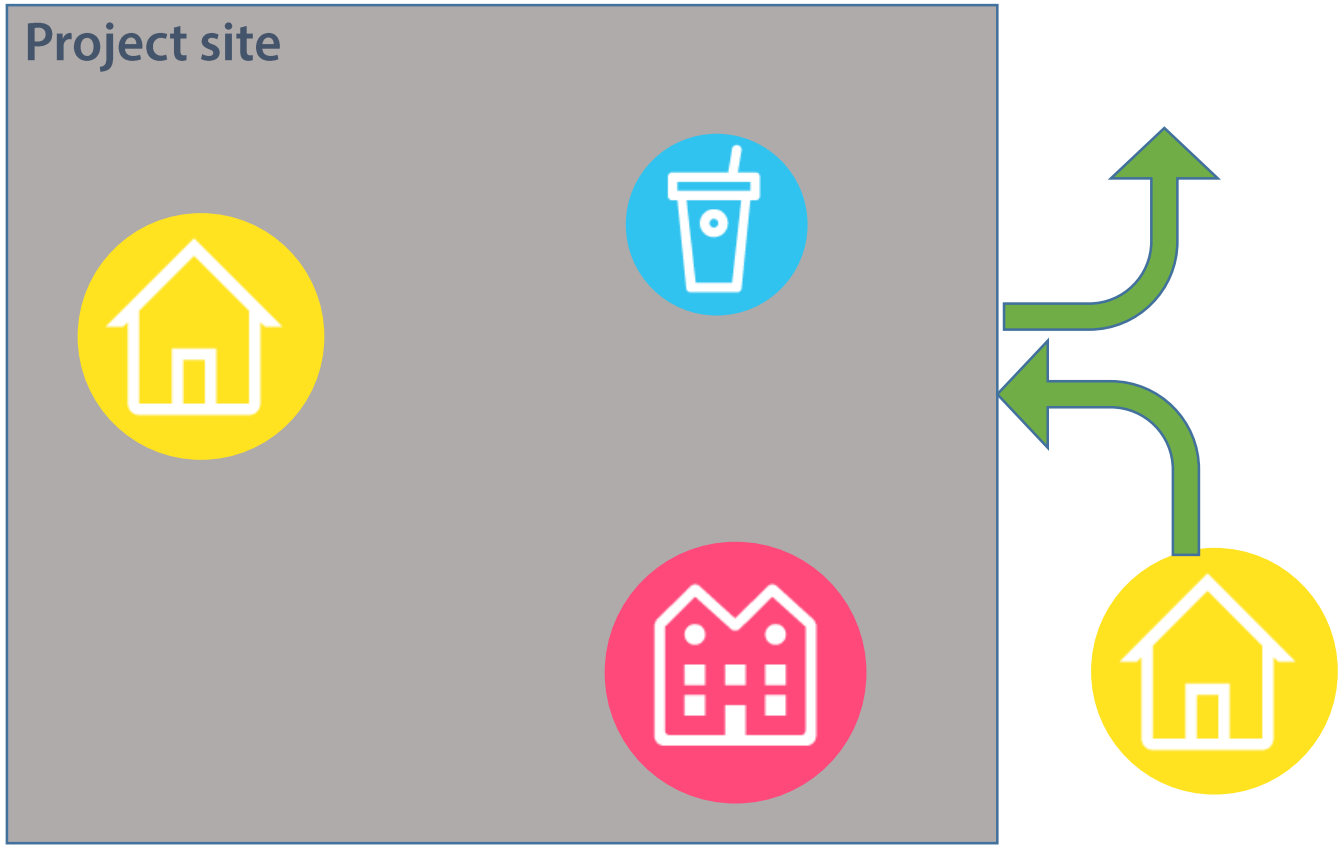
- Cautions to use data collected specific to the local study
  - Use the data carefully
  - Understand how the data was collected
  - Understand the sites surveyed within each land use
  - Pass-by and Internal Capture Trip Deductions
  - Weighted Averages vs. Regression Equations
  - THESE ARE ESTIMATES!

Individual Projects

- office
- shopping
- houses

trips crossing driveway
trips within project site
mode
primary, pass by, diverted
inbound, outbound
time of day
peak of street or peak of generator

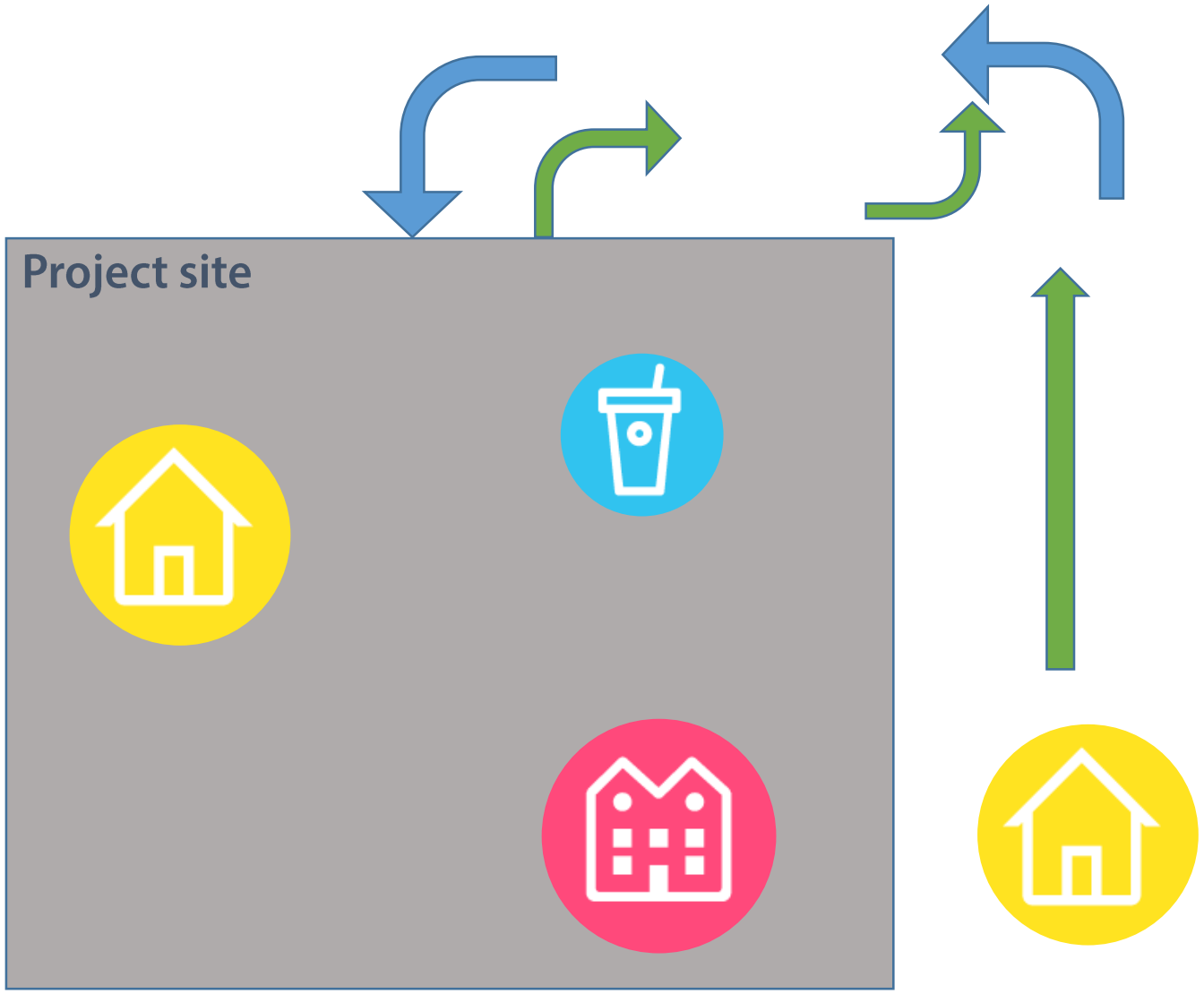
Individual Projects – Pass by



- office
- shopping
- houses

trips crossing driveway
trips within project site
mode
primary, pass by, diverted
inbound, outbound
time of day
peak of street or peak of generator

Individual Projects – Diverted

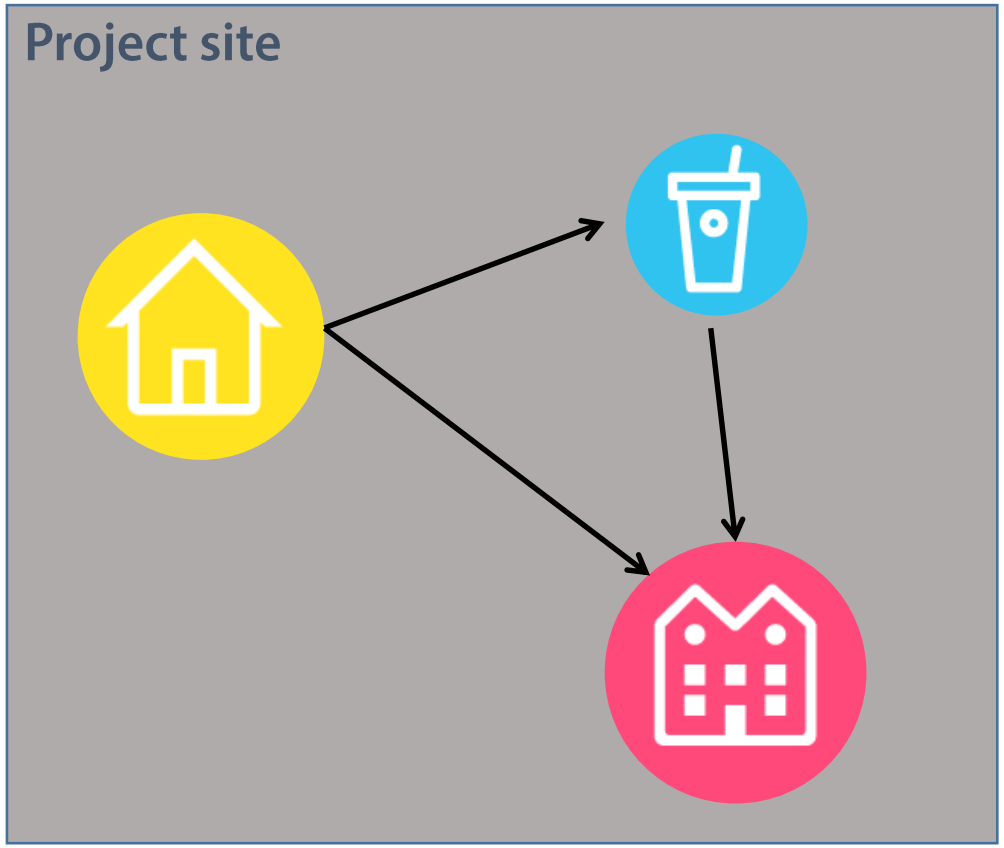


- office
- shopping
- houses

trips crossing driveway
trips within project site
mode
primary, pass by, diverted
inbound, outbound
time of day
peak of street or peak of generator

Individual Projects – Internal Trips

- office
- shopping
- houses



Limitations of Current Practice

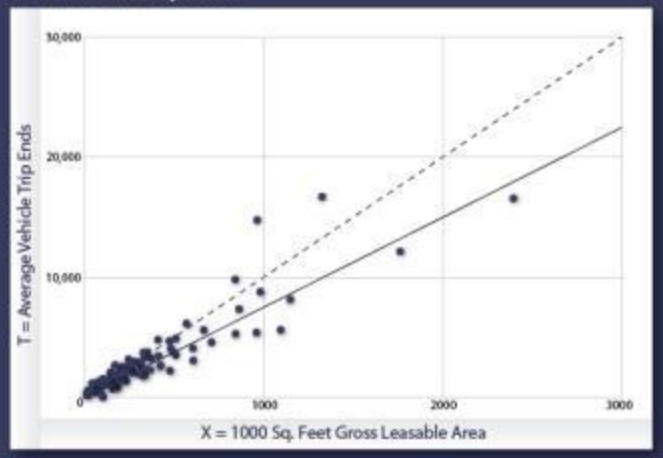
Single-Family Detached Housing (210)

Average Vehicle Trip Ends vs: Dwelling Units (On a Weekday)

Number of Studies: **350**
Avg. Number of Dwelling Units: **197**
Directional Distribution: **50% entering - 50% exiting**

Trip Generation per Dwelling Unit
Average Rate: **9.57** | Range of Rates **4.31** to **21.85** | Standard Deviation **3.69**

Data Plot and Equation



X Actual Data Points — Fitted Curve - - - - Average Rate

Fitted Curve Equation: Ln(T) = 0.65 Ln(X) + 5.83 R2 = 0.78

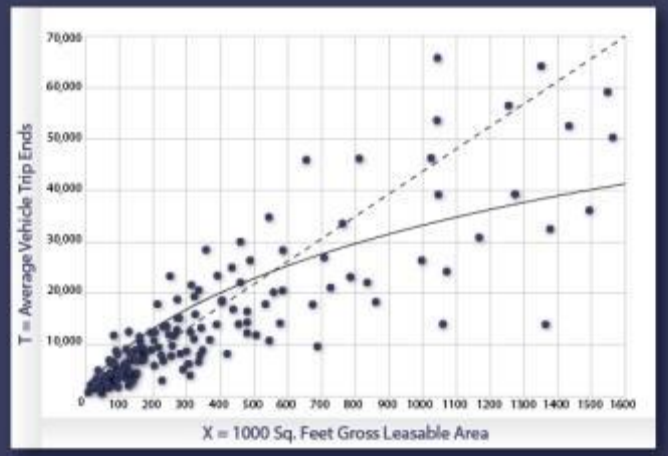
Shopping Center (820)

Average Vehicle Trip Ends vs: 1000 Sq. Feet Gross Leasable Area (On a Weekday)

Number of Studies: **302**
Avg. Number of Dwelling Units: **328**
Directional Distribution: **50% entering - 50% exiting**

Trip Generation per 1000 Sq. Feet Gross Leasable Area
Average Rate: **42.94** | Range of Rates **12.50** to **270.89** | Standard Deviation **21.38**

Data Plot and Equation



X Actual Data Points — Fitted Curve - - - - Average Rate

Fitted Curve Equation: Ln(T) = 0.65 Ln(X) + 5.83 R2 = 0.78

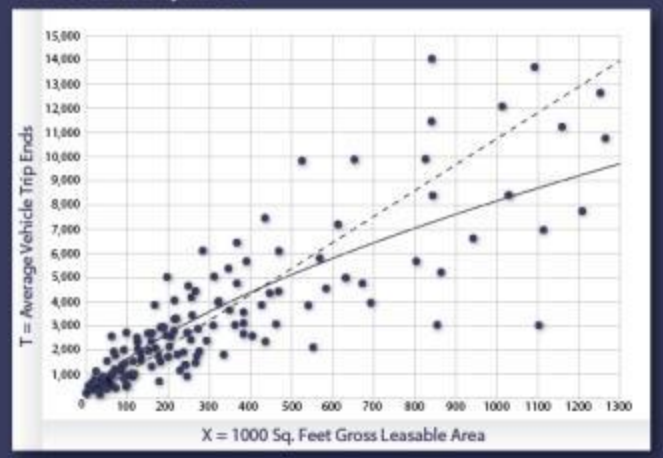
General Office Building (710)

Average Vehicle Trip Ends vs: 1000 Sq. Feet Gross Floor Area (On a Weekday)

Number of Studies: **78**
Avg. Number of Dwelling Units: **199**
Directional Distribution: **50% entering - 50% exiting**

Trip Generation per 1000 Sq. Feet Gross Floor Area
Average Rate: **11.01** | Range of Rates **3.58** to **28.80** | Standard Deviation **6.13**

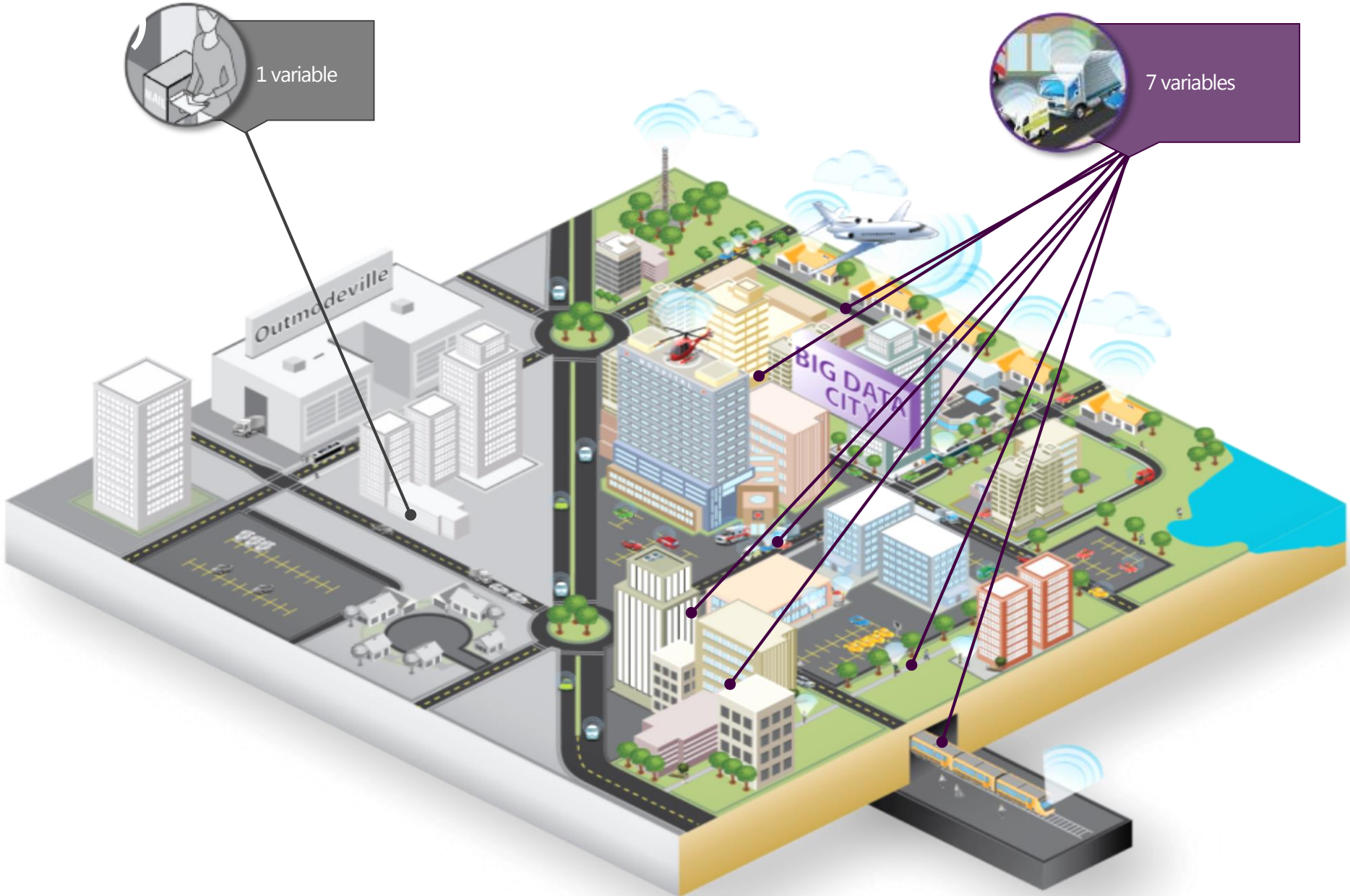
Data Plot and Equation



X Actual Data Points — Fitted Curve - - - - Average Rate

Fitted Curve Equation: Ln(T) = 0.77 Ln(X) + 3.65 R2 = 0.80

MXD+ Tool has 7-Variable Sensitivity



The built environment

Density

Diversity

Design

Destinations

Distance to Transit

Development Scale

Demographics

7Ds

That influence Trip Generation (and VMT)

Mixed-Use Trip Generation

- Can be estimated in a wide context, instead of the single project estimated by the ITE method.
- Gives credit to development for smart growth characteristics
- Sensitive to 7 of the 8 "D"s
- Sensitive to all common land use types
- More than 200 real sites' worth of data supporting it
- Can analyze daily and both peak hours
- At least as accurate as current ITE methods

ITE Mix-Used Method

DAILY

Analyst: SRF
Date: ●●●●●●
Project #: 1041-XXXX

MULTI-USE DEVELOPMENT
TRIP GENERATION
AND INTERNAL CAPTURE SUMMARY

Name of Development/Tile: **TIA**
Time Period: **Daily**

LAND USE A	Office		
ITE LU Cod	710	General Office	
Size:	195.00	KSF	
	Total	Internal	External
Enter	1,116	51	1064
Exit	1,116	113	1002
Total	2,231	165	2066
%	100%	7%	93%

LAND USE ID:	B	Residential	
ITE LU Code:	210	Single-Family	
Size:	168.00	DU	
	Total	Internal	External
Enter	839	211	627
Exit	839	154	684
Total	1,677	366	1311
%	100%	22%	78%

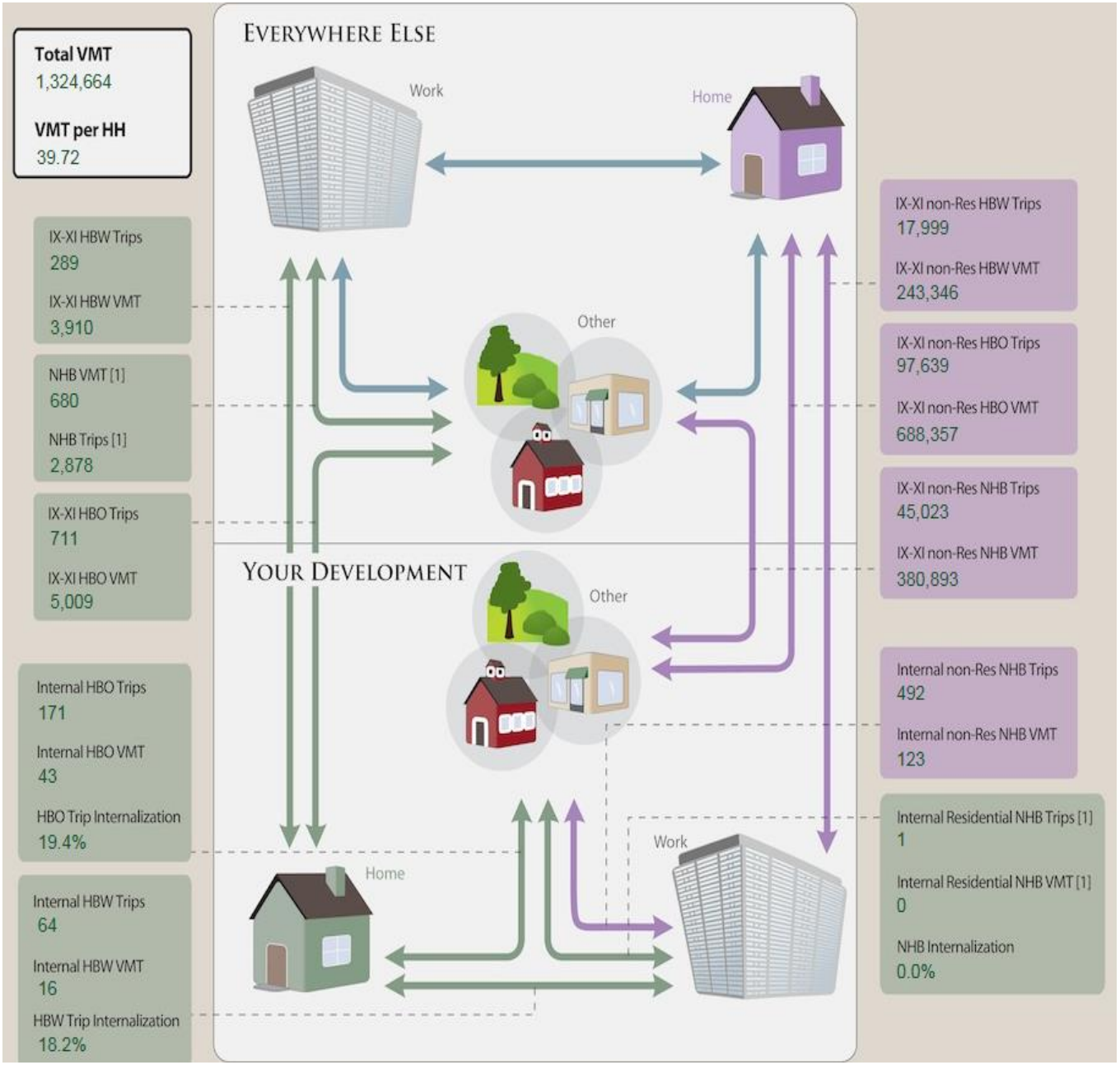
LAND USE C	Retail		
ITE LU Cod	820	Shopping Center	
Size:	35.00	ksf	
	Total	Internal	External
Enter	1,716	378	1338
Exit	1,716	429	1287
Total	3432	807	2625
%	100%	24%	77%

LAND USE ID:	D	Residential	
ITE LU Code:	230	Multi-Family	
Size:	2,332.00	DU	
	Total	Internal	External
Enter	11636.5	211	11425
Exit	11636.5	154	11482
Total	23273	366	22907
%	100%	2%	98%

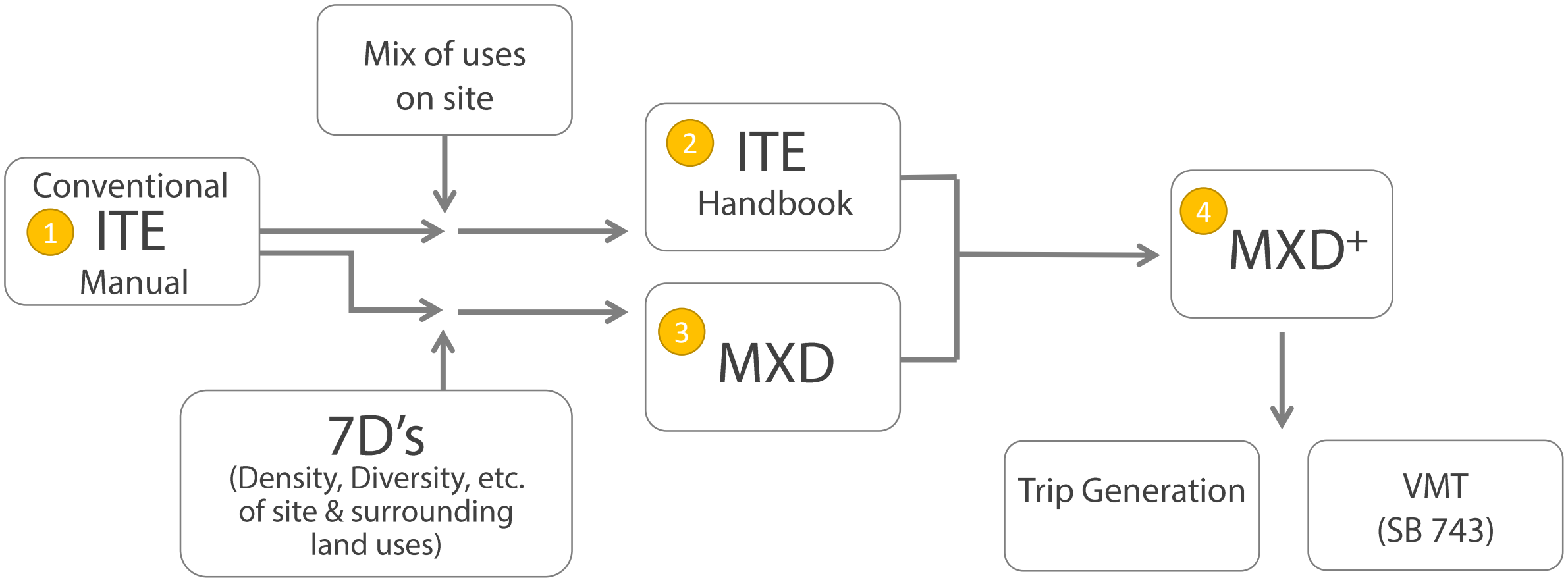
Net External Trips for Multi-Use Development						
Land Use ID	A	B	C	D	Total	
Enter	1064	627	1338	11425	14455	
Exit	1002	684	1287	11482	14455	
Total	2066	1311	2625	22907	28911	INTERNAL CAPTURE
Single-Use Trip Gen. Est.	2231	1677	3432	23273	30613	6%

MXD Method

- Developed based on research done for the EPA .
- More statistically valid and reliable to estimate trip internalization for mixed-use developments, compared to ITE method.

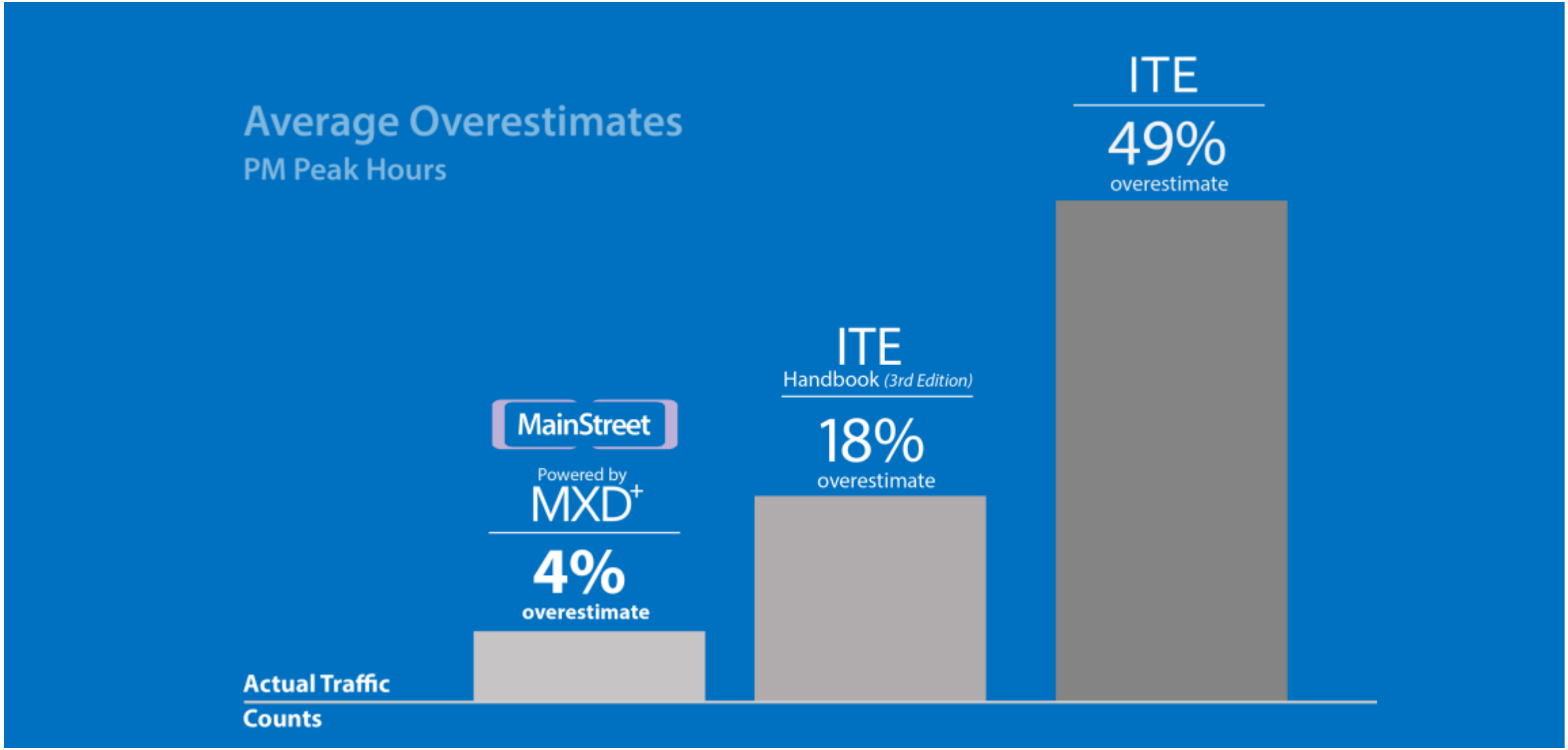


MXD+ Process


Mix of uses on site
Conventional
1 ITE
Manual
2 ITE
Handbook
3 MXD
4 MXD+
7D's
(Density, Diversity, etc. of site & surrounding land uses)
Trip Generation
VMT
(SB 743)

MXD+/MainStreet Can Prevent Oversizing Infrastructure

MXD+/MainStreet More Accurately Predicts Trip Generation



Travel Demand Management

- Transit passes, car\vanpool, company shuttle\bus
- Parking cashout, charge for parking
- Flextime, telecommute, remote offices
- Peak spreading

Examples

- Industries change over time due to technology (warehouse trip generation)
- Offices vary greatly (tech company)
- Details on SANDAG local calibration

Examples – Warehouse Trip Generation (Data Collection)

TABLE 1
STUDY INDUSTRIAL PEAK HOUR TRIP GENERATION RATES BY VEHICLE TYPE

Industrial Site	Daily Trip Rate[1]			AM Peak Hour of the Generator[2]					AM Peak Hour Rate[3]					PM Peak Hour of the Generator[4]					PM Peak Hour Rate[5]				
				Cars		Trucks		Total	Cars		Trucks		Total	Cars		Trucks		Total	Cars		Trucks		Total
	Cars	Trucks	Total	In	Out	In	Out		In	Out	In	Out		In	Out	In	Out		In	Out	In	Out	
Site 1 (550,000 sf)	2.13	0.45	2.58	0.09	0.03	0.05	0.00	0.17	0.05	0.03	0.06	0.01	0.15	0.04	0.06	0.03	0.00	0.13	0.02	0.03	0.02	0.00	0.07
Site 2 (511,718 sf)				0.18	0.04	0.01	0.03	0.26	0.06	0.02	0.03	0.04	0.15	0.10	0.17	0.00	0.05	0.32	0.02	0.08	0.00	0.04	0.14
Site 3 (548,525 sf)	0.94	0.57	1.51	0.05	0.01	0.02	0.00	0.08	0.02	0.00	0.03	0.01	0.06	0.09	0.07	0.00	0.01	0.17	0.09	0.07	0.00	0.01	0.17
Site 4 (2,832,464 sf)	2.76	0.65	3.42	0.10	0.05	0.02	0.02	0.19	0.09	0.04	0.02	0.03	0.18	0.07	0.14	0.02	0.02	0.25	0.05	0.12	0.03	0.02	0.22
Weighted Average	2.22	0.61	2.98	0.09	0.04	0.02	0.02	0.17	0.07	0.03	0.02	0.02	0.14	0.06	0.12	0.02	0.02	0.22	0.05	0.09	0.02	0.02	0.18

1. Daily trips per 1,000 square feet.
2. AM peak hour rate per 1,000 square feet between 5:00 and 7:00 AM
3. AM peak hour rate per 1,000 square feet between 7:00 and 9:00 AM.
4. PM peak hour rate per 1,000 square feet between 2:00 and 4:00 PM.
5. PM peak hour rate per 1,000 square feet between 4:00 and 6:00 PM.

Examples – Warehouse Trip Generation (Comparison)

TABLE 2
WAREHOUSE/DISTRIBUTION TRIP GENERATION RATE COMPARISON

Land Use	Daily Trip Rate	AM Peak Rate[1]			PM Peak Rate[1]		
		In	Out	Total	In	Out	Total
ITE Industrial Park (Land Use 130) [1]	6.96	0.69	0.15	0.84	0.18	0.68	0.86
ITE Warehousing(Land Use 150)[1]	4.96	0.37	0.08	0.45	0.12	0.35	0.47
City of Stockton Model – Industrial[1]	2.40	0.13	0.03	0.16	0.03	0.10	0.13
City of Fontana – Heavy Warehouse[1]	3.55	0.05	0.02	0.07	0.02	0.05	0.07
San Bernardino/Riverside County – Warehouse/Distribution Center[1]	1.10	0.05	0.03	0.08	0.03	0.05	0.08
Study Data Collection[1]	2.98	0.09	0.05	0.14	0.07	0.11	0.18

1. Trips per 1,000 square feet.

Source: ITE, Fehr & Peers, 2007, City of Fontana, 2003, Crain & Associates, 2005.

Examples – Office (picking the correct units and method)

General Office Building
(710)

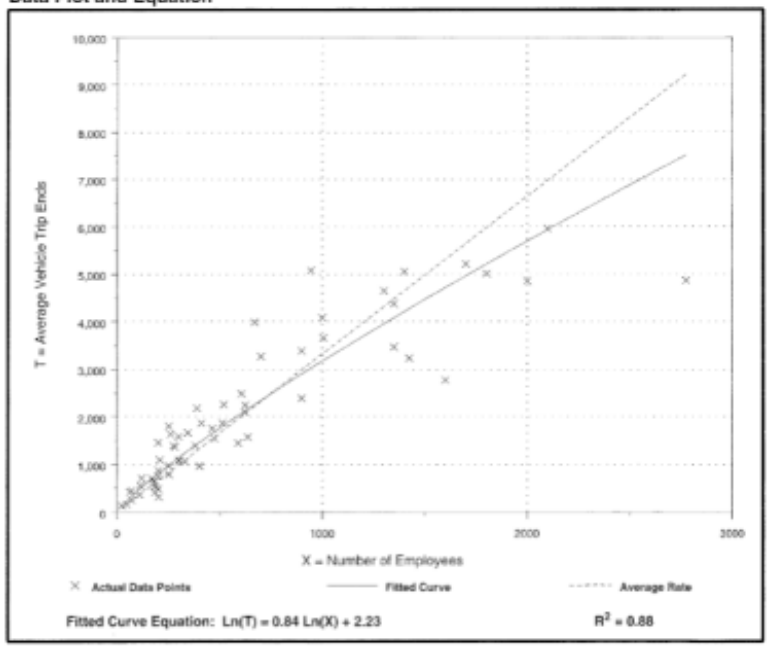
Average Vehicle Trip Ends vs: Employees
On a: Weekday

Number of Studies: 62
Avg. Number of Employees: 610
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
3.32	1.59 - 7.28	2.16

Data Plot and Equation



3.32 Daily Trips per employee

General Office Building
(710)

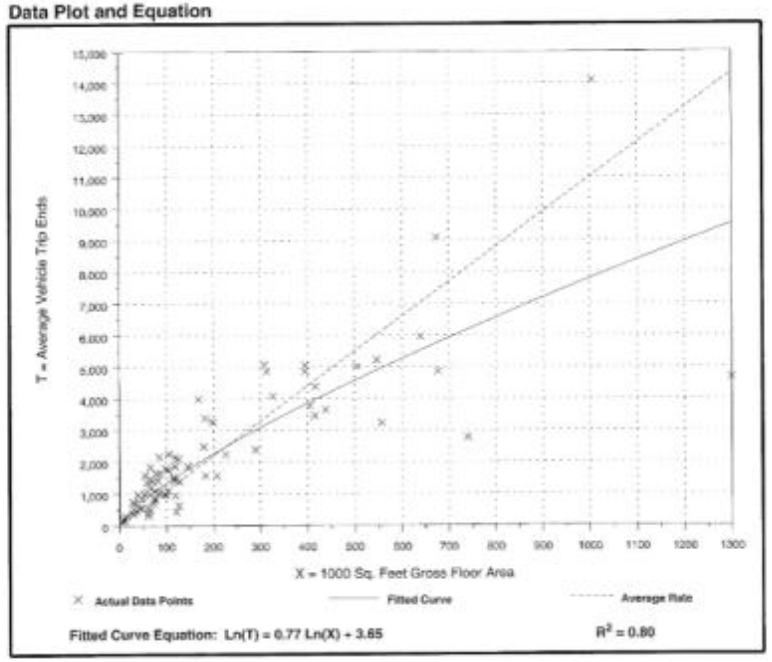
Average Vehicle Trip Ends vs: 1000 Sq. Feet Gross Floor Area
On a: Weekday

Number of Studies: 78
Average 1000 Sq. Feet GFA: 199
Directional Distribution: 50% entering, 50% exiting

Trip Generation per 1000 Sq. Feet Gross Floor Area

Average Rate	Range of Rates	Standard Deviation
11.01	3.58 - 28.80	6.13

Data Plot and Equation



11.01 Daily Trips per KSF

Examples – Office (picking the correct units and method)

Within data range

Development			
	KSF	Employee/KSF	Employees
Traditional Office	100	1	100
Tech Company	100	3	300

Trips						
	Average Rate		Equation		Difference	
	KSF	Employees	KSF	Employees	KSF	Employees
Executive Office	1,101	332	1,334	450	233	118
Tech Company	1,101	996	1,334	1,131	233	135
Difference	-	664	-	682		

Outside data range

Development			
	KSF	Employee/KSF	Employees
Traditional Office	3000	1	3000
Tech Company	3000	3	9000

Trips						
	Average Rate		Equation		Difference	
	KSF	Employees	KSF	Employees	KSF	Employees
Executive Office	33,030	9,960	18,305	7,827	(14,725)	(2,133)
Tech Company	33,030	29,880	18,305	19,696	(14,725)	(10,184)
Difference	-	19,920	-	11,869		

MXD Study – SANDAG SGOAs

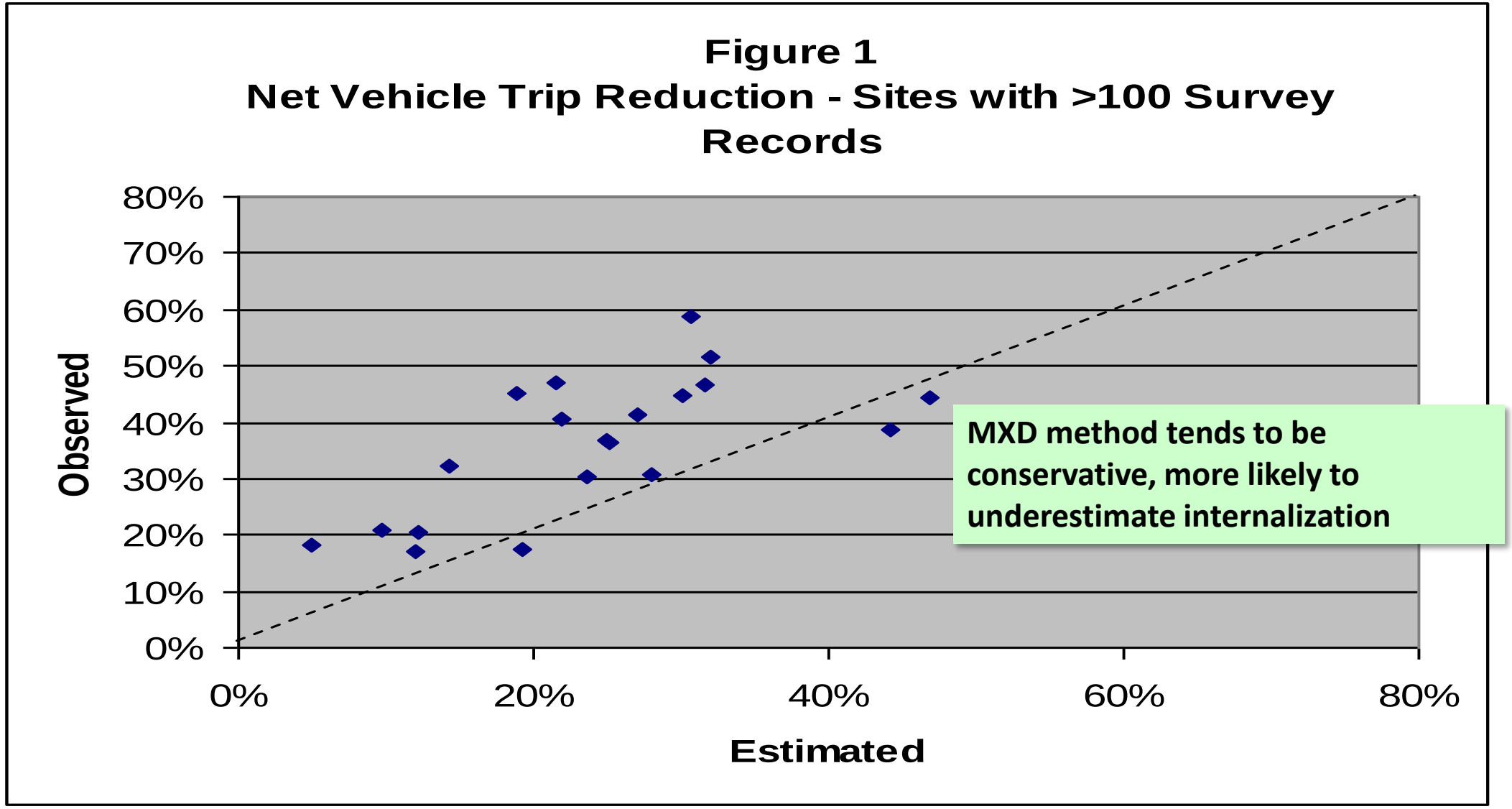
- List of 57 SGOAs (Smart Growth Opportunity Areas) chosen by SANDAG staff from CTP
- 20 of those had at least 100 trip records in household survey
- Comparison of trip reduction *percentages* between these sites and MXD model
- Counts not possible (too big)

MXD Study – SANDAG SGOAs

- Collected the local data simultaneously, under the same methodology.

- Calculated the same “D” variables and estimated the regression equations.

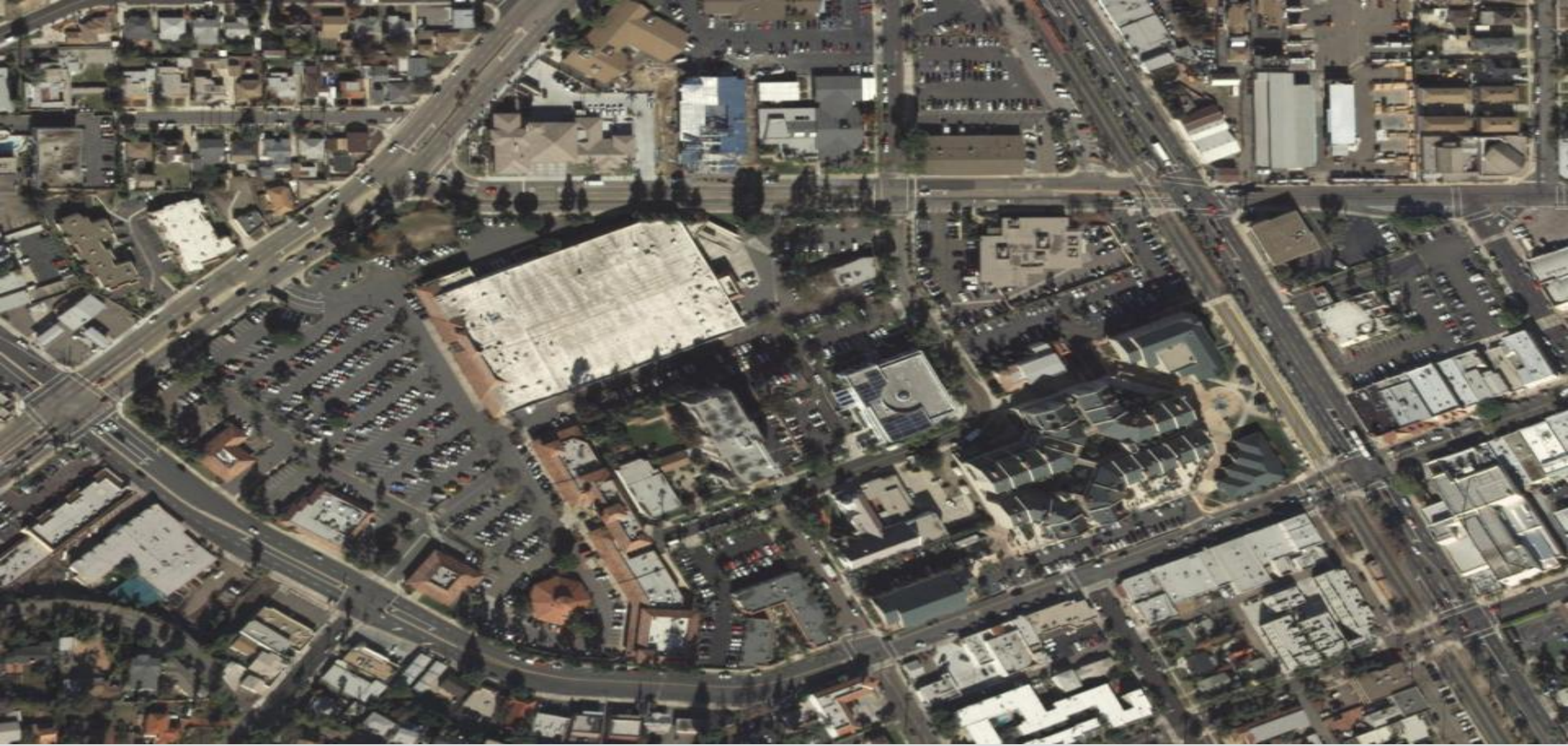
MXD Model Validation – SGOAs



Site Selection – Counted Sites

- Visited 30+ sites
- Sites were initially selected based on input from SANDAG staff, member agencies, and Project Team
- Final Sites chosen based on
  - sufficient mix of land uses
  - feasibility of count data collection

Site #1 - Rio Vista Trolley Station Promenade
San Diego



Site #2 – La Mesa Village Plaza

La Mesa

Site #3 - Uptown District
San Diego

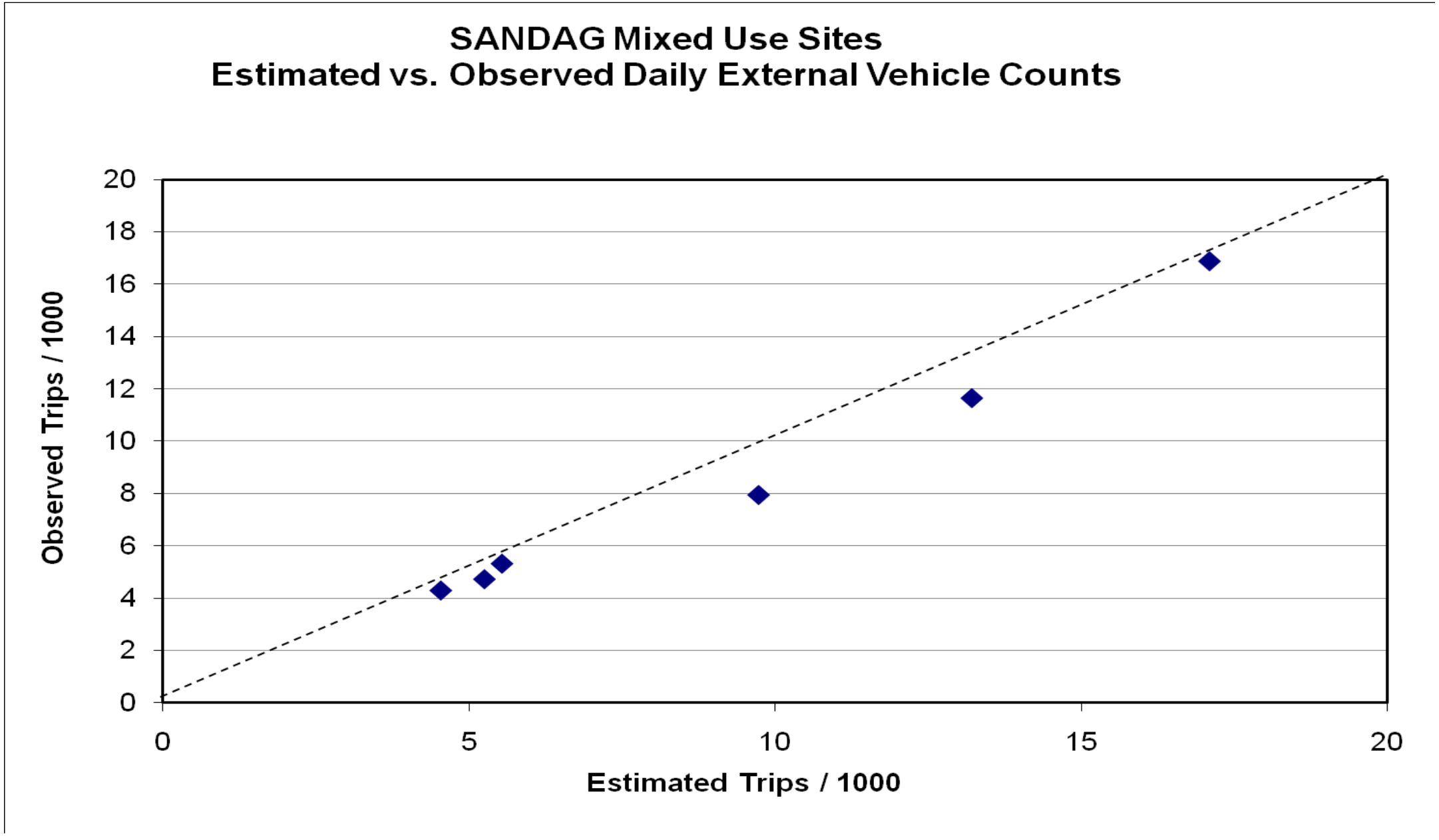
Site #4 - Morena/Linda Vista Trolley Station
San Diego

Site #5 - Hazard Center

San Diego

Site #6 – Otay Ranch Heritage Town Center
Chula Vista

MXD Model Validation – Counted Sites



MXD Model Validation – Counted Sites

Site	Raw Trips	MXD Model Trips	Counts
Rio Vista	6,689	5,538	5,307
La Mesa Village Plaza	5,681	4,539	4,280
Uptown Center	20,214	17,097	16,886
Morena Linda Vista	6,375	5,251	4,712
Hazard Center	15,051	13,214	11,644
Otay Ranch	10,505	9,730	7,935

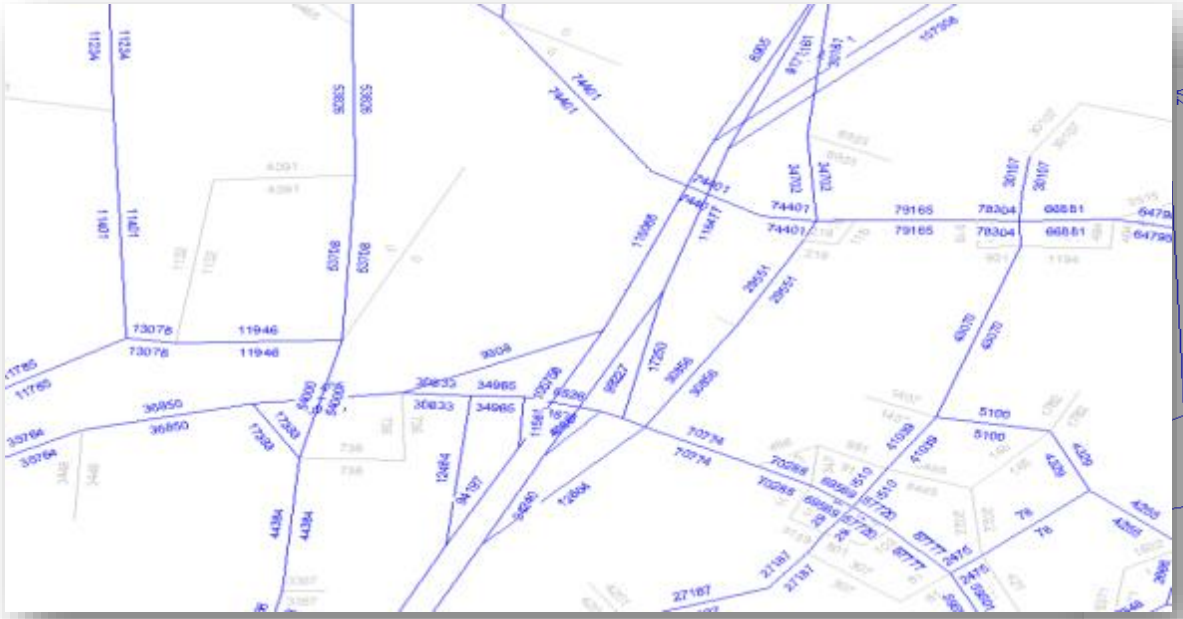
Note: MXD model volume somewhat higher than count at all sites

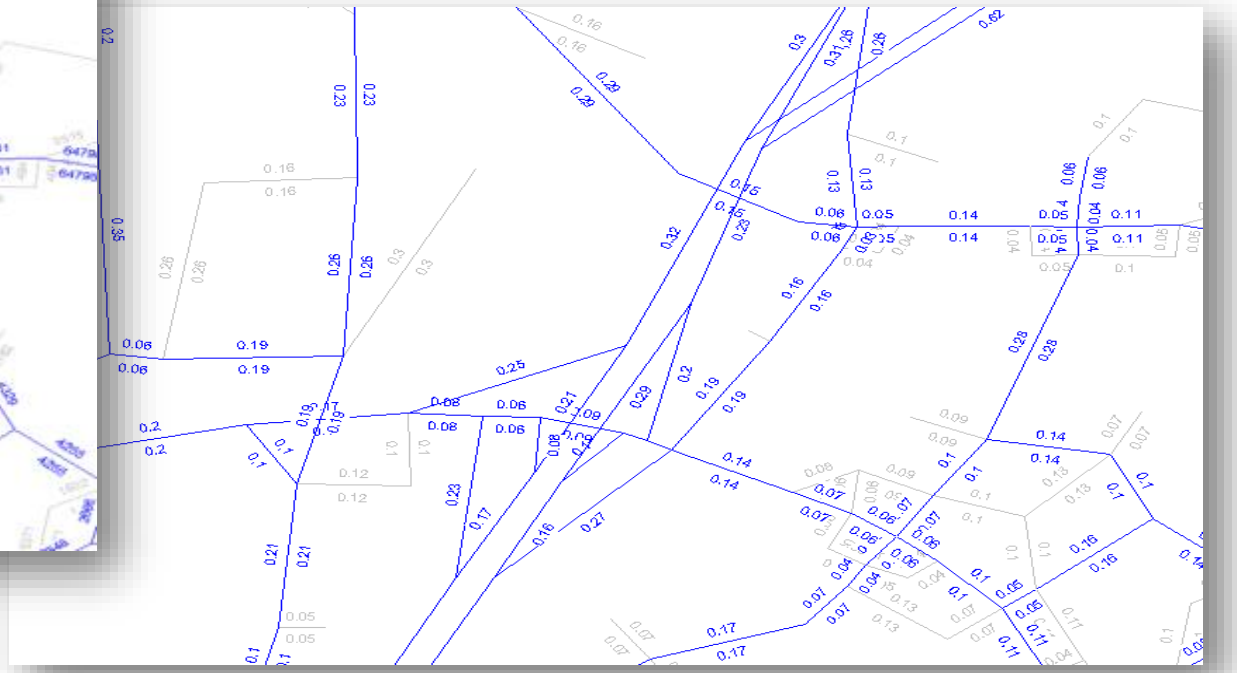
Conclusions: SANDAG Smart Growth Trip Generation Tool

- National MXD Equations match up well with San Diego empirical data
- Model estimates to HH survey comparisons show MXD model is valid but somewhat conservative
- Model estimates to counted sites comparisons also show MXD model is valid
- Ready for use on smart growth traffic analyses

Next Training – VMT FORECASTING

VMT = Volume x Distance or
Trips x Trip Length





Q & A