Berkeley Transportation Systems, Inc.

Integration of WIM Data into an Archived Data User Service

Integration Examples

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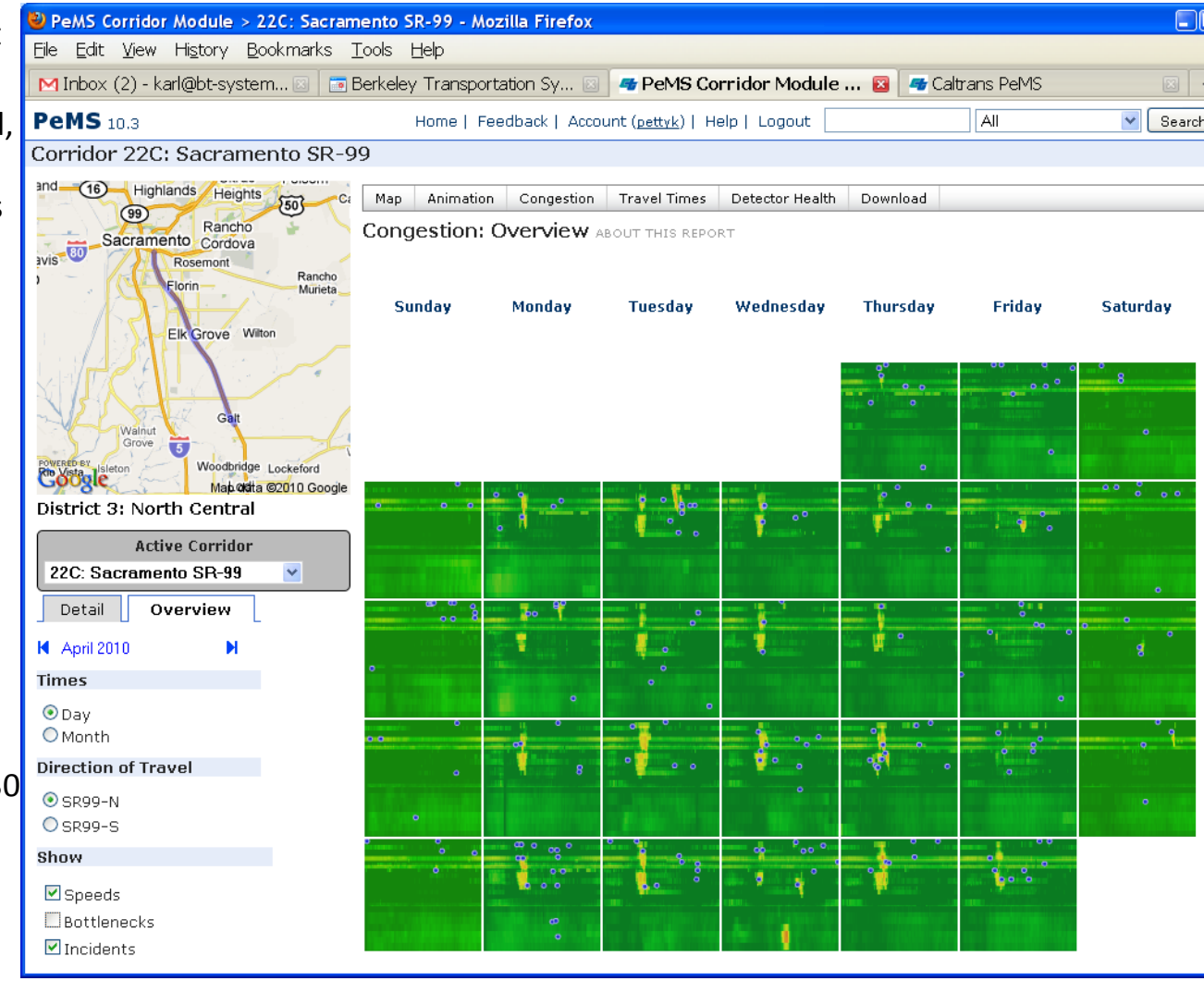
Dr. Karl Petty, David Parsons, Tiffany Barkley, Bill Morris
Berkeley Transportation Systems, Inc.

Overview

- Weight-in-Motion data is a rich, valuable source of traffic information
- Historically the ADMS's have been driven by ITS sensors from freeway operations
- There are a number of uses of this data and incorporation into an ADMS would be beneficial to a DOT
- Talk agenda:
  - California Freeway Performance Measurement System (PeMS)
  - Integrating WIM Data into PeMS
  - Using WIM Data in PeMS
  - WIM Reports and Visualizations
  - Application to MEPDG
  - Next Steps

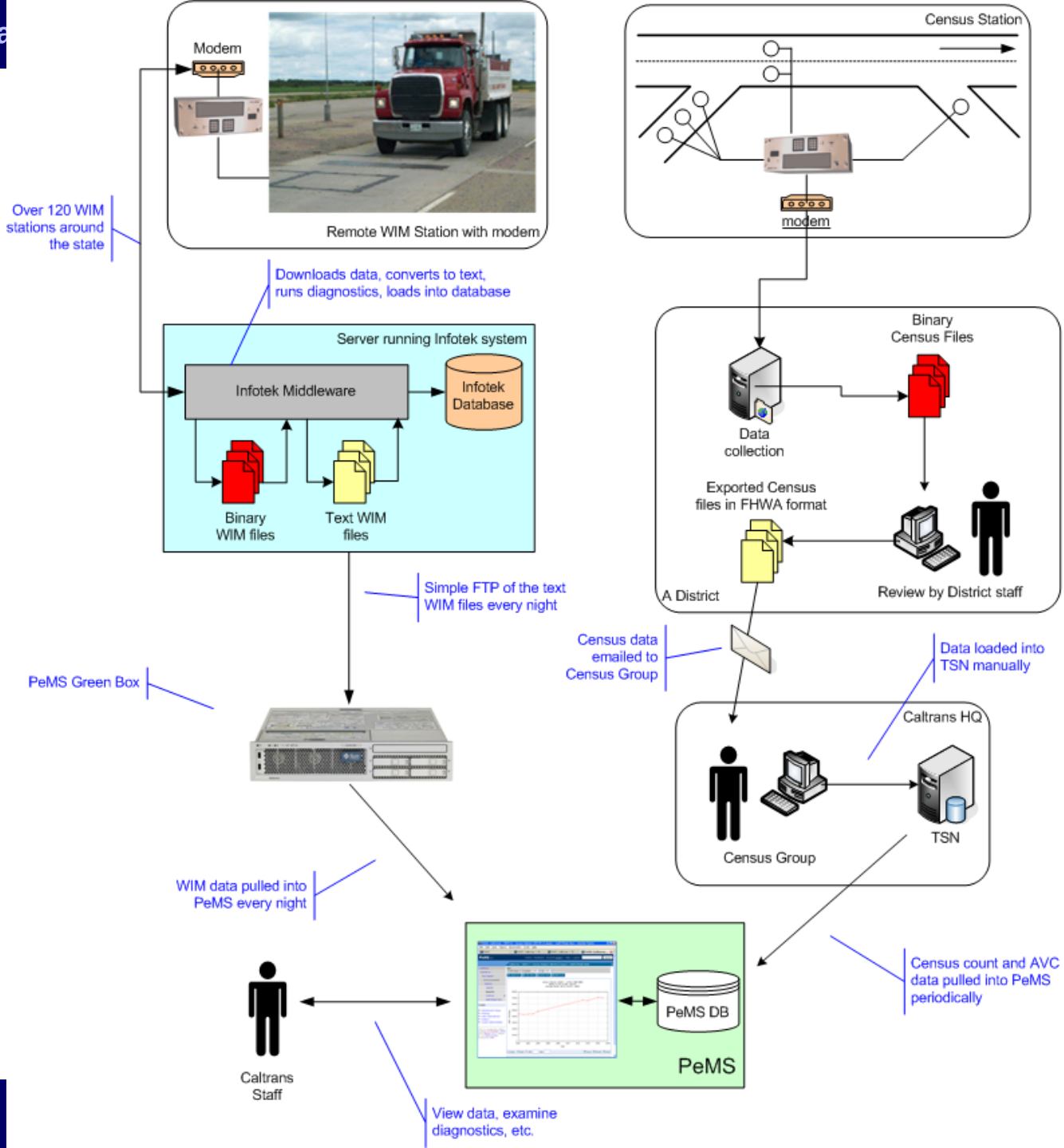
What is PeMS?

- Real-time Archive Data Management System (rt-ADMS)
- PeMS collects many types of detailed, raw data in real-time and in batch mode – primarily freeway operations data
- It processes the data in real-time:
- Diagnostics
- Imputation for missing values
- Aggregations
- Fusing of different sources
- Computes many performance measures (travel time, delay, etc).
- Large # of tools to plot, chart, etc.
- Stores raw data forever
- Caltrans deployment:
- Has 32,000 sensors reporting every 30 seconds
- Over 19,000 census stations
- Started in 1999, ~12TB of data



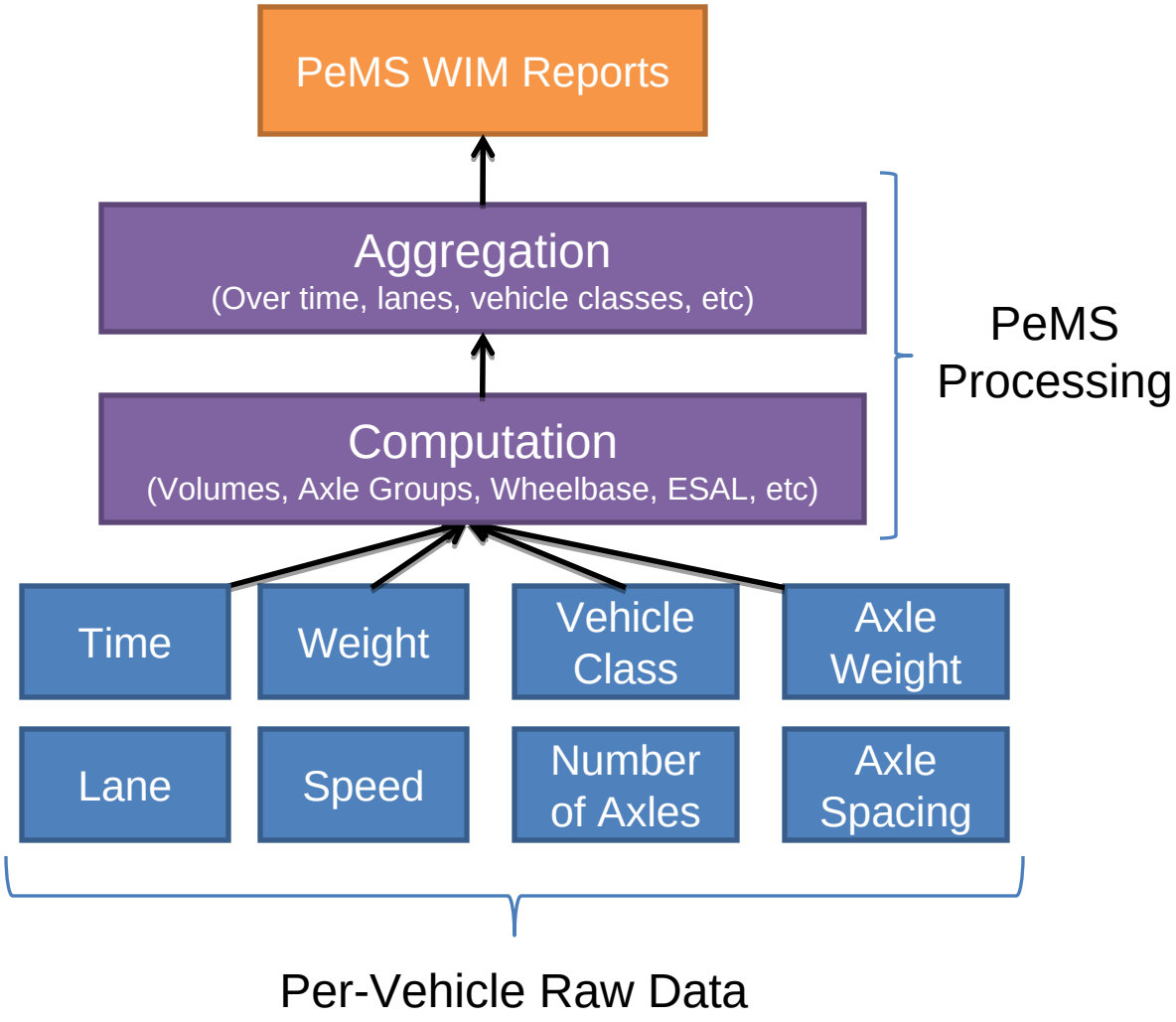
Data Flows

- The WIM data flows through the Infotek system automatically
- WIM data is pulled from all the stations every night
- Receiving data from 184 stations
- Started in Spring of 2008
- PeMS paradigm: store raw data in database forever



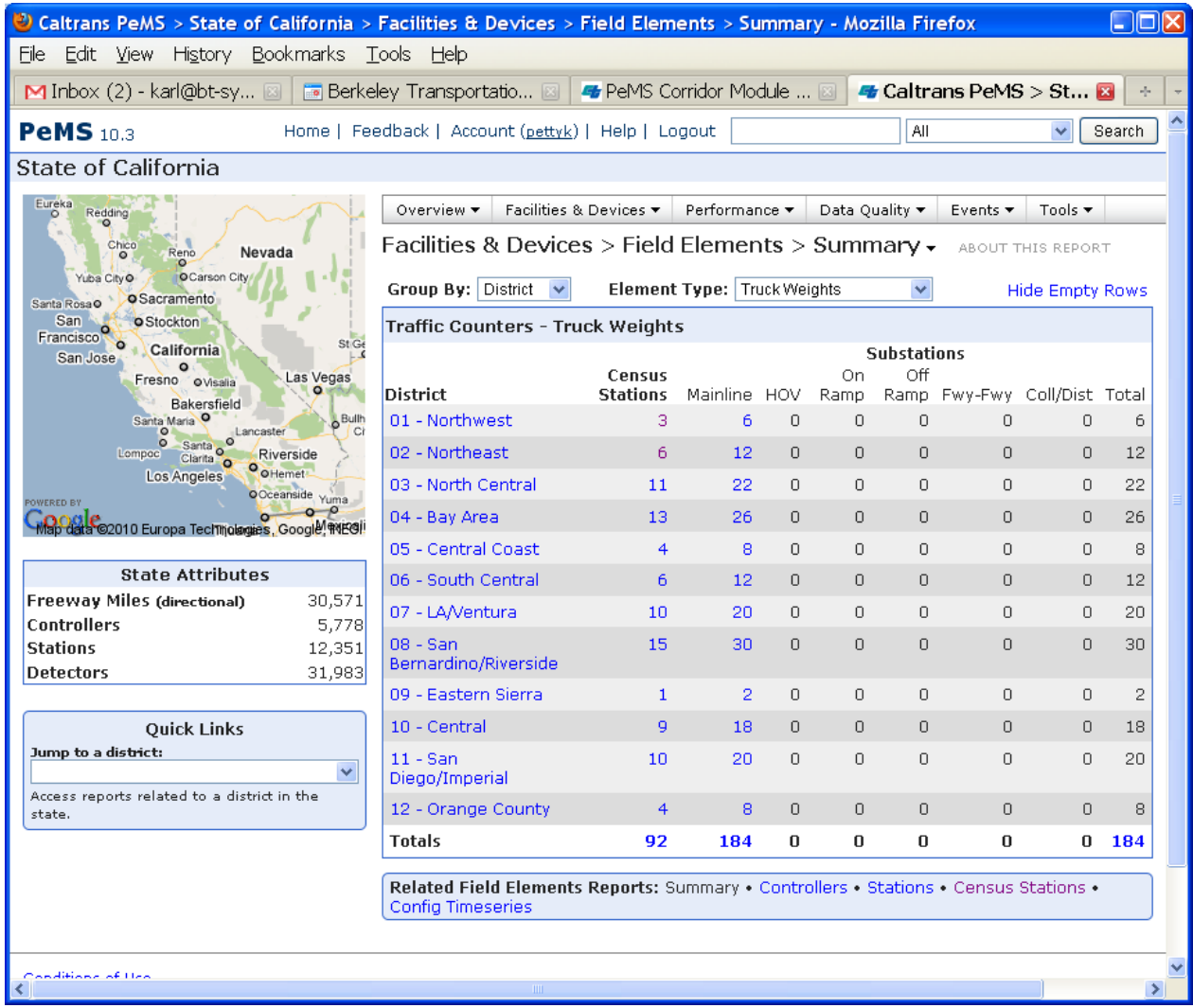
Integrating WIM data into PeMS

- Format is compatible with FHWA's Traffic Monitoring Guide (TMG)
- PeMS stores raw records as well as aggregates
- Raw data is processed to compute individual vehicle measures
- These are then aggregated up over time
- Stored at the per-station level
- Various reports on built on top of this



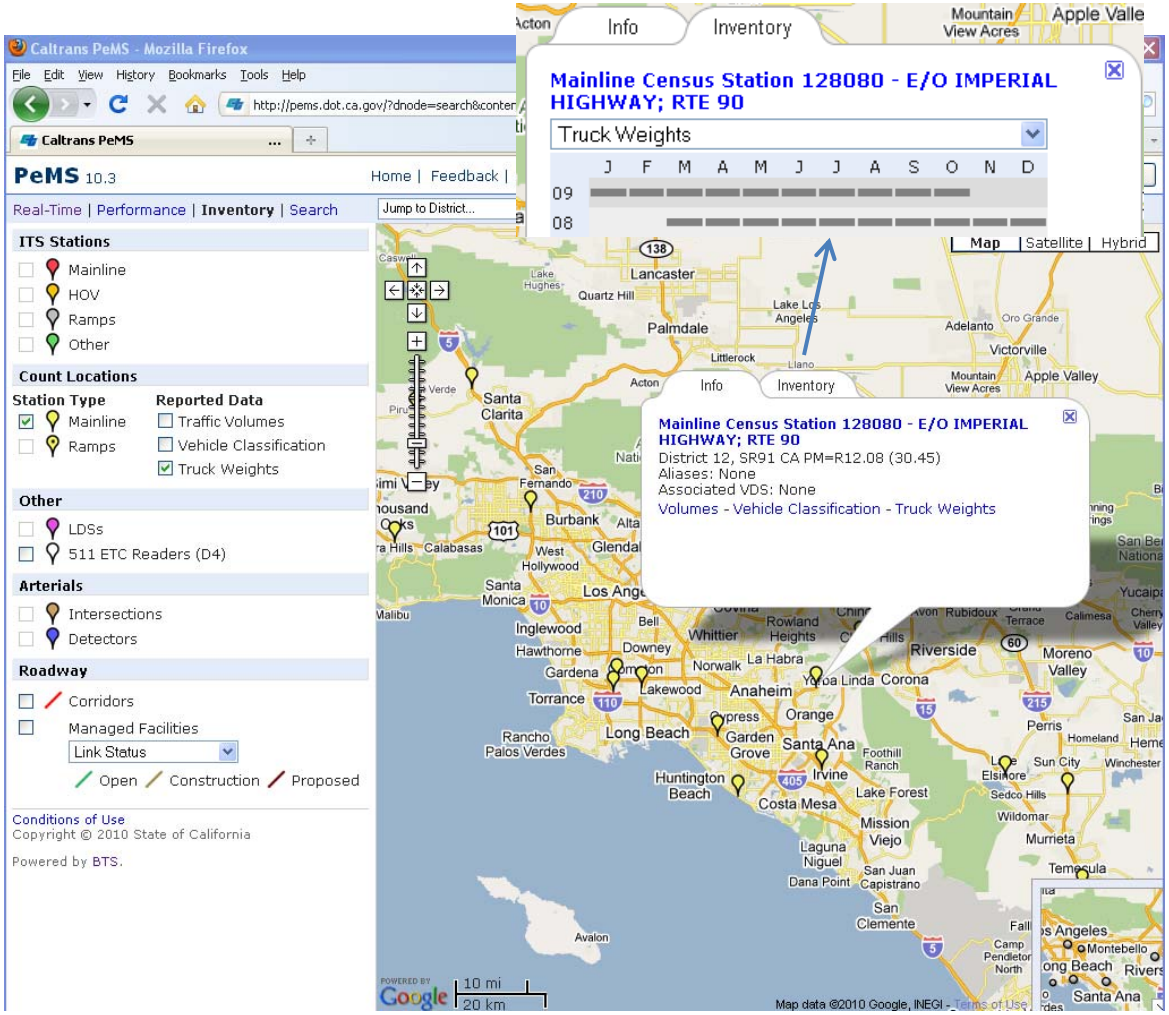
WIM Data in PeMS

- Table shows the number of WIM stations
- Grouped by District
  - 12 Districts in Caltrans
- Total of 184 individual stations
- Users can drill in here to the region that they want
- Or they can jump to the map…



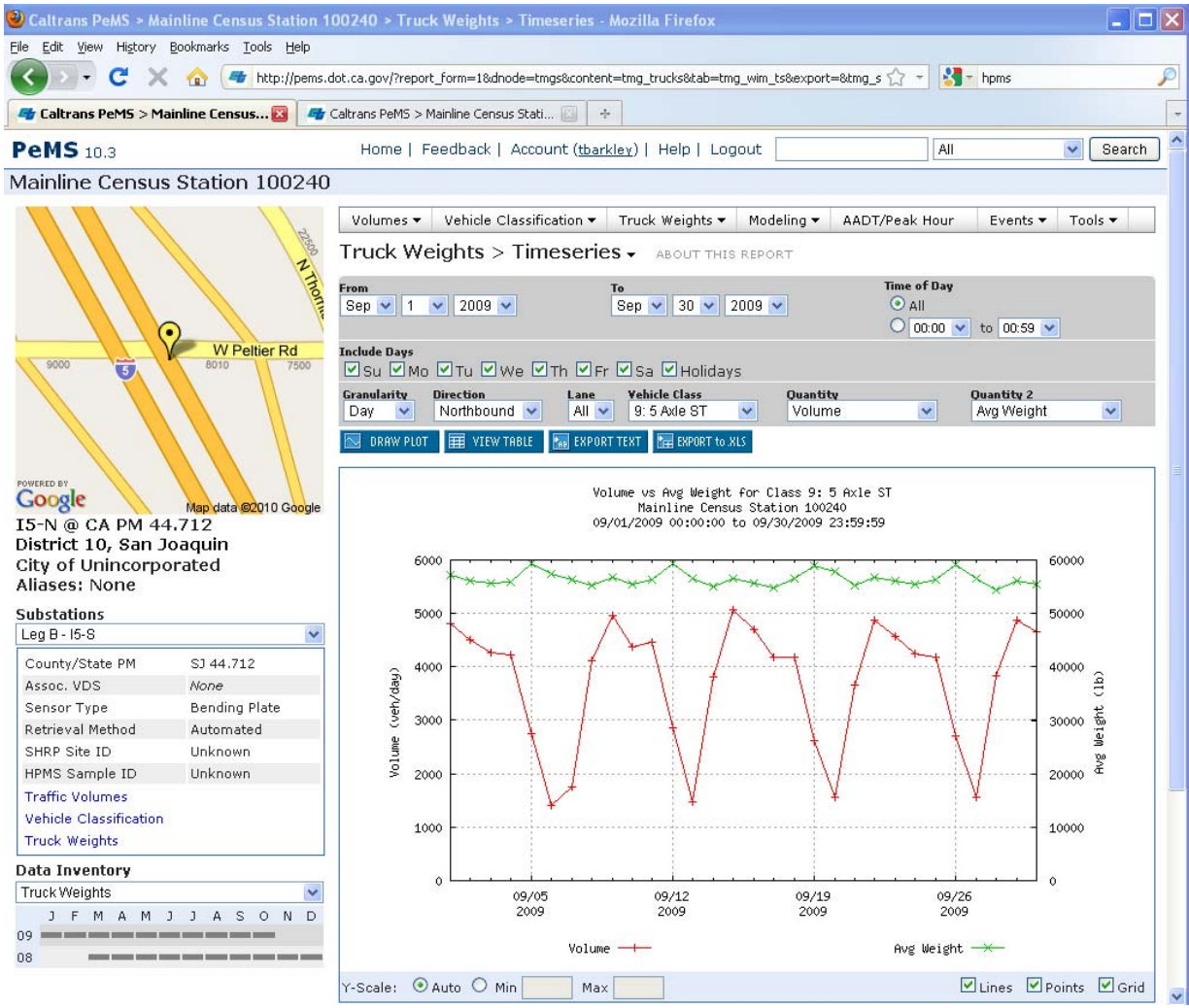
WIM Data in PeMS: Maps

- Users search for WIM stations on a map and jump to truck weight reports
- Inventory Widget shows months and years for which a station has truck weight data
  - Stations don't always report continuously like ITS stations
  - Finding data in time is important



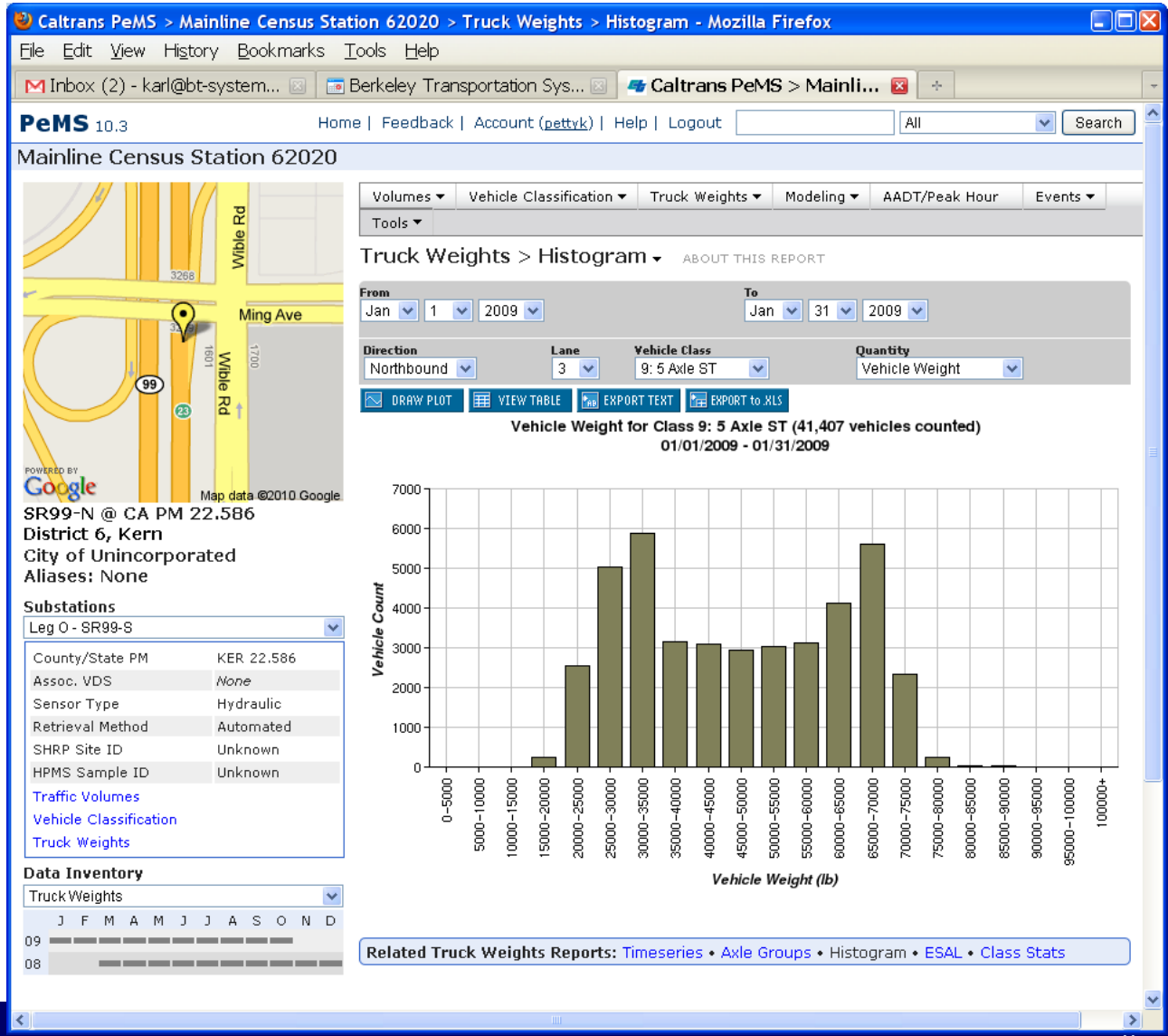
WIM Reports: Timeseries

- Here, we are plotting:
  - Daily Volumes and Average Weight
  - Class 9 (5 Axle ST) only
  - All Lanes
  - I-5 S South of Stockton
- Peak volumes on Tuesdays and peak weights on Saturdays
- Can also plot monthly volumes to view seasonal variations in truck traffic measures
- Plots average: volumes, speeds, weights, lengths, wheelbases over time.



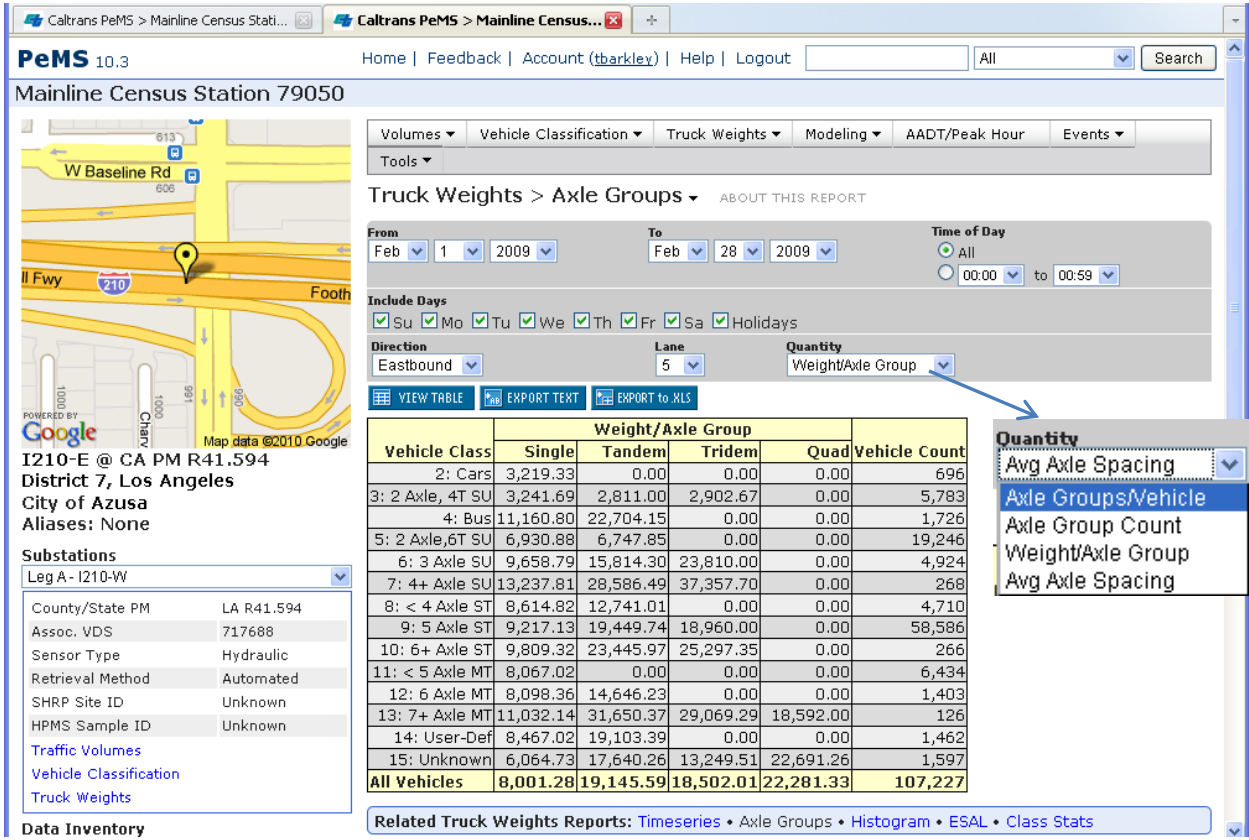
WIM Reports: Histogram

- Plots the distribution of length and width quantities by vehicle class.
- Here, we are plotting the distribution of vehicle weights for Class 9 vehicles in the right-lane (lane 3)
- Can also plot single axle, tandem axle, etc, weights
- Application: Axle Group load distribution required for Load Spectra analysis



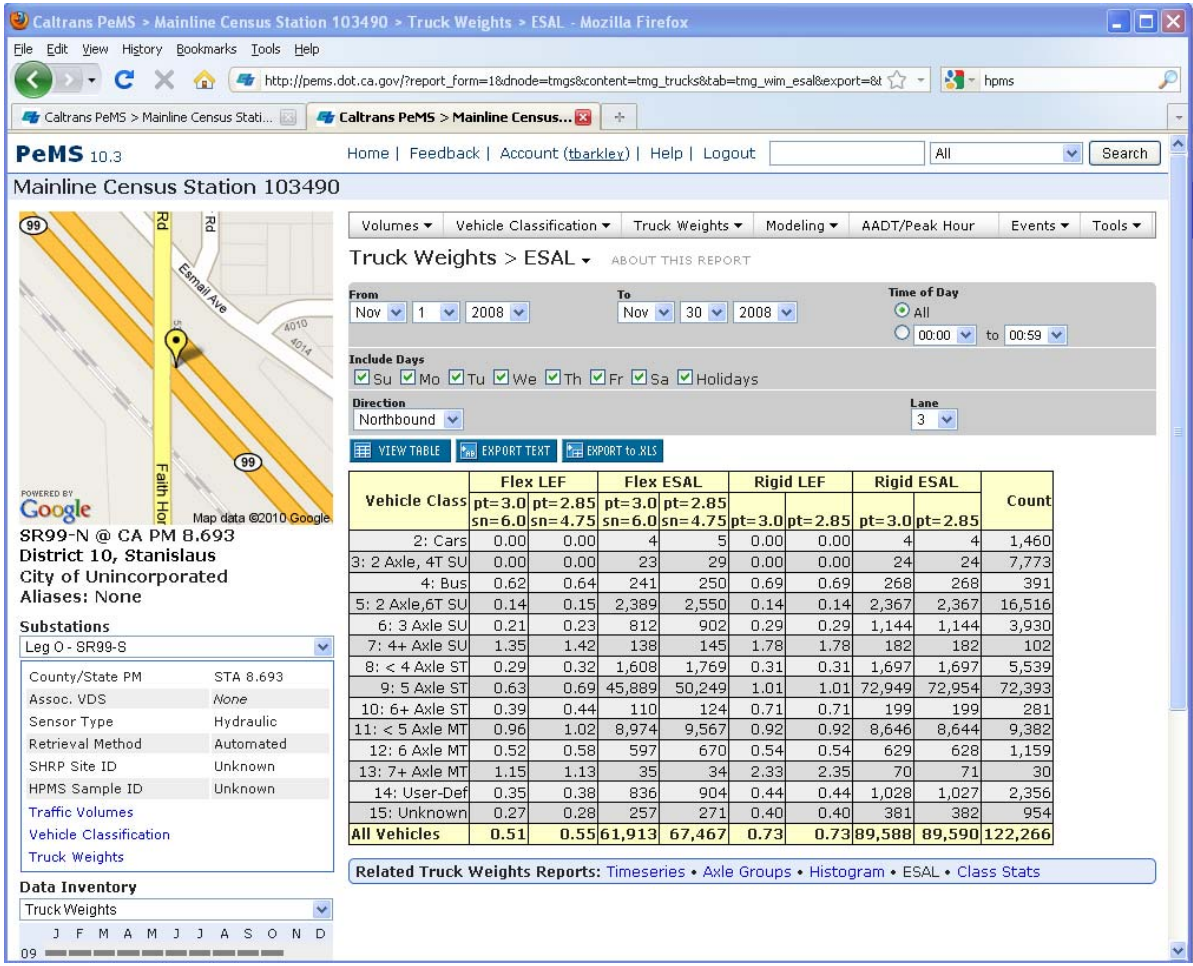
WIM Reports: Axle Groups

- Tabular view of axle group information by vehicle class
  - Axle Groups/Vehicle
  - Axle Group Count
  - Weight/Axle Group
  - Average Axle Spacing
- PeMS assigns axle groups from inter-axle spacing information in the raw WIM data
- Here, we are viewing Average Weight per Axle Group in the right-most lane of WB I-210 east of Pasadena



WIM Reports: ESAL

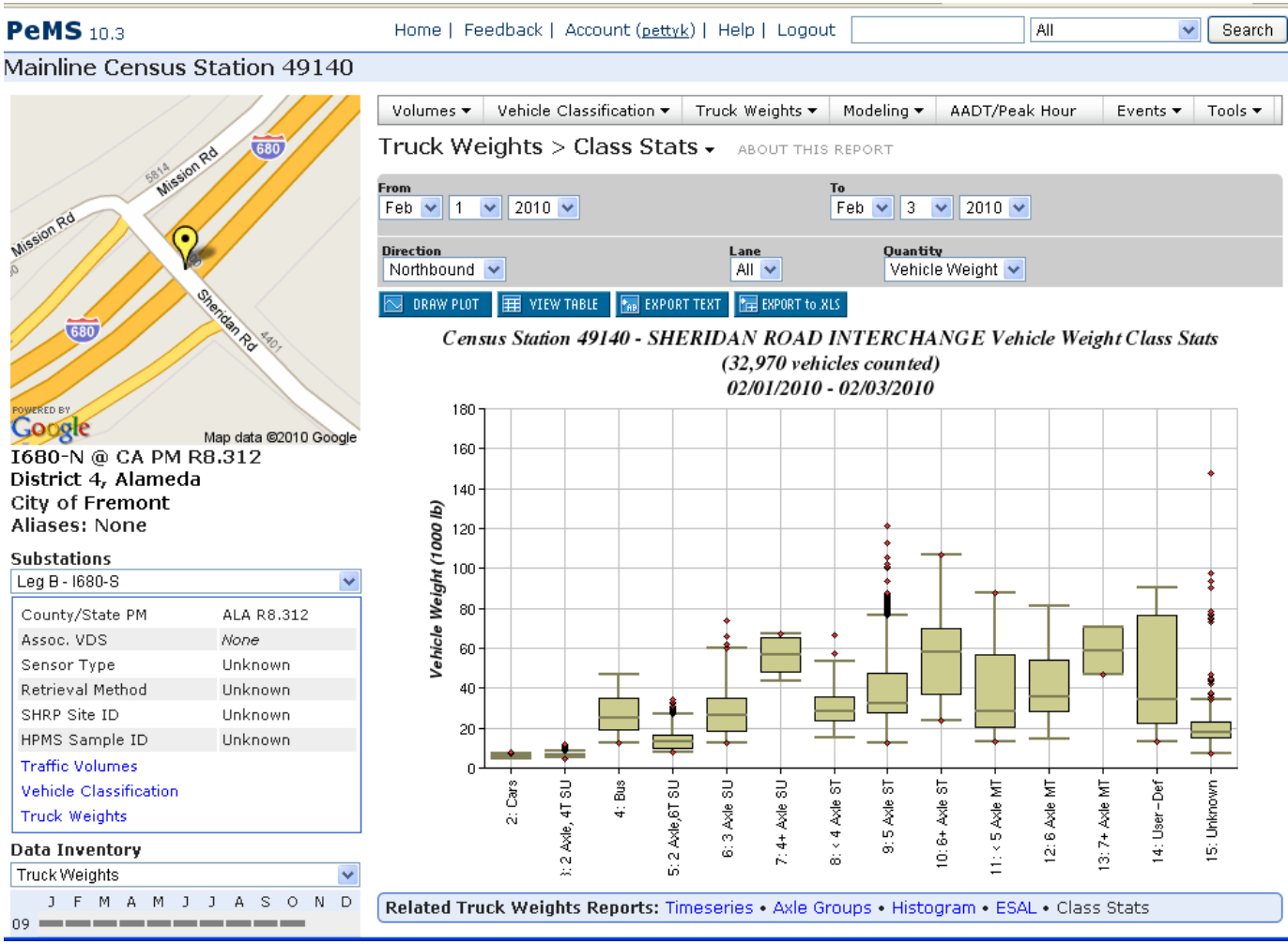
- Based on formulas in the 1993 AASHTO design guide
- Table shows:
  - Flexible and Rigid pavement
  - LEF: Load Equivalency Factors
  - ESAL: cumulative Equivalent Single Axle Load
  - Uses common parameters
- LEF=ratio of the damage per pass of a particular axle group to that of a single axle group with an 18,000 lb load
- ESAL=sum of LEFS over all vehicles in a given time period
- Application: Supports the most common analysis approach of estimating pavement damage with ESALs



Vehicle Class	Flex LEF pt=3.0 sn=6.0	Flex LEF pt=2.85 sn=4.75	Flex ESAL pt=3.0 sn=6.0	Flex ESAL pt=2.85 sn=4.75	Rigid LEF pt=3.0	Rigid LEF pt=2.85	Rigid ESAL pt=3.0	Rigid ESAL pt=2.85	Count
2: Cars	0.00	0.00	4	5	0.00	0.00	4	4	1,460
3: 2 Axle, 4T SU	0.00	0.00	23	29	0.00	0.00	24	24	7,773
4: Bus	0.62	0.64	241	250	0.69	0.69	268	268	391
5: 2 Axle,6T SU	0.14	0.15	2,389	2,550	0.14	0.14	2,367	2,367	16,516
6: 3 Axle SU	0.21	0.23	812	902	0.29	0.29	1,144	1,144	3,930
7: 4+ Axle SU	1.35	1.42	138	145	1.78	1.78	182	182	102
8: < 4 Axle ST	0.29	0.32	1,608	1,769	0.31	0.31	1,697	1,697	5,539
9: 5 Axle ST	0.63	0.69	45,889	50,249	1.01	1.01	72,949	72,954	72,393
10: 6+ Axle ST	0.39	0.44	110	124	0.71	0.71	199	199	281
11: < 5 Axle MT	0.96	1.02	8,974	9,567	0.92	0.92	8,646	8,644	9,382
12: 6 Axle MT	0.52	0.58	597	670	0.54	0.54	629	628	1,159
13: 7+ Axle MT	1.15	1.13	35	34	2.33	2.35	70	71	30
14: User-Def	0.35	0.38	836	904	0.44	0.44	1,028	1,027	2,356
15: Unknown	0.27	0.28	257	271	0.40	0.40	381	382	954
All Vehicles	**0.51**	**0.55**	**61,913**	**67,467**	**0.73**	**0.73**	**89,588**	**89,590**	**122,266**

WIM Reports: Class Stats

- Class Stats Reports compare the distributions of quantities across all vehicle classes.
- Here, we are plotting vehicle weight distributions by class in Fremont, CA.
- Boxes extend from 25th percentile value to the 75th percentile value
- Whiskers: min and max point within 1.5 * IQR
- Outliers are little dots
- Can plot:
  - Vehicle Length
  - Vehicle Weight
  - Speed
  - Axle Count
  - Total Vehicles



Application: Supply data for MEPDG

- ADMS reports can support MEPDG software data needs
- Mechanistic-Empirical Pavement Design Guide (MEPDG) is the new recommended standard for pavement analysis.
  - Considers load spectra instead of ESALS
  - Reflects improved ability to characterize traffic
- Implication: More intensive data inputs required from designers
- ADMS can assist with this

MEPDG Input	ADMS Support
Average Annual Daily Truck Traffic (AADTT)	Sum of Monthly Timeseries volumes for all truck classes
Annual Truck Distribution Spectra	Sum of Monthly Timeseries volumes within each vehicle class
Monthly Distribution Factors	Monthly Timeseries volumes for all truck classes
Time of Day Distribution Factors	Hourly Timeseries volumes for all truck classes
Axle Load Spectra	Histogram of Weight by Axle Group

Application: WIM data in delay cost calculations

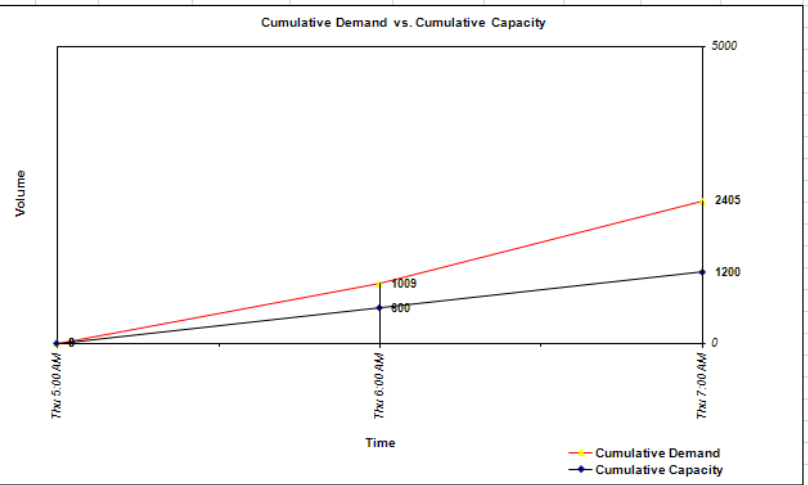
- Lane closure requests require estimation of delay due to late pickup
- Historically spreadsheet driven (a few different formats)

Caculated by : Rhodel DeClaro — Date : Mar 7, 2009

Dir	County	Route	Prefix	Postmile	Closure Type	Project Operation
EB	SJ	088		14.000	Multi-Lane Closure	Pavement Rehabilitation

Location Description	Chart No.	Count Date	Remarks
In Ione-Martell Cut-off to Begin Passir	1	05/25/06	None

VOLUME FACTOR TABLE		COST FACTOR TABLE		THROUGHPUT CAPACITY TABLE	
Diversion:	0%	Cost per Truck:	$24/veh-hr	Existing Number of Lanes:	2
Truck Volume Percent:	5.50%	Cost per Passenger Car:	$9/veh-hr	Number of Lanes Opened:	1
Passenger Car Percent:	94.5%	Cost for Mixed Traffic:	$10/veh-hr	1-Lane Capacity:	600 veh/hr
Equivalent Passenger Car per Truck:	1.5				



Day - Time	Demand (veh/hr)	Adjusted Demand (veh/hr)	Cumulative Demand (veh)	Cumulative Capacity (veh)	Queue Backup (veh)	Queue Length (mile)	Total Delay (veh-hr)	Individual Delay (minutes)
Thu 5:00 AM								
Thu 6:00 AM	982	1009	1009	600	409	0.97	205	41
Thu 7:00 AM	1359	1396	2405	1200	1205	2.85	807	121

DELAY & COST SUMMARY TABLE		
Total Delay:	(205 + 807) veh-hr =	1,012 veh-hr
Total Delay Cost :	(1012 veh-hr) x ($9.83/veh-hr) =	$9,940
Delay Cost Per Hour :	($9940) / (2 hr) =	$4,970

DAMAGE = none, does not exceed $6000/hr requirement

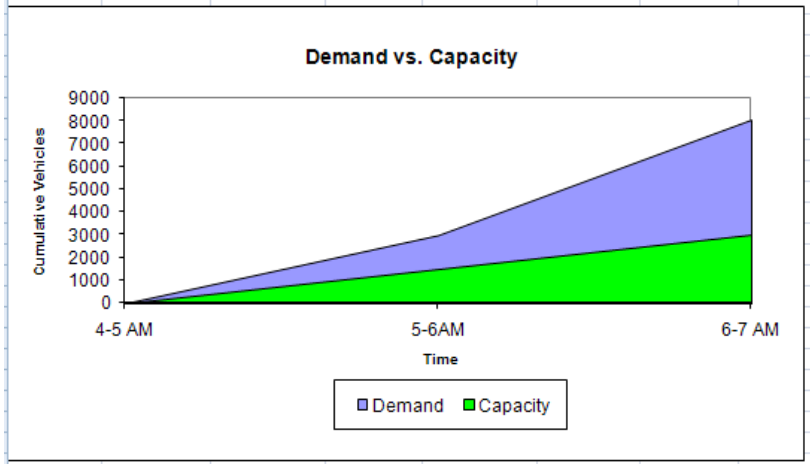
EA : 11- xxxxxx

Direction/RTE/PM: NB/SD-5/R58.76/R60.96

Operation: Multilane Closure

Percent Truck:	2.6%	Cost per Truck:	$28/Veh-Hr
Percent Passenger Cars:	97.4%	Cost per Passenger Car:	$12/Veh-Hr
Number of Lanes Existing:	3 Lanes	Cost for Mixed Flow Traffic:	$12/Veh-Hr
Number of Lanes Open:	1 Lanes	Single-Lane Capacity:	1500 Veh/Hr
		Open-Lane Capacity:	1500 Veh/Hr

Time	Demand (Veh)	Cumulative Demand (Veh)	Cumulative Capacity (Veh)	Difference (Veh)	Area (Veh-Hr)	Queue Length (mile)	Indiv. Delay (minutes)
4-5 AM							
5-6AM	**3010**	3010	1500	1510	755	2.4	60
6-7 AM	**5089**	8099	3000	5099	3304.5	8.0	204

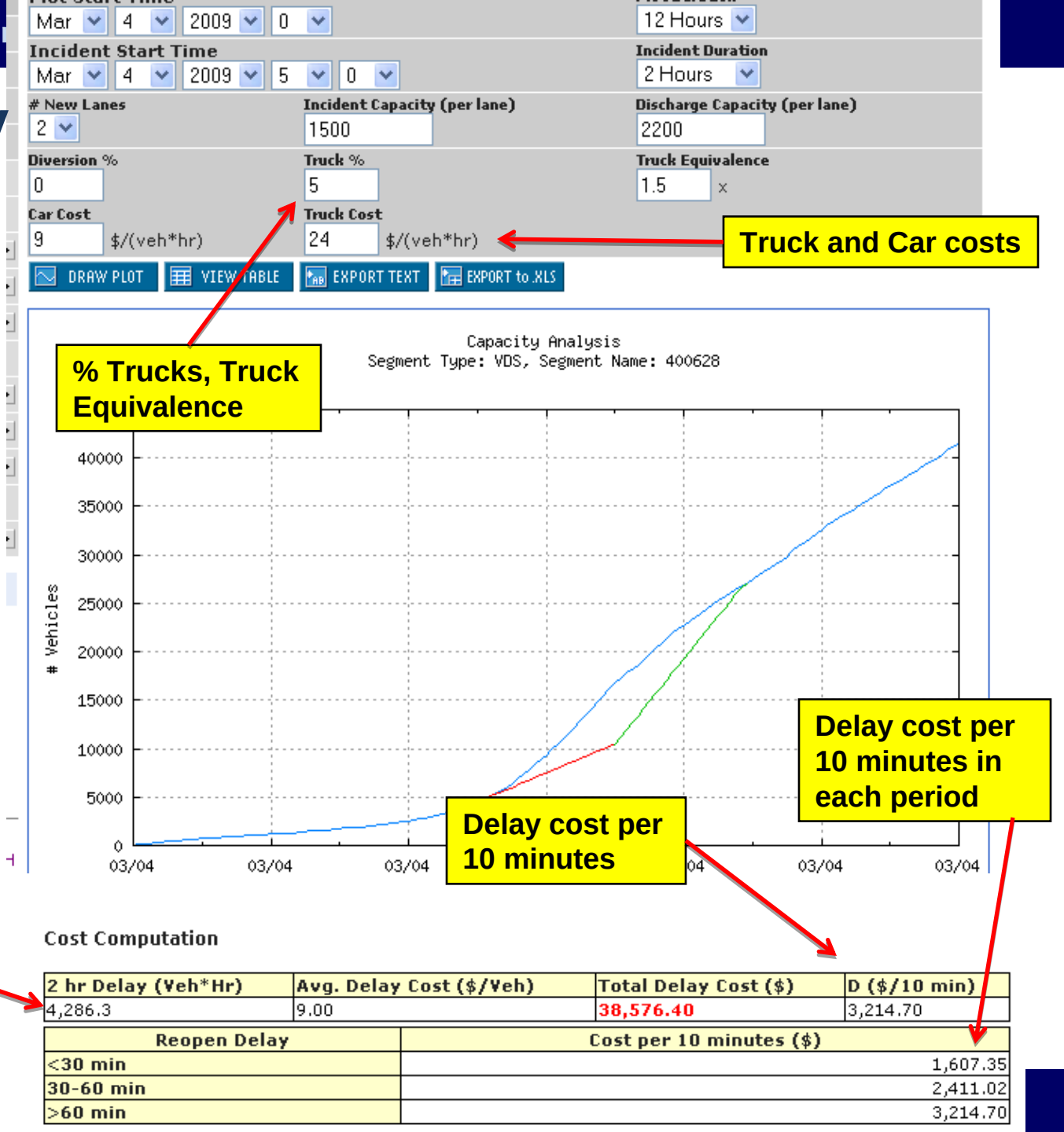


Max. Individual Delay:	204 minutes
Vehicle Delay Hours:	4,060 veh-hr
Total Cost of Delay:	$48,447
Delay Cost/10min:	$4,037

1st Half Hour	2nd Half Hour	2nd Hour
$2,019	$3,028	$4,037

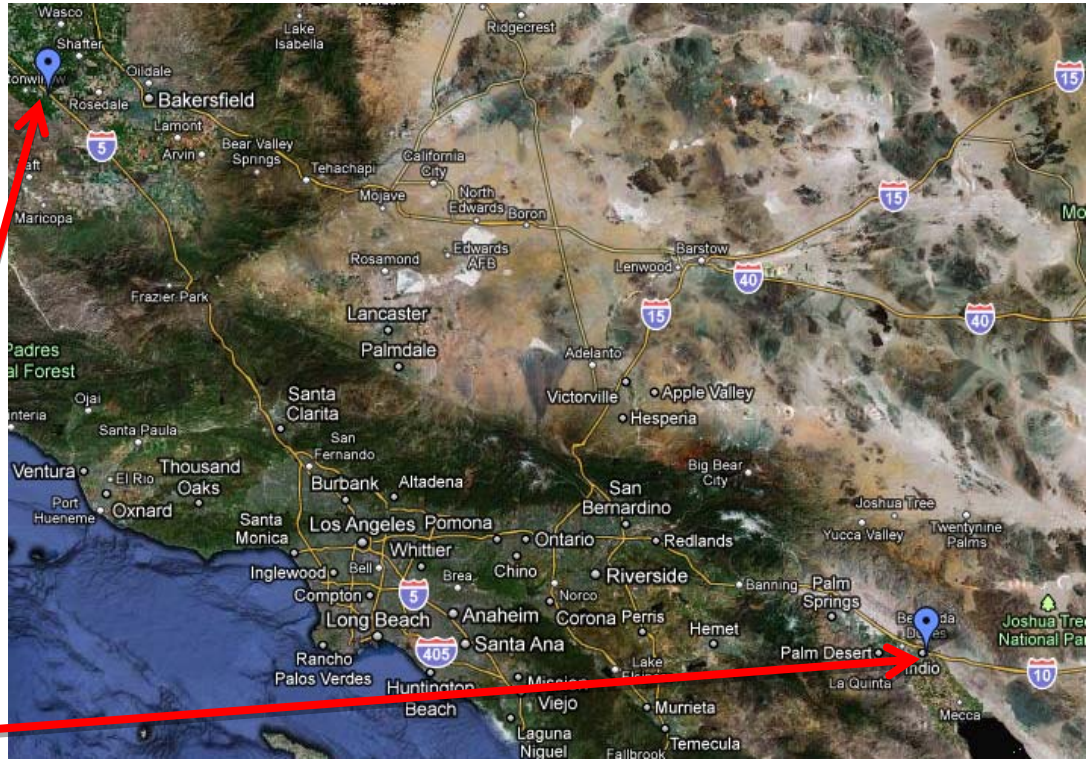
WIM & Delay

- PeMS automates the development of these charts
- Leverages data from an ITS station for input flow
- Typically needed to estimate the truck % (or look it up in a table)
- Can use WIM data from adjacent stations directly



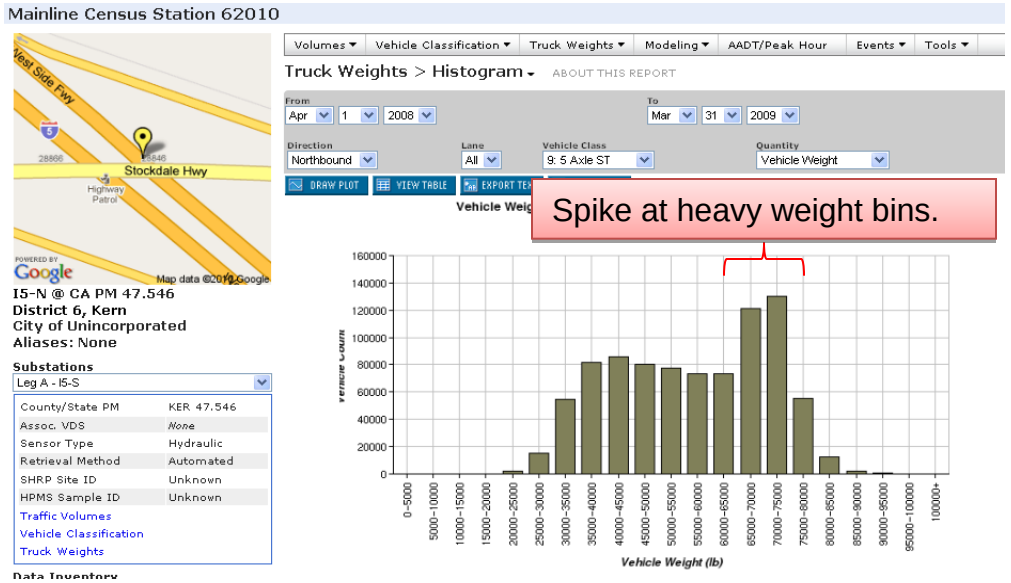
Application: Regional differences in truck weights

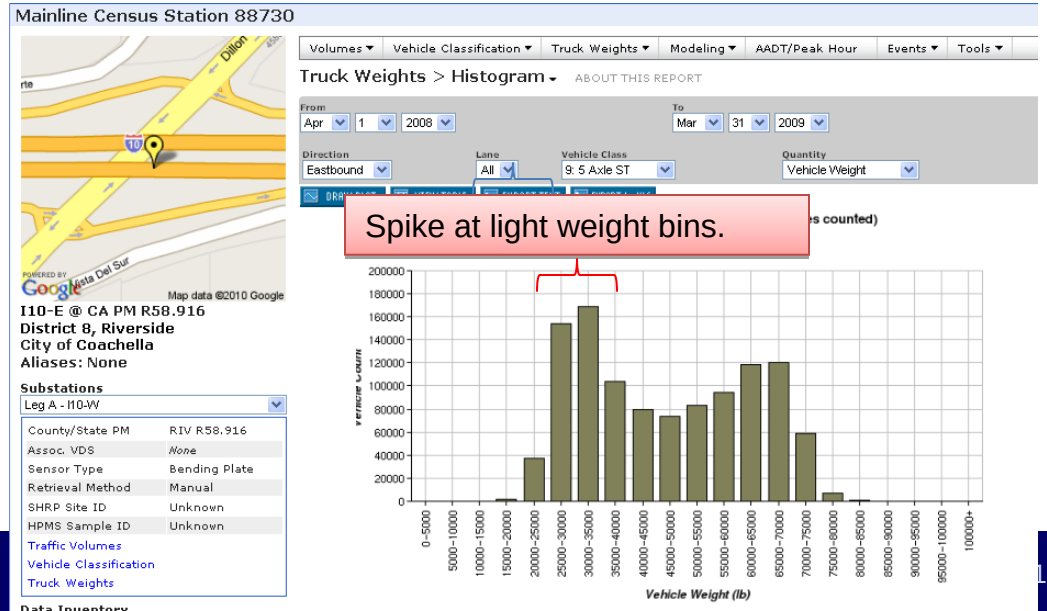
- **Example**: Are trucks heavier leaving Los Angeles to the north or to the east?
- Using PeMS plots of WIM data, we can compare load spectras by vehicle class across the state.
- We can use WIM data from these station on I-5N north of LA and I-10E east of LA to answer this question



Application: Regional Differences in truck weights

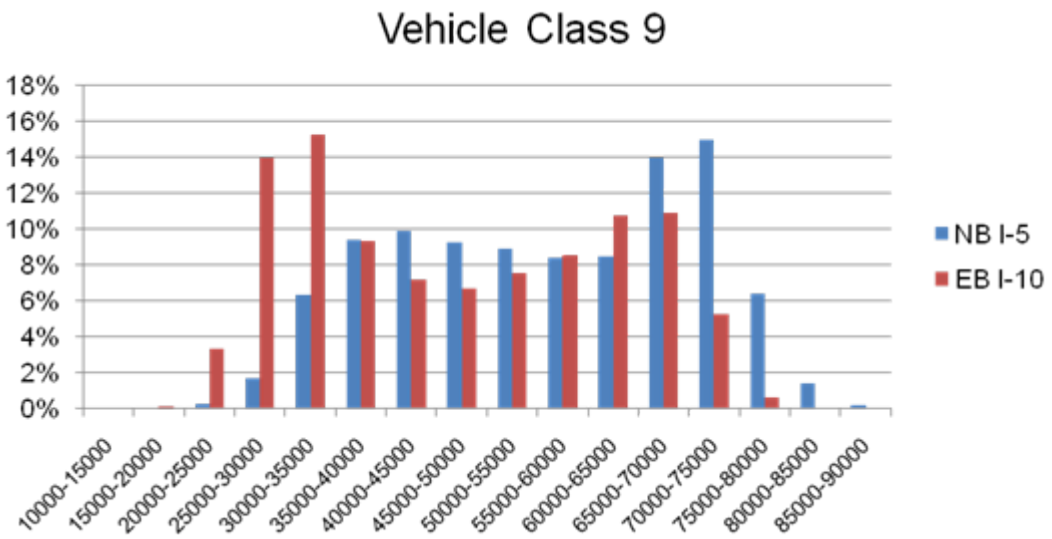
- Plot vehicle weights for Class 9 over an entire year
  - April 2008 – Mar 2009
- Top plot shows I5-North, bottom plot shows I10-East.
- Vehicle weights look higher north of LA.
- Can export to .XLS for further analysis

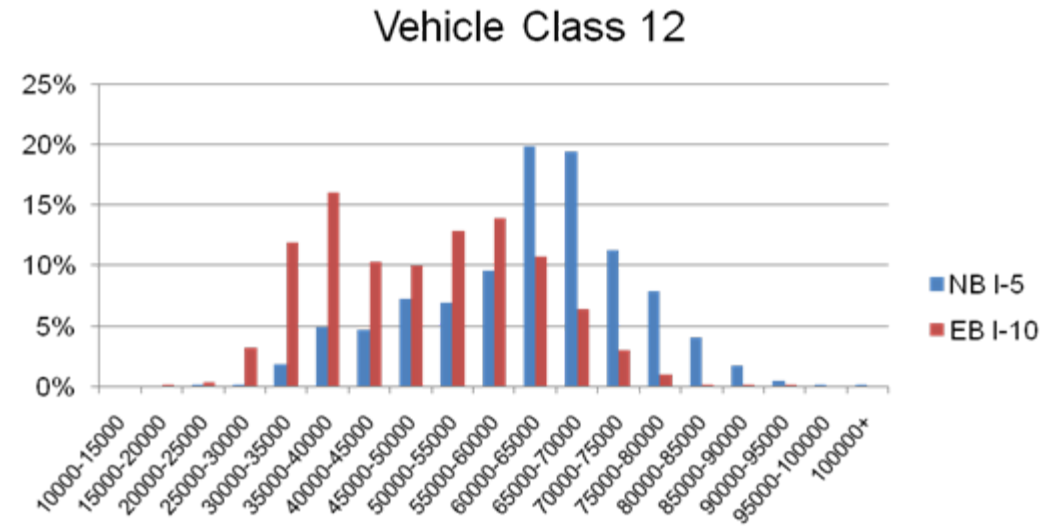




Application: Regional Differences in truck weights

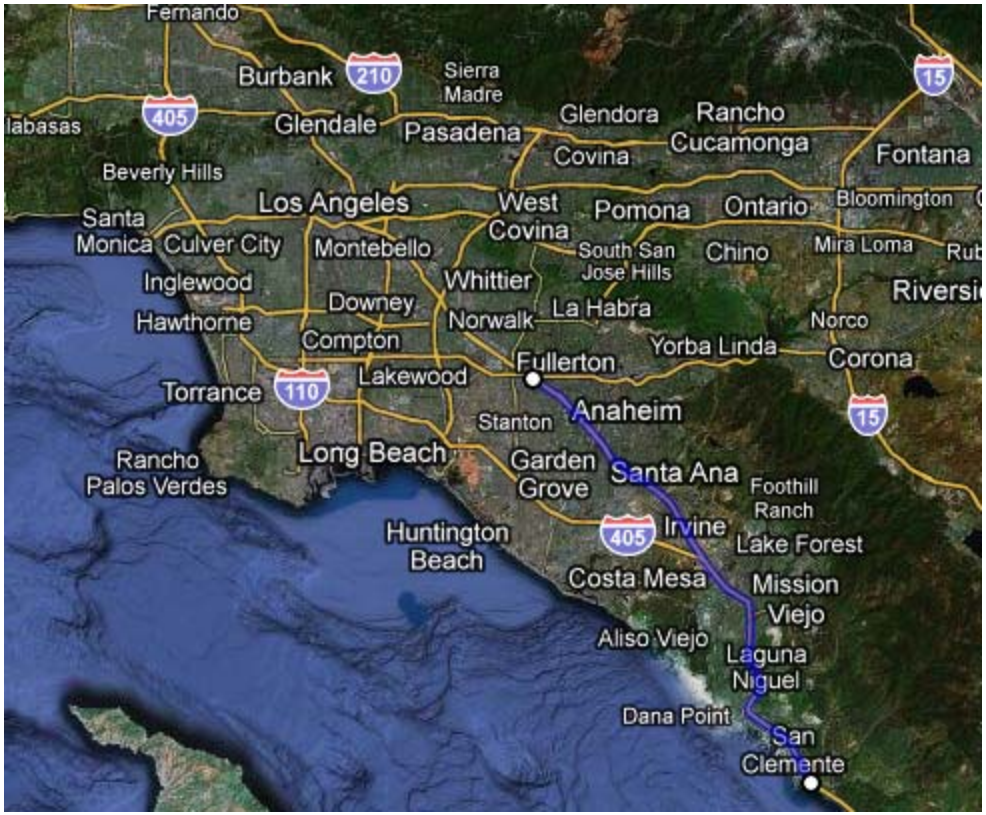
- Plotting weight bins by percentage of total confirms that truck weights are lighter leaving LA to the east than to the north.
- Trend is the same for Vehicle Class 12!
- **Conclusion**: Trucks leaving LA to the north are heavier
- Reason?
- We can speculate wildly:
  - Trucks going north on I-5 are leaving LA full?
  - Trucks going on EB I-10 are returning to Mexico empty?





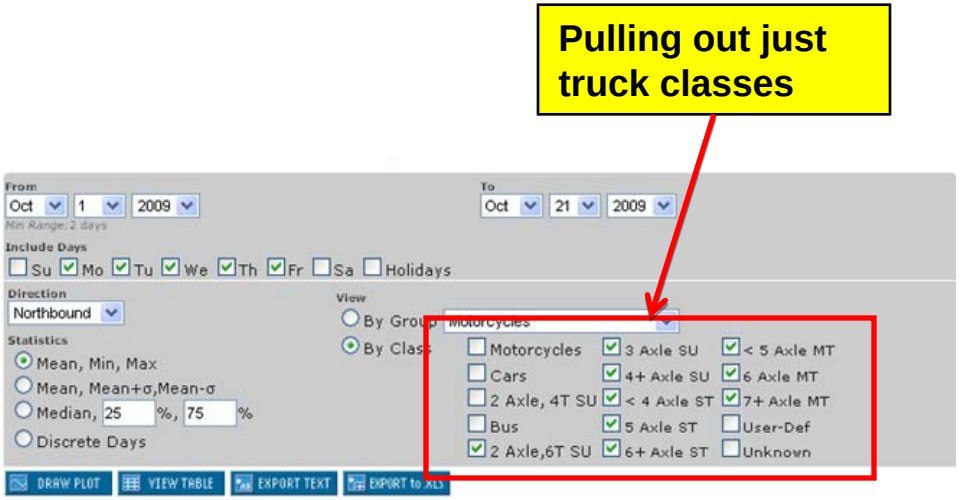
Application: Trucks and Congestion

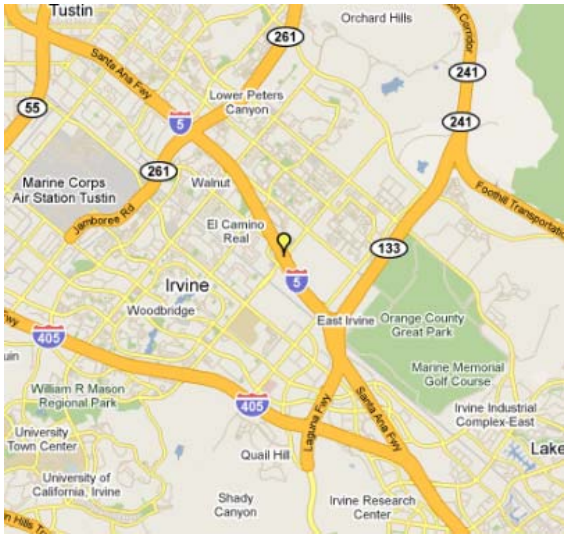
- Flip previous example around:
  - Instead of looking at the cost for delay due to a closure, look at the cost to trucks that delay is causing
- **Example:** We want to figure out the average weekday delay cost to trucks on I-5 N in Orange County (a major freight corridor).
- Steps:
  1. Use WIM data to find the weekday truck volumes by hour
  2. Use loops to find the weekday delay by hour along the route
  3. Use cost factor to calculate weekday cost of delay to trucks

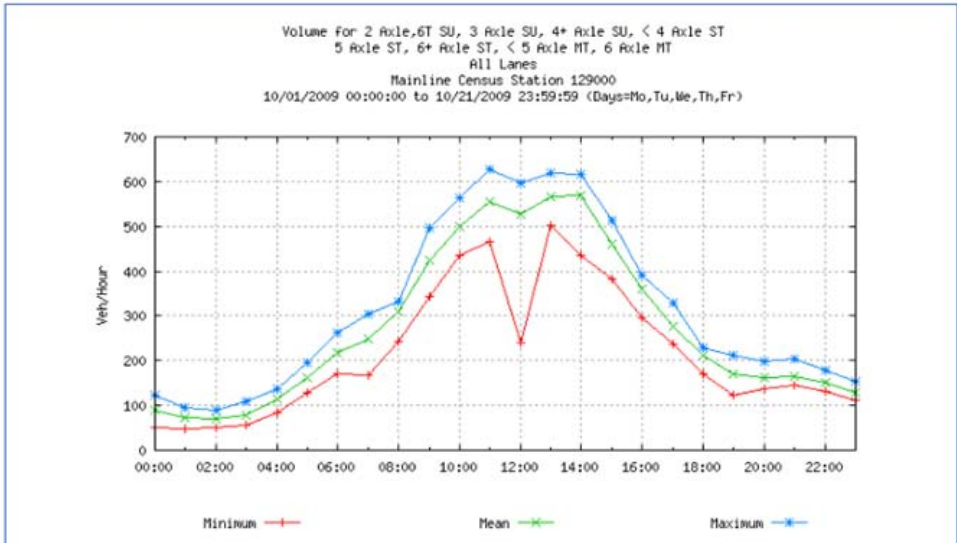


Application: Trucks and Congestion

- Here, we are plotting the average weekday truck volume by hour of the day at a WIM station along the route.
- Peak volumes are between the hours of 9:00 AM and 3:00 PM

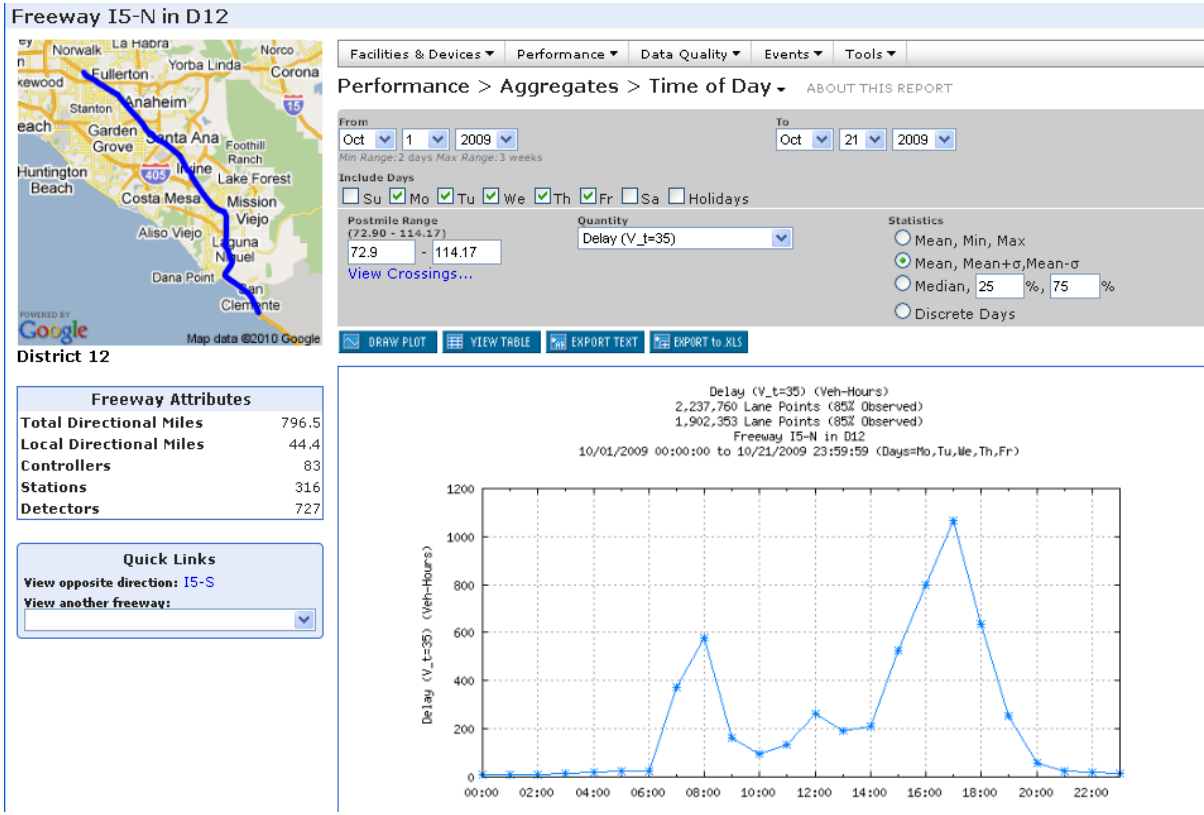






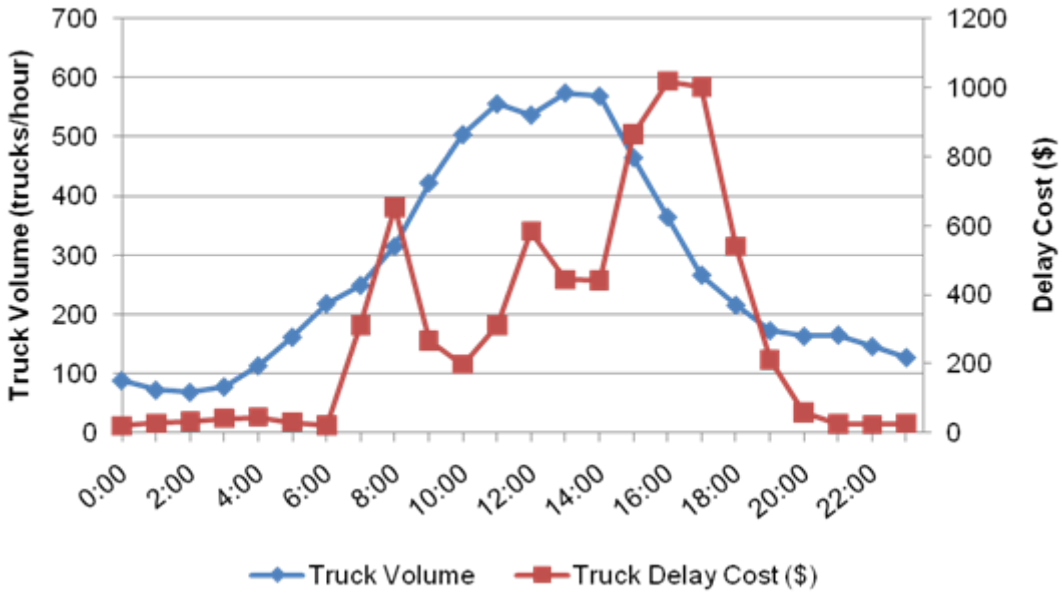
Application: Trucks and Congestion

- Congestion data
- Here, we are plotting the average delay (in veh-hours) along the entire 40 mile route, based on loop detector data (not WIM data)
- Delay peaks at 8:00 AM and between 4:00 PM and 7:00 PM
- From previous slide, we can see that most trucks travel in the off-peak hours.



Application: Trucks and Congestion

- We assume that a truck-hour of delay=$28.70
- Results: Average weekday truck delay cost=$7,200 on this corridor ($144,000 per month!)
- Chart shows that, even though more trucks travel in the midday period, the most cost is incurred during the PM peak.



- Definite argument for demand shifting for trucks
- Can be shared with partners to assist with goods movement strategies

Next Steps

- Adjusting congestion reports by average truck volumes
- Associating truck volumes with incident delays
- Supply information for Pavement Management Programs
- Hourly and Monthly Adjustment Factors by vehicle class
- Error reports that detail violations
- Export files that can be directly imported into MEPDG and other design software (better organization of reports)

Berkeley Transportation Systems, Inc.

Questions