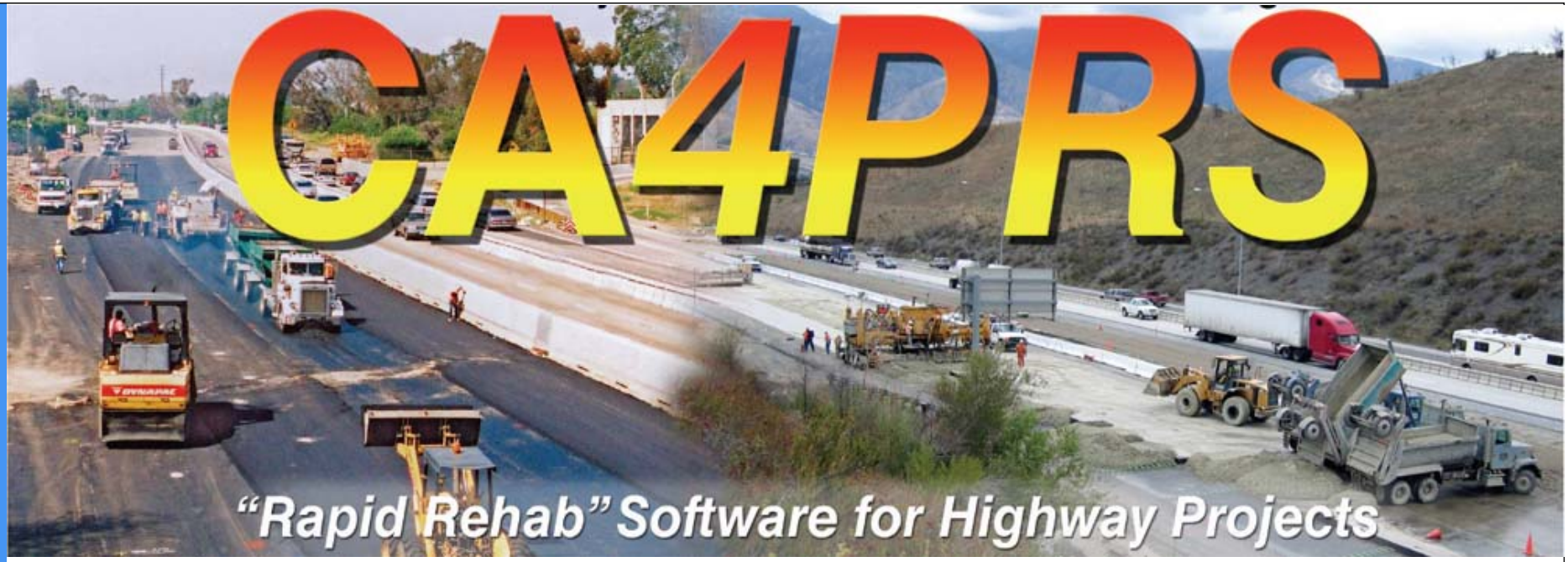


Construction Analysis for Pavement Rehabilitation Strategies

Accelerated Road Work for Work Zone Safety & Mobility
Peer Exchange Workshop

June 5-6, 2012

E.B. Lee
Institute of Transportation Studies
Univ. of California at Berkeley

Chang Mo Kim
University of California at Davis

Transportation Trends (1970-2010)

Congestion

Aging

Freights

1970

Up 32%

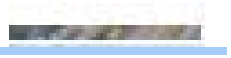
Up 63%

Up 90%

Up 132%

Up 580%

Up 6%

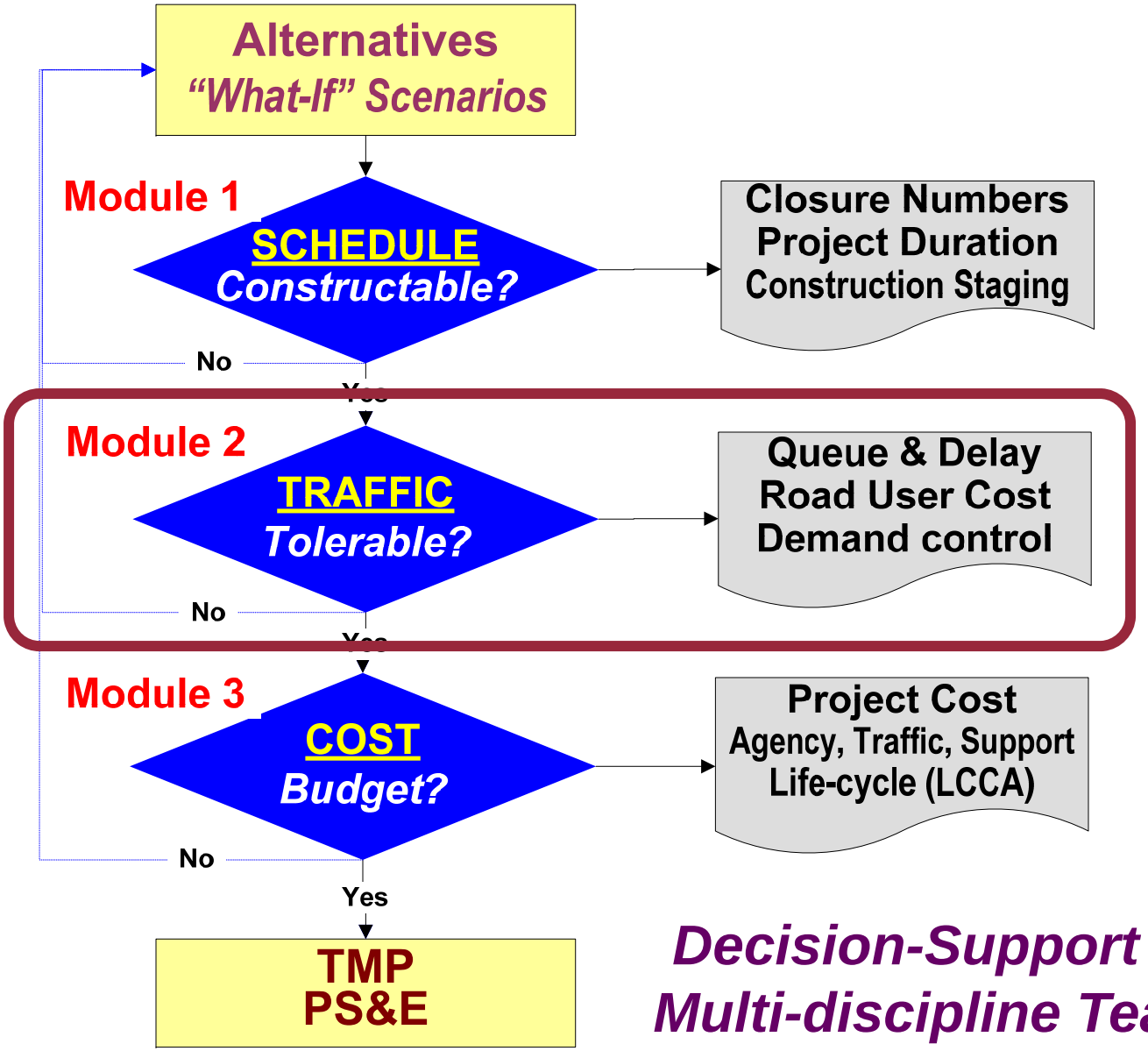


Americans *Drivers* *Vehicles* *Travel Miles* *Ton Miles* *Highways*

CA4PRS History

- CA4PRS Software Development
  - Pooled-fund (CA, FL, MN, TX, WA): UC Berkeley 2003
  - Help DOT agencies develop more economical highway construction and TMP strategies
- FHWA Outreach
  - 2009 Market-ready Innovation and Technology Product
  - Arranged Free-group License for State DOTs
  - Training: 1,200 Eng (20 DOTs), 12 univ., Online course
- AASHTO Promotion
  - CAST: WZ Traffic Tools: 2007-2009

CA4PRS Analysis Process



Decision-Support Model
Multi-discipline Teamwork

CA4PRS Comparison Alternatives

- Pavement Design Alternatives
  - Maintenance & Rehabilitation Strategies
    - ***Rigid: JPCP, CRCP, Precast***
    - ***Flexible: Overlay, Milling-filling AC, Full-depth AC***
  - Variation: Cross-section, Mix, Base type
- Work-zone Traffic Alternatives
  - Closure timing (Night, Day, Weekend, Continuous)
  - Optimized Lane Closure Hours & Numbers
  - WZ Demand Sensitivity & Capacity Sensitivity
- Contractor's Logistics Alternatives
  - Site access and Construction sequence
  - Constructability (demo/mix): Resource optimization
- Competing Objectives: Integration & Collaboration

CA4PRS Estimate
Agency (Project) Cost

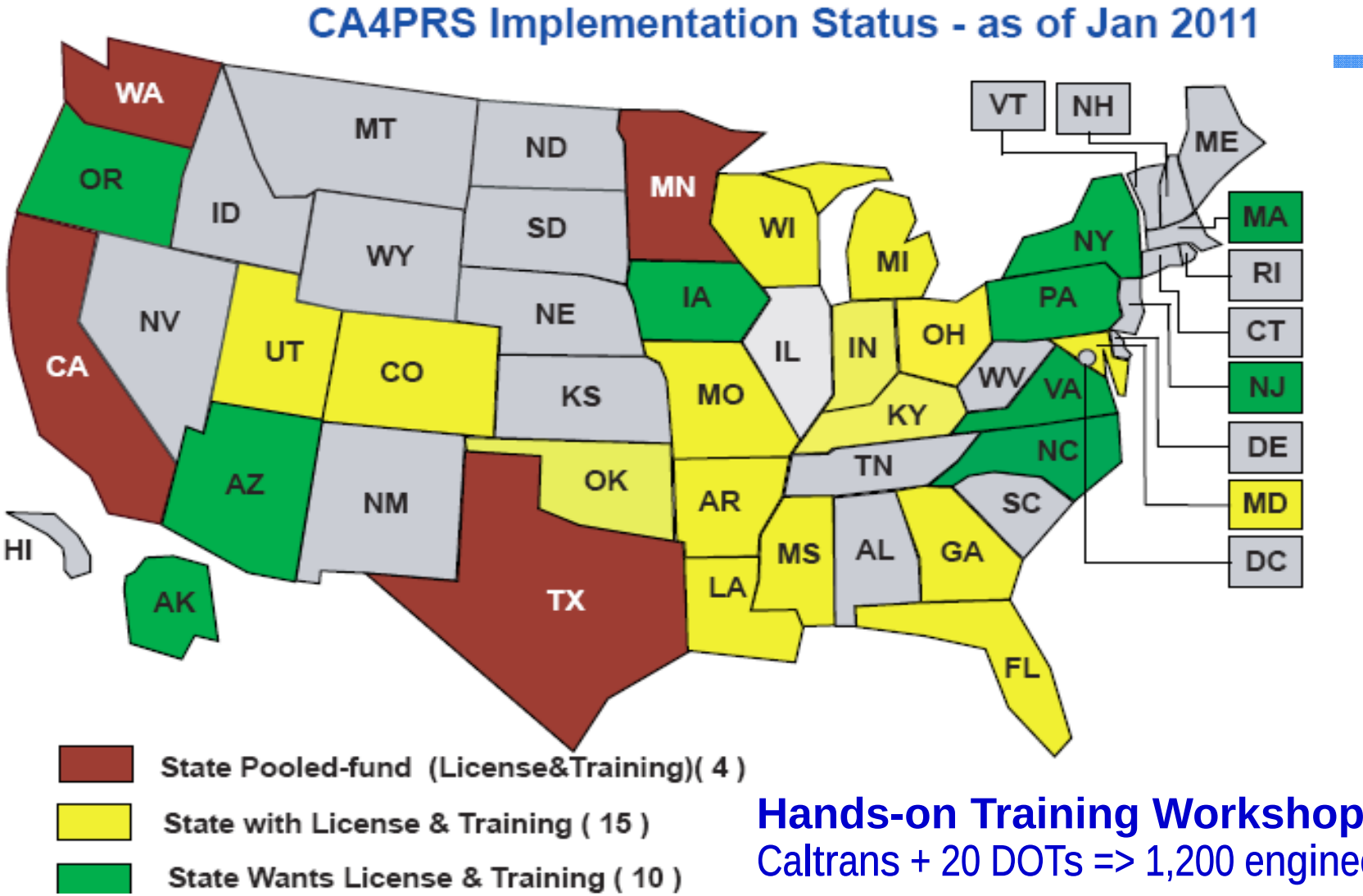
- Pavement Cost: Itemized unit-price and quantity
  - Materials (PCC, HMA, RAC, Pre-cast), Base, Subbase
  - Item unit-price from bid-database
- Non-pavement Cost: % of construction cost
  - Earth work cost; Drainage cost
  - Specialty items(Retaining/Barrier), Stormwater (SWPPP)
- Traffic Costs
  - TMP (COZEEP, I/D) and Traffic-handling, Outreach
- Indirect Cost: % of construction cost
  - Minor Items, Mobilization, Supplemental, Contingency
  - Support: Agency (Plan, Design, Traffic, Construction)
- Other Optional Costs
  - Structures and ROW

=> Total Project Cost

CA4PRS Implementation
in the Project Life Cycle Process

- Planning Stage (PSR/PA&ED): Scope and Priority
  - VE Analysis and Life-cycle Cost Analysis
- Design Stage: PS&E & TMP packages
  - Working-days (CPM); Construction staging plans
  - TMP Report and Lane closure chart
  - Contract Type Selection: A (cost)+B(schedule); I/D
- Construction Stage
  - Validate contractor's work-plans and CCOs
- Upcoming Enhancement Modules
  - V3.0 Roadway Widening Module
  - V4.0 Bridge Replacement Module
  - V5.0 LCCA Interaction Module

CA4PRS Nationwide Implementation Map



Hands-on Training Workshops:
Caltrans + 20 DOTs => 1,200 engineers

U. S. Department of Transportation
Federal Highway Administration

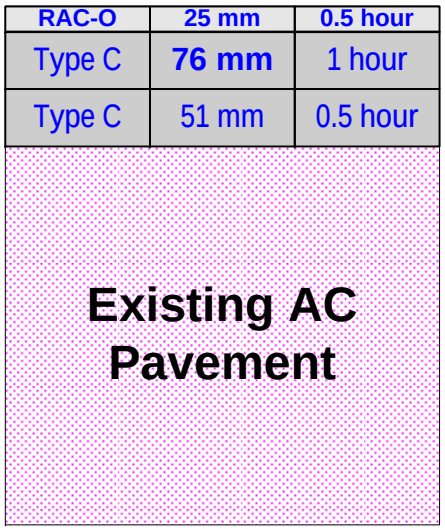
Caltrans

AASHTO
The Voice of Transportation

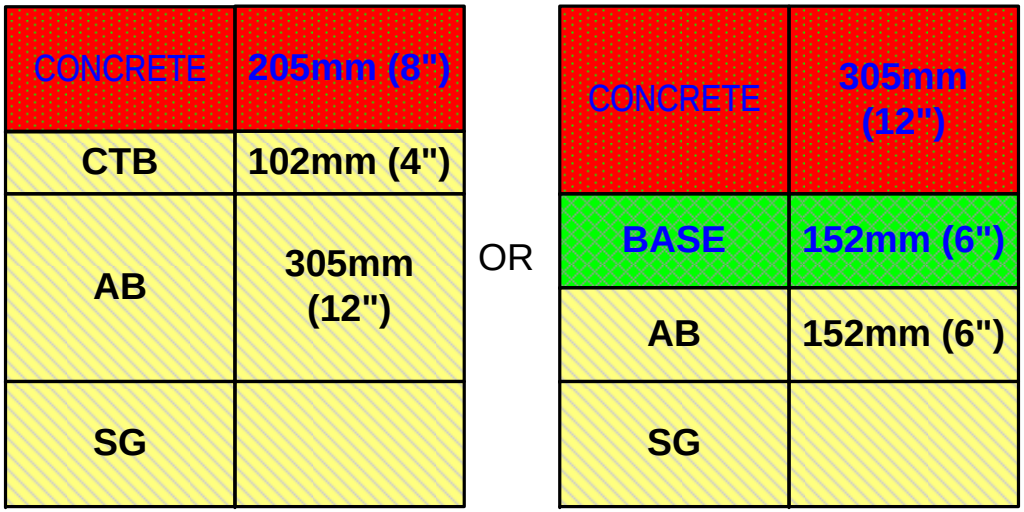
CA4PRS Implementation Projects List (as of Feb 2011)

CA DOT (Caltrans) Projects								
No	Route	Location	Type	Cost	Savings	Distance	Year	Status
1	I-10	Pomona, D7	AC Rehab	$16M	$0.3M	1 mile	2000	Partially adopted
2	I-710	Long Beach, D7	AC Rehab	$17M	$1M	5 miles	2003	Adopted
3	I-15	Devore-I, D8	PCC Rehab	$16M	$8M	3 miles	2005	Adopted
4	I-15	Devore-II, D8	PCC Rehab	$24M	$4M	5 miles	2007	Adopted
5	I-15	Ontario, D8	PCC Rehab	$59M	$5M	8 miles	2009	Adopted
6	I-280	Santa Clara, D4	PCC CAPM	$20M	($2M)	6 miles	2009	Not adopted
7	US-101	San Jose, D4	AC CAPM	$27M	$3M	7 miles	2009	Partially Adopted
8	I-680	San Ramon, D4	Rehab	$70M	$1M	12 miles	2010	Partially Adopted
9	US-101	Ukiah, D1	PCC CAPM	$19M	$2M	6 miles	2010	Partially adopted
10	I-5	Redding, D2	AC Rehab	$50M	-	14 miles	2011	Not adopted
11	I-80	Sacramento, D3	PCC Rehab	$92M	$4M	9 miles	2011	Partially adopted
12	I-5	Sacramento, D3	AC Rehab	$88M	-	17 miles	2011	Partially adopted
13	SR-99	Elk Grove, D3	AC CAPM	$21M	($3.5M)	14 miles	2010	Not adopted
14	I-5	Yolo/Colusa, D3	AC CAPM	$25M	-	24 miles	2010	Not adopted
15	I-5	Stockton, D10	CRCP Rehab	$45M	-	3 mile	2012	Adopted
Other State DOT Projects								
16	I-5	Seattle, WA	PCC Rehab	$5	-	2 miles	2005	Verification
17	I-494	St. Paul, MN	AC Rehab	$10M	-	10 miles	2004	Verification
18	I-15	St. George, UT	AC Rehab	$16	$2M	8 miles	2010	Verification
19	I-35	Oklahoma City, OK	PCC Rehab	$13M		6 miles	2010	Verification
20	SR-39	Ogden, UT	PCC Rehab	$8M		1.3 miles	2011	Progress (implement)
21	I-95	Richmond, VA	AC Rehab	$20M		5 miles	2012	Progress (Verification)
22	I-5	Burlington, WA	AC Rehab	$15M		12 miles	2011	Adopted

Concrete Pavement Cross-sections



(a) Milling Filling AC

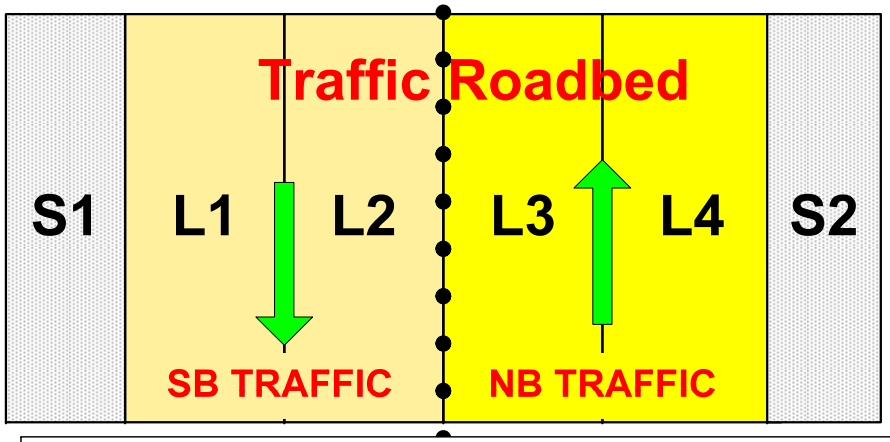


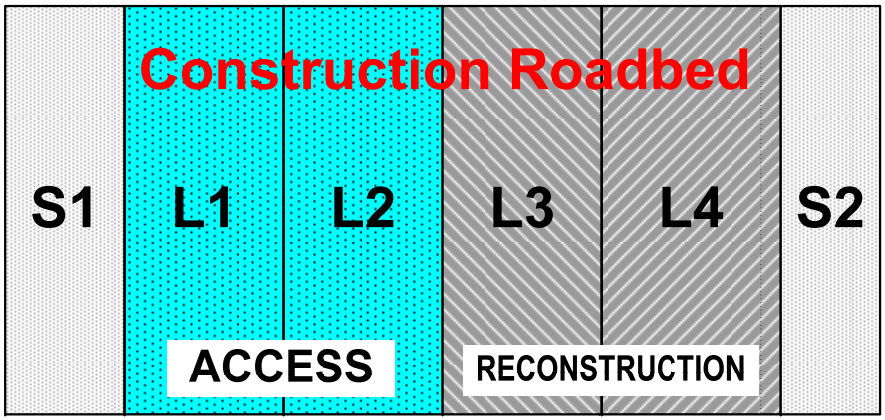
(b) Concrete Slab Replacement

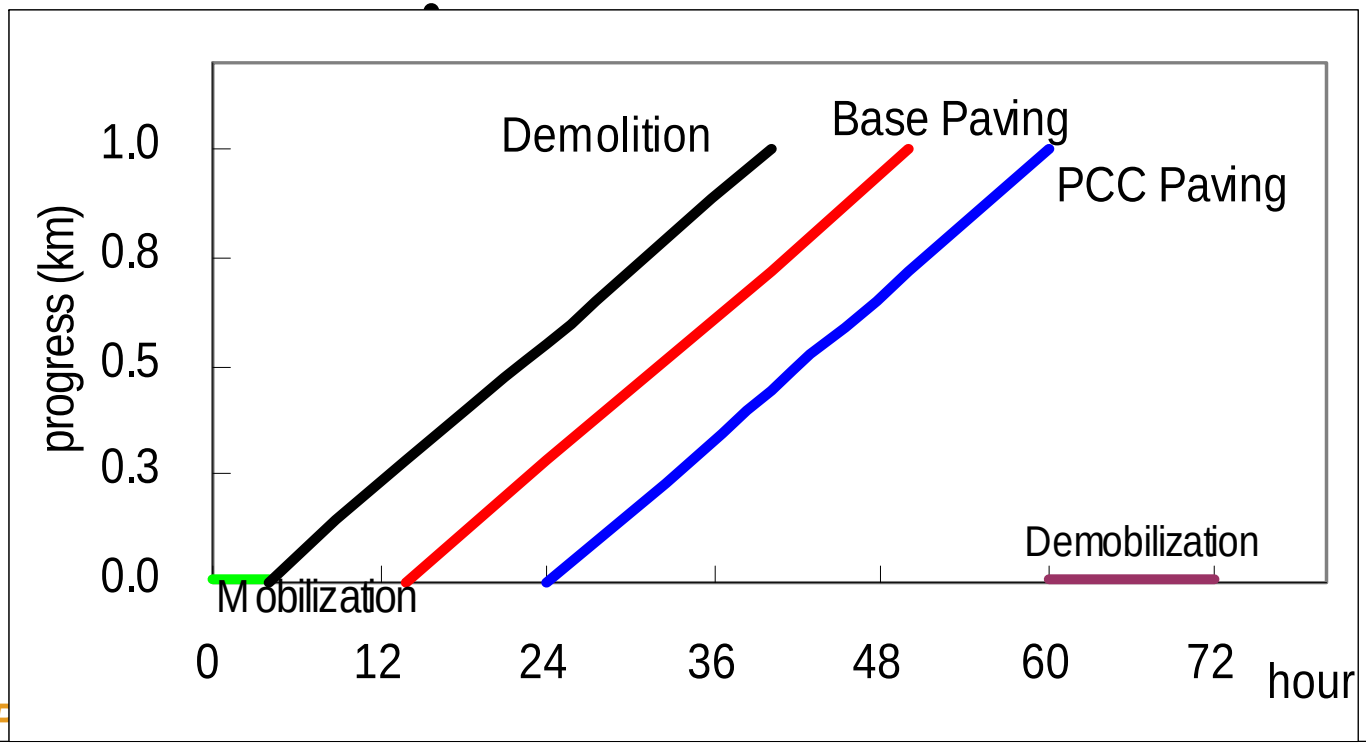
(c) Concrete Slab & Base Reconstruction

Closure <=> Access <=> Production

Full Closure for Concurrent Method







Long Closure

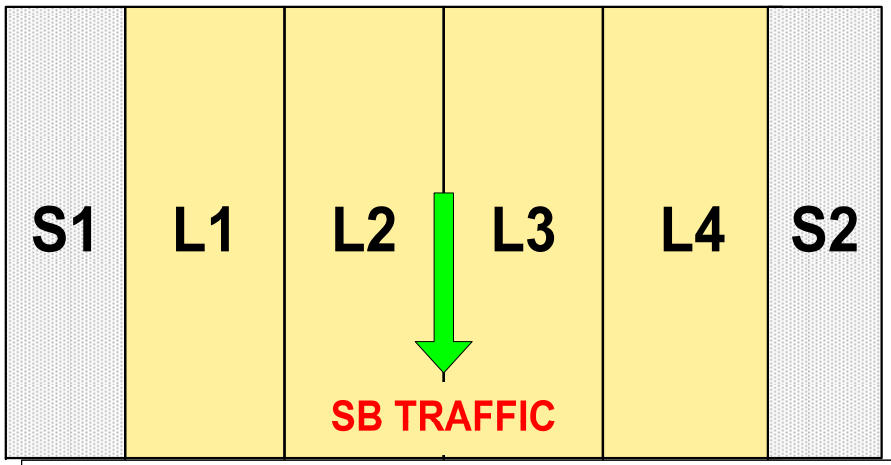
Better Access

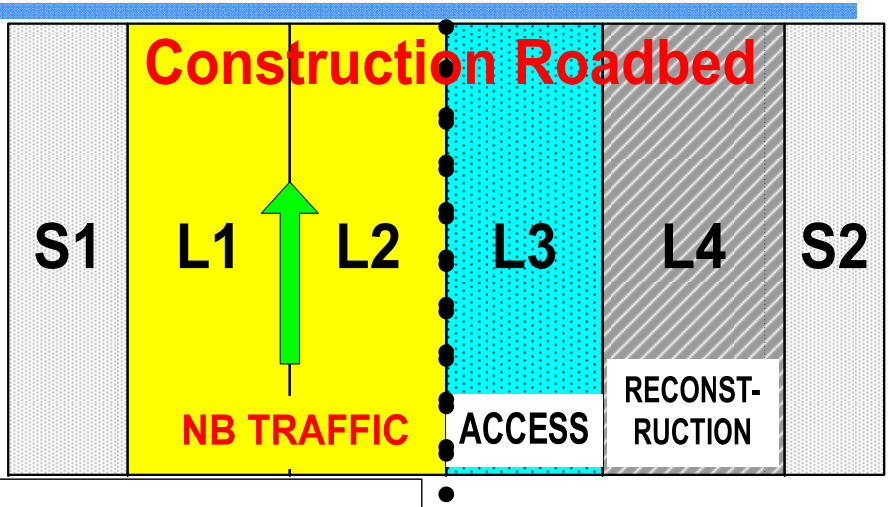
Faster Schedule

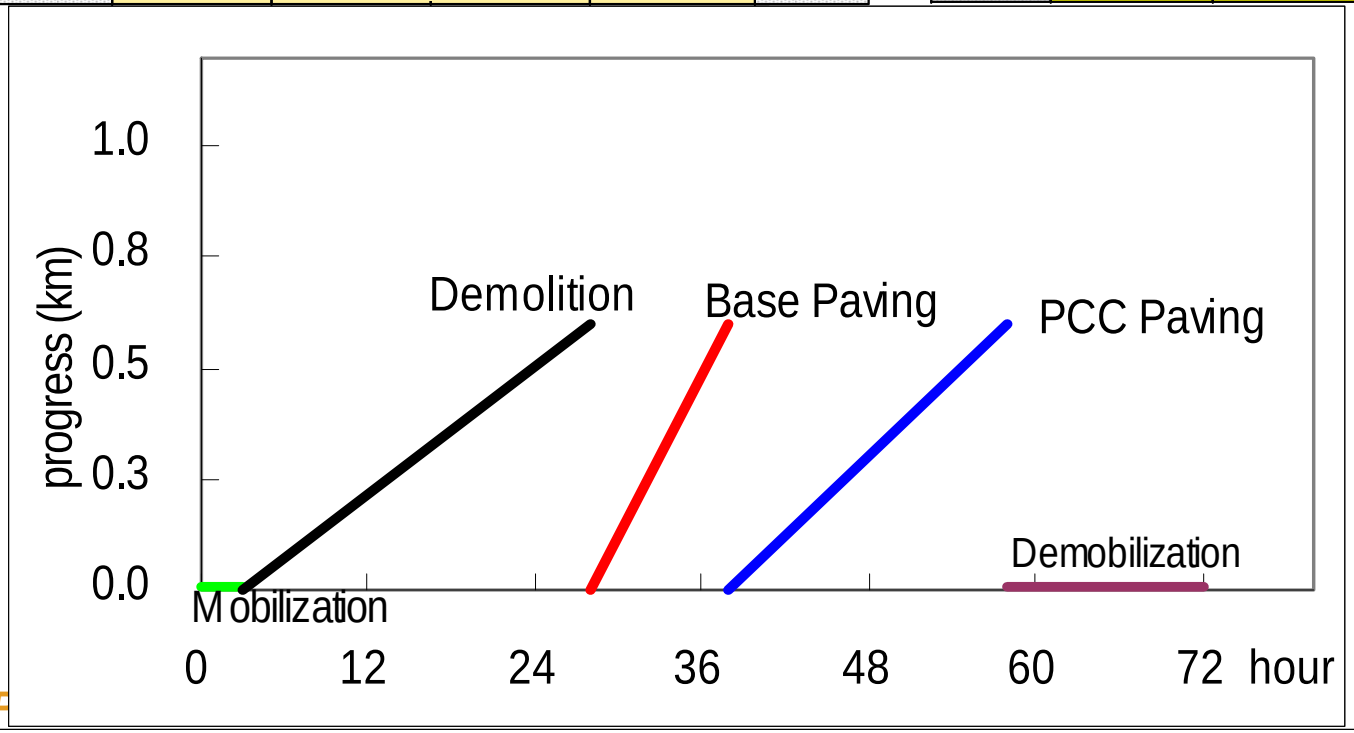
Higher Delay / Closure

Closure <=> Access <=> Production

Partial Closure for Sequential Method







Short Closure

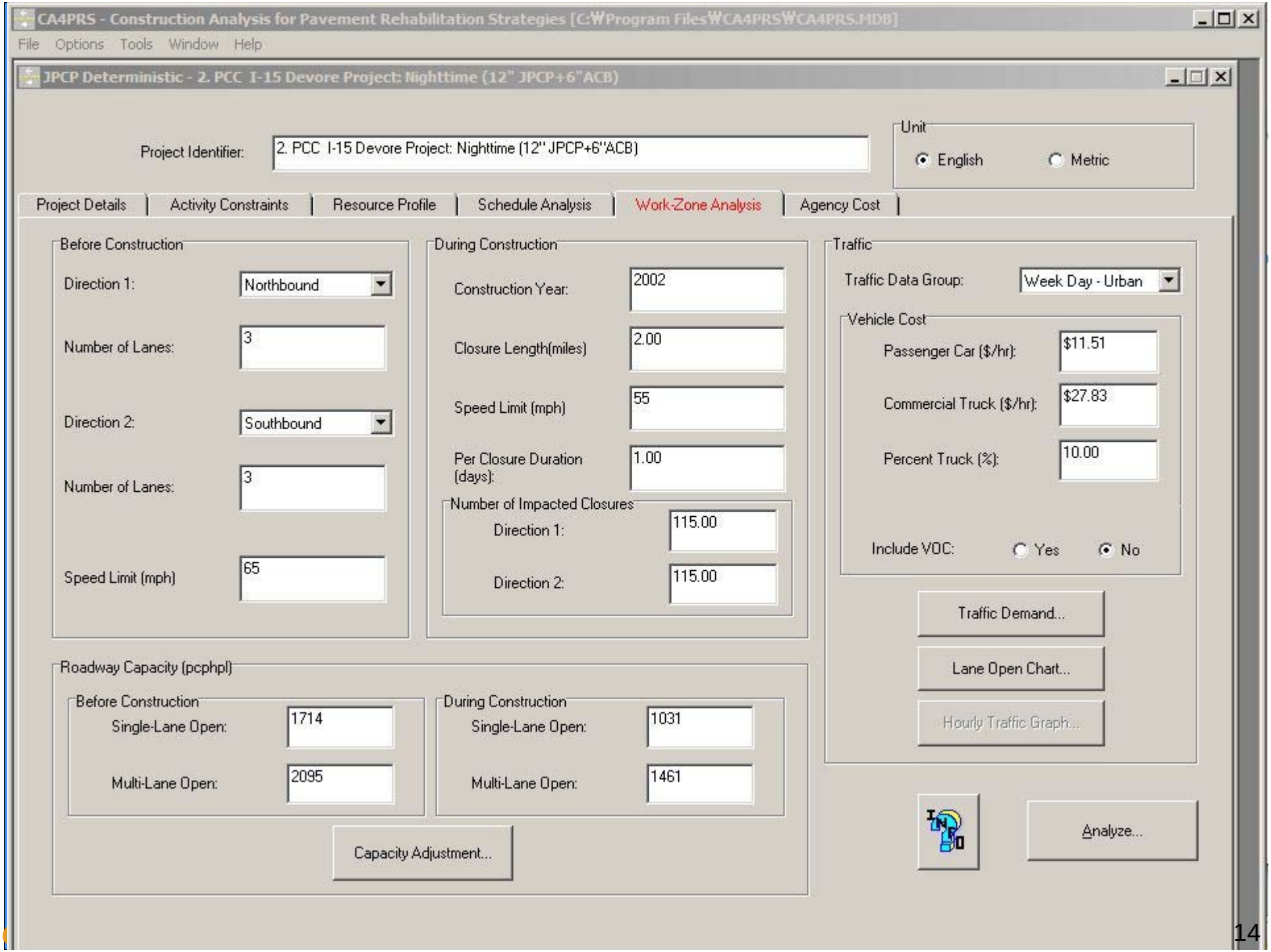
Limited Access

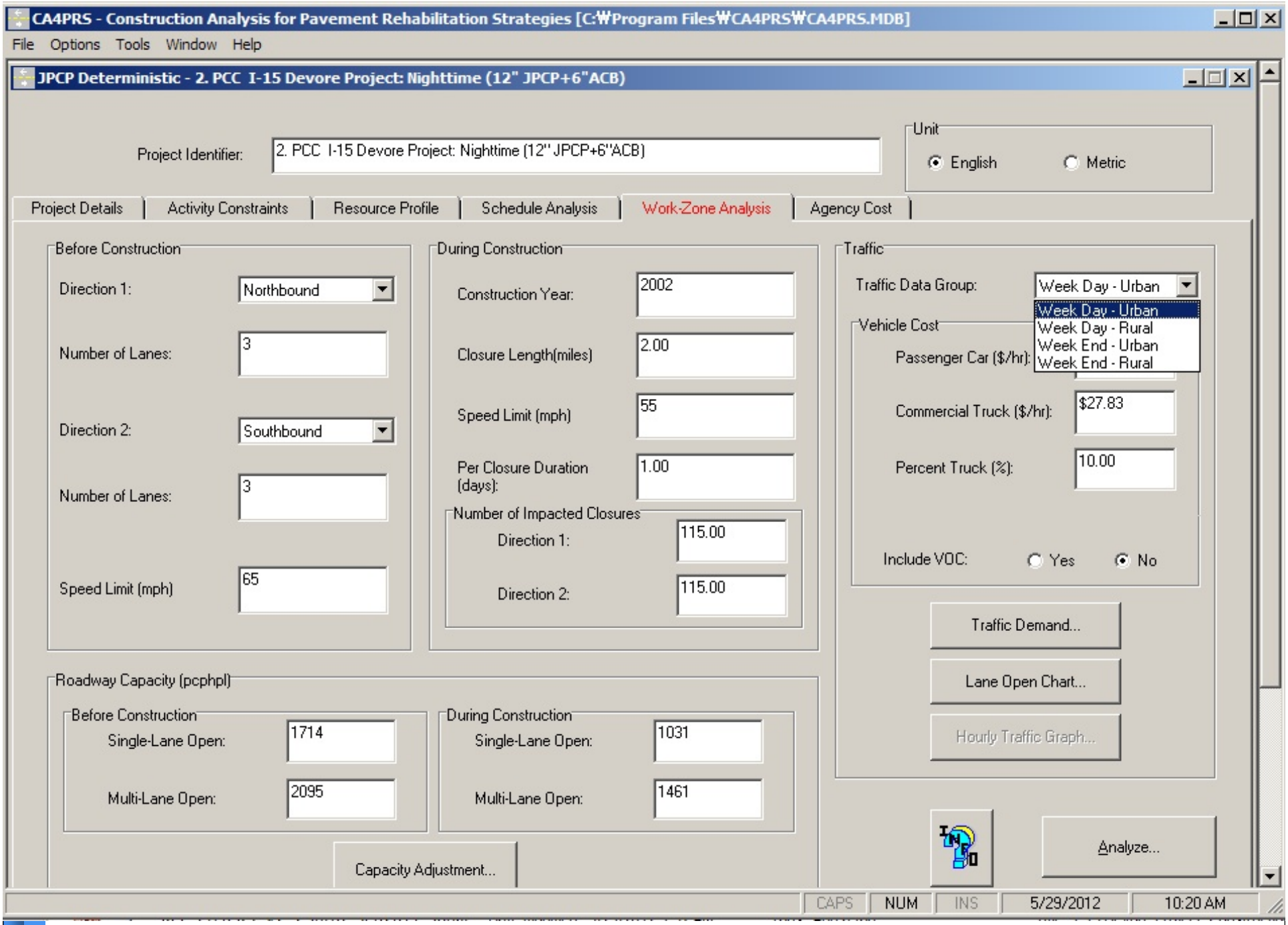
Slower Schedule

Less Delay / Closure

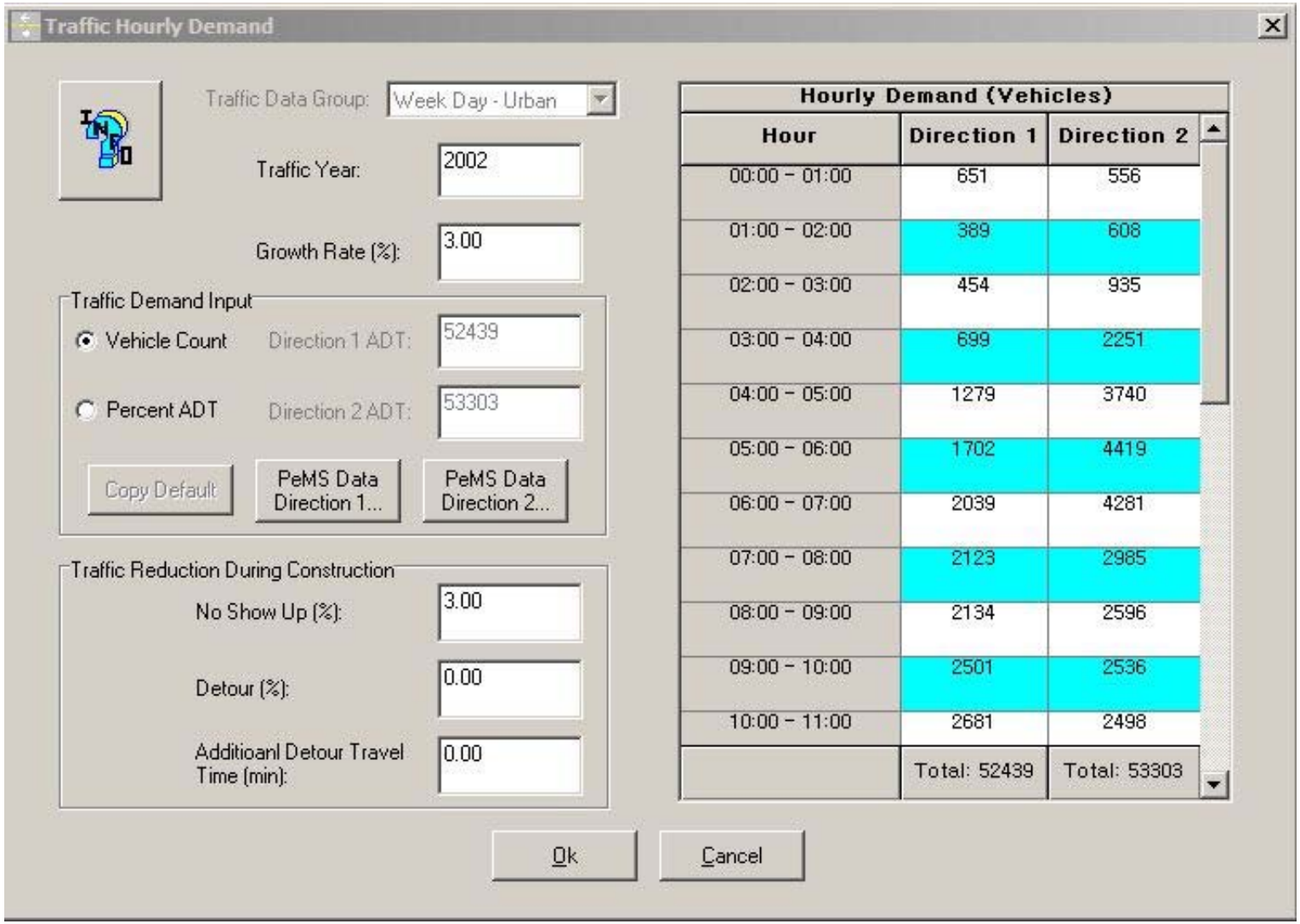
CA4PRS WZ Traffic Module Inputs & Outputs (HCM Model)

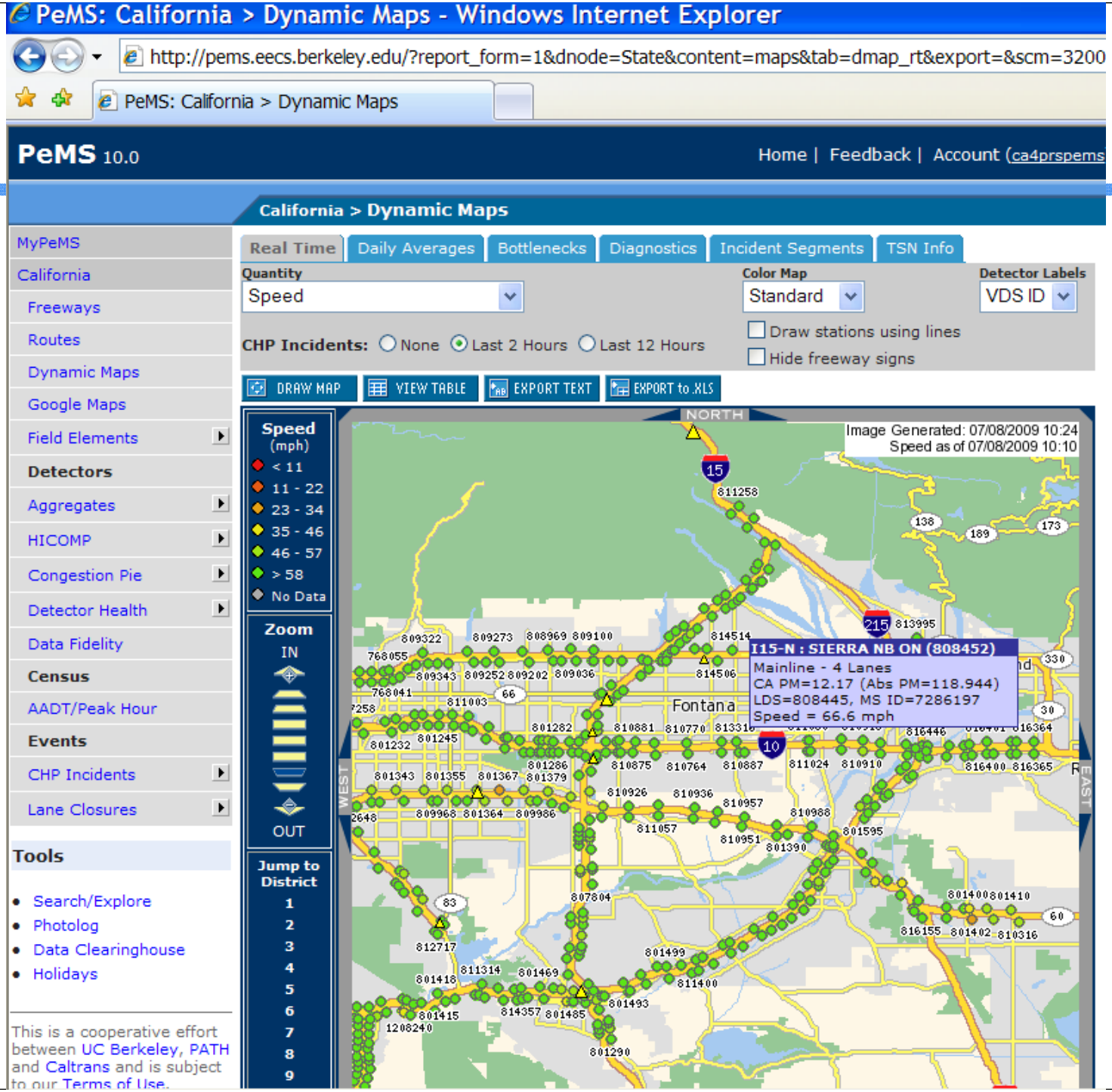
- **Basic Input Data**
  - Closure schedule.
  - 24-hour traffic volumes.
  - User's Time values (vehicle cost)
- **WZ Impact Analysis Outputs**
  - Max queue length and max delay per closure
  - Total Road User Cost
  - WZ Capacity (Sensitivity) and Demand Management
- **Road user cost (RUC) Components**
  - Delay cost; Vehicle operation costs: Detour cost
- **WZ Analysis Application**
  - Evaluate TMP (Lane Closure) Strategies
  - Contract: Incentives/Disincentive & A+B


CA4PRS - Construction Analysis for Pavement Rehabilitation Strategies [C:₩Program Files₩CA4PRS₩CA4PRS.MDB]
File Options Tools Window Help
JPCP Deterministic - 2. PCC I-15 Devore Project: Nighttime (12" JPCP+6"ACB)
Project Identifier:
2. PCC I-15 Devore Project: Nighttime (12" JPCP+6"ACB)
Unit
English
Metric
Project Details
Activity Constraints
Resource Profile
Schedule Analysis
Work-Zone Analysis
Agency Cost
Before Construction
Direction 1:
Northbound
Number of Lanes:
3
Direction 2:
Southbound
Number of Lanes:
3
Speed Limit (mph)
65
During Construction
Construction Year:
2002
Closure Length(miles)
2.00
Speed Limit (mph)
55
Per Closure Duration (days):
1.00
Number of Impacted Closures
Direction 1:
115.00
Direction 2:
115.00
Traffic
Traffic Data Group:
Week Day - Urban
Vehicle Cost
Passenger Car ($/hr):
$11.51
Commercial Truck ($/hr):
$27.83
Percent Truck (%):
10.00
Include VOC:
Yes
No
Traffic Demand...
Lane Open Chart...
Hourly Traffic Graph...
Roadway Capacity (pcphpl)
Before Construction
Single-Lane Open:
1714
Multi-Lane Open:
2095
During Construction
Single-Lane Open:
1031
Multi-Lane Open:
1461
Capacity Adjustment...
Analyze...


CA4PRS - Construction Analysis for Pavement Rehabilitation Strategies [C:₩Program Files₩CA4PRS₩CA4PRS.MDB]
File Options Tools Window Help
JPCP Deterministic - 2. PCC I-15 Devore Project: Nighttime (12" JPCP+6"ACB)
Project Identifier:
2. PCC I-15 Devore Project: Nighttime (12" JPCP+6"ACB)
Unit
English
Metric
Project Details
Activity Constraints
Resource Profile
Schedule Analysis
Work-Zone Analysis
Agency Cost
Before Construction
Direction 1:
Northbound
Number of Lanes:
3
Direction 2:
Southbound
Number of Lanes:
3
Speed Limit (mph)
65
During Construction
Construction Year:
2002
Closure Length(miles)
2.00
Speed Limit (mph)
55
Per Closure Duration (days):
1.00
Number of Impacted Closures
Direction 1:
115.00
Direction 2:
115.00
Traffic
Traffic Data Group:
Week Day - Urban
Week Day - Urban
Week Day - Rural
Week End - Urban
Week End - Rural
Vehicle Cost
Passenger Car ($/hr):
Commercial Truck ($/hr):
$27.83
Percent Truck (%):
10.00
Include VOC:
Yes
No
Traffic Demand...
Lane Open Chart...
Hourly Traffic Graph...
Roadway Capacity (pcphpl)
Before Construction
Single-Lane Open:
1714
Multi-Lane Open:
2095
During Construction
Single-Lane Open:
1031
Multi-Lane Open:
1461
Capacity Adjustment...
Analyze...
CAPS
NUM
INS
5/29/2012
10:20 AM

Importing Traffic Demand




PeMS: California > Dynamic Maps - Windows Internet Explorer
http://pems.eecs.berkeley.edu/?report_form=1&dnode=State&content=maps&tab=dmap_rt&export=&scm=3200
PeMS: California > Dynamic Maps
PeMS 10.0
Home | Feedback | Account (ca4prspems
California > Dynamic Maps
MyPeMS
California
Freeways
Routes
Dynamic Maps
Google Maps
Field Elements
Detectors
Aggregates
HICOMP
Congestion Pie
Detector Health
Data Fidelity
Census
AADT/Peak Hour
Events
CHP Incidents
Lane Closures
Tools
Search/Explore
Photolog
Data Clearinghouse
Holidays
This is a cooperative effort between UC Berkeley, PATH and Caltrans and is subject to our Terms of Use.
Real Time
Daily Averages
Bottlenecks
Diagnostics
Incident Segments
TSN Info
Quantity
Speed
Color Map
Standard
Detector Labels
VDS ID
CHP Incidents: None Last 2 Hours Last 12 Hours
Draw stations using lines
Hide freeway signs
DRAW MAP
VIEW TABLE
EXPORT TEXT
EXPORT to .XLS
Speed (mph)
< 11
11 - 22
23 - 34
35 - 46
46 - 57
> 58
No Data
Zoom
IN
OUT
Jump to District
1
2
3
4
5
6
7
8
9
NORTH
WEST
EAST
Image Generated: 07/08/2009 10:24
Speed as of 07/08/2009 10:10
I15-N : SIERRA NB ON (808452)
Mainline - 4 Lanes
CA PM=12.17 (Abs PM=118.944)
LDS=808445, MS ID=7286197
Speed = 66.6 mph
Fontana

CA4PRS

PeMS: California > I15-N > 808452 (ML - 4 lanes) > Aggregates - Windows Internet Explore

http://pems.eecs.berkeley.edu/?report_form=1&dnode=VDS&content=loops&tab=det_tod&export=&station_id=80

PeMS: California > I15-N > 808452 (ML - ...

PeMS 10.0 Home | Feedback | A

California > I15-N > 808452 (ML - 4 lanes) > Aggregates

- California
- District 8
- San Bernardino County
- (Unincorporated)
- I15-N
- 808452
- **Detectors**
- Aggregates
- Planning
- Modeling
- TMG Report
- Detector Health
- Data Fidelity
- Inputs
- **Events**
- Lane Closures

Tools

- Search/Explore
- Photolog
- Data Clearinghouse
- Holidays

This is a cooperative effort between UC Berkeley, PATH and Caltrans and is subject to our Terms of Use. Powered by BTS.

Timeseries | Time of Day | Day of Week | Quantity Relationships

From: Jun 1 2009 To: Jun 30 2009

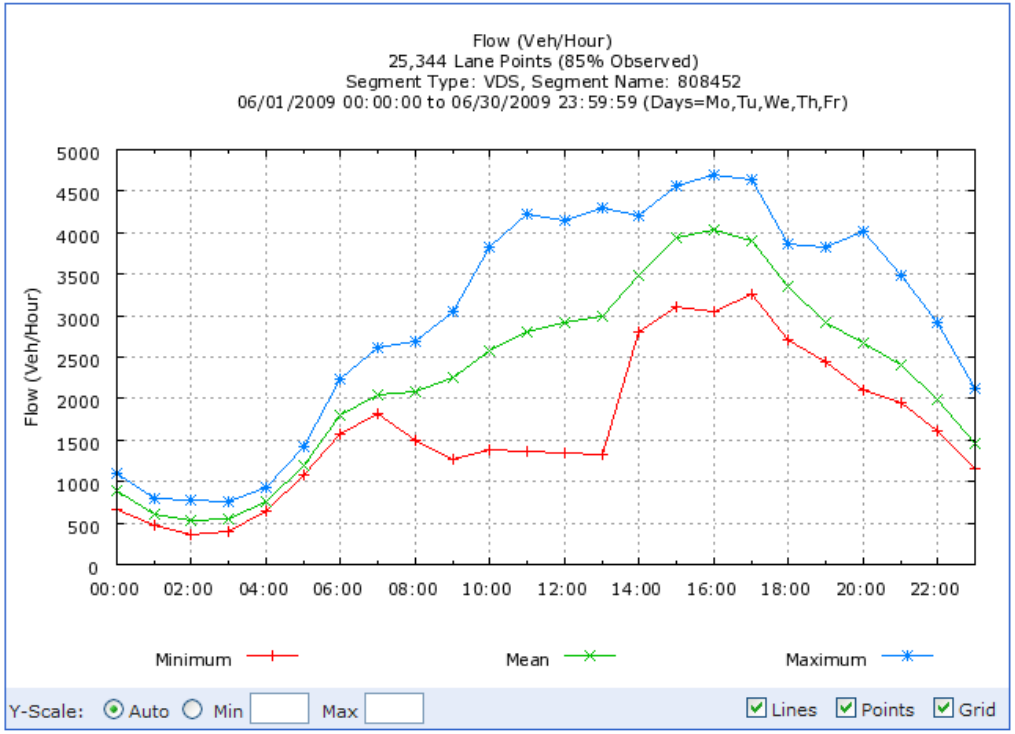
Max Range: 1 month

Include Days: Su Mo Tu We Th Fr Sa Holidays

Quantity: Flow

Statistics: Mean, Min, Max / Mean, Mean+σ,Mean-σ / Median, 25 %, 75 % / Discrete Days

DRAW PLOT | VIEW TABLE | EXPORT TEXT | EXPORT to XLS



Y-Scale: Auto Min Max Lines Points Grid

CA4PRS

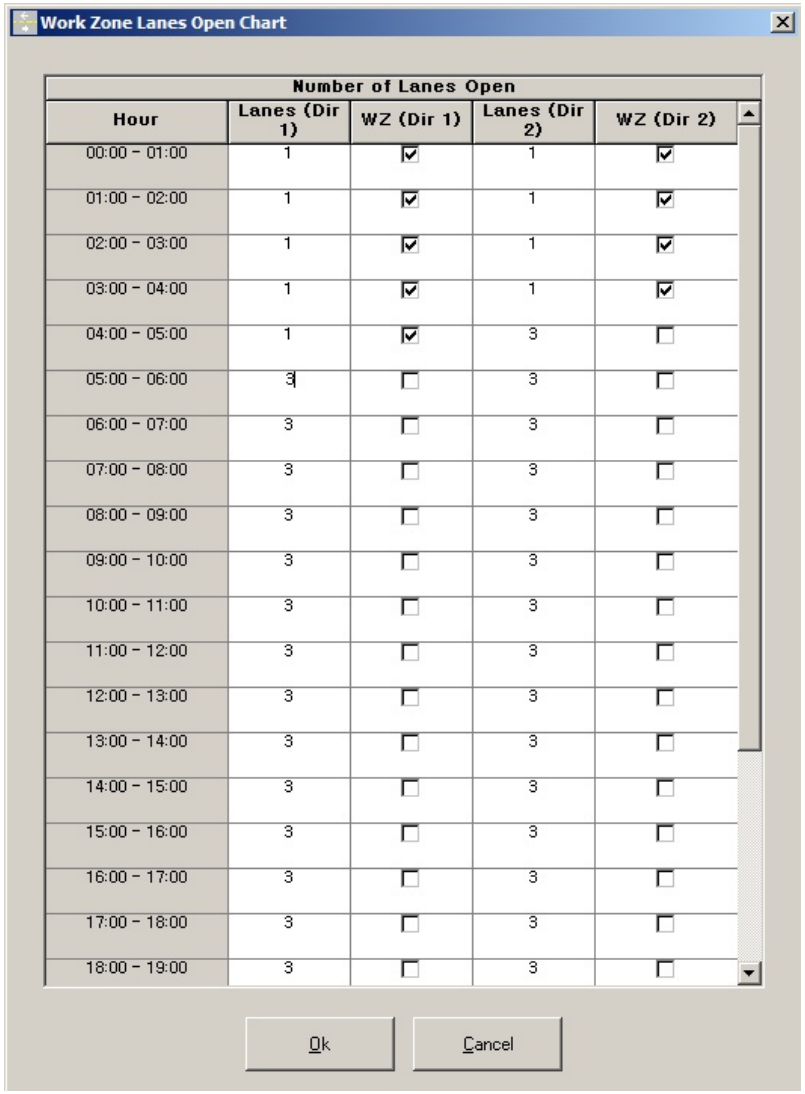
Microsoft Excel - pems_output[1].xls

File Edit View Insert Format Tools Data

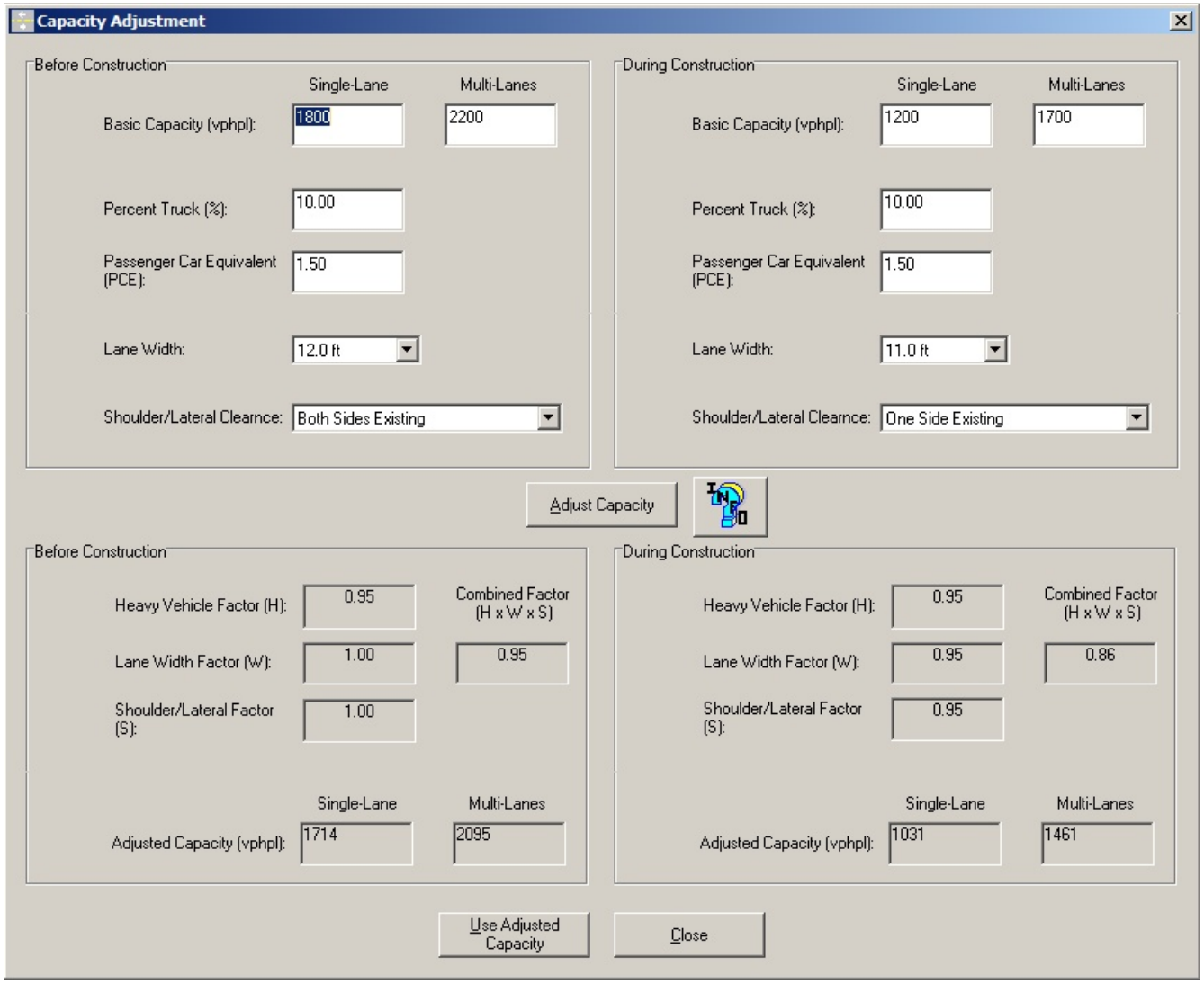
C1 Mean

	A	B	C	D
1	Time	Minimum	Mean	Maximum
2	0:00	662	892	1,093
3	1:00	466	609	796
4	2:00	351	528	778
5	3:00	399	545	757
6	4:00	649	752	923
7	5:00	1,077	1,201	1,414
8	6:00	1,565	1,790	2,233
9	7:00	1,819	2,055	2,618
10	8:00	1,503	2,076	2,687
11	9:00	1,268	2,253	3,044
12	10:00	1,383	2,580	3,834
13	11:00	1,360	2,805	4,218
14	12:00	1,349	2,908	4,146
15	13:00	1,335	2,995	4,291
16	14:00	2,806	3,481	4,203
17	15:00	3,102	3,946	4,563
18	16:00	3,056	4,037	4,688
19	17:00	3,266	3,906	4,636
20	18:00	2,714	3,345	3,871
21	19:00	2,437	2,908	3,831
22	20:00	2,101	2,677	4,023
23	21:00	1,943	2,402	3,480
24	22:00	1,602	1,997	2,908
25	23:00	1,154	1,456	2,113

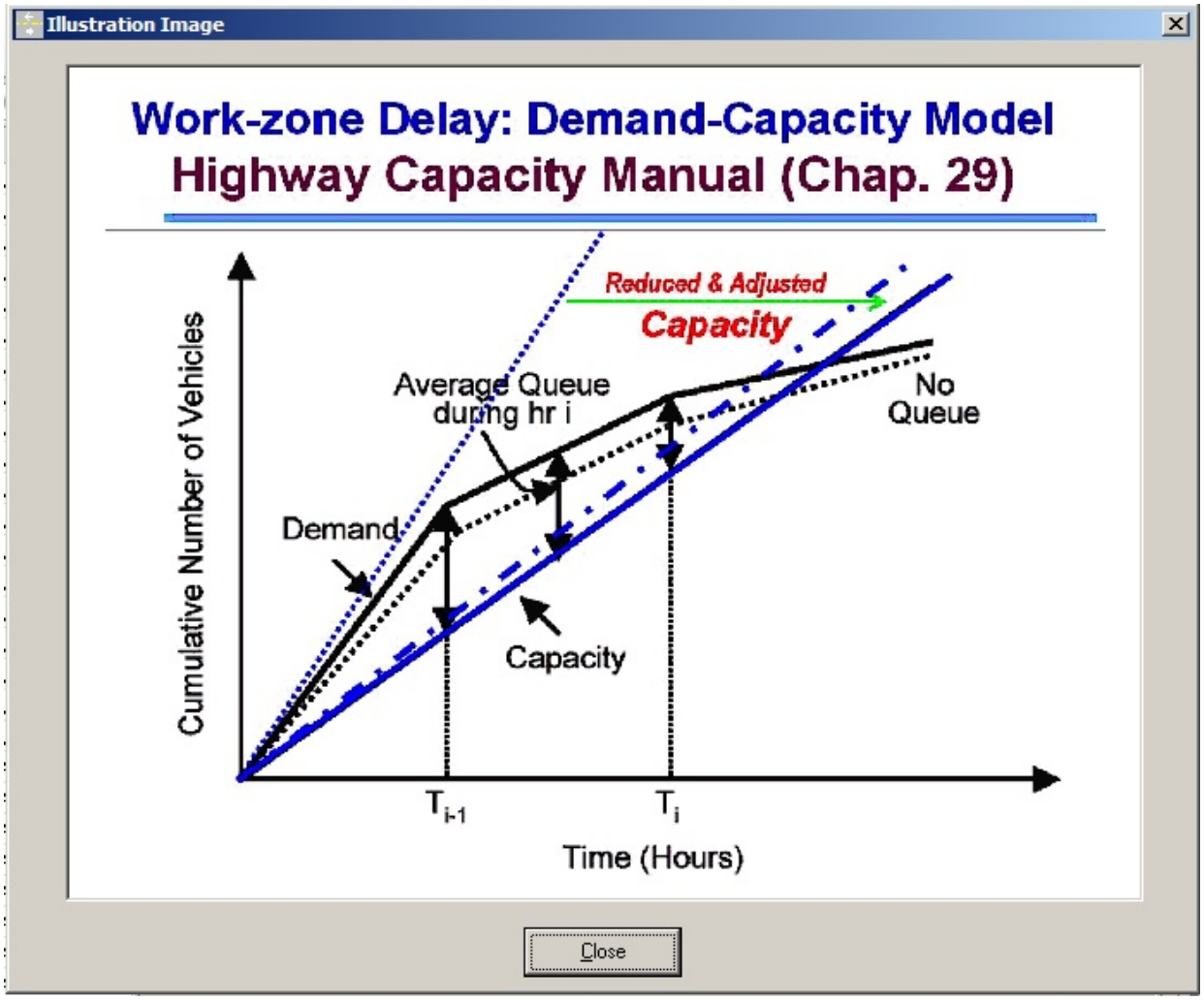
Lane Closure Charts



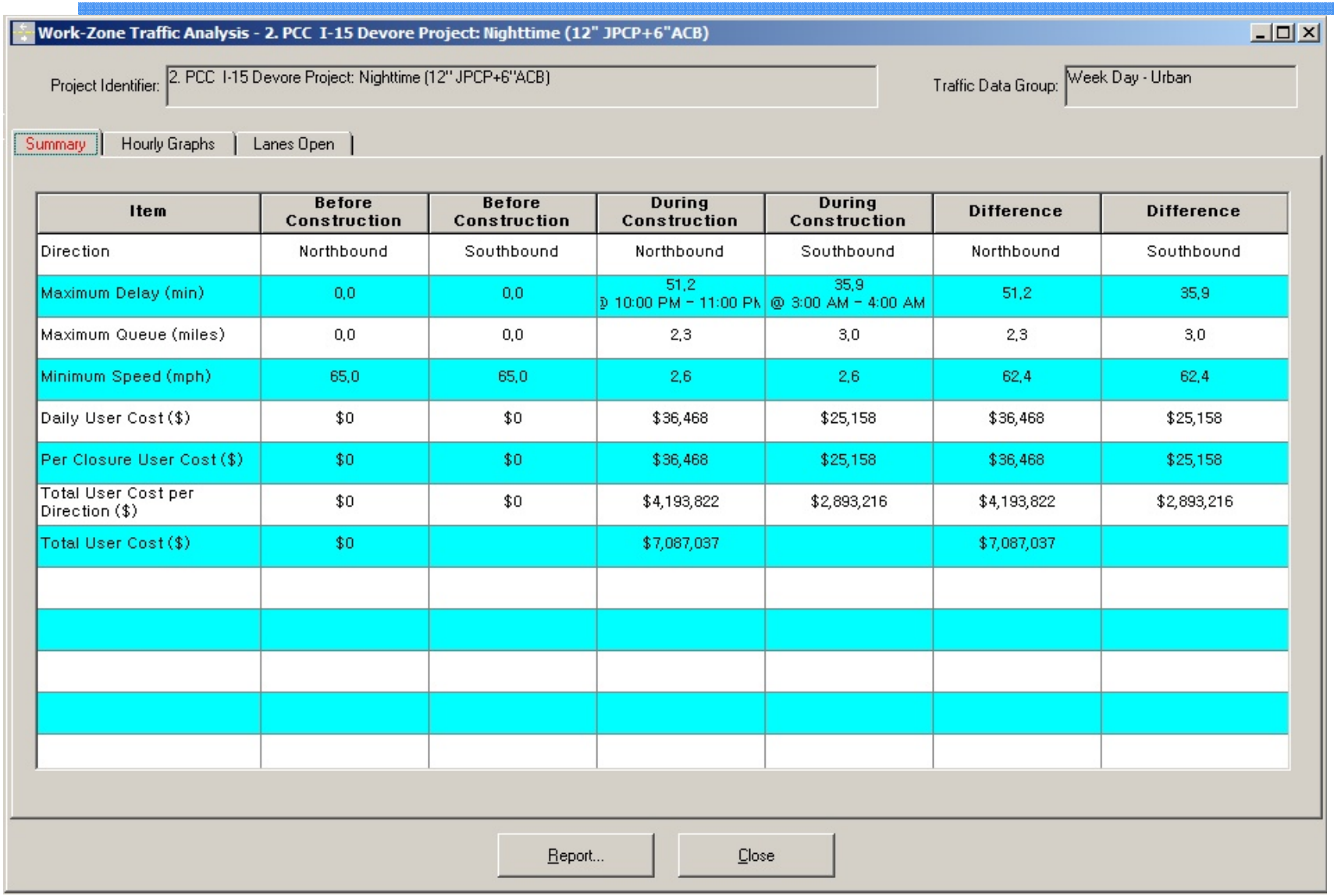
Work Zone Capacity



Delay Calculation

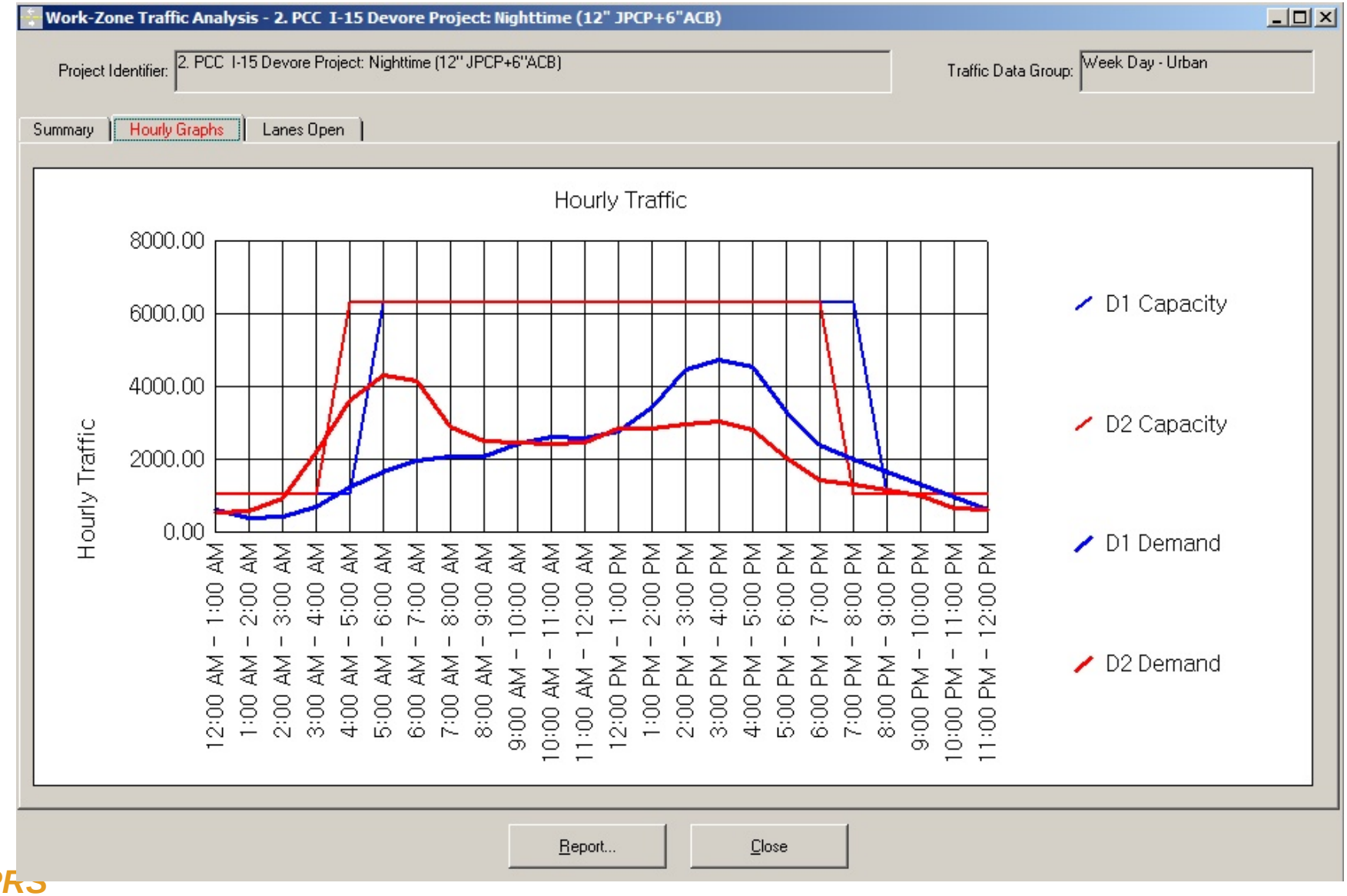


Outputs: Summary of Results

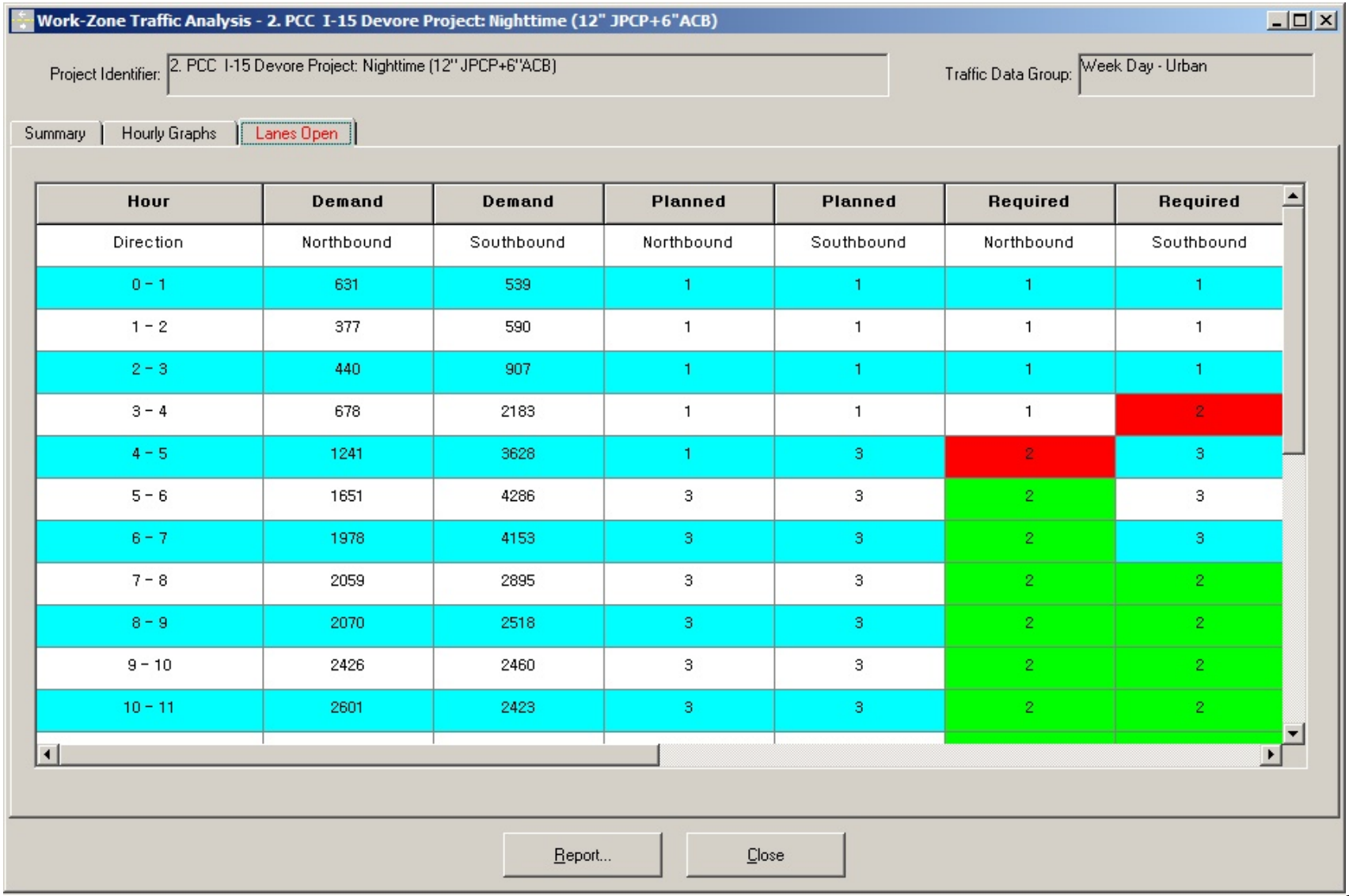


Item	Before Construction	Before Construction	During Construction	During Construction	Difference	Difference
Direction	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
Maximum Delay (min)	0,0	0,0	51,2 @ 10:00 PM - 11:00 PM	35,9 @ 3:00 AM - 4:00 AM	51,2	35,9
Maximum Queue (miles)	0,0	0,0	2,3	3,0	2,3	3,0
Minimum Speed (mph)	65,0	65,0	2,6	2,6	62,4	62,4
Daily User Cost ($)	$0	$0	$36,468	$25,158	$36,468	$25,158
Per Closure User Cost ($)	$0	$0	$36,468	$25,158	$36,468	$25,158
Total User Cost per Direction ($)	$0	$0	$4,193,822	$2,893,216	$4,193,822	$2,893,216
Total User Cost ($)	$0		$7,087,037		$7,087,037	

Output: Hourly Traffic Patterns



Output: Lane Required



Hour	Demand	Demand	Planned	Planned	Required	Required
Direction	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
0 - 1	631	539	1	1	1	1
1 - 2	377	590	1	1	1	1
2 - 3	440	907	1	1	1	1
3 - 4	678	2183	1	1	1	2
4 - 5	1241	3628	1	3	2	3
5 - 6	1651	4286	3	3	2	3
6 - 7	1978	4153	3	3	2	3
7 - 8	2059	2895	3	3	2	2
8 - 9	2070	2518	3	3	2	2
9 - 10	2426	2460	3	3	2	2
10 - 11	2601	2423	3	3	2	2

Example - Sensitivity Analysis on Demand Management

Scenarios	Demand Control	Maximum Delay	Maximum Queue	Daily User Cost	Total User Cost
Scenario 1	No show 0 % Detour 0 %	57 min	3.3 miles	$ 71K	$ 8.2M
Scenario 2	No show 5 % Detour 5 %	37 min	2.6 miles	$ 41K	$ 4.7M
Scenario 3	No show 10 % Detour 10 %	24 min	1.9 miles	$ 19K	$ 2.2M

Scenario 1

Scenario 2

Scenario 3

I-15 Devore PCC Reconstruction Project, 2005

I-15 Devore WZ Capacity: Full-closure Dynamic Lane Configuration Using QCMB

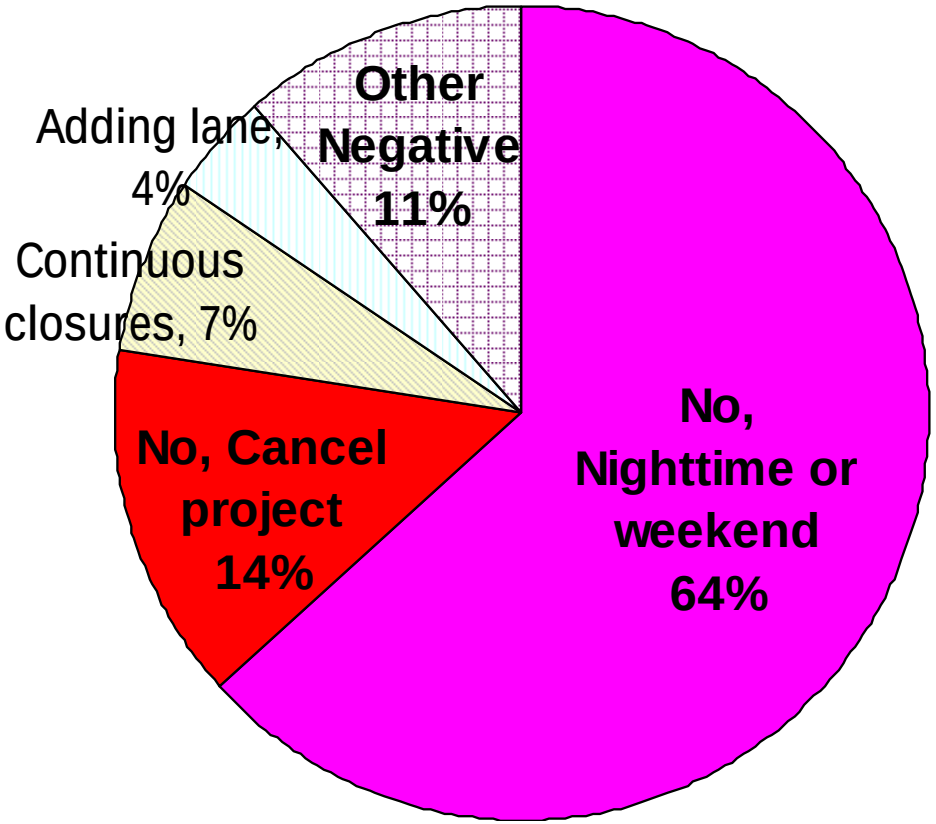
I-15 Devore Pre-construction Analysis

CA4PRS Schedule-Traffic-Cost Comparison

Construction Scenario	Construction Schedule		WZ Traffic Delay		Cost	
	Total Closures	Closure Hours	Max. Delay(Min)	Delay (RUC) Cost ($M)	Agency Cost ($M)	Total Cost ($M)
One Roadbed Continuous (24/7)	2	400	80	5.0	25.0	30.0
72-Hour Weekday Non-stop	8	576	50	8.0	26.0	34.0
55-Hour Weekend Extended	16	880	80	14.0	27.0	41.0
9-Hour Nighttime Closures	230	2,100	50	7.0	31.0	38.0
8-Hour Nighttime Closures	300	2,400	20	3.0	33.0	36.0
7-Hour Nighttime Closures	410	2,900	10	1.0	35.0	36.0

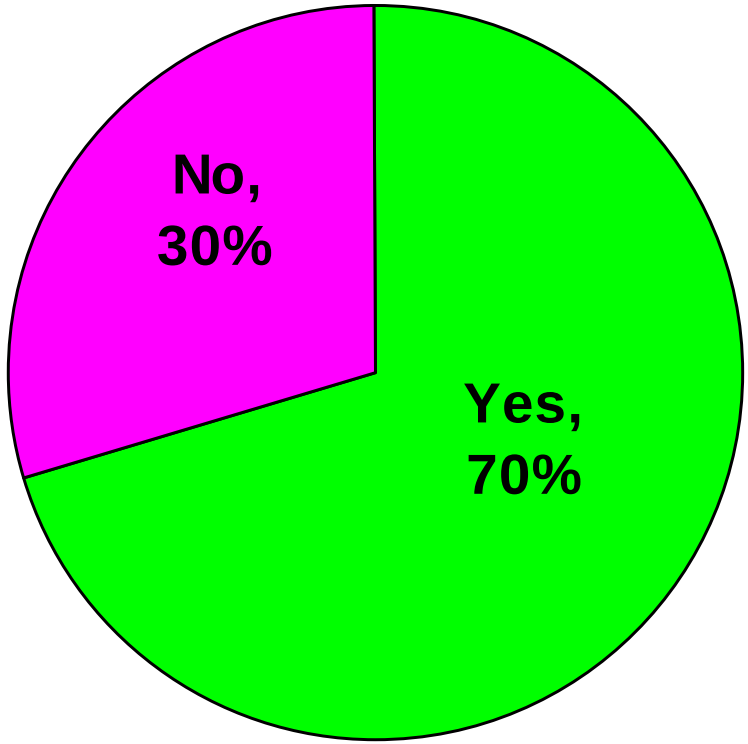
I-15 Devore Web Surveys
Public Perception

Before- construction



Do you support 72-h (3-weekday) Weekday closures?

After-construction



Do you support future "Rapid-Rehab" projects?

CA4PRS on Caltrans Web

Construction Analysis for Pavement Rehabilitation Strategies
Caltrans "Rapid Rehab" Software

A Decision-Support Tool to Integrate Design, Construction, and Traffic for Highway Projects

Development Background

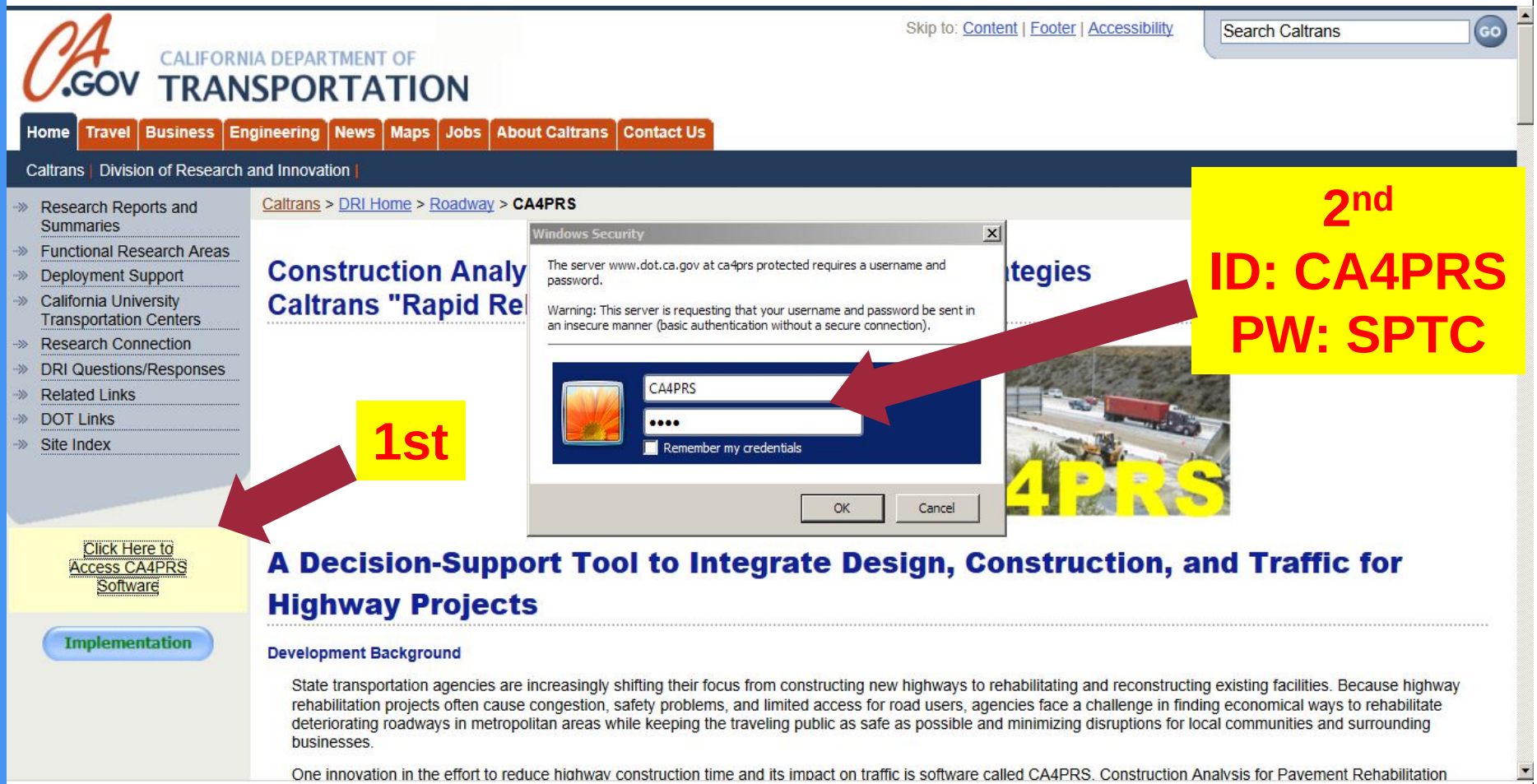
State transportation agencies are increasingly shifting their focus from constructing new highways to rehabilitating and reconstructing existing facilities. Because highway rehabilitation projects often cause congestion, safety problems, and limited access for road users, agencies face a challenge in finding economical ways to rehabilitate deteriorating roadways in metropolitan areas while keeping the traveling public as safe as possible and minimizing disruptions for local communities and surrounding businesses.

One innovation in the effort to reduce highway construction time and its impact on traffic is software called CA4PRS, Construction Analysis for Pavement Rehabilitation Strategies. CA4PRS is a schedule and traffic analysis tool that helps planners and designers select effective, economical rehabilitation strategies. Funded through an FHWA (Federal Highway Administration) pooled-fund, multistate consortium (California, Minnesota, Texas, and Washington), CA4PRS was developed by the University of California Pavement Research Center (UCPRC) through the UC Berkeley Institute of Transportation Studies. FHWA formally endorsed CA4PRS as a "Priority, Market-Ready Technologies and Innovations" product in 2008 for national wide deployment. Caltrans IT recently added CA4PRS into the standard software list for its statewide implementation.

http://www.dot.ca.gov/hq/research/roadway/ca4prs/index.htm

CA4PRS Download and Installation

http://www.dot.ca.gov/hq/research/roadway/ca4prs/index.htm



More Information?

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