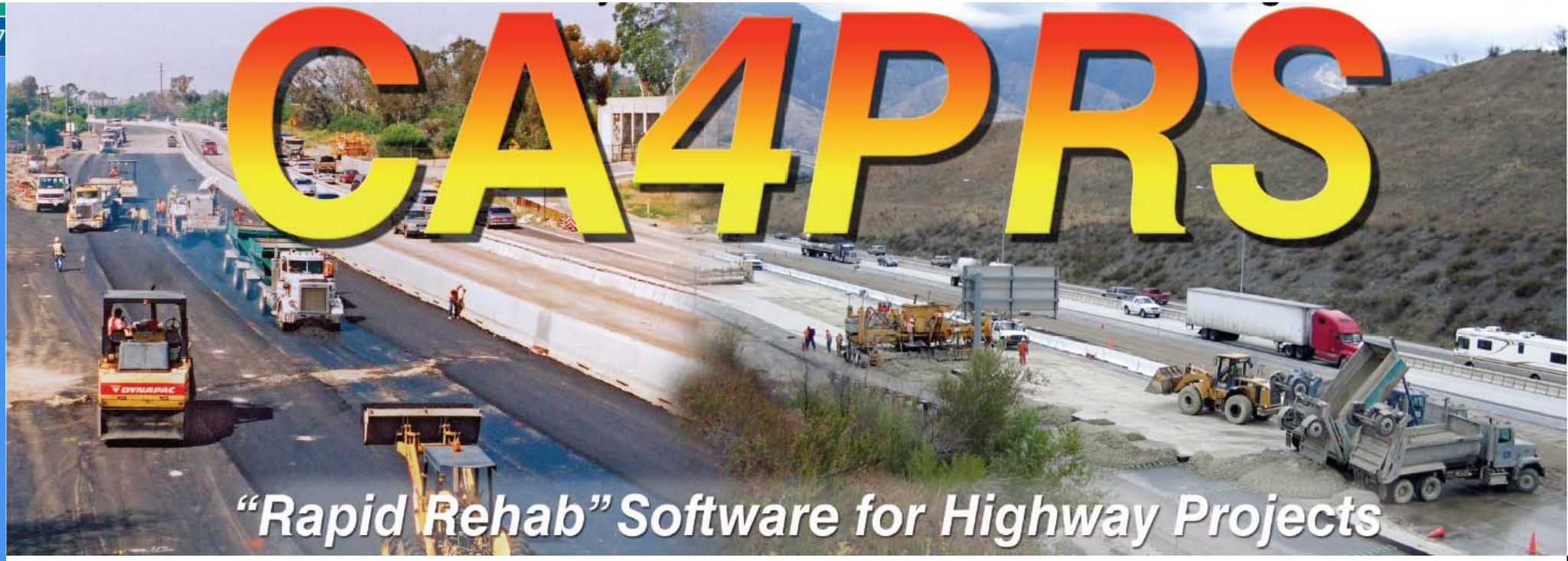


Construction Analysis for Pavement Rehabilitation Strategies

(Caltrans LMS #:100181)

Hands-on Training Workshop for District

Instructor: E.B. Lee, *Ph.D, PE, PMP*

University of California at Berkeley
Institute of Transportation Studies

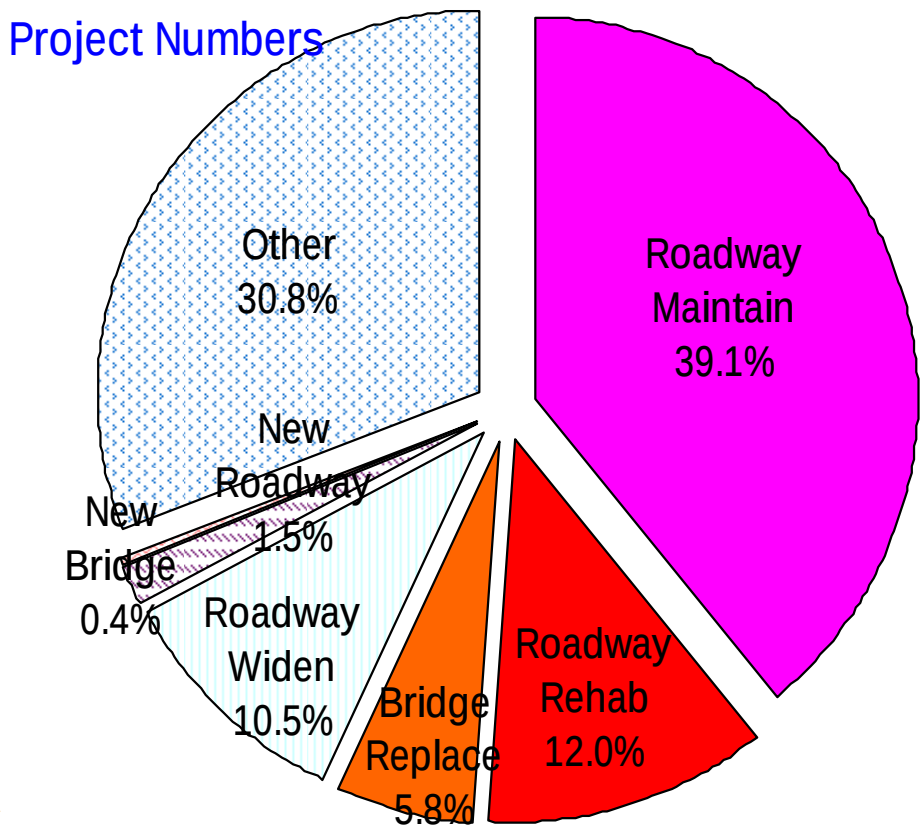
CA4PRS Introduction

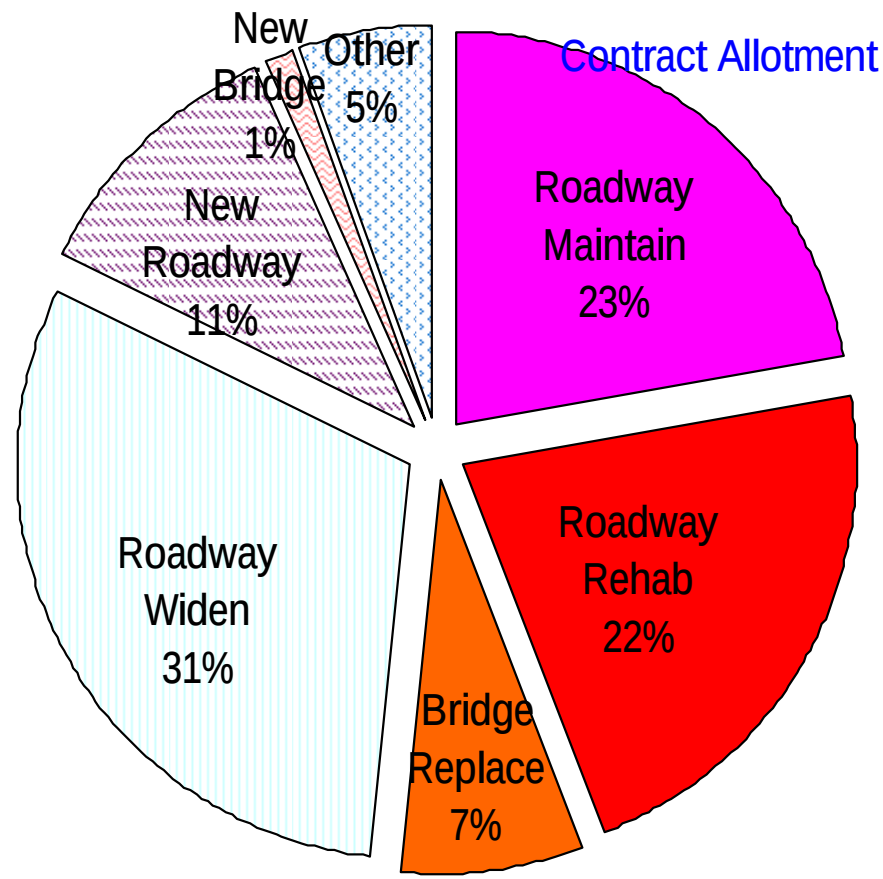
- Development Background
- Modeling Alternatives
- Implementation Projects
- Deployment Outreach
- Constructability Consideration
- Work-zone Traffic and TMP
- Cost Comparison
- Screen Shots

Development Background

Highway Infrastructure Renewal

- **Need of Highway Renewal for Sustainability**
  - Many pavements have reached their design life (20-yr)
  - DOTs shift their focus to highway sustainability (4-R)
  - Caltrans Long-life Pavement Rehabilitation Strategy
- **1,400 Caltrans Highway Projects ('00-'08)**

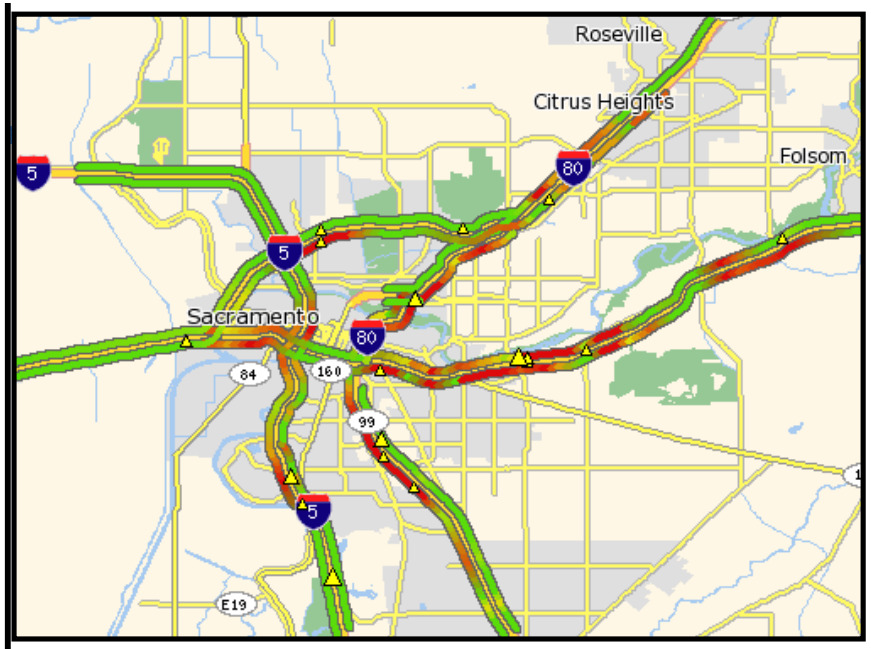


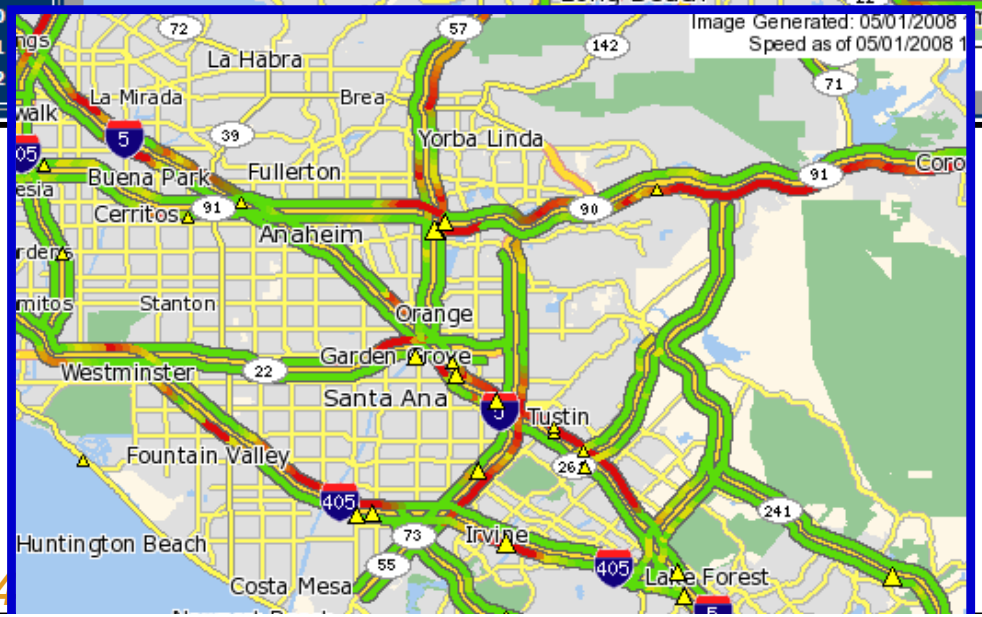


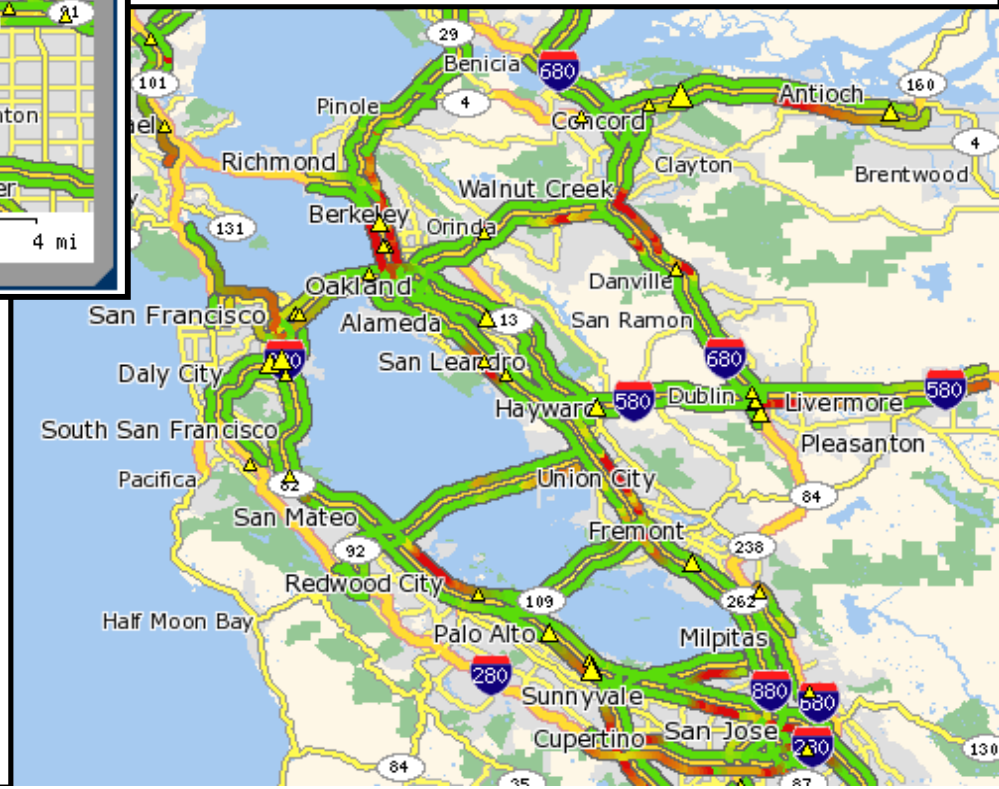
Deteriorated Urban Freeway Pavements (I-10 Pomona)

Traffic Disruption from Construction Work-zone (I-15 Devore)

Freeways are Saturated with Traffic!!!





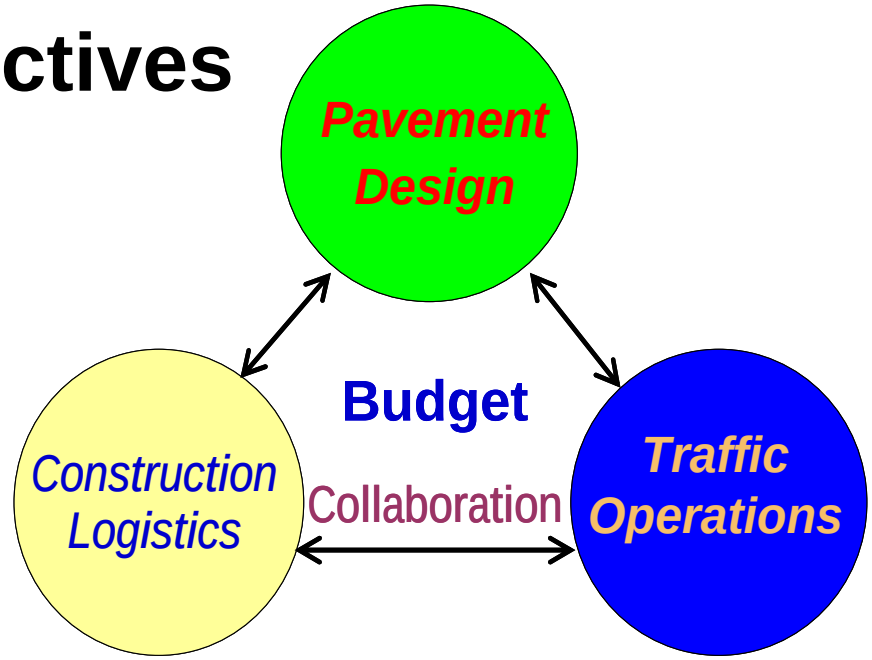


Challenges in Highway Construction

- **Work-zone (WZ) Impacts Mobility and Safety**
  - WZ lane closures create adverse impacts on travelers, local communities, and neighboring businesses
  - WZ responsible for about 12 percent of highway delay
  - Safety: 40,000 injuries, 1028 fatalities in CWZ (2003)
- **Federal Work-zone Rule:** 23 CFR Part 630 Subpart J
  - Improve WZ Safety and Mobility (Oct 2007)
  - Develop agency-level policy for statewide process
  - Implement project-level standard procedures
    - WZ impact assessment
    - TMP in PS&E (Significant project)
    - Public outreach strategies
  - Caltrans: Deputy Directive (DD-60R; Sep 2007)
  - Use *CA4PRS* as a tool for WZ rule compliance

How Do We Meet This Challenge?

- **Balance Competing Objectives**
  - (1) Longer-lasting design
  - (2) Faster construction delivery
  - (3) Tolerable traffic delays
  - (4) Agency budget constraint
  - ➢ Need analytical & tools

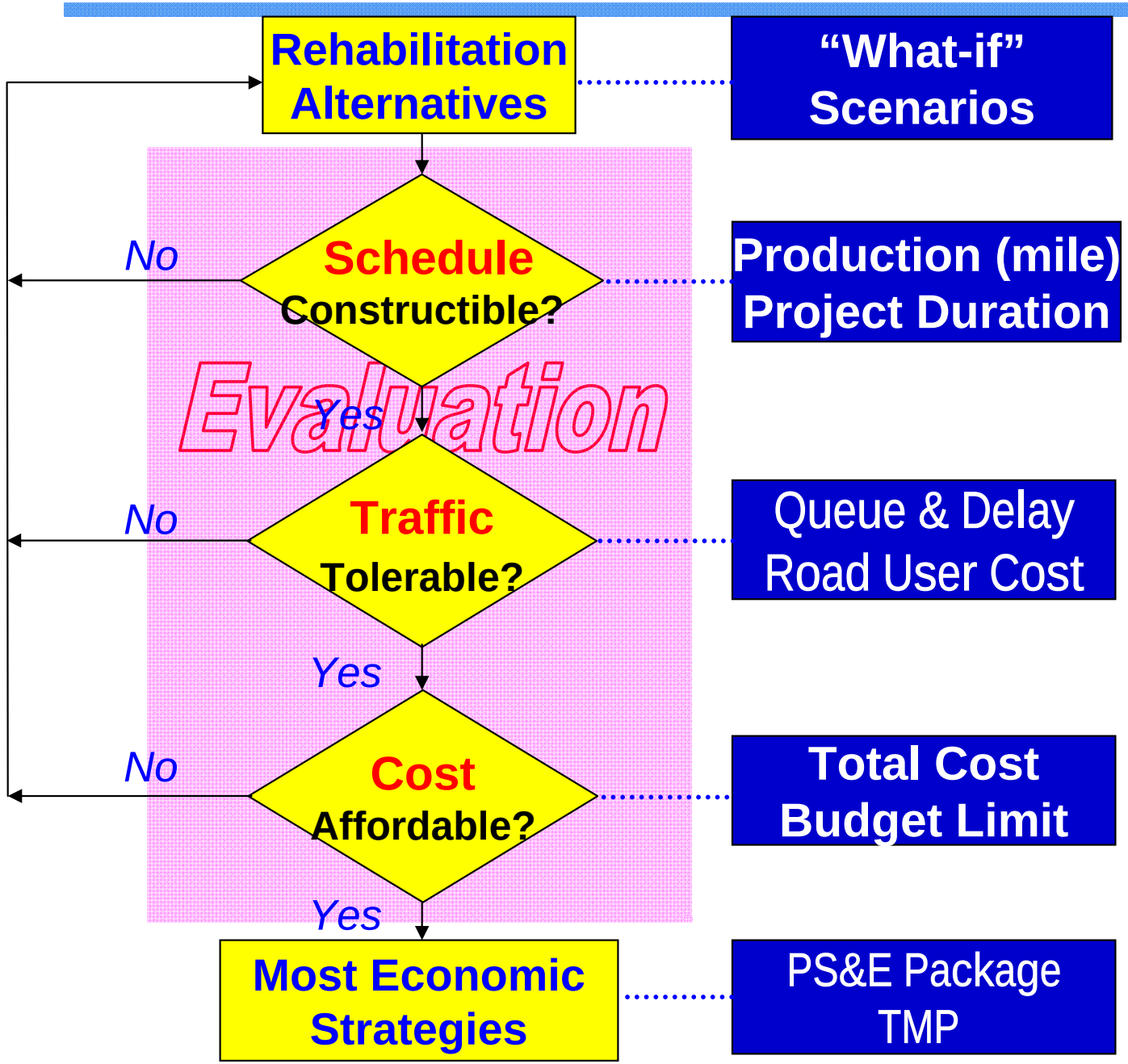


- **CA4PRS: Decision-support Model (a "Tool")**
  - Help agency select economical rehab strategies
  - Save engineering time (speed up the delivery)
  - Improve analysis accuracy (avoid manual process)
  - Streamline team-collaboration (Design-Traffic-Construction)
  - Justify for stakeholders and public (local community)

Modeling Alternatives

(What-If Scenarios)

CA4PRS Three-Step Analysis Process



Rehabilitation Alternatives and Input-parameters in *CA4PRS*

TRAFFIC	DESIGN	CONSTRUCTION
Nighttime Weekend Daytime (shift) Continuous	PCCP (JPCP) CRCP AC Overlay Full-depth AC	Concurrently Sequentially Access Environment
Full-closure (CF) Full-closure Partial-closure	Cross-section Concrete Mix Shoulder	Trucks Plant Crew

CA4PRS Inputs and Outputs for Schedule-Traffic Analysis

- **Scheduling Analysis Inputs**
  - Total project scope
  - Construction windows and activity constraints
  - Contractor's resource and logistics
  - Pavement cross-section changes and materials
- **Scheduling Analysis Outputs**
  - Maximum production (lane-km) per closure
  - Closure numbers and total project duration
- **Traffic Analysis Inputs**
  - Traffic (hourly) demand and its reduction
  - Hourly lane closure scheme
  - Time value of traveling public
- **Traffic Analysis Outputs**
  - Work-zone queue and maximum Delay per Closure
  - Total Road User Cost (RUC)
  - Demand and Capacity Sensitivity

PCC => PCC (Jointed Concrete)

Typical CA Pavement Cross-section

Existing Profile

CONCRETE	203mm (8")
CTB	102mm (4")
AB	305mm (12")
SG	

New Profile

CONCRETE	203mm (8")
CTB	102mm (4")
AB	305mm (12")
SG	

(a) 203 mm Concrete Slab

CONCRETE	205mm (8")
CTB	102mm (4")
AB	305mm (12")
SG	

CONCRETE	305mm (12")
LCB/ACB	152mm (6")
AB	152mm (6")
SG	

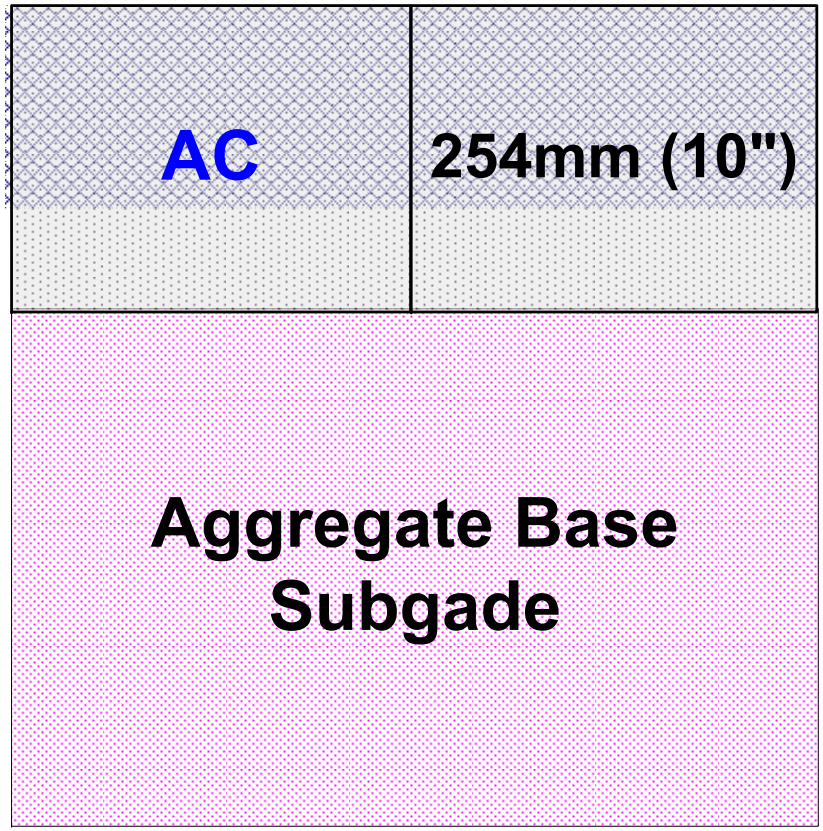
(b) 305 mm Concrete Slab

Removed | Retained | New PCC | New Base

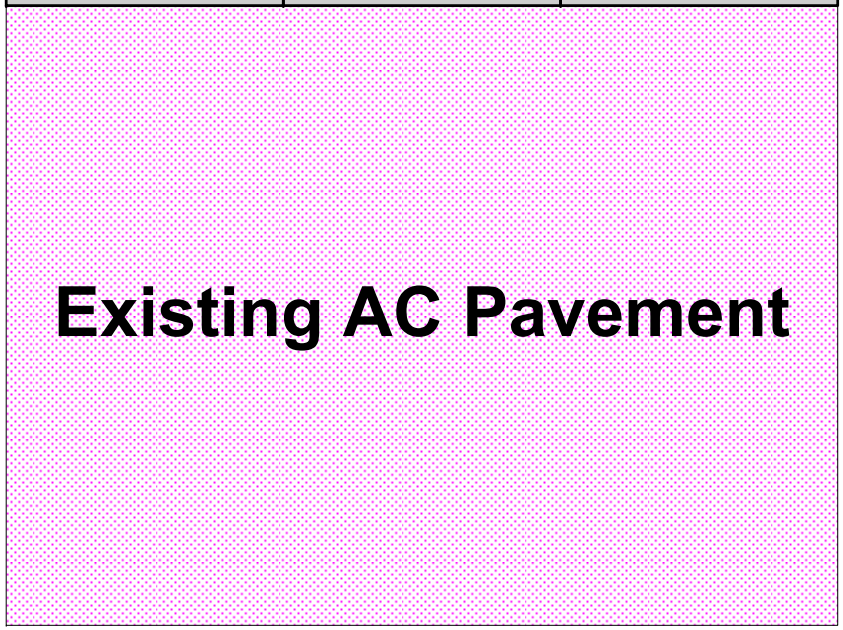
AC => AC (Milling and AC Overlay)

Typical CA Pavement Cross-section

Existing AC Pavement



Total thick.=152mm (6")		
Layer	Thick.	Cooling
OGAC	25 mm	0.5 hour
Type C	76 mm	2 hour
Type C	51 mm	1 hour



Milling | Retained | AC

PCC => AC (Crack-seat AC Overlay and Full-depth AC Replacement) Typical CA Cross-section

Existing Pavement

PCC	203mm (8")
CTB	102mm (4")
AB	305mm (12")
SG	

CSOL

Total thick. = 230 mm (9")		
Layer	Thick.	Cooling
OGFC	25 mm	0.5 hour
PBA-6a	75 mm	4 hour
AR-8000	75 mm	4 hour
AR-8000	55 mm	2 hour
PCC	203mm (8")	
CTB	102mm (4")	
AB	305mm (12")	
SG		

Retained | Fabric | AC(CSOL)

OR

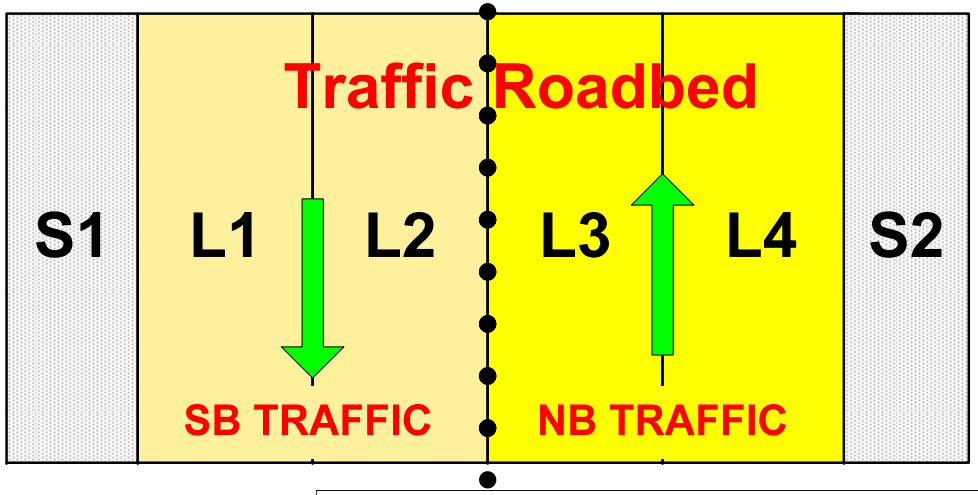
FDAC

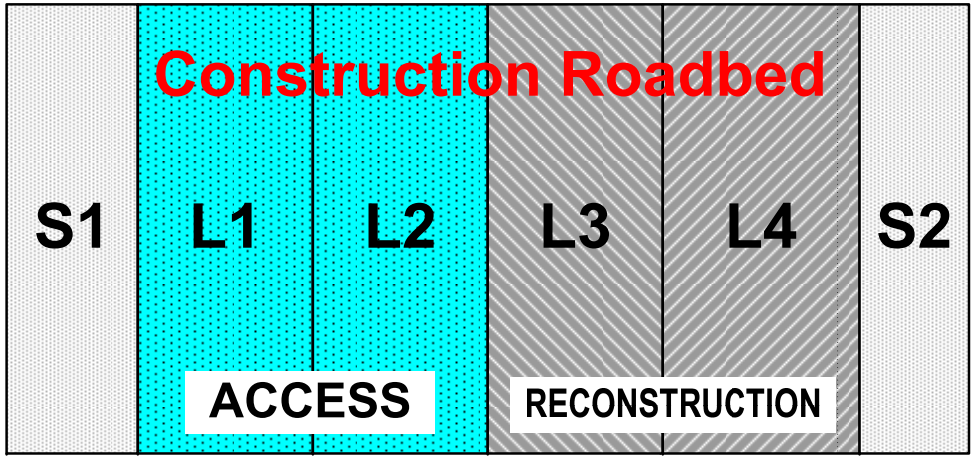
Total thick.=330mm (13")		
Layer	Thick.	Cooling
OGFC	25 mm	0.5 hour
PBA-6a	76 mm	1.5 hour
AR-8000	77 mm	6.5 hour
AR-8000	76 mm	2 hour
Rich-bottom	76 mm	1 hour
AB	279mm (11")	
SG		

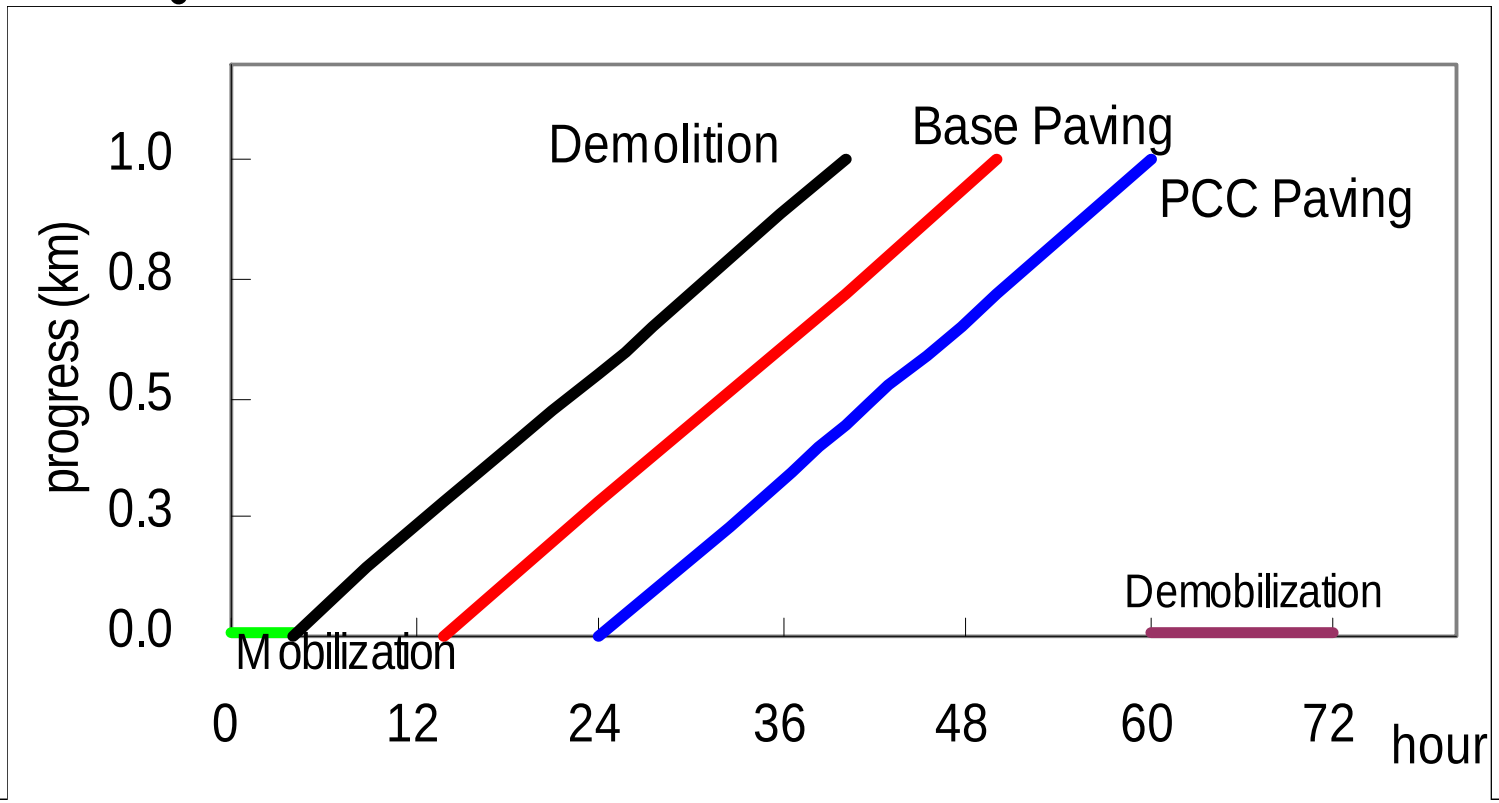
Removed | Retained | AC

Balance of Closure – Access – Production

Full Closure for PCC Concurrent Method

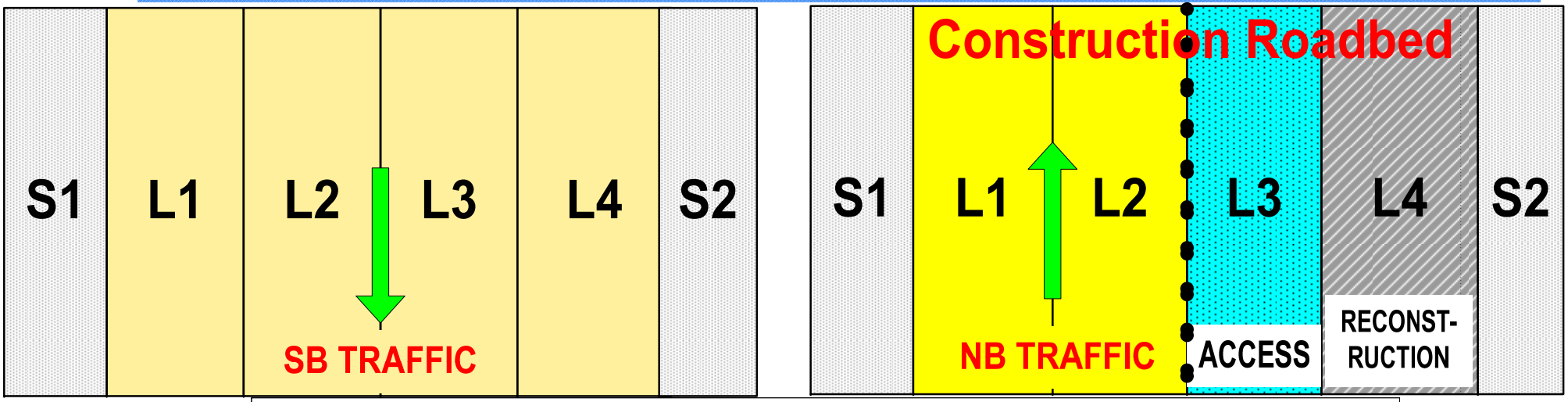


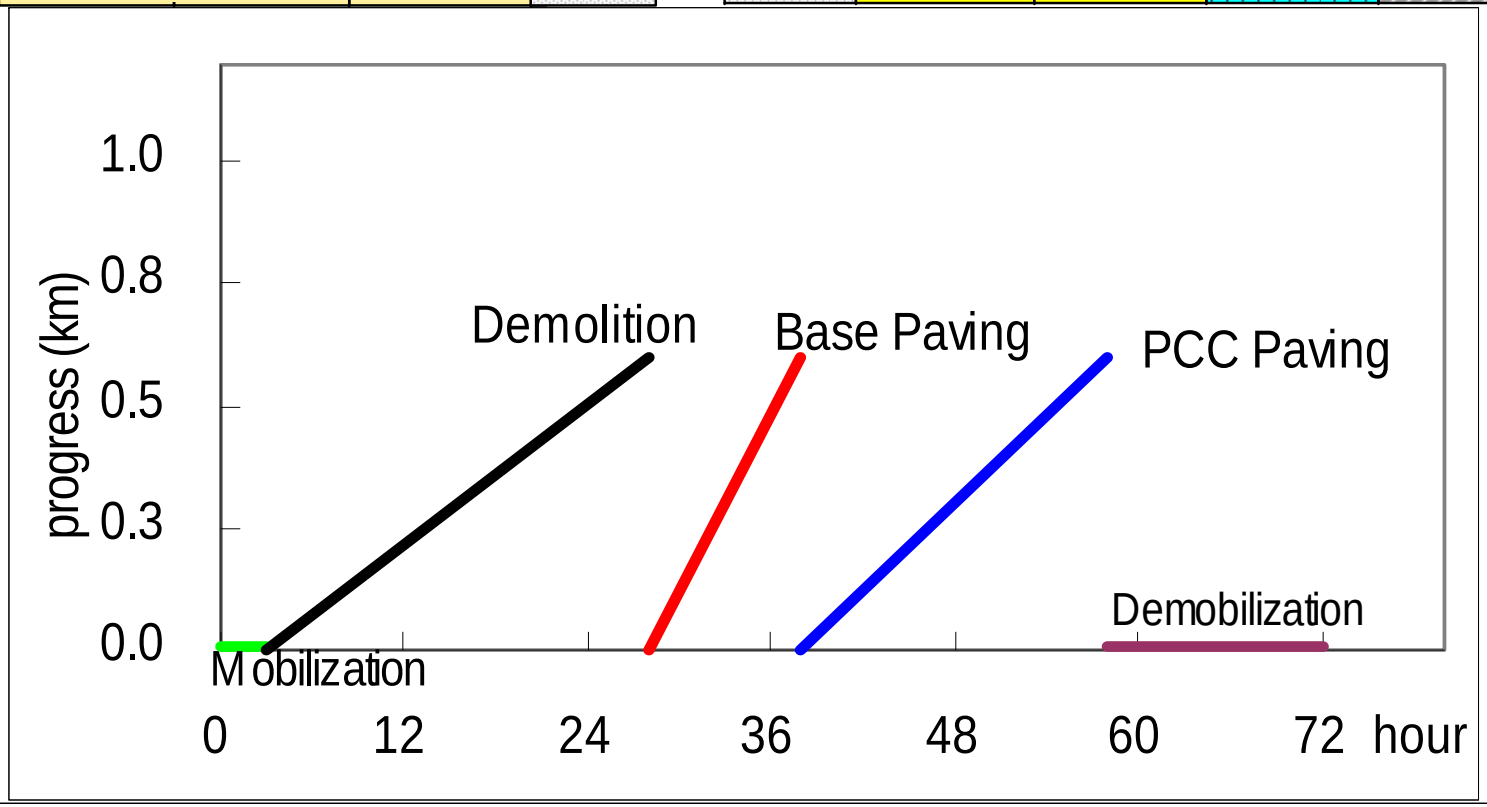




Balance of Closure – Access – Production

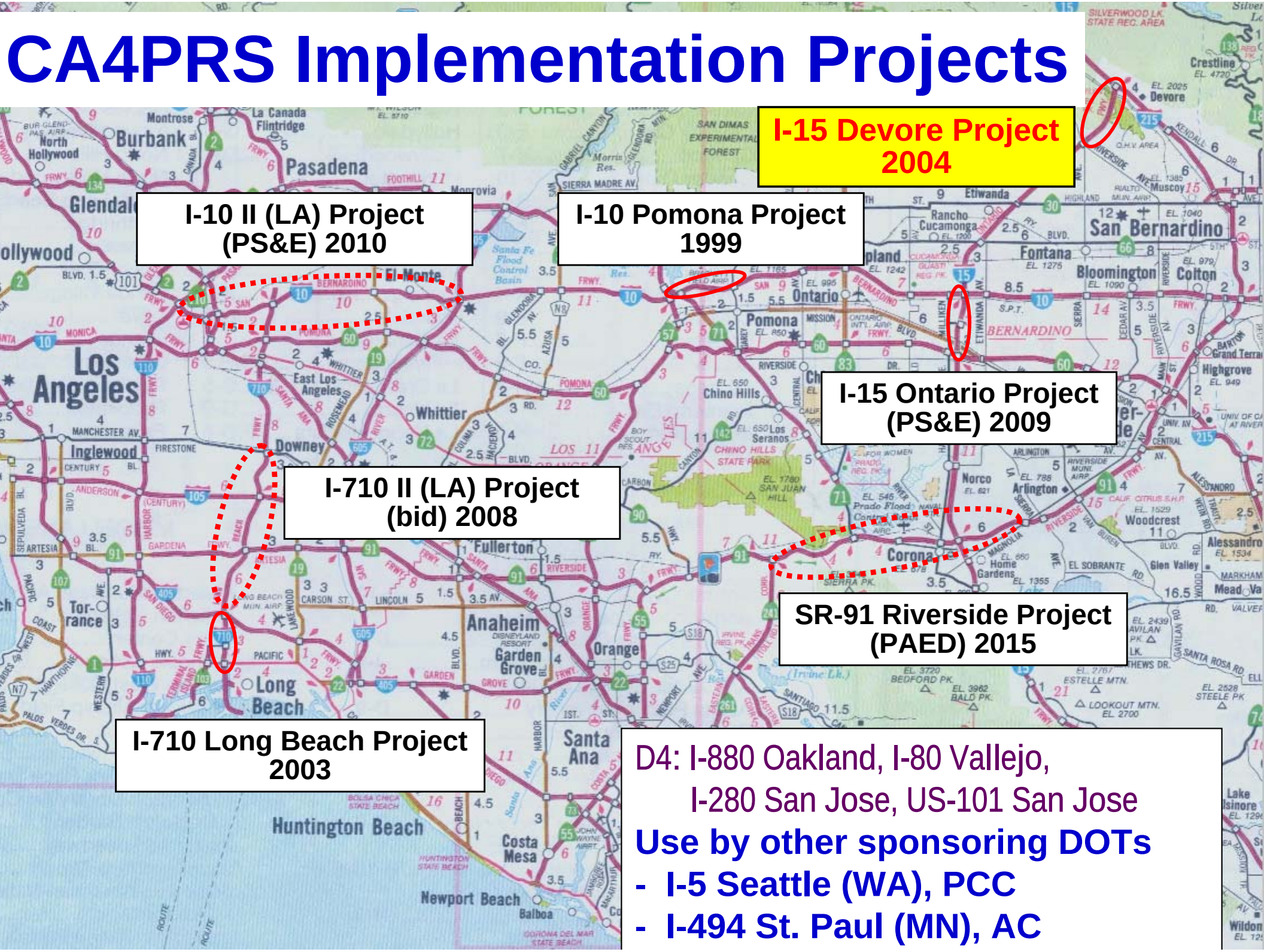
Half Closure for PCC Sequential Method





Implementation Projects

CA4PRS Implementation Projects



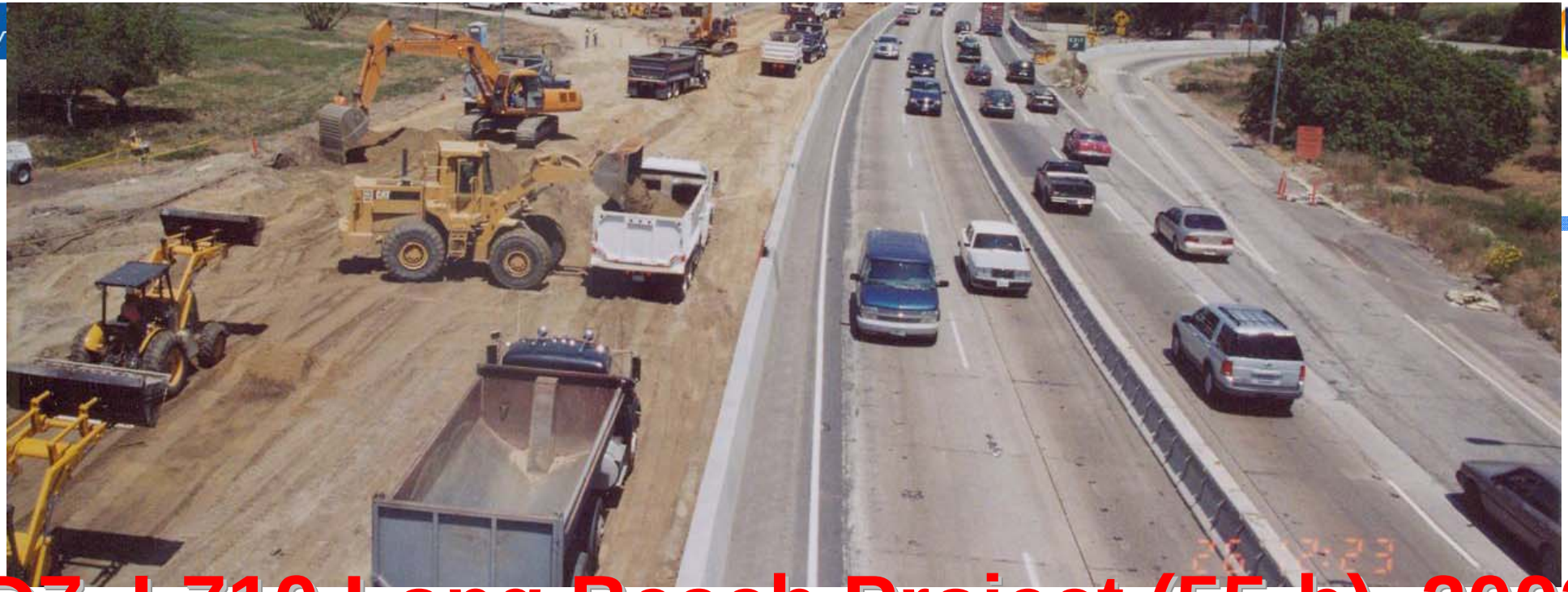
D7 I-10 Pomona with FSHCC, 2000

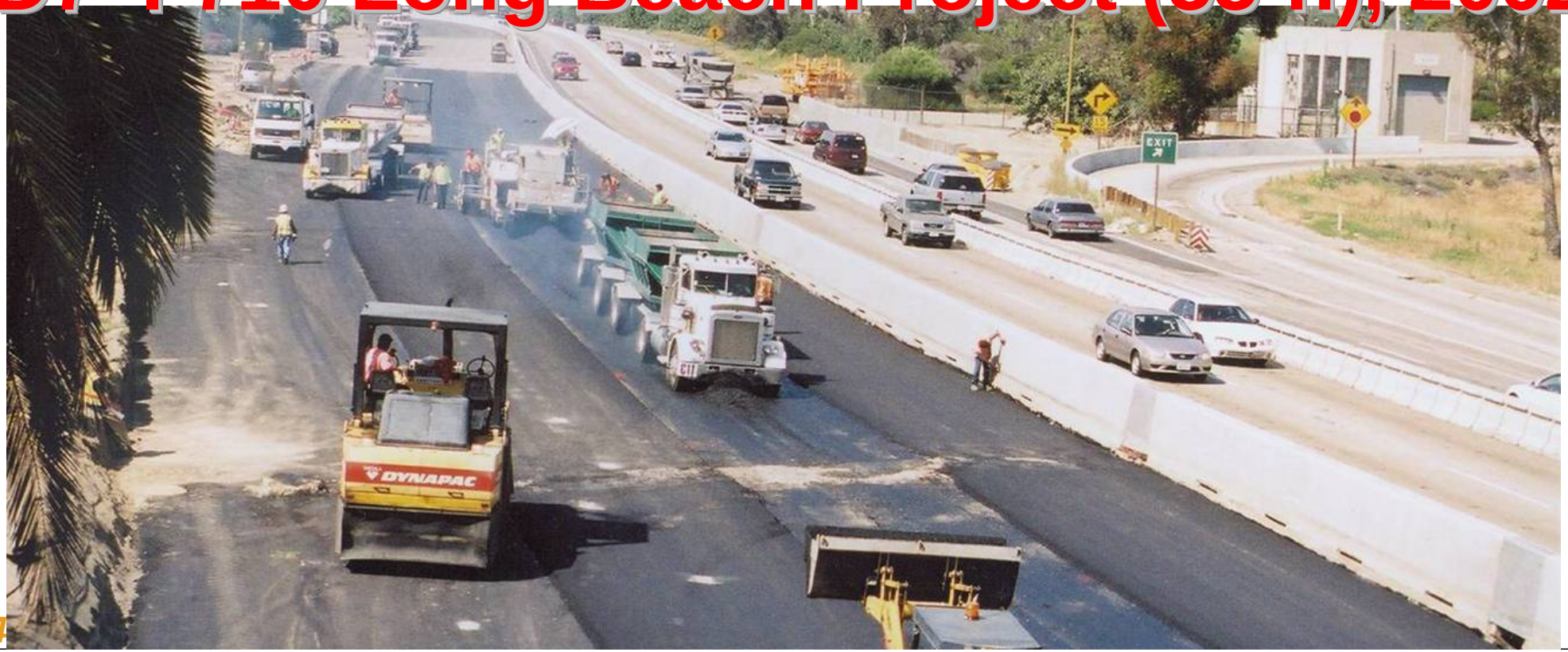
I-10 Pomona: Productivity Comparison
(Nighttimes vs. Weekend)

	Nighttime Closure		Weekend Closure
	7-hour Closure	10-hour Closure	55-hour Closure
Main Work (hours)	2 hour	5 hours	43 hours
Auxiliary Work (hours)	5 hours	5 hours	8 hours
Slabs Rebuilt	15	50	615
Net Progress (slabs / hour)	7.5	10	14
Total Progress (slabs / hour)	2	5	11

55-Hour Weekend Closure = 13 no. 10-H Nights (130H)
= 41 no. 7-H Nights (287H)

D7 I-710 Long Beach Project (55-h), 2002

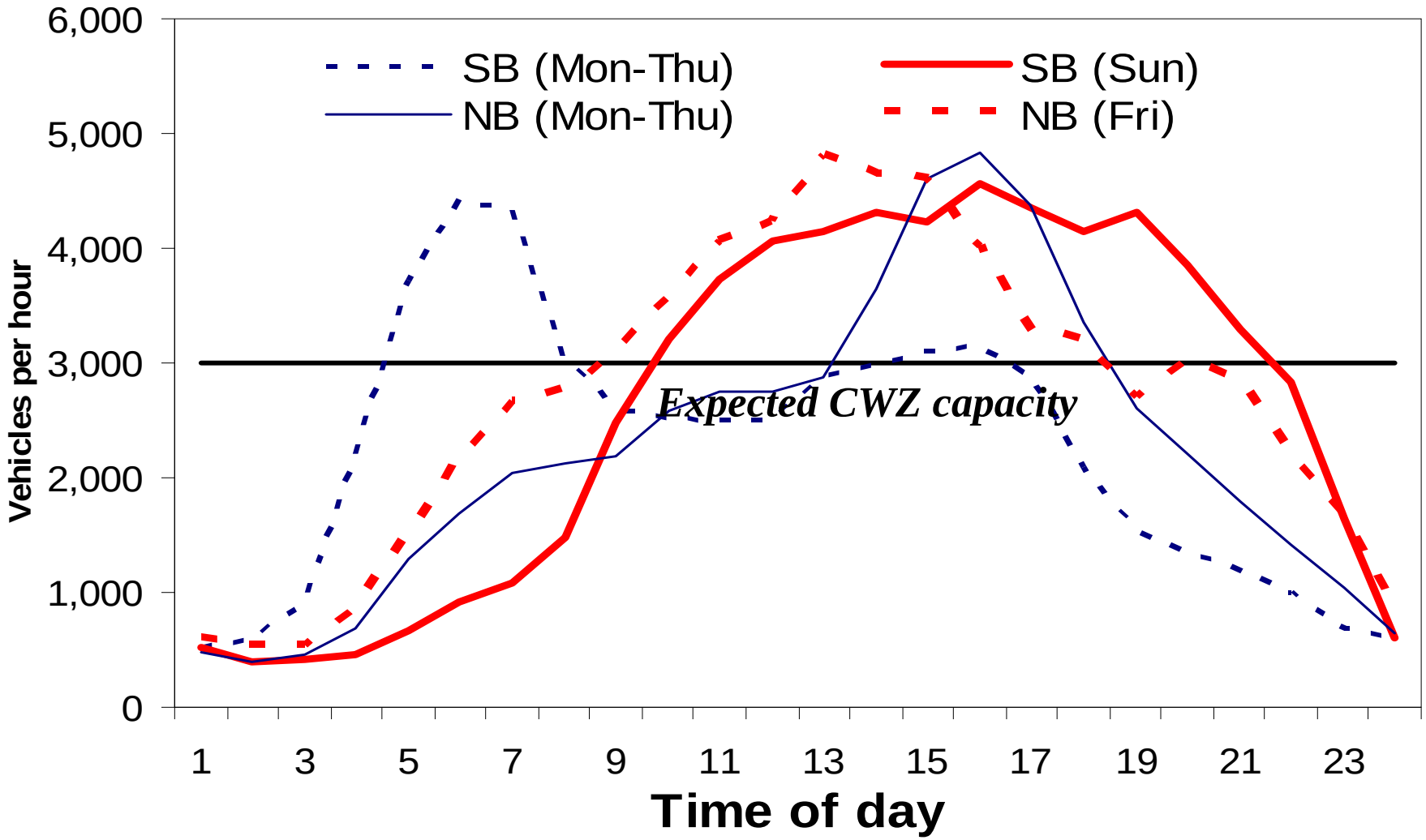




D8 I-15 Devore Project (24/9), 2004

I-15 Devore Daily Traffic Patterns

- Approximately 120,000 ADT (10% trucks)
- Weekdays Commuters + Weekend Leisure



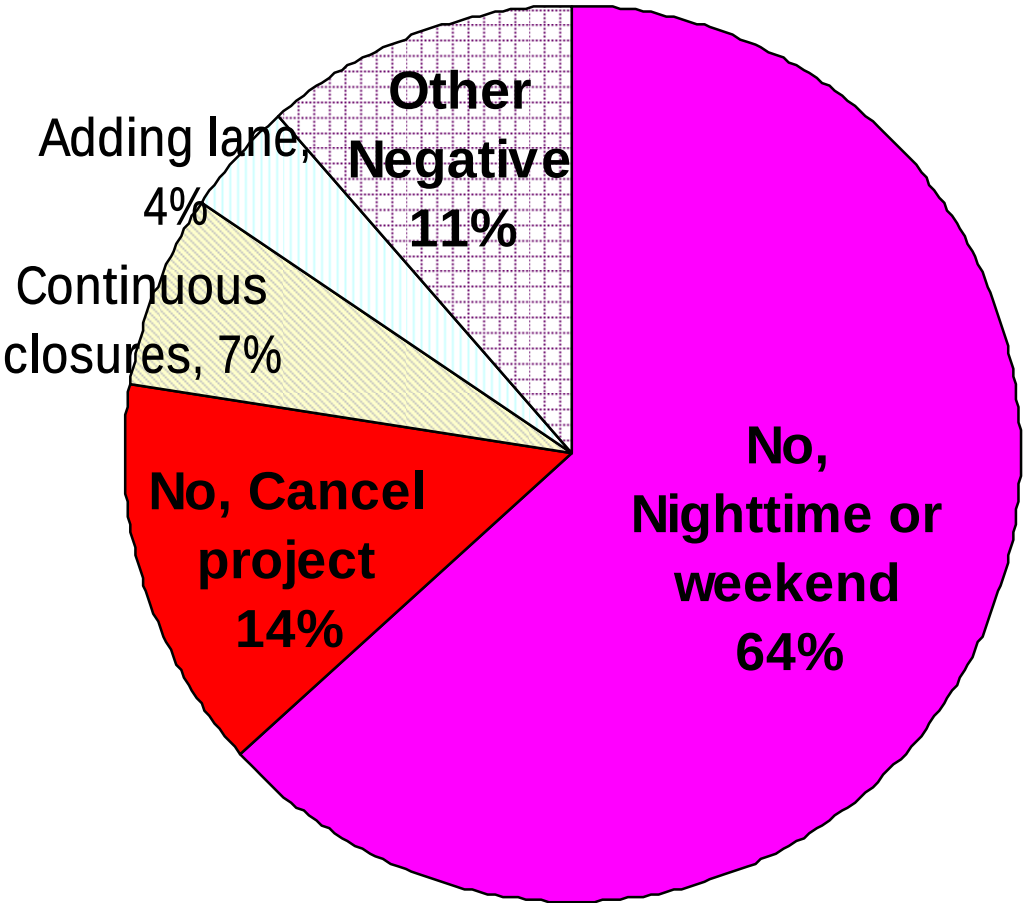
I-15 Devore (RSC) : Preconstruction CA4PRS Analysis *Schedule-Traffic-Cost*

Construction Scenario	*Schedule Comparison*		Cost Comparison ($M)			Max. Peak Delay (Min)
	Total Closures	Closure Hours	User Delay	Agency Cost	Total Cost	
One Roadbed Continuous (24/7)	2	400	5.0	15.0	20.0	80
72-Hour Weekday Continuous	8	512	5.0	16.0	21.0	50
55-Hour Weekend Continuous	14	770	14.0	17.0	31.0	80
10-Hour Night-time Closures	220	2,200	7.0	21.0	28.0	30

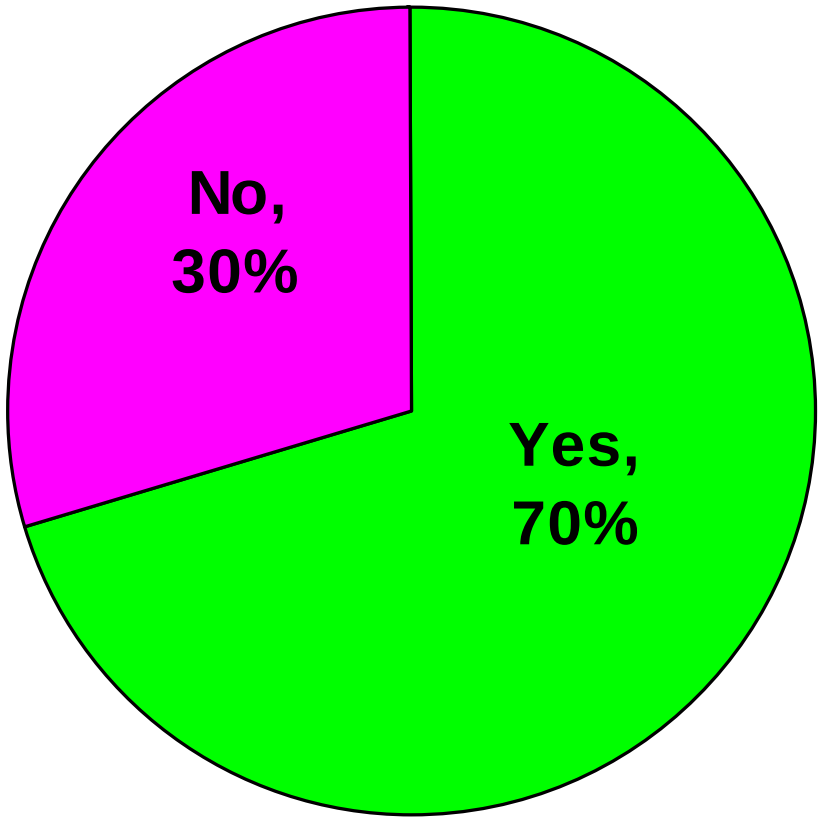
Using CA4PRS on I-15 Devore, "Rapid Rehab (24/7)", saved $6M agency cost and $2M road user cost, compared to nighttime closures.

I-15 Devore Web-Surveys
Public Perception Changes

Before- construction



After-construction

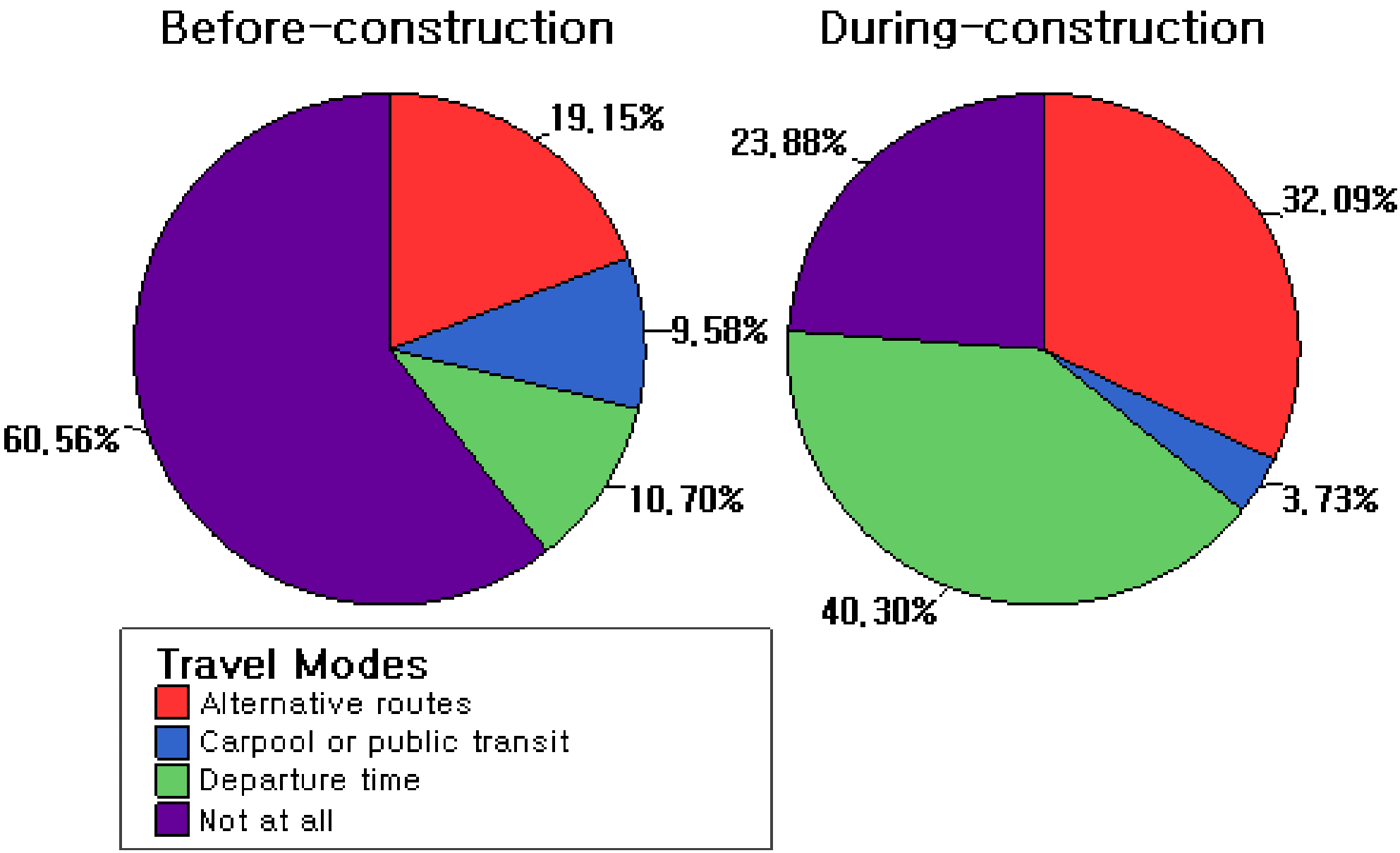


Do you support 72-h (3-weekday) Weekday closures?

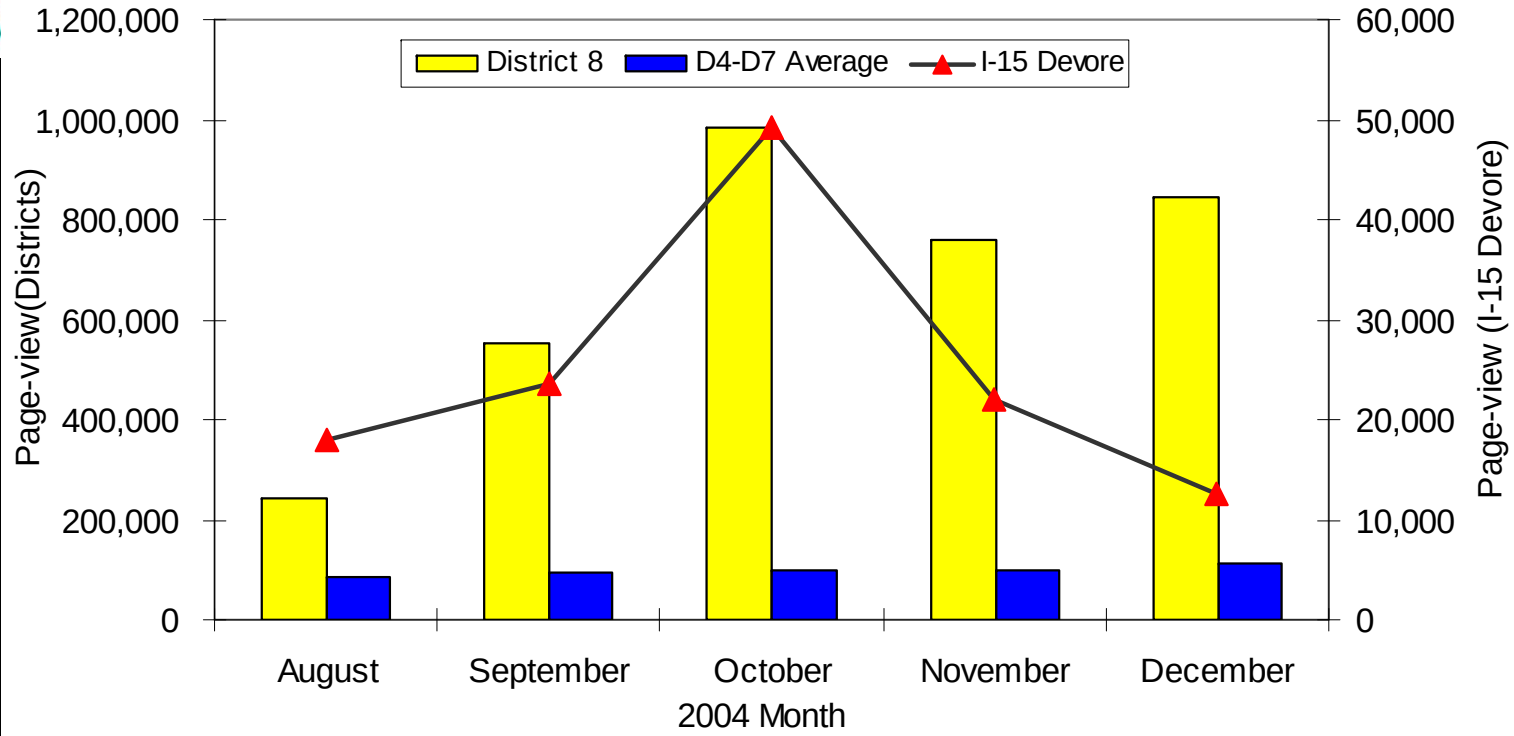
Do you support future "Rapid-Rehab" projects?

I-15 Devore Web-Surveys

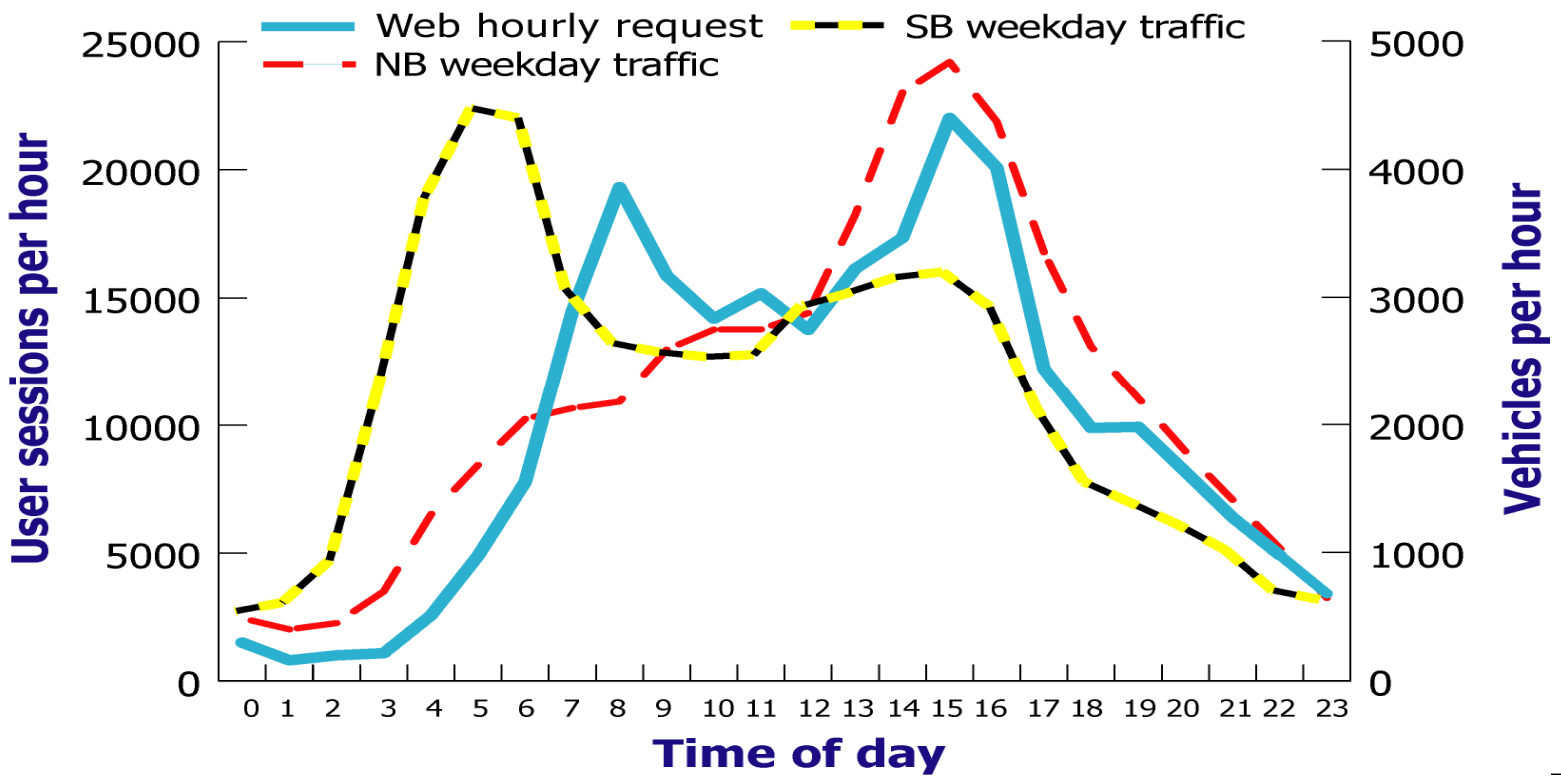
Travel Mode Changes



I-15 Devore Project Internet (Web) Public Outreach



Web Access & Traffic Pattern

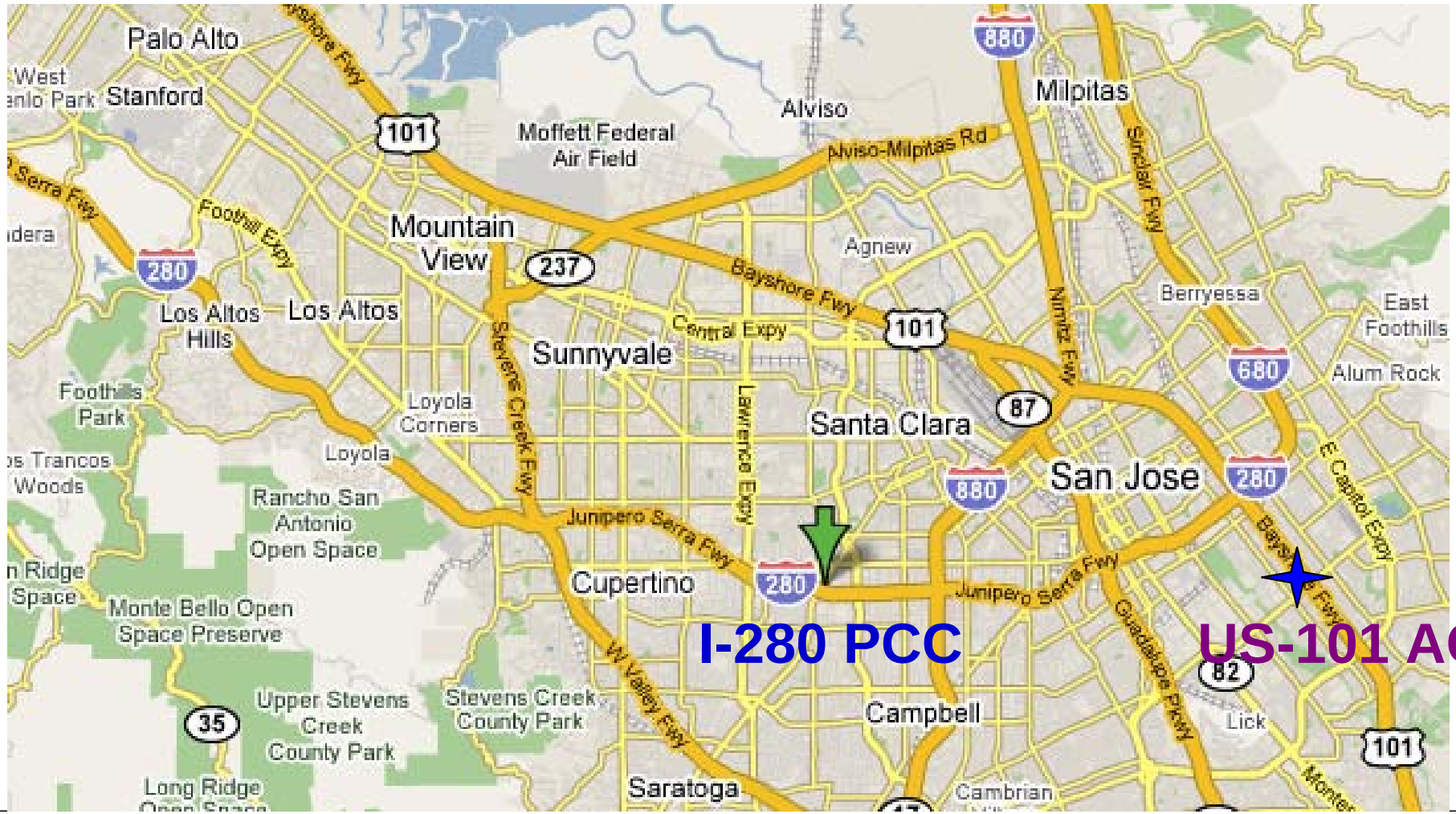


D8 I-15 Devore II (Weekend) Project, 2007

I-280 San Jose Project (EA 04-272021: $20M)

(Saratoga – Steven Creek (PM 5.1/7.8), Start 2009)

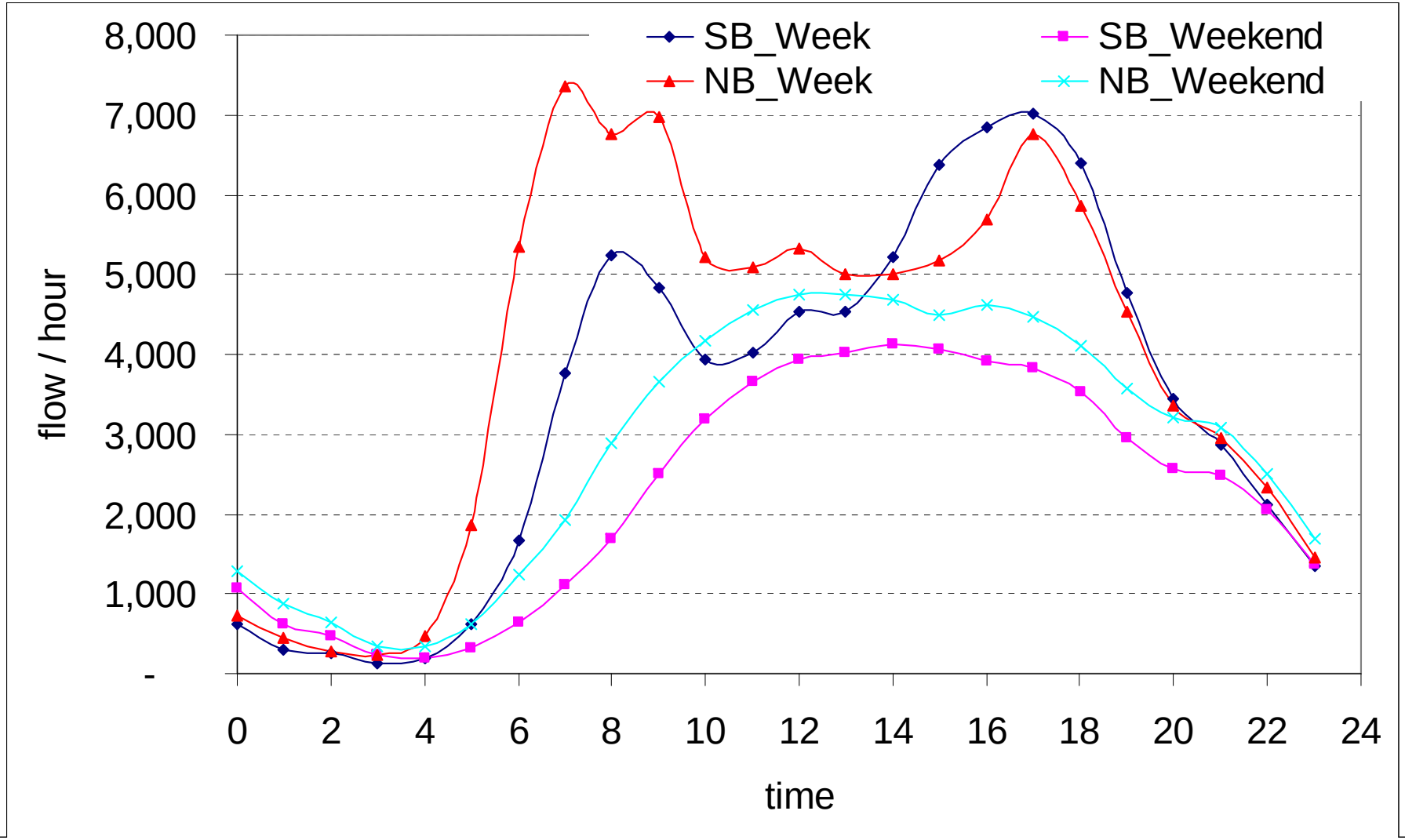
- **Replace 9” PCC (FSHCC) Slabs during Nighttime**
- **Lane reconstruction (1-mile section on SB & NB)**
- **Random slab replacement (5% of 17 lane-mile)**



I-280 San Jose Project

Hourly and Daily Traffic Demand

- AADT = 150,000 – 200,000
- 4-5 lanes for each direction



I-280 San Jose PCC Project

CA4PRS Construction and Traffic Analysis

Scenarios	Construction			Traffic		
	Production (Closure no)		Duration (Total Closure Number)	Queue	Max Delay	User Cost
	Continuous Lane (2-mile)	Random Slab (5%)		mile	min	$M
6-h Night (FSHCC)	**15 meter** 220 closure	**10 meter** 150 closure	**370**	**0**	**0**	**0**
7-h Night	**35 m** 100 closure	**20 m** 65 closure	**165**	**0**	**0**	**0**
8-h Night	**60 m** 60 closure	**40 m** 40 closure	**100**	**0**	**5**	**0.5**
9-h Night	**85 m** 40 closure	**50 m** 30 closure	**70**	**1.8**	**30**	**9**
55-h Weekend (RSC)	**1,700 m** 2 closure	**800 m** 2 closure	**4**	**5** (20%) **1** (30%)	**80** **15**	**4** **0.5**

I-280 San Jose Project: Cost Comparison
(Nighttime versus Weekend Construction)

CONSTRUCTION			COST (Millions)				
Closure Alternative		Closures	Concrete	TMP	PY (Field)	Total	Saving
Night Closure (FSHCC: 4-h Mix)	6-hour	**370**	**$5.3**	**$1.1**	**$0.6**	**$7.0**	**-**
	7-hour	**165**	**$5.3**	**$0.5**	**$0.3**	**$6.1**	**$0.9**
	8-hour	**100**	**$5.3**	**$0.3**	**$0.2**	**$5.8**	**$1.2**
	9-hour	**70**	**$5.3**	**$0.2**	**$0.1**	**$5.6**	**$1.4**
Weekend (RSC: 12-h Mix)	55-hour	**4**	**$3.4**	**$0.4**	**$0.1**	**$3.9**	**$3.1**

*** 55-h Weekend Closures Save about $3M vs Nighttime (6-h) Closures**

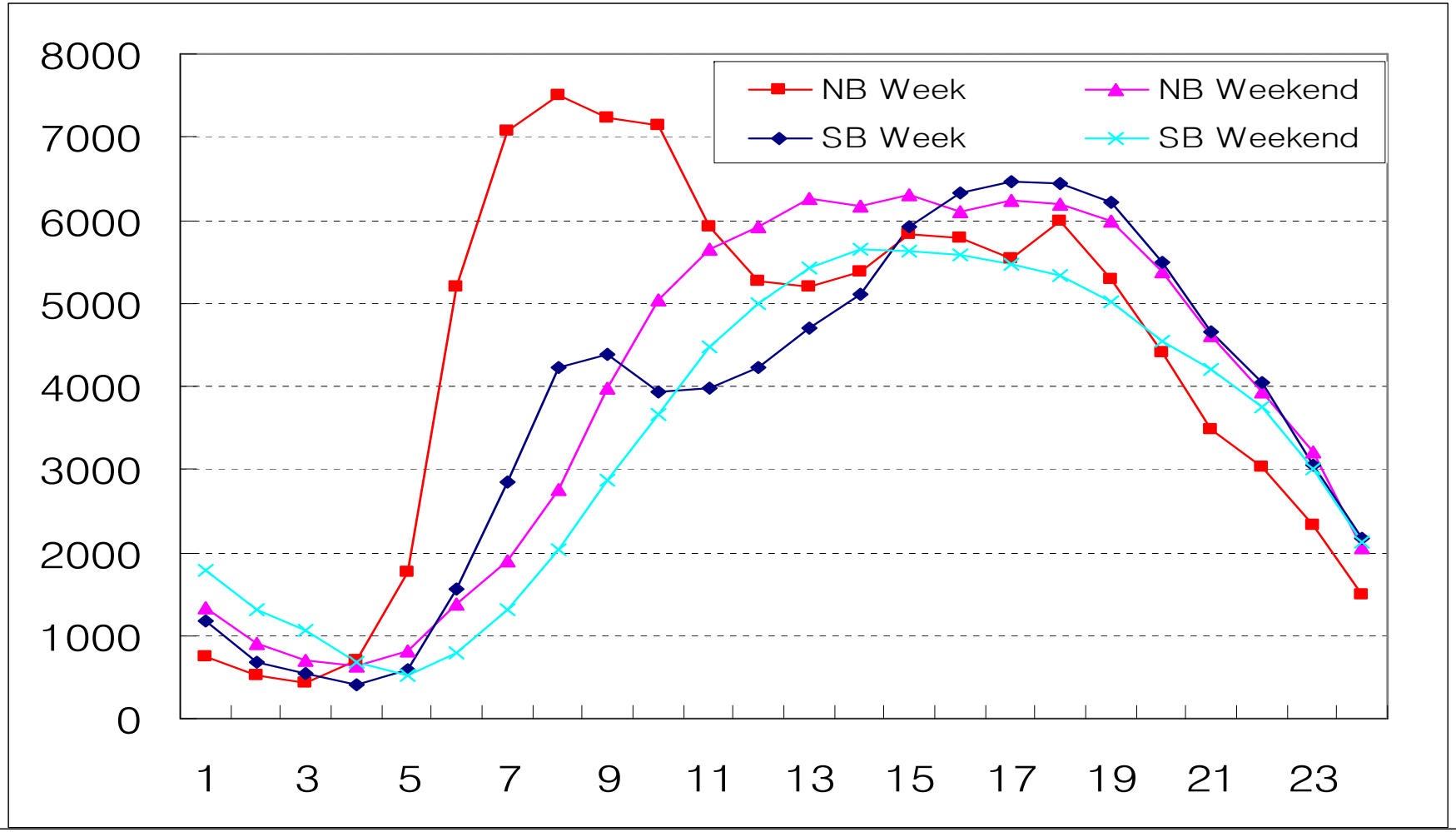
***TMP = Barriers, Signs, COZEEP, FSP, PIO and Outreach, HAR, CCTV**

*** Caltrans PY = Field Engineers + additional TMP Engineering**

US-101 San Jose Project ($47M)

Milling and AC Overlay (PM R27.5/40.2), 2009

- 7 miles x 4 lanes x 2 directions
- 4” Milling => 2” RAC-O + 2” OGAC Paving
- AADT = 180,000 – 200,000 (4-5 lanes per direction)



US-101 San Jose AC Project (EA 04-0C9001)
(Nighttime Closures: Schedule-Traffic-Cost)

	Construction		Traffic		Cost
Nighttime Closure	Production meter/night	Closure number	Max delay (min)	RUC ($M)	TMP + PY ($M)
6-h	**230**	**420**	**-**	**-**	**3.6**
7-h	**320**	**300**	**-**	**-**	**2.6**
8-h	**410**	**240**	**10**	**1**	**2.2**
9-h	**500**	**200**	**25**	**4**	**2.0**

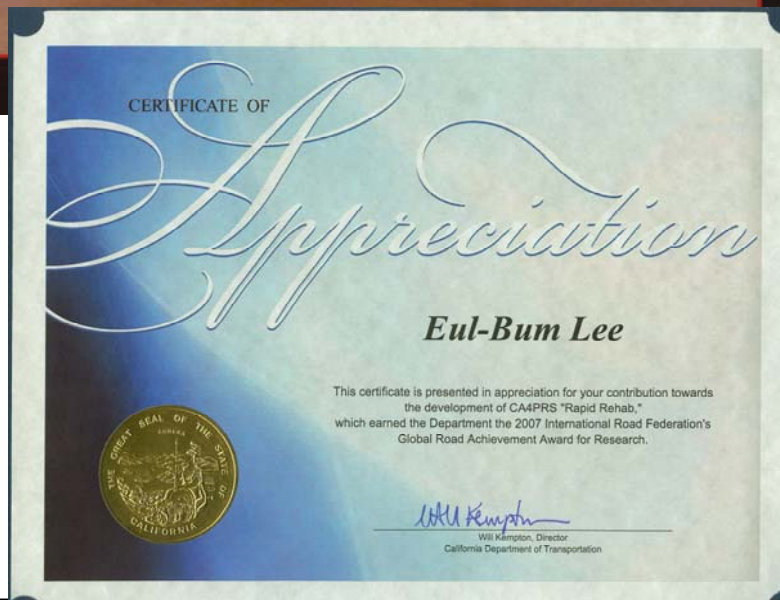
D4 Traffic recently changed lane-closure charts from 6-h to 8-h closures based on CA4PRS analysis.

Saving (6-h=>8h) = $1.5M ($1.0M (TMP) + $0.5M (PY).

Deployment Outreach

CA4PRS 2007 International Road Federation Award Ceremony (March 20, 2008)

The Director (Mr. Kempton) Emphasized to Implement CA4PRS on more (All) Caltrans Projects.



CA4PRS in Caltrans Web

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- Deployment Support
- California University Transportation Centers
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- DOT Links
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Click Here to Access CA4PRS Software
This is free for Caltrans only. Installation password is provided on the DRI Intranet.

Implementation

Caltrans > DRI Home > Roadway > CA4PRS

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

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

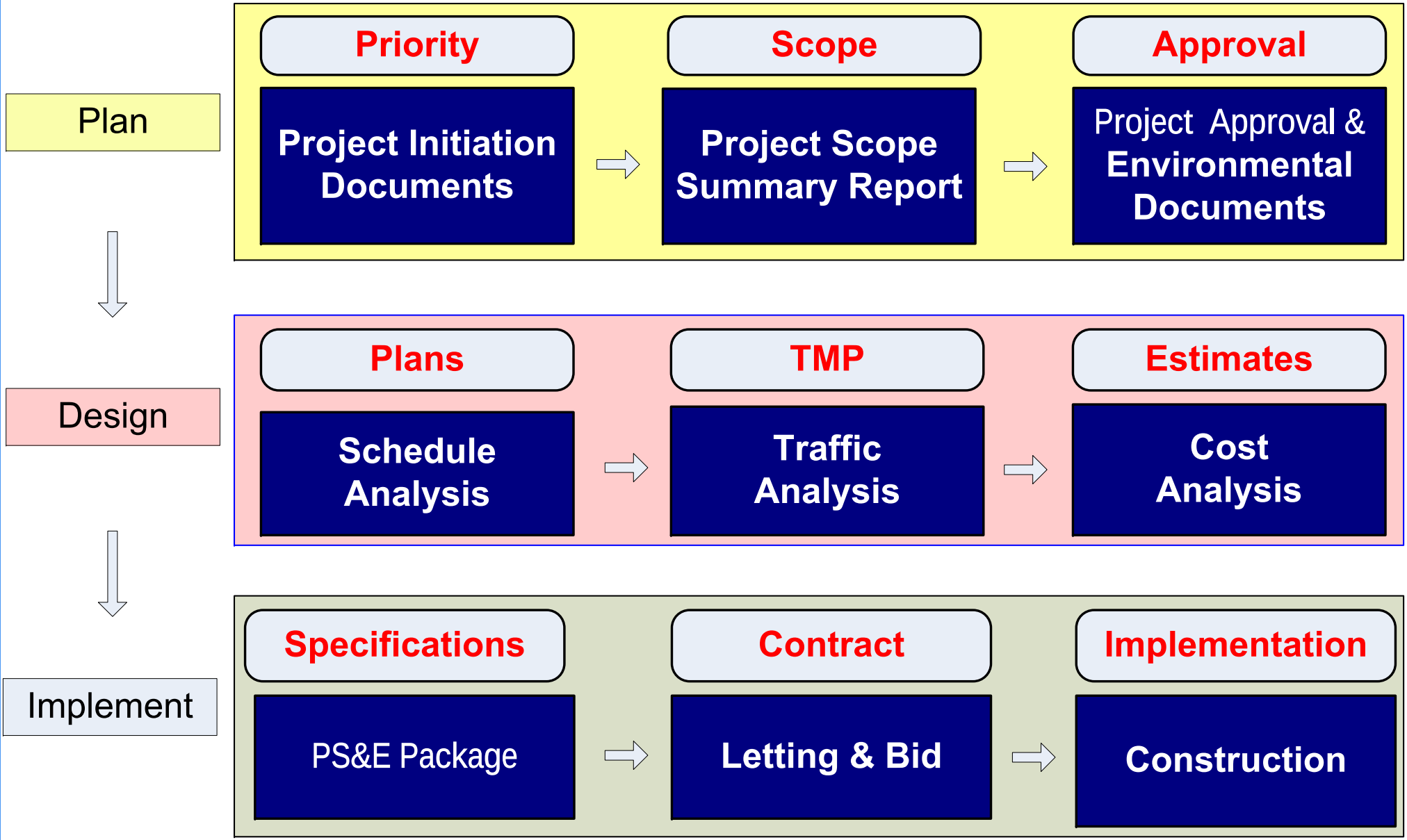
Development Background

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

How CA4PRS Help Engineers in Highway Projects Process Cycle?



CA4PRS Implementation in Project Life Cycle

- Planning stage: PSSR and PA&ED
  - Project prioritization: VA study and LCCA
  - Project scoping and alternatives evaluation
- Design stage: PS&E package and TMP
  - Construction schedule: **Working-days estimate**
  - Traffic delay & user cost: Transportation Management Plan
  - Construction staging-plan and Constructability check
  - Contracting methods: A+B, Incentives/Disincentives
- Construction stage: Contractor's work plans
  - Convince public (media) in outreach
  - Validate contractor's work plan
  - Evaluate contractor's request of change orders

CA4PRS: State- and Nation-wide Implementation (as of 2008)

- Developed by UCB for SPTC (FHWA pool-fund)
  - About 10 state DOTs and 10 universities are licensed
- Publications: 30 magazine articles, journal papers
- Caltrans: IT approved as Standard
  - To install engineer's workstations: D4, D6, D7, D8
  - To follow up Deputy-directive/Memo for requirement
- FHWA nationwide deployment
  - Priority, Market-ready Technologies and Innovations
  - Tool for FHWA Work-zone Safety & Mobility Rule
  - To arrange a free group license for 50 state DOTs
  - AASHTO TIG Promotion (CAST) and AASHTOWare
- International Road Federation (IRF) Award
  - 2007 Global Road Achievement

CA4PRS Lead in Design, Traffic, Research

Email from Traffic Operations Chief: Jun 27, 2008)

- With the success of the Fix-It I-5 project, the Bay Bridge, Devore and even MacArthur Maze, the concept of "Get in, get to work and get out" as stated by the Director needs to be expanded.
- While policies are in place to do so, we need to encourage more full closures to occur and to build them into our standard business practices rather than having them be only for special situations. I have discussed with Mike Miles, Rick Land, Mark Leja and Lenka Culik-Caro and have their support to move forward. We are still considering next steps. Mike may propose expansion of full closures in his contract with the Director.
- **However, one of the steps to fully implement full closures is to fully deploy CA4PRS.** Lenka said that you had discussed the use of the software for a Bay Area project.
- What is the status of the software? What additional improvements, if any, are needed to the software? Who is the lead for CA4PRS in DRI?

Robert Copp
Chief, Division of Traffic Operations
California Department of Transportation
1120 ' N' Street, MS #36; Sacramento, CA 95814
Phone: 916-654-2352; Fax: 916-653-6080

Criteria for CA4PRS Candidate Projects
Implementation of Extended Closures

- Major maintenance (CAPM), rehabilitation/reconstruction (HM21) of pavement projects (Widening module in development: 2009).
- "Rapid Rehab" Projects with extended closures can potentially shorten schedule, reduce overall delay, and save cost.
- Projects need "What-if Scenarios Analysis" for alternative comparisons.
- High-profile projects need extensive public and media outreaches.
- Minimum 2 lanes for each direction (more, better candidate).
- Traffic level about 50,000 – 250,000 ADT (more, better candidate).
- Minimum size (project cost) of $5 millions (bigger, better candidate).
- Better, if Weekend traffic demand is less than on Weekday demand.
- Better, if counter-flow traffic for work-zone can be adopted.
- Projects need multiple staging-construction plan, lane-closure charts.
- Projects need VA study (PSSR) or Life-cycle cost analysis (PS&E).

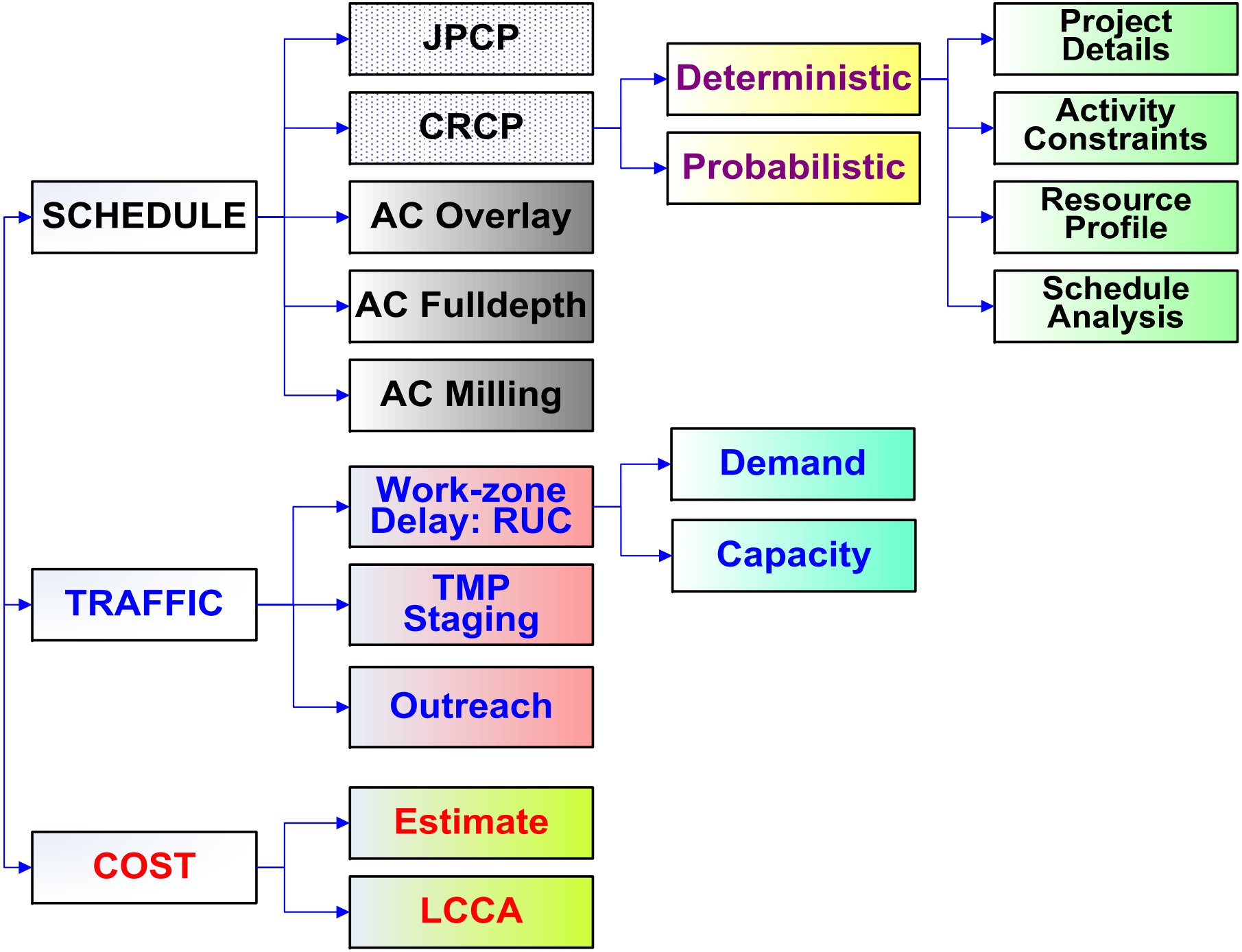
CA4PRS Training and Continuous Enhancement

- **Windows PC-based Stand-alone Application**
  - MS ACCESS database (historical projects)
- **3-day Hands-on user training workshops**
  - About 45 trainings (700 engineers): Caltrans + DOTs
  - Online (self-paced) training course in development
- **Enhancement roadmap (current version is 2.0)**
  - Version 1.0 and 1.5: Schedule module for Rehab
  - Version 2.0: Work-zone Traffic module (Cost in progress)

  - Version 2.5: Roadway widening module (2009)
  - Version 3.0: Interchange & Bridge replacements (2010)
  - Version 3.5: Precast panel replacement (2010)
  - Version 4.0: Interaction with LCCA – Realcost (2011)

Constructability Issues

CA4PRS Analysis Framework



Scenarios for Hands-on Training

- Copy (input) screenshots from the class-folder
- Explain definitions and compare result & outputs
- PCCP (JPCP): I-15 Devore Project
  - 72-hour weekday vs. 55-hour weekend closure
  - 12” full-depth PCC vs. 8” PCC slab replacement
  - Full closure (Concurrent) Half closure (Sequential)
  - 9-hour Nighttime closure (8 pm – 5 am)
  - Deterministic vs. Probabilistic approach
- CRCP: I-35 Austin Project
- CSOL and FDAC: I-710 Long Beach Project
- MACO: I-15 Mountain Path Project
- Traffic (RUC): I-15 Devore and PeMS

Loading cycle-time and Hauling truck numbers

Demolition packing efficiency (0.5 – 0.75)

Discharging cycle-time

Concrete and HMA

Delivery truck numbers

AC Cooling-time Estimate Interaction with Multicool

MultiCool Data

Construction Start Date: 7/17/2003

Latitude (Deg North): 40

Existing Surface

Material Type: PCCP

Moisture Content: Dry

Moisture State: Unfrozen

Surface Temperature (C): 21.1

Mix Specifications

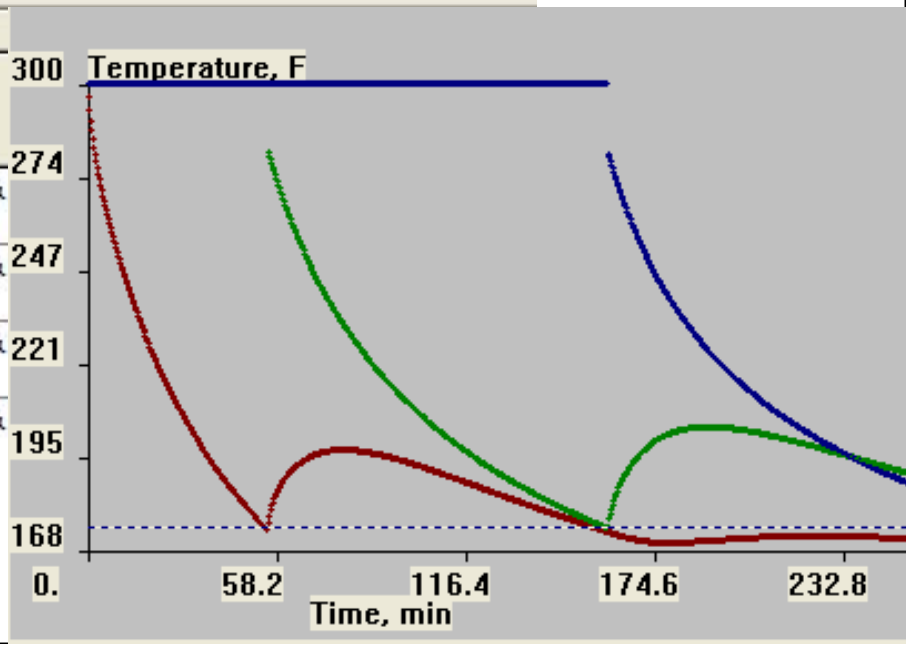
Mix Type: Dense Graded

Delivery Temperature (C): 148.89

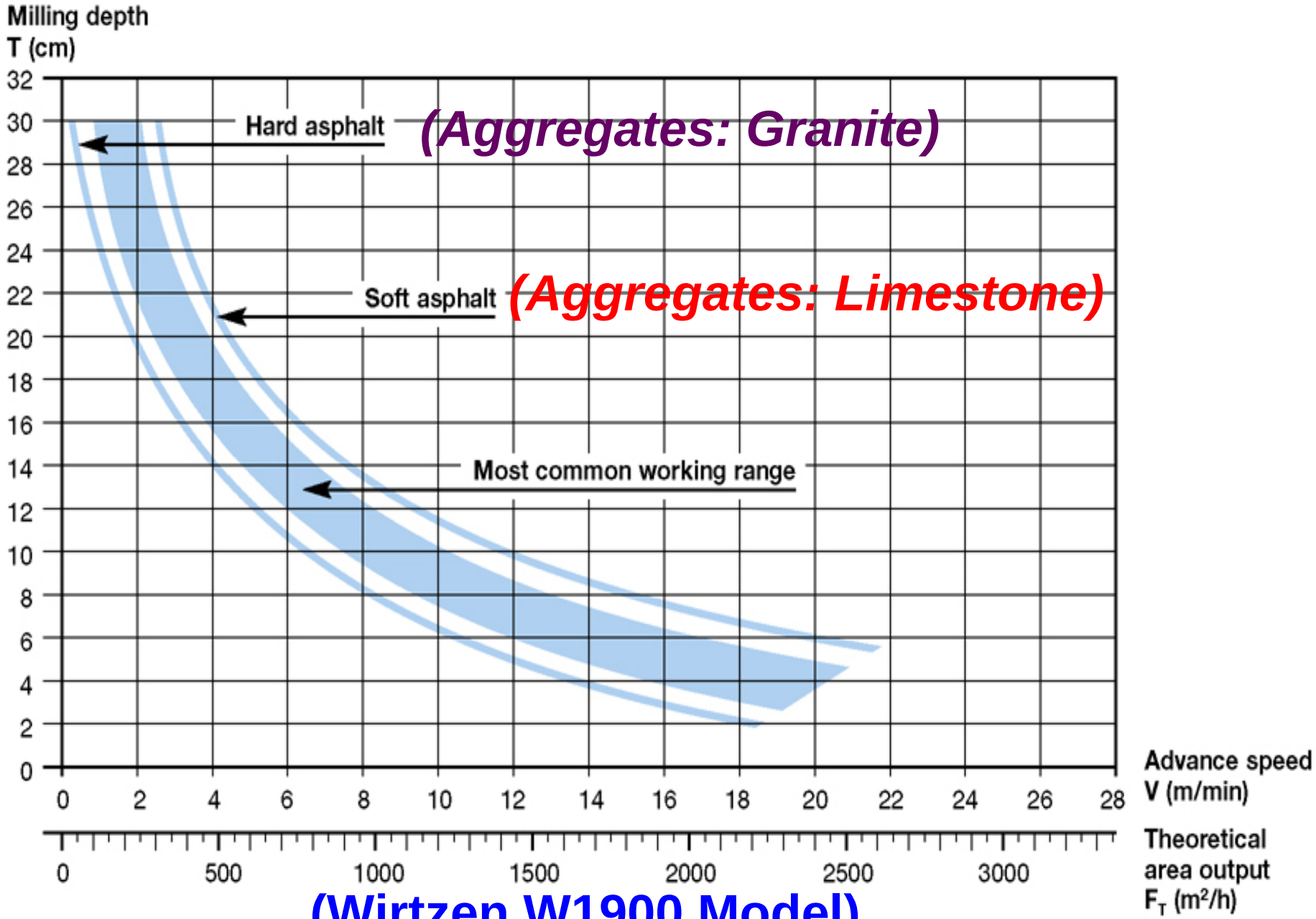
Stop Temperature (C): 73.89

Open to Traffic Temperature (C): 61

Environmental Condition				
Period	Time	Ambient Temperature (C)	Average Wind Speed (kph)	
1	12:00 AM	12.8	8.1	Clear &
2	06:00 AM	15.6	8.1	Clear &
3	12:00 PM	26.7	8.1	Clear &
4	06:00 PM	18.3	8.1	Clear &

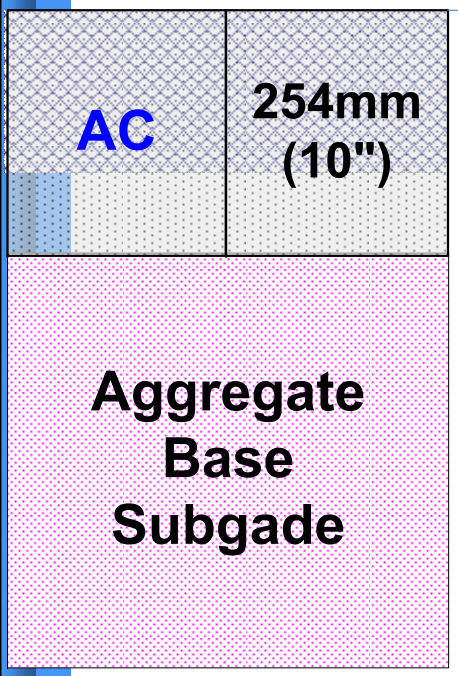


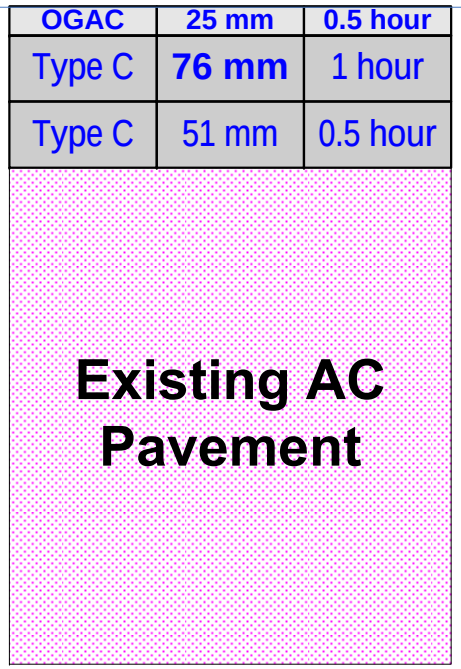
Cold Milling Machine Hourly Productivity
Depends on Depth and AC Condition

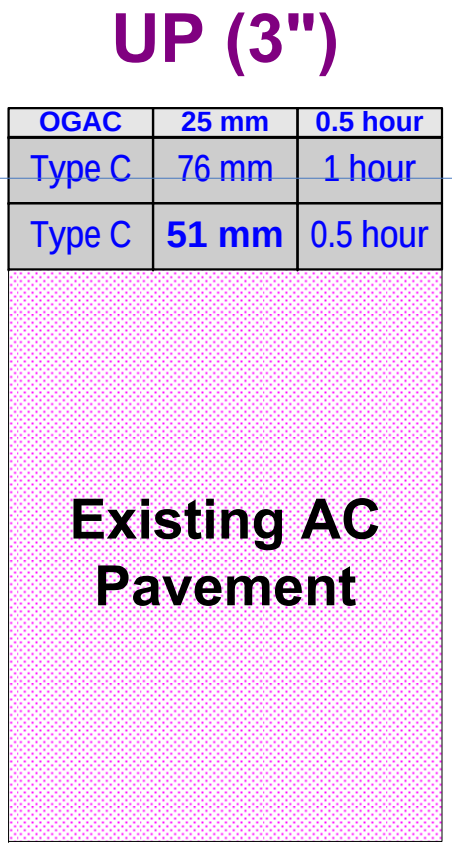


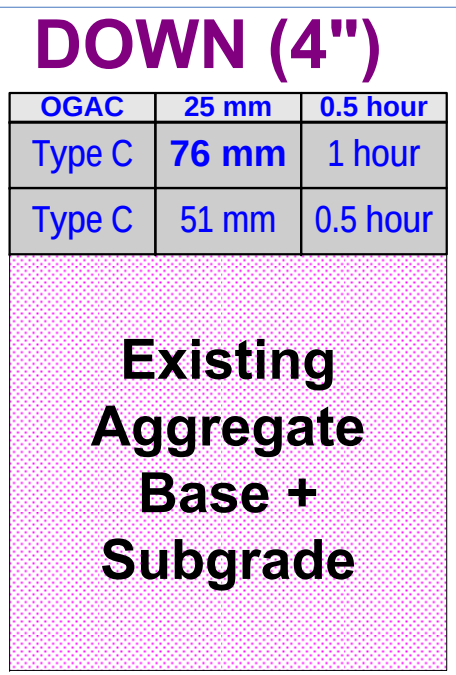
(Wirtzen W1900 Model)

Roadway Elevation Change (Milling and Filling AC): No-change, Up, or Down









Milling	Retained	AC

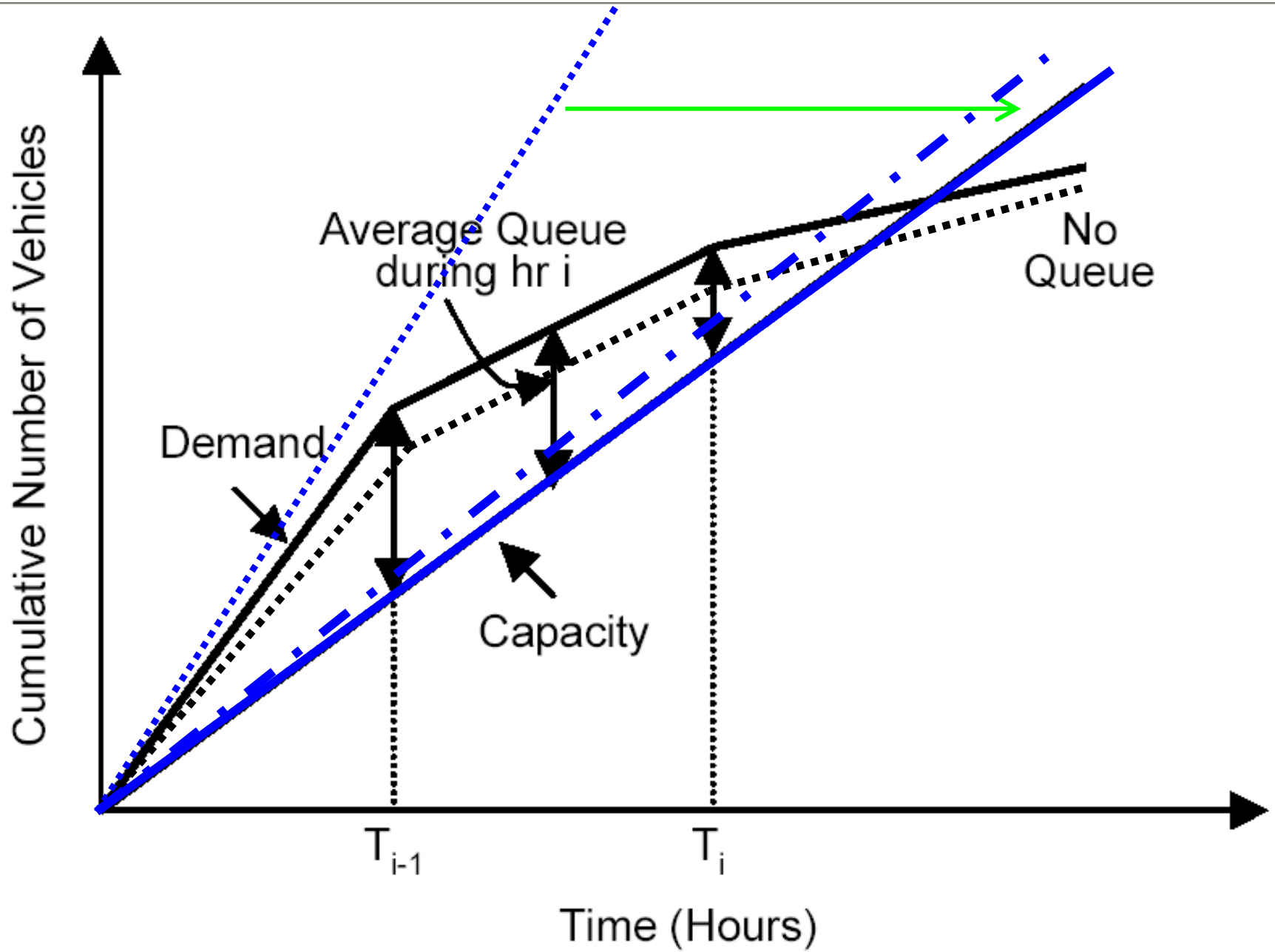
Milling = 6"
AC = 6"

Milling = 3"
AC = 6"

Milling = 10"
AC = 6"

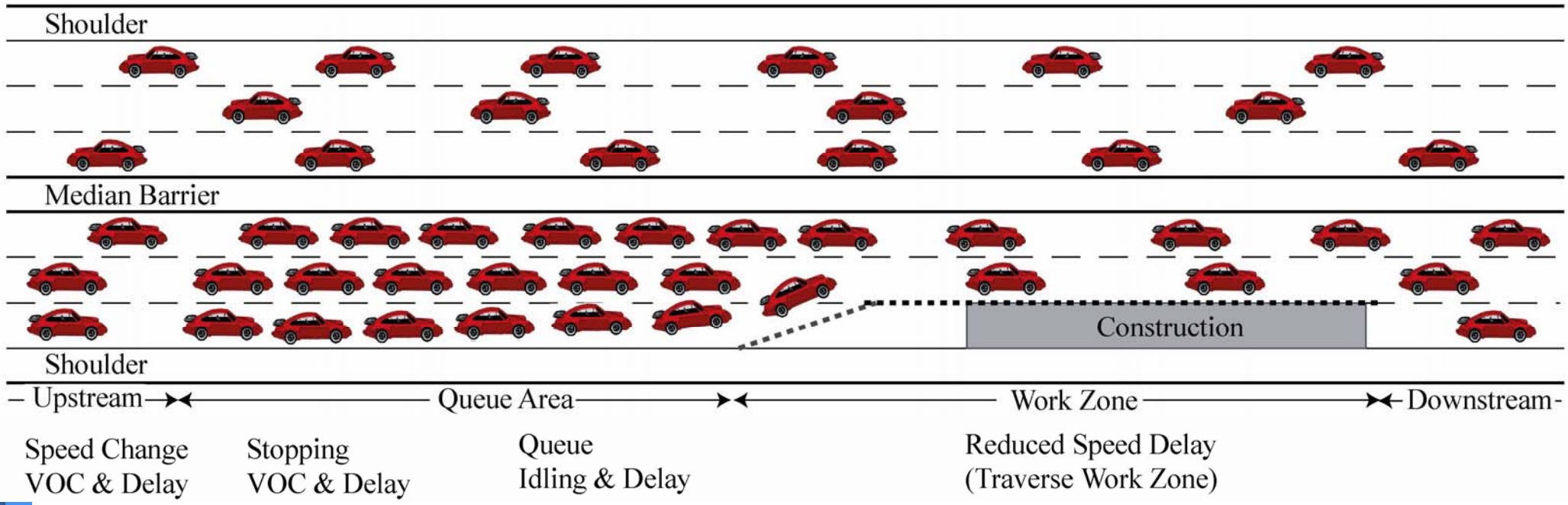
CWZ Traffic Analysis (Road user cost) for TMP

Work-zone Delay: Demand-Capacity Model
Highway Capacity Manual (Chap. 29)



Road Use Cost Components for Demand-Capacity Model

- Road user cost (RUC)
  - Delay cost (traveler's time value): cars and trucks
  - Vehicle operation costs: maintenance, fuel, emission, crash
  - Detour cost: circuity or diversion (need network analysis)
- RUC components – Unrestricted or forced flow



Factors Affecting Work-zone Delay and Road User Costs

- User delay and vehicle operation costs
  - Not consider crash, emission, or circuity
- Closure factors
  - Closure duration and number: Construction schedule
  - WZ closure distance
  - Time value (car and trucks) and discount factor
- Demand factors
  - Demand and reduction: outreach and detours
  - Annual growth (r): Future ADT = Base ADT x $(1+ r)^{years}$
- Capacity factors
  - Number of lanes open: Time of the day
  - Capacity adjustment for work-zone
    - *Grade, truck percentage, lane width, shoulder*
  - WZ speed limit

Work-zone Capacity Adjustment Based on Highway Capacity Manual 2000 (22-7 and 22-8)

Adjusted Capacity (vph) = Basic Capacity **(pcphpl)** × H × W × S ×N

(PCPHPL = Passenger Car per Hour per Lane)

(1) Basic Work Zone Capacity (PCPHPL)

Closure-type	Two-lane Highway	Multi-lane Highway
Lane-drop only	1,200	1,800
Median Cross-over	1,100	1,600

(2) Heavy Vehicle Adjustment Factor (H):

H = 100/[100+P(PCE-1)]; P = percentage of truck,

PCE = Passenger Car Equiv.; (Down or level: 1.5, Rolling: 2.5, Mountain: 4.5)

(3) Lane Width Adjustment Factor (W)

Width 12.0 ft (W = 1.00); 11.0 ft (W = 0.95); 10.0 ft (W = 0.90)

(4) Shoulder/Lateral Clearance Adjustment Factor (S)

Both Shoulder (S = 1.00); One Shoulder (S = 0.95);No Shoulder: S = 0.90

(5) Number of Lanes Open (N)

Traffic Simulation Tools to Help DOT Analyze WZ Traffic for TMP

- **Traffic Analysis tools**
  - Corridor model: CA4PRC, Quickzone, FreQ
  - Simulation model: Micro-, Maso-, Macro-scopic
  - Network planning model: EMME2, TransCAD, VISUM
- **Microscopic simulation software**
  - Paramics, VISSIM, TransModeler, Corsim
  - Assess the work zone impact on network (limited)
  - Graphics are very useful for public outreach, especially animation (video presentation)
  - Expensive license, labor extensive inputs, and iterative calibration: => outsourcing to consultants
  - Not geared for construction work-zone behavior

Cost Comparison
(LCCA Interaction)

Caltrans Bid Cost DB Website

http://sv08data.dot.ca.gov/contractcost

California Department Of Transportation: Contract Cost Data - Windows Internet Explorer

http://sv08data.dot.ca.gov/contractcost/

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DATABASE STATS

- 722,060 records in database
- Latest bid-open-date imported: 11-29-2007

Caltrans > District 8 > **Cost Data**

Welcome to the Contract Cost Database Search Page. This site allows you to search historic bid data for Caltrans construction cost data. Use of this site constitutes acceptance of the conditions of use. For more help on using this site click here. For the most recent bid data click here.

Search Parameters

Item Code or Description* concrete pavement

Include data from top 2 bidder(s). (Note: Does not include irregular bidders).

To make multiple selections from the boxes below, hold the control key down as you make selections. Leave the boxes unselected or blank to query for all the values.

District(s)	Year(s)
District 01	2007
District 02	2006
District 03	2005
District 04	2004
District 05	2003
District 06	2002
District 07	2001
District 08	2000
District 09	1999
District 10	1998
District 11	1997
District 12	1996

clear selection | clear selection

show counties | show map

Optional Parameters:

(Fill in as many as you need, or leave them blank to search all)

Total Price (for item)

Min $

Max $

Quantity

Min

Max

Unit -any- convert to this unit whenever possible

Reset | Search

Line Item Code for Bid Database

Pavement Rehabilitation Items

120100	TRAFFIC CONTROL SYSTEM
150846	REMOVE CONCRETE PAVEMENT
153103	COLD PLANE ASPHALT CONCRETE PAVEMENT
190101	ROADWAY EXCAVATION
260201	CLASS 2 AGGREGATE BASE
280000	LEAN CONCRETE BASE
390102	ASPHALT CONCRETE (TYPE A)
390103	ASPHALT CONCRETE (TYPE B)
390131	HOT MIX ASPHALT
390132	HOT MIX APHALT (TYPE A)
390133	HOT MIX ASPHALT (TYPE B)
390134	HOT MIX ASPHALT (OPEN GRADED)
394046	PLACE ASPHALT CONCRETE DIKE (TYPE D)
401000	CONCRETE PAVEMENT
401005	CONCRETE PAVEMENT (APPROACH SLAB)
401100	REPLACE CONCRETE PAVEMENT
401108	REPLACE CONCRETE PAVEMENT (RAPID STRENGTH CONCRETE)
839701	CONCRETE BARRIER (TYPE 60)

Cost Estimate Factors
(TMP, Mobilization, Supporting Costs)

Rehab Size	TMP %	Daily TMP	Duration (Days)
0 – $5M	6.1%	$2,003	82
$5M - $10M	3.9%	$2,322	137
$10M - $20M	3.6%	$2,522	215
$20M - $100M	2.6%	$2,716	271
$100M	2.4%		

Type	TMP (%)	Mobilize (%)	Support Factor
Minor Maintenance (HM1)	9.7	5.3	0.19
Major Maintenance (CAPM) Rehab (HM21), Reconstruct	3.5	7.9	0.2
Roadway Widening	1.6	8.6	0.28
Realignment	2.1	8.4	0.25
New Roadway Construction	0.9	9	0.24
Bridge Maintenance	6.9	8.4	
New Bridge (Structure)	0.8	9.2	
Others	1.6	12.5	
Average	7.5	7.5	

Caltrans LCCA Process

Steps

1. Establish Design Alternatives
2. Determine Activity Timing (M&R)
3. Estimate Agency and User Costs
4. Compute Life-Cycle Costs (NPV)
5. Analyze the Results (Comparison)

CA4PRS - LCCA Interaction

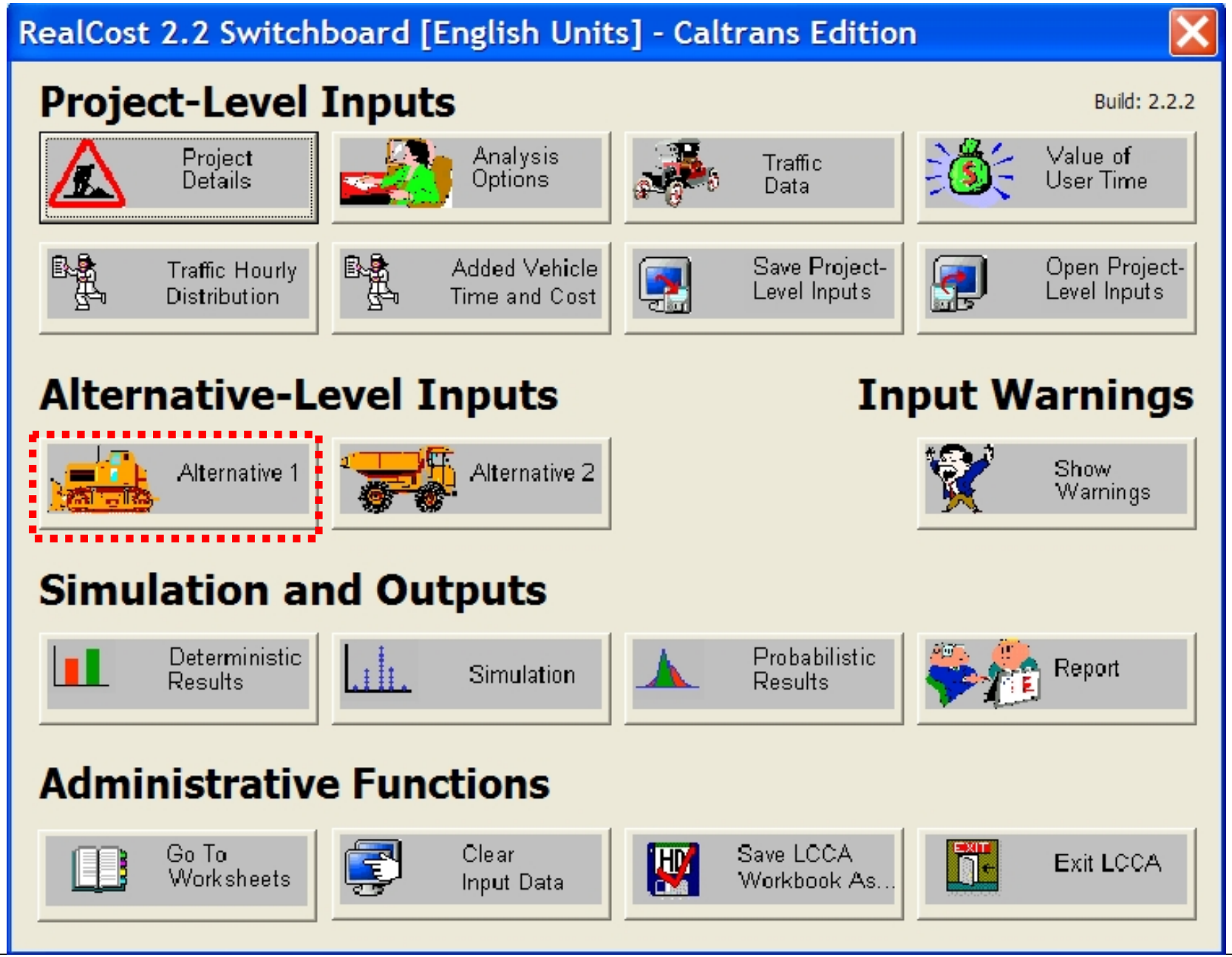
- **Example: I-5 Orange reconstruction project**
  - Required LCCA for PSSR (5 mile x 4 lanes / direction)
- **Alternative 1 (Rigid – Concrete)**
  - 1'st Rehab: 9" PCC slab replacement (design - 20 years)
  - 2'nd Rehab: 6" Crack-seat AC Overlay (design - 15 years)
- **Alternative 2 (Flexible – Asphalt Concrete)**
  - 1'st Rehab: 6" AC Overlay; **5 years later** (design - 10 years)
  - 2'nd Rehab: 3" Milling and 6" AC Overlay (design - 10 years)
  - 3'rd Rehab: 4" RAC Overlay (design - 10 years)
- **CA4PRS – LCCA Interaction** (NPV for 40 years)
  - Basic inputs for LCCA - Rehabilitation alternative/activity:
    - *Schedule estimate (Working days)*
    - *Work-zone delay (Road user cost)*
    - *Agency cost (Construction cost)*
  - CA4PRS output components tie with LCCA inputs

LCCA Example Analysis

Alter-native	Activity	Treat-ment	Design life (yr)	Agency Cost ($M)	Delay Cost ($M)
Alt. 1	Activity 1	PCC	20	30	10
	Activity 2	CSOL	15	25	10
	Sum (NPV)			55 (44)	20 (14)
Alt. 2	Activity 1	ACOL	10	20	8
	Activity 2	MACO	10	25	10
	Activity 3	RACO	10	20	12
	Sum (NPV)			65 (42)	30 (16)

Caltrans LCCA Implementation

FHWA Realcost Software



CA4PRS Interaction with LCCA (Realcost) for Schedule (Duration) and WZ Delay

Alternative 1

Alternative Description: Flexible Pavement

Initial Construction | Rehabilitation 1 | Rehabilitation 2 | Rehabilitation 3 | Rehabilitation 4 | Rehabilitation 5 | Rehabilitation 6

Activity Description: Reconstruction 6" overlay

Activity Cost and Service Life Inputs

Agency Construction Cost ($1000): 7411

Activity Service Life (years): 10

User Work Zone Costs ($1000):

(Inactive if User Costs are to be Caculated by Software)

Maintenance Frequency (years): 4

Agency Maintenance Cost 10

Activity Work Zone Inputs

Work Zone Length (miles): 1

Work Zone Duration (days): 100

Work Zone Capacity (vphpl): 1450

Work Zone Speed Limit (mph): 45

No of Lanes Open in Each Direction During Work Zone: 2

Work Zone Hours

	Inbound Start	Inbound End	Outbound Start	Outbound End
First Period of Lane Closure:	0	24	0	24
Second Period of Lane	0	0	0	0
Third Period of Lane Closure:	0	0	0	0

Copy Activity

Paste Activity

Open... | Save... | Ok | Cancel

Acronyms List

1a	CA4PRS	Construction Analysis for Pavement Rehabilitation Strategies
1b	LCCA	Life-Cycle Cost Analysis
1c	MEPDG	Mechanistic-Empirical Pavement Design Guide
2a	CRCP	Continuous Reinforced Concrete Pavement
2b	JPCP	Joint Plain Concrete Pavement
2c	PCCP	Portland Cement Concrete Pavement
3a	CSOL	Crack and seat (PCC and AC) OverLay
3b	FDAC	Full Depth AC (Replacement)
3c	MACO	Milling and Asphalt Concrete Overlay
4a	ACB	Asphalt Concrete Base
4b	CTB	Cement Treated Base
4c	LCB	Lean Concrete Base
5a	AADT	Annual Average Daily Traffic
5b	CWZ	Construction Work Zone
5c	RUC	Road User Cost
6a	HCM	Highway Capacity Manual
6b	HDM	Highway Design Manual
7a	HMA	Hot Mix Asphalt
7b	RAC-O	Rubberized Asphalt Concrete Open-Graded
8a	PID	Project Initiation Document
8b	PSSR	Project Scope Summary Report
8c	PA&ED	Project Approval and Environmental Document
8d	PS&E	Plans, Specifications, and Estimates
9a	FSHCC	Fast-Setting Hydraulic Cement Concrete
9b	RSC	Rapid Strength Concrete

More Information?

- **Contacts**
  - **Dr. E.B. Lee (UC Berkeley)**
    - ***(510) 665-3637; eblee@berkeley.edu***
  - **Michael Samadian (Caltrans)**
    - ***(916) 324-2048;*** *Michael_M_Samadian@dot.ca.gov*
  - **Dr. Nadarajah Sivaneswaran (Siva)** (FHWA)
    - ***(202) 493-3147; n.sivaneswaran@dot.gov***
  - **Keith Platte (AASHTO-TIG)**
    - ***Tel: (202) 624-7830; kplatte@aashto.org***

- **GOOGLE "CA4PRS"**

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