WORK ZONE DELAY ESTIMATION

Work Zone Management, Accelerated Construction, and Smart Work Zones

TEAM Monthly Meeting

November 16, 2004

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TOPICS

- FHWA directive
- QuickZone background, functions, requirements, and methodology
- TxDOT accelerated construction and A+B bidding
- IH-410 project, QuickZone model development and preliminary results
- Other QuickZone case studies and further enhancements
- Smart Work Zones

FHWA DIRECTIVE

- The “soft cost” of traveler delay is typically not considered when key decisions about project staging and duration are made.
- FHWA recommendation to develop an analytical tool to estimate and quantify work zone delays.

QuickZone BACKGROUND

- Work Zone Delay Impact Analysis Tool
  - FHWA-sponsored
  - Developed by Mitretek Systems
  - Available for purchase at McTrans or PCTrans ($195)
- Microsoft Excel-based Application
- Open Source Code
- Targeted at State and Local Traffic Construction Staff, Operations and Planning, and Construction Contractors

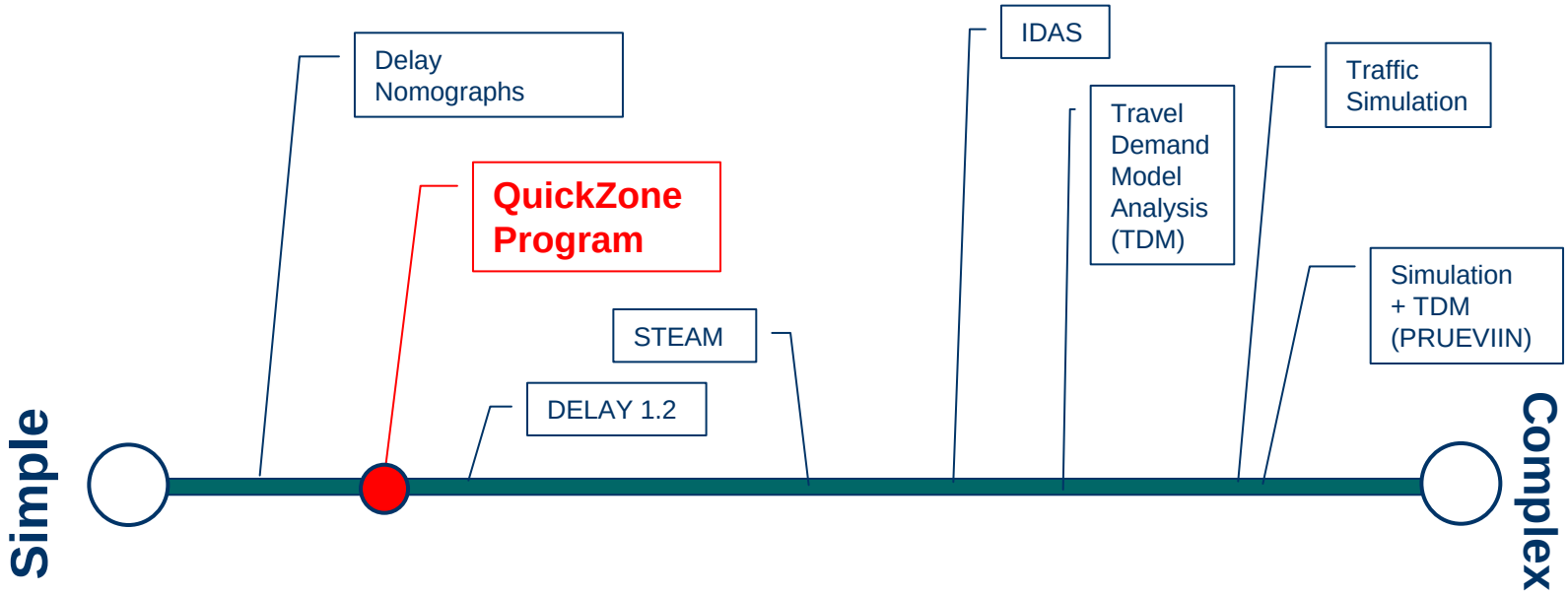
QuickZone FUNCTIONS

- **Quantifies** corridor delay resulting from capacity decreases in work zones
- **Identifies** delay impacts of alternative construction phasing plans
- **Supports Trade-Off Analyses** between construction costs and delay costs
- **Considers Alternate Phasing Schedules**:
  - Time-of-day (peak vs. off-peak)
  - Season (summer vs. winter)
- **Assesses Impacts of Delay Mitigation Strategies**:
  - E.g., Variable message sign deployments
  - Signal retiming on detour routes

QuickZone REQUIREMENTS

- Network
  - Links & Nodes
  - Link Characteristics
- Demand Characteristics
  - At minimum: AADT and some distribution of hourly demand
  - Hourly Counts
  - Seasonality
- Capacity
  - Normal Conditions
  - Work Zone Conditions

QuickZone METHODOLOGY



Limited,
Rough Estimation
Short Run Times
Limited Training
Lower Set-Up Costs
Quicker Development

Comprehensive,
Precise Calculation
Longer Run Times
Training Required
Higher Set-Up Costs
Longer Development

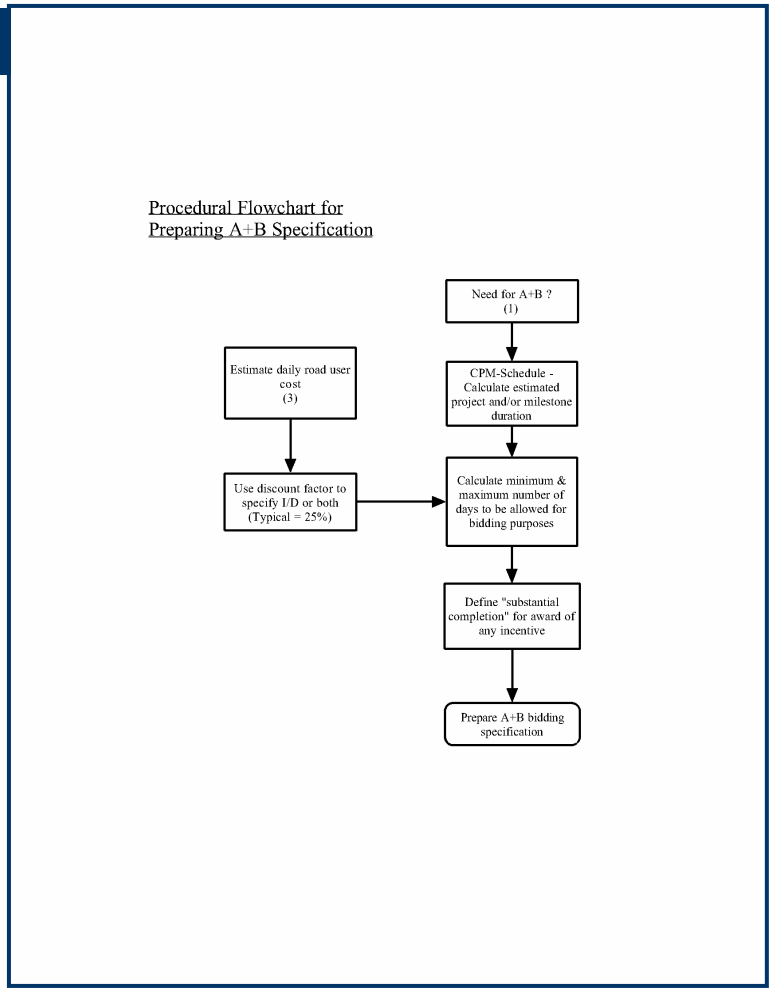
TxDOT ACCELERATED CONSTRUCTION

- A+B Provisions. Consider for large and or highly critical projects where early completion should be a consideration for award.

- Milestones with Incentives/Disincentives. Identify specific project phases that have a significant impact on traffic or business.

A+B BIDDING

- Incentive for early completion up to cap (number of days).
- Contractor's duration becomes CPM.
- Disincentive for late delivery, no cap.
- Contractor's rule of thumb: 5% of total cost to be "worth it"

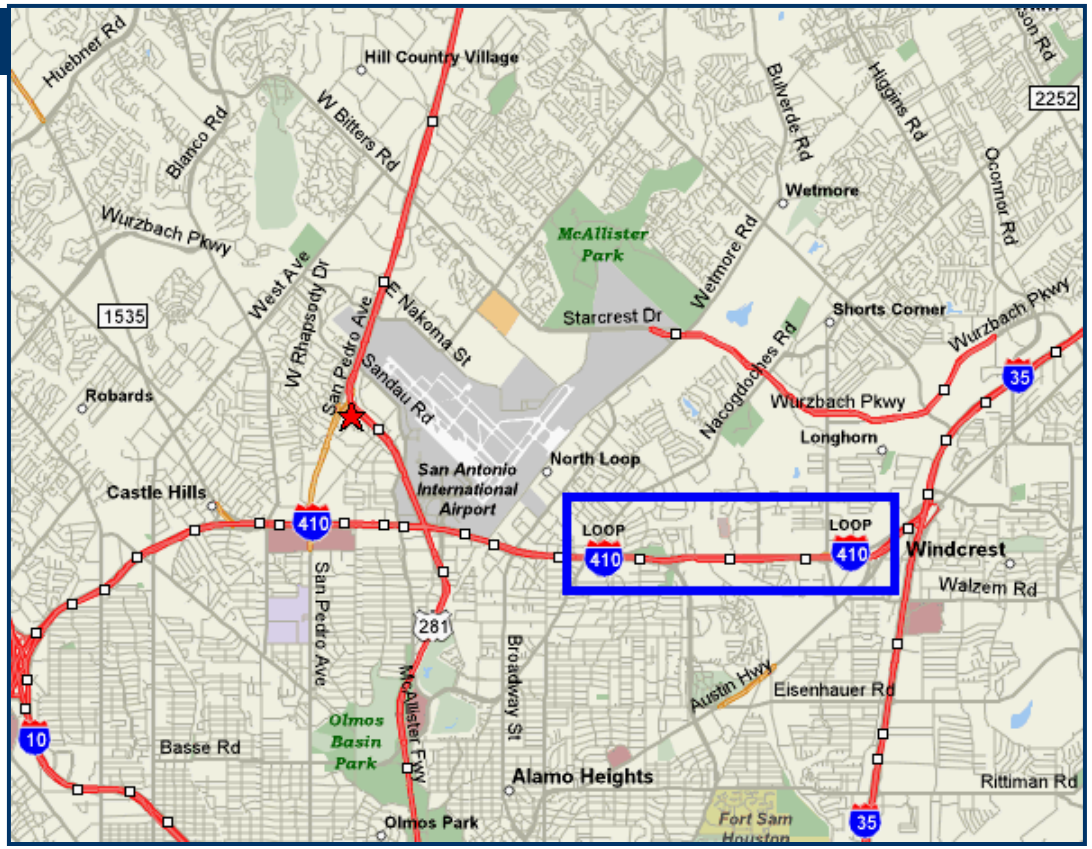


A+B BIDDING

	"A+B"	"A"	"B"	RUC Rate	
Bidder	Cost	Cost	Days	$/Day	Total "B"
CONTRACTOR A	$198,568,662.01	$154,717,662.01	933	$47,000	$43,851,000.00
CONTRACTOR B	$213,023,330.91	$147,975,330.91	1,384	$47,000	$65,048,000.00
CONTRACTOR C	$227,386,257.93	$183,488,257.93	934	$47,000	$43,898,000.00
CONTRACTOR D	$231,579,868.49	$180,349,868.49	1,090	$47,000	$51,230,000.00
CONTRACTOR E	$249,632,889.62	$177,534,889.62	1,534	$47,000	$72,098,000.00

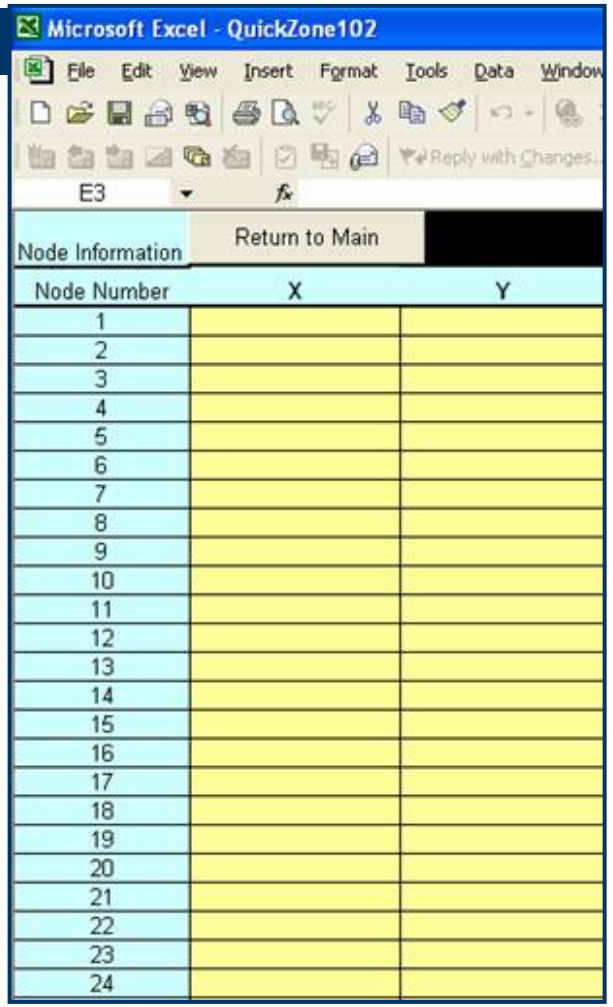
IH-410 WIDENING

- Widening of IH-410 in San Antonio from Nacagoches Road to Perrin-Beitel Road.
- 6 Lanes to 8 Lanes
- 2003 ADT = 150,000
- Approximately $70 Million



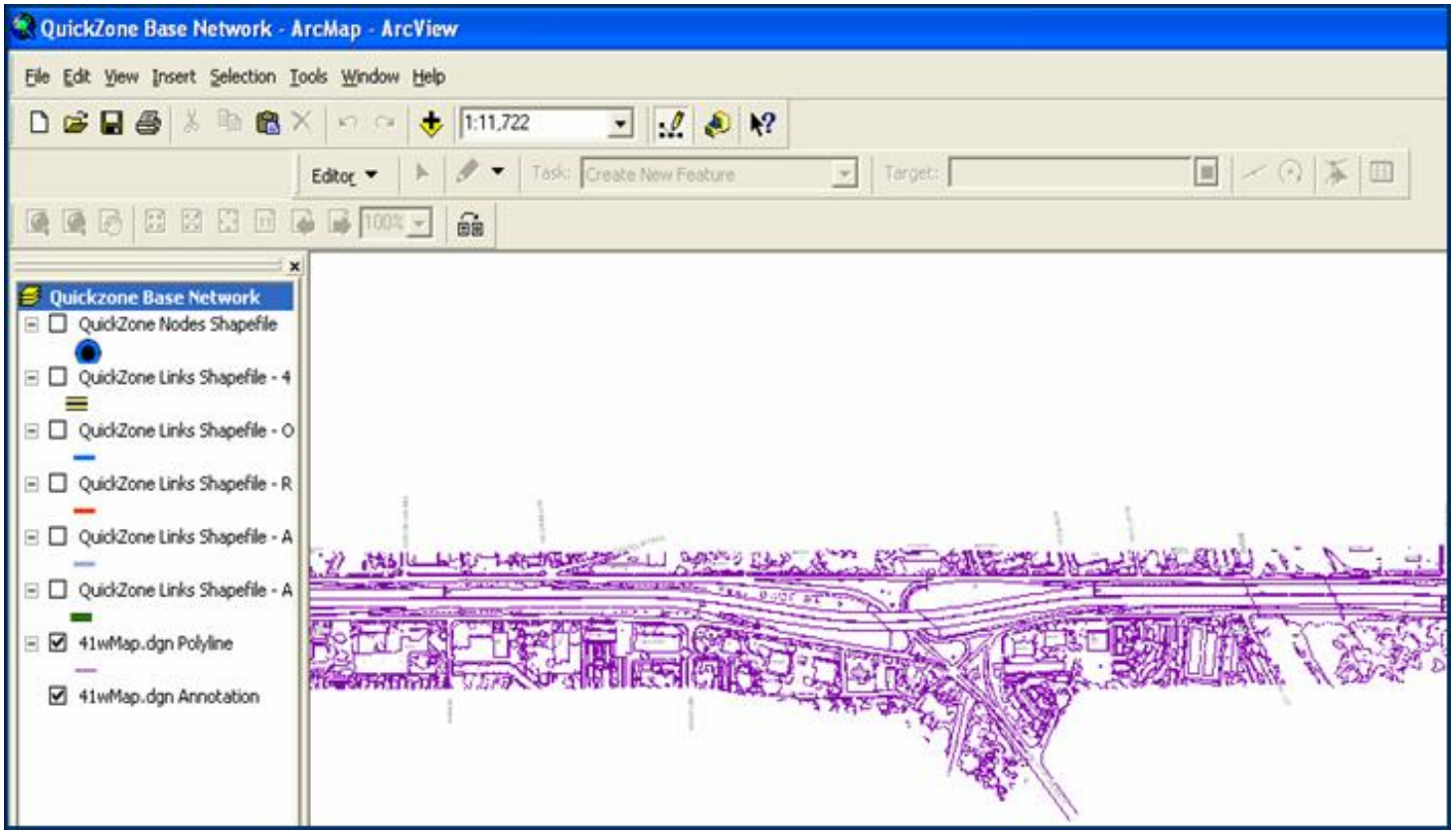
NETWORK CONSTRUCTION

- Frequently noted shortcoming with QuickZone: Coding Large Networks (More on this later)



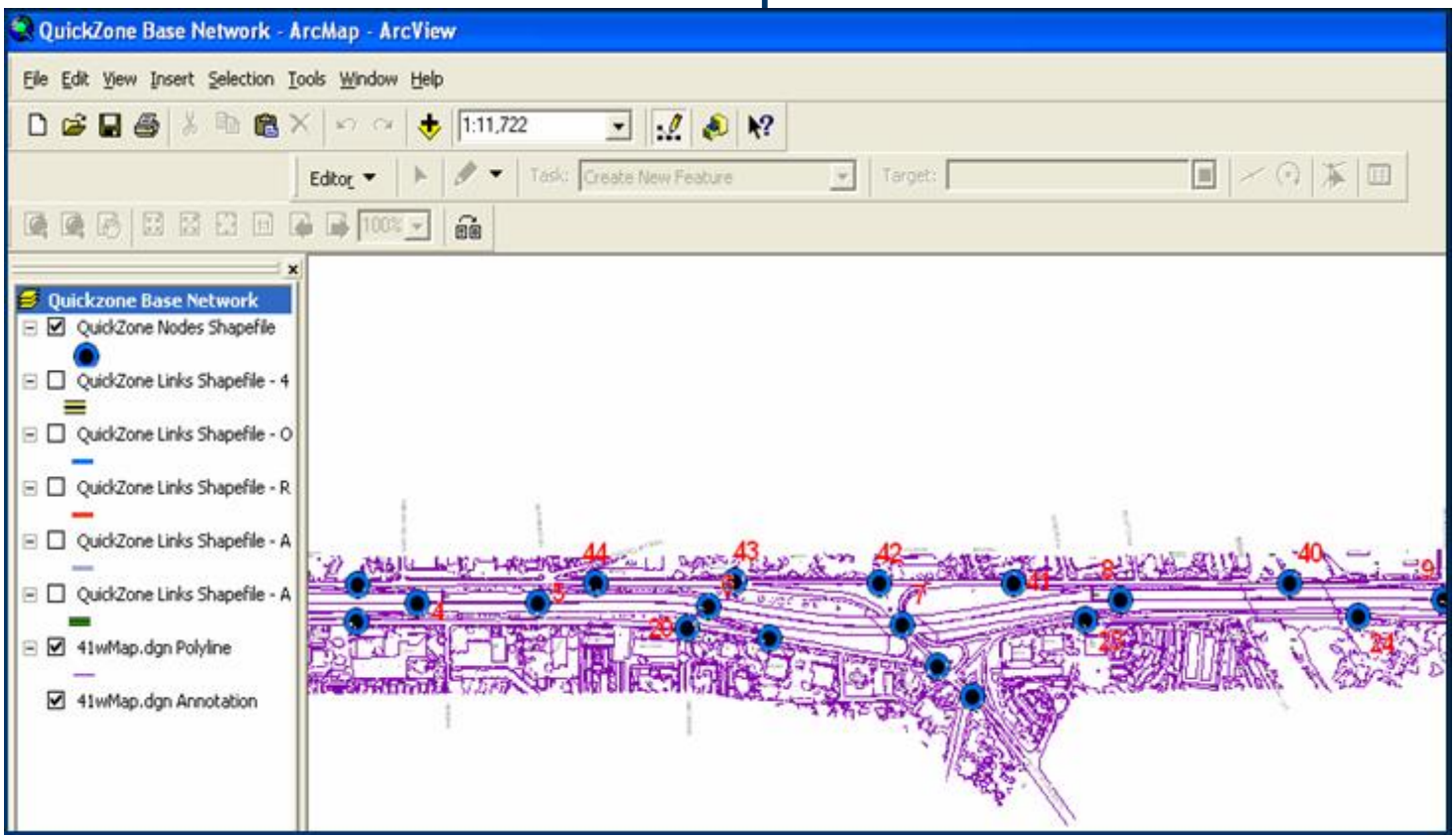
NETWORK CONSTRUCTION

- GIS-driven network development – base map



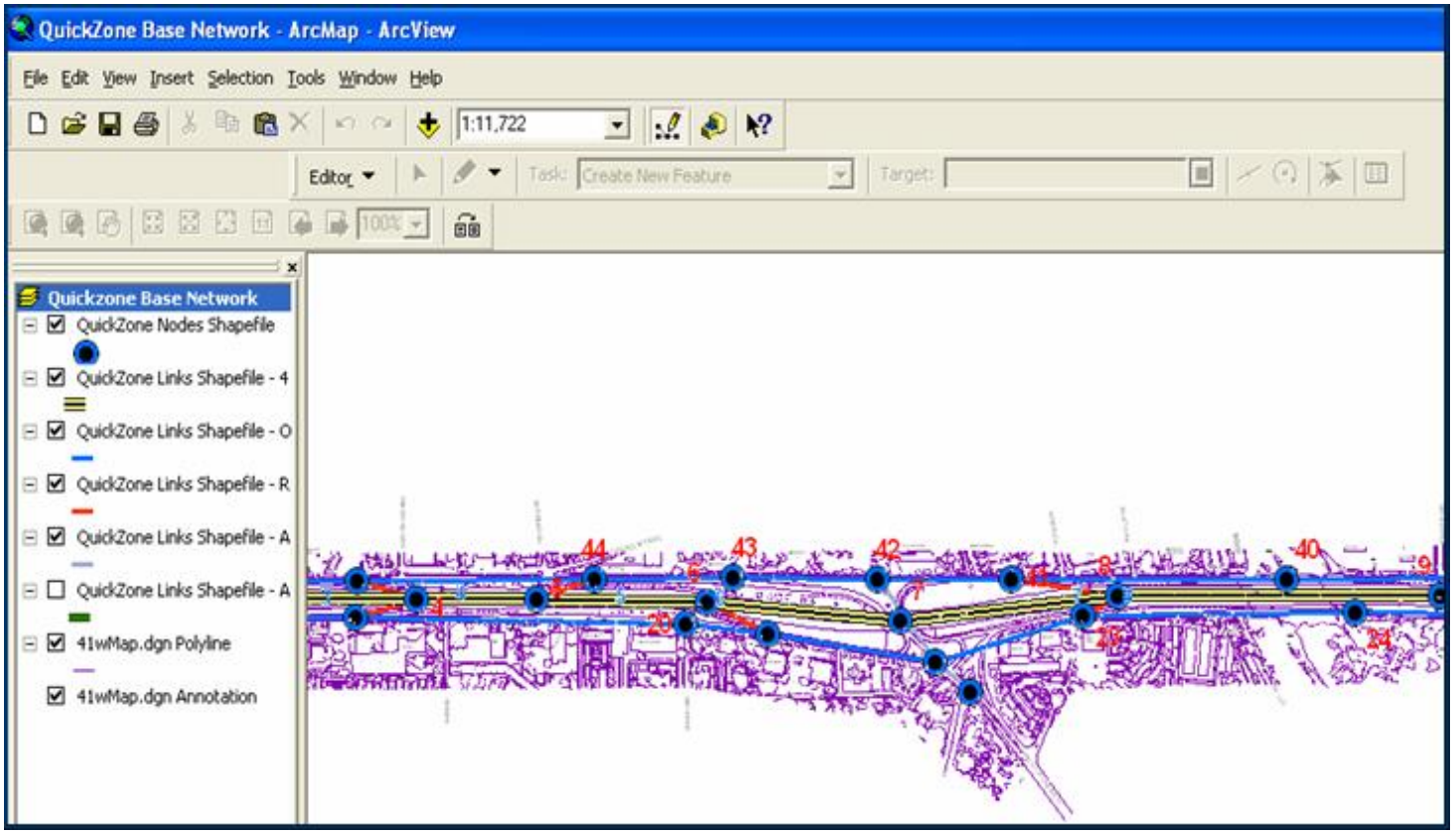
NETWORK CONSTRUCTION

- GIS-driven network development - nodes



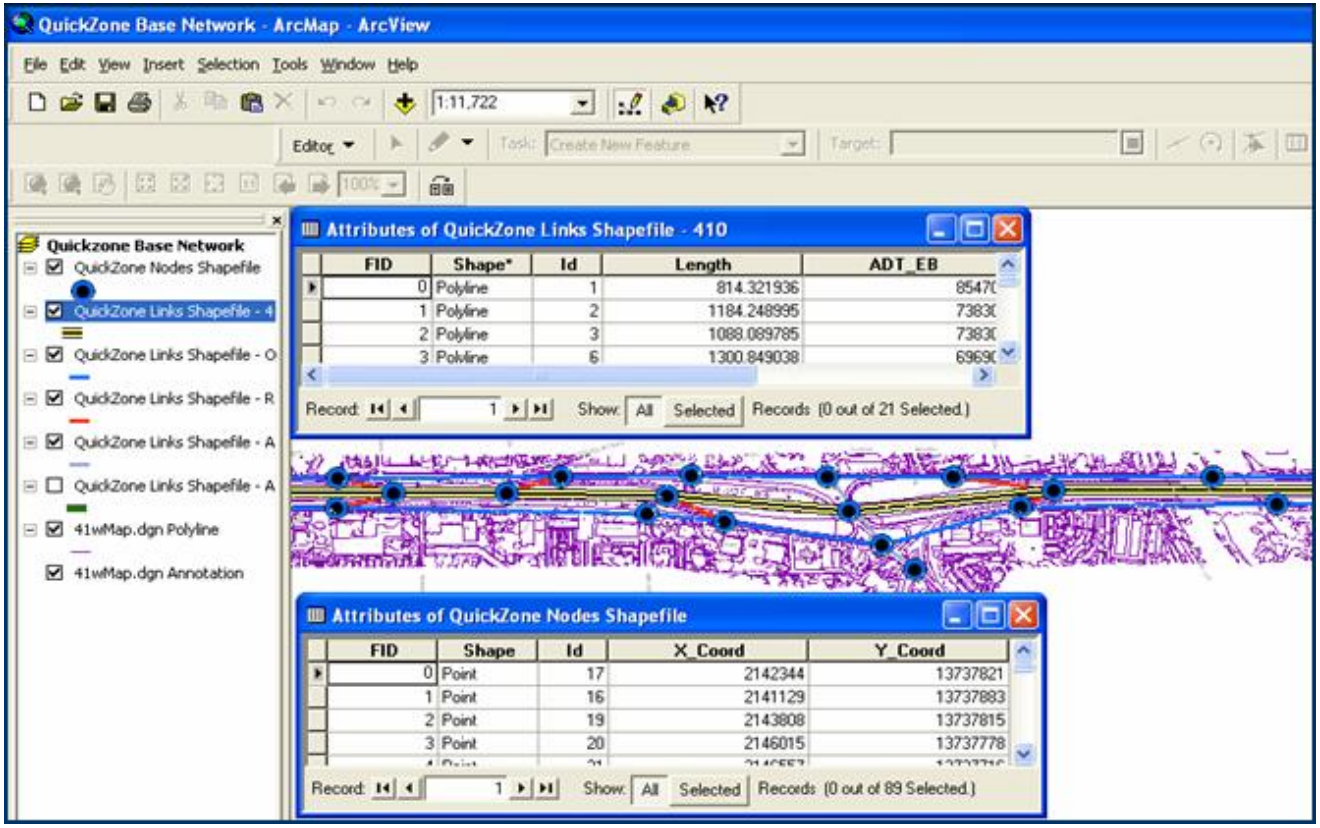
NETWORK CONSTRUCTION

- GIS-driven network development - links



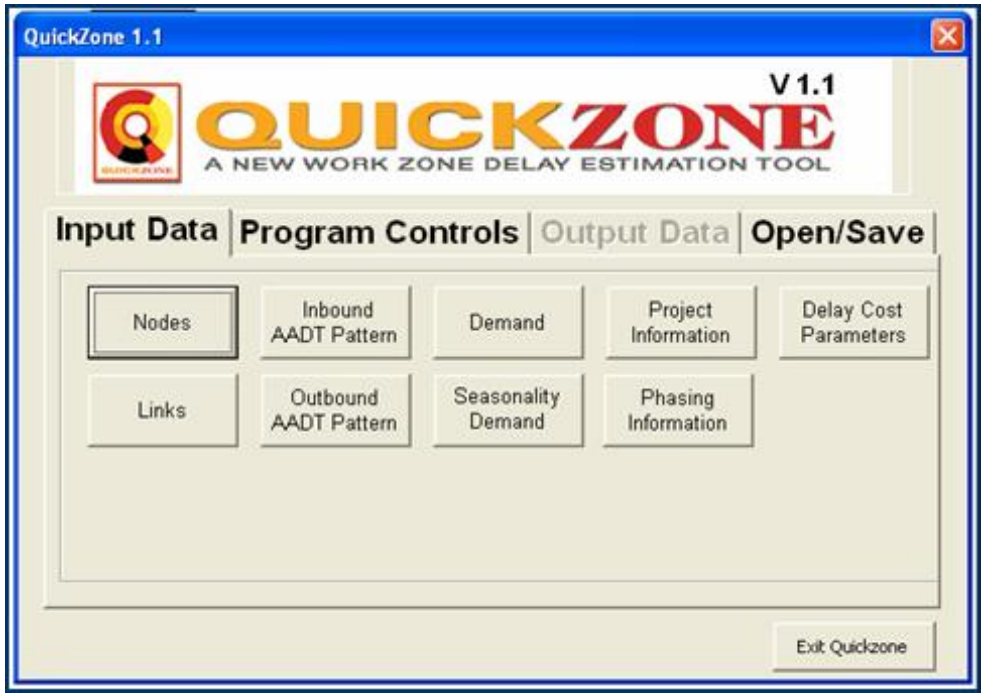
NETWORK CONSTRUCTION

- GIS-driven network development - attributes



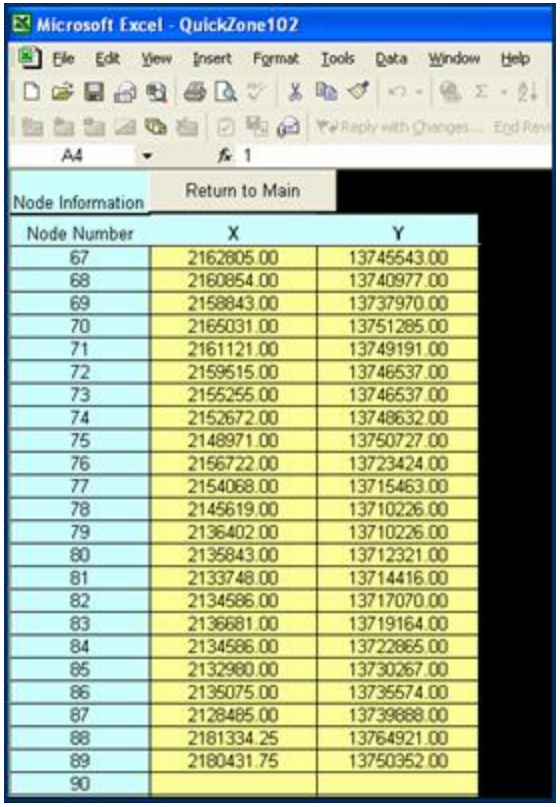
QuickZone MODEL

- Nodes
- Links
- AADT Patterns
- Demand
- Seasonality
- Project Information
- Phasing Information
- Delay Cost Parameters

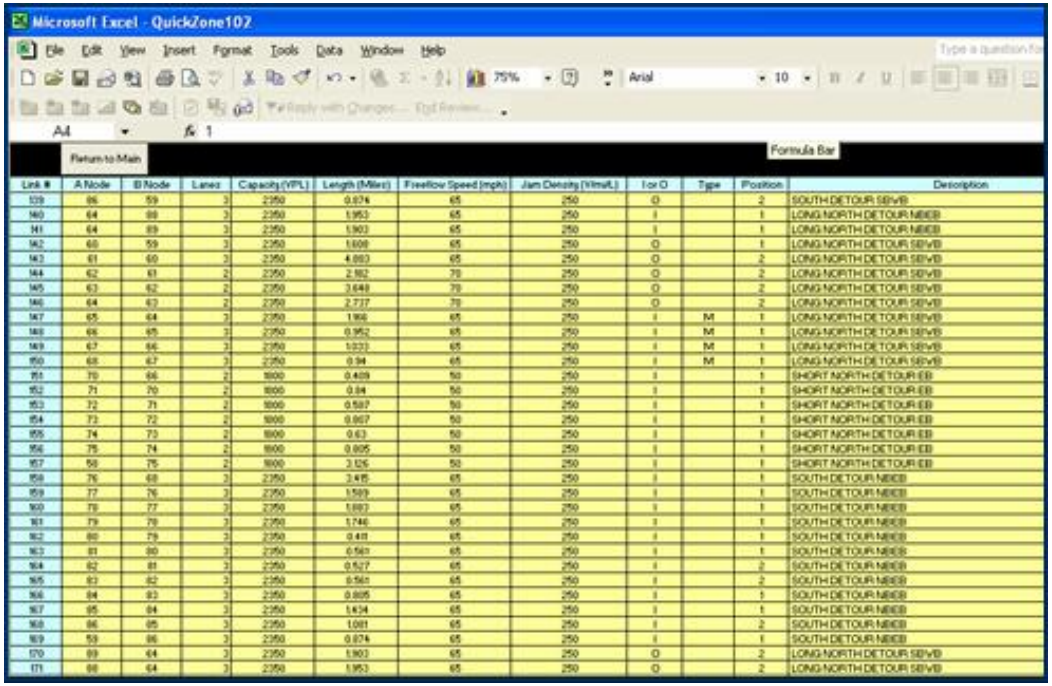


QuickZone MODEL

- Nodes and links



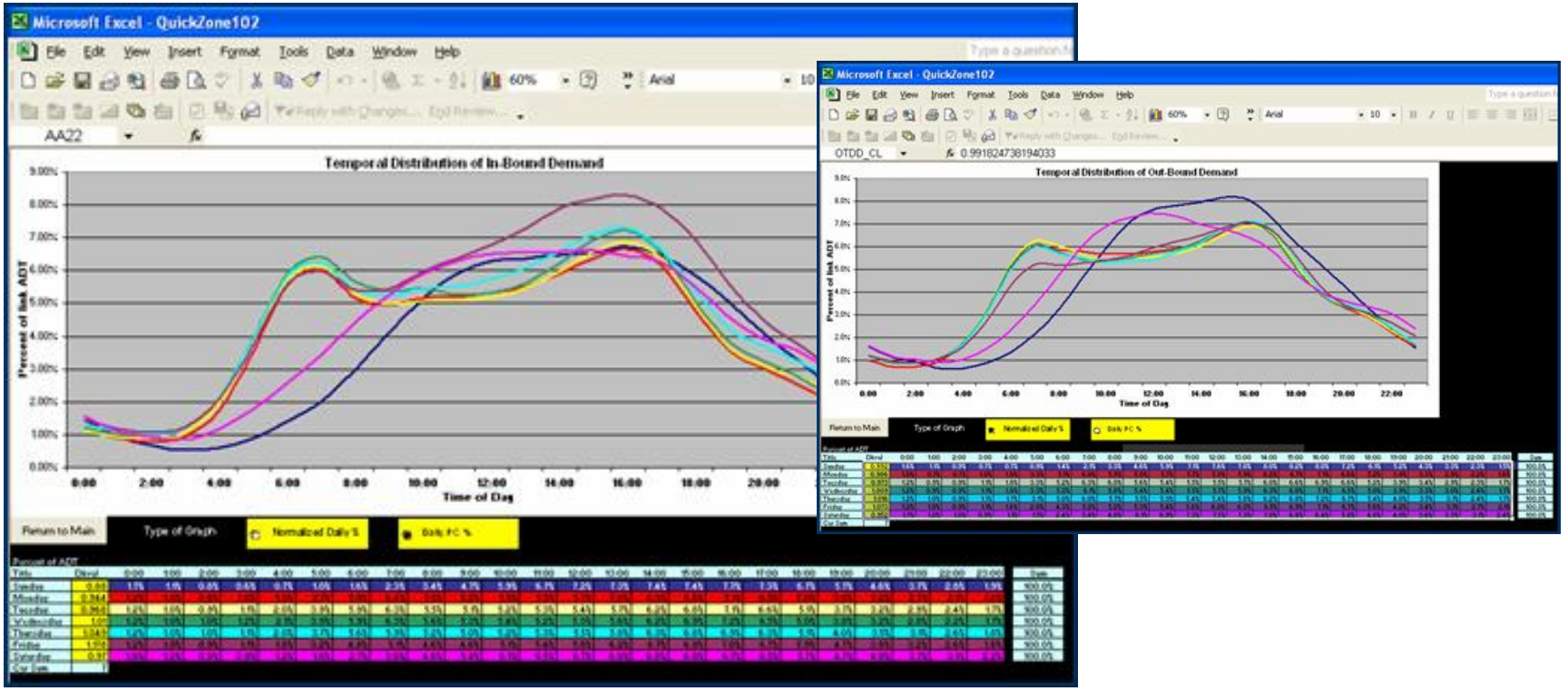
Node Number	X	Y
67	2162805.00	13745543.00
68	2160854.00	13740977.00
69	2158843.00	13737970.00
70	2165031.00	13751285.00
71	2161121.00	13749191.00
72	2159515.00	13746537.00
73	2155255.00	13746537.00
74	2152672.00	13748632.00
75	2148971.00	13750727.00
76	2156722.00	13723424.00
77	2154068.00	13715463.00
78	2145619.00	13710226.00
79	2136402.00	13710226.00
80	2135843.00	13712321.00
81	2133748.00	13714416.00
82	2134586.00	13717070.00
83	2136681.00	13719164.00
84	2134586.00	13722865.00
85	2132980.00	13730267.00
86	2135075.00	13735574.00
87	2128485.00	13739888.00
88	2181334.25	13764921.00
89	2180431.75	13750352.00
90		



Link #	A Node	B Node	Lanes	Capacity (VPL)	Length (Miles)	Freeflow Speed (mph)	Jam Density (V/mi/L)	I or O	Type	Position	Description
139	86	59	3	2350	0.074	65	250	O		2	SOUTH DETOUR SB/VB
140	64	88	3	2350	1.953	65	250	I		1	LONG NORTH DETOUR NB/EB
141	64	89	3	2350	1.903	65	250	I		1	LONG NORTH DETOUR NB/EB
142	60	59	3	2350	1.608	65	250	O		1	LONG NORTH DETOUR SB/VB
143	61	60	3	2350	4.883	65	250	O		2	LONG NORTH DETOUR SB/VB
144	62	61	2	2350	2.162	70	250	O		2	LONG NORTH DETOUR SB/VB
145	63	62	2	2350	3.648	70	250	O		2	LONG NORTH DETOUR SB/VB
146	64	63	2	2350	2.737	70	250	O		2	LONG NORTH DETOUR SB/VB
147	65	64	3	2350	1.998	65	250	I	M	1	LONG NORTH DETOUR SB/VB
148	66	65	3	2350	0.952	65	250	I	M	1	LONG NORTH DETOUR SB/VB
149	67	66	3	2350	1.033	65	250	I	M	1	LONG NORTH DETOUR SB/VB
150	68	67	3	2350	0.94	65	250	I	M	1	LONG NORTH DETOUR SB/VB
151	70	66	2	1800	0.409	50	250	I		1	SHORT NORTH DETOUR EB
152	71	70	2	1800	0.84	50	250	I		1	SHORT NORTH DETOUR EB
153	72	71	2	1800	0.587	50	250	I		1	SHORT NORTH DETOUR EB
154	73	72	2	1800	0.867	50	250	I		1	SHORT NORTH DETOUR EB
155	74	73	2	1800	0.63	50	250	I		1	SHORT NORTH DETOUR EB
156	75	74	2	1800	0.605	50	250	I		1	SHORT NORTH DETOUR EB
157	58	75	2	1800	3.126	50	250	I		1	SHORT NORTH DETOUR EB
158	76	68	3	2350	3.415	65	250	I		1	SOUTH DETOUR NB/EB
159	77	76	3	2350	1.593	65	250	I		1	SOUTH DETOUR NB/EB
160	78	77	3	2350	1.882	65	250	I		1	SOUTH DETOUR NB/EB
161	79	78	3	2350	1.746	65	250	I		1	SOUTH DETOUR NB/EB
162	80	79	3	2350	0.48	65	250	I		1	SOUTH DETOUR NB/EB
163	81	80	3	2350	0.561	65	250	I		1	SOUTH DETOUR NB/EB
164	82	81	3	2350	0.527	65	250	I		2	SOUTH DETOUR NB/EB
165	83	82	3	2350	0.561	65	250	I		2	SOUTH DETOUR NB/EB
166	84	83	3	2350	0.805	65	250	I		1	SOUTH DETOUR NB/EB
167	85	84	3	2350	1.434	65	250	I		1	SOUTH DETOUR NB/EB
168	86	85	3	2350	1.081	65	250	I		2	SOUTH DETOUR NB/EB
169	59	86	3	2350	0.074	65	250	I		1	SOUTH DETOUR NB/EB
170	89	64	3	2350	1.903	65	250	O		2	LONG NORTH DETOUR SB/VB
171	88	64	3	2350	1.953	65	250	O		2	LONG NORTH DETOUR SB/VB

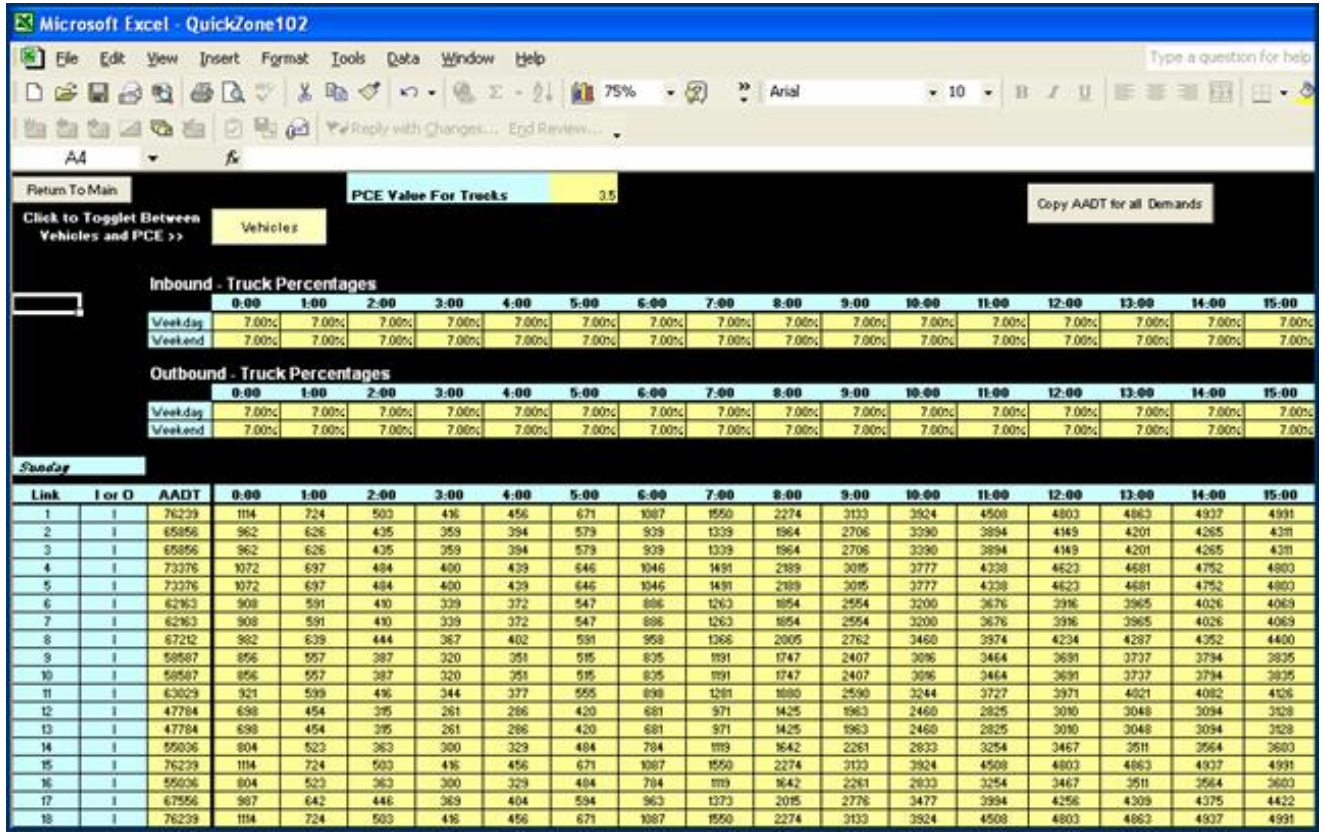
QuickZone MODEL

- Temporal distribution of demand



QuickZone MODEL

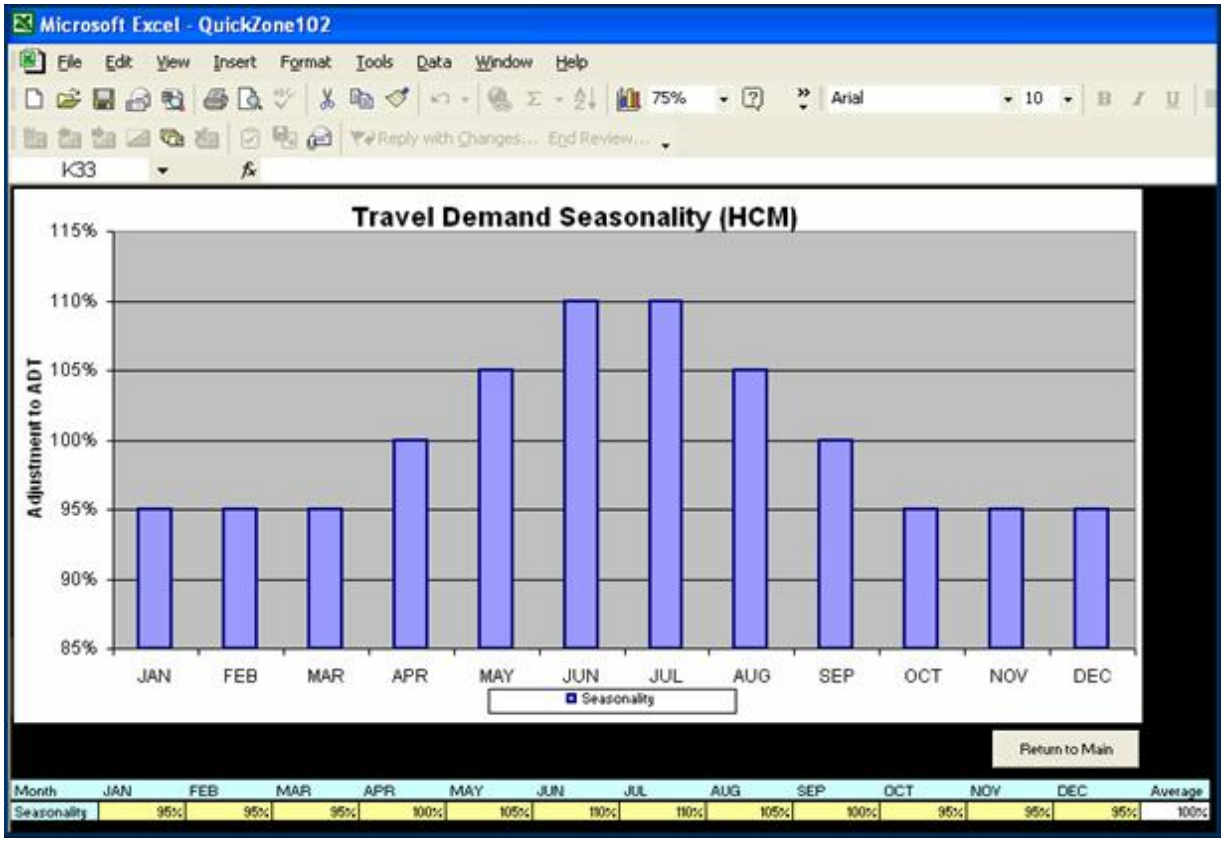
- Demand



Link	I or O	AADT	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00
1	I	76239	1114	724	503	416	456	671	1087	1550	2274	3133	3924	4508	4803	4863	4937	4991
2	I	65856	962	626	435	359	394	579	939	1339	1964	2706	3390	3894	4149	4201	4265	4311
3	I	65856	962	626	435	359	394	579	939	1339	1964	2706	3390	3894	4149	4201	4265	4311
4	I	73376	1072	697	484	400	439	646	1046	1491	2189	3015	3777	4338	4623	4681	4752	4803
5	I	73376	1072	697	484	400	439	646	1046	1491	2189	3015	3777	4338	4623	4681	4752	4803
6	I	62163	908	591	410	339	372	547	886	1263	1854	2554	3200	3676	3916	3965	4026	4069
7	I	62163	908	591	410	339	372	547	886	1263	1854	2554	3200	3676	3916	3965	4026	4069
8	I	67212	982	639	444	367	402	591	958	1366	2005	2762	3460	3974	4234	4287	4352	4400
9	I	58587	856	557	387	320	351	515	835	1191	1747	2407	3016	3464	3691	3737	3794	3835
10	I	58587	856	557	387	320	351	515	835	1191	1747	2407	3016	3464	3691	3737	3794	3835
11	I	63029	921	599	416	344	377	555	898	1281	1880	2590	3244	3727	3971	4021	4082	4126
12	I	47784	698	454	315	261	286	420	681	971	1425	1963	2460	2825	3010	3048	3094	3128
13	I	47784	698	454	315	261	286	420	681	971	1425	1963	2460	2825	3010	3048	3094	3128
14	I	55036	804	523	363	300	329	484	784	1119	1642	2261	2833	3254	3467	3511	3564	3603
15	I	76239	1114	724	503	416	456	671	1087	1550	2274	3133	3924	4508	4803	4863	4937	4991
16	I	55036	804	523	363	300	329	484	784	1119	1642	2261	2833	3254	3467	3511	3564	3603
17	I	67556	987	642	446	369	404	594	963	1373	2015	2776	3477	3994	4256	4309	4375	4422
18	I	76239	1114	724	503	416	456	671	1087	1550	2274	3133	3924	4508	4803	4863	4937	4991

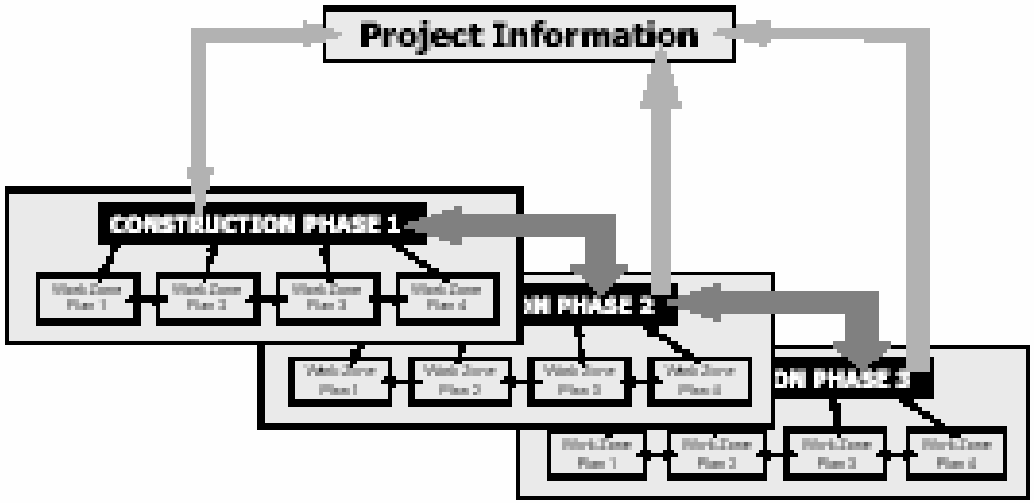
QuickZone MODEL

- Travel demand seasonality



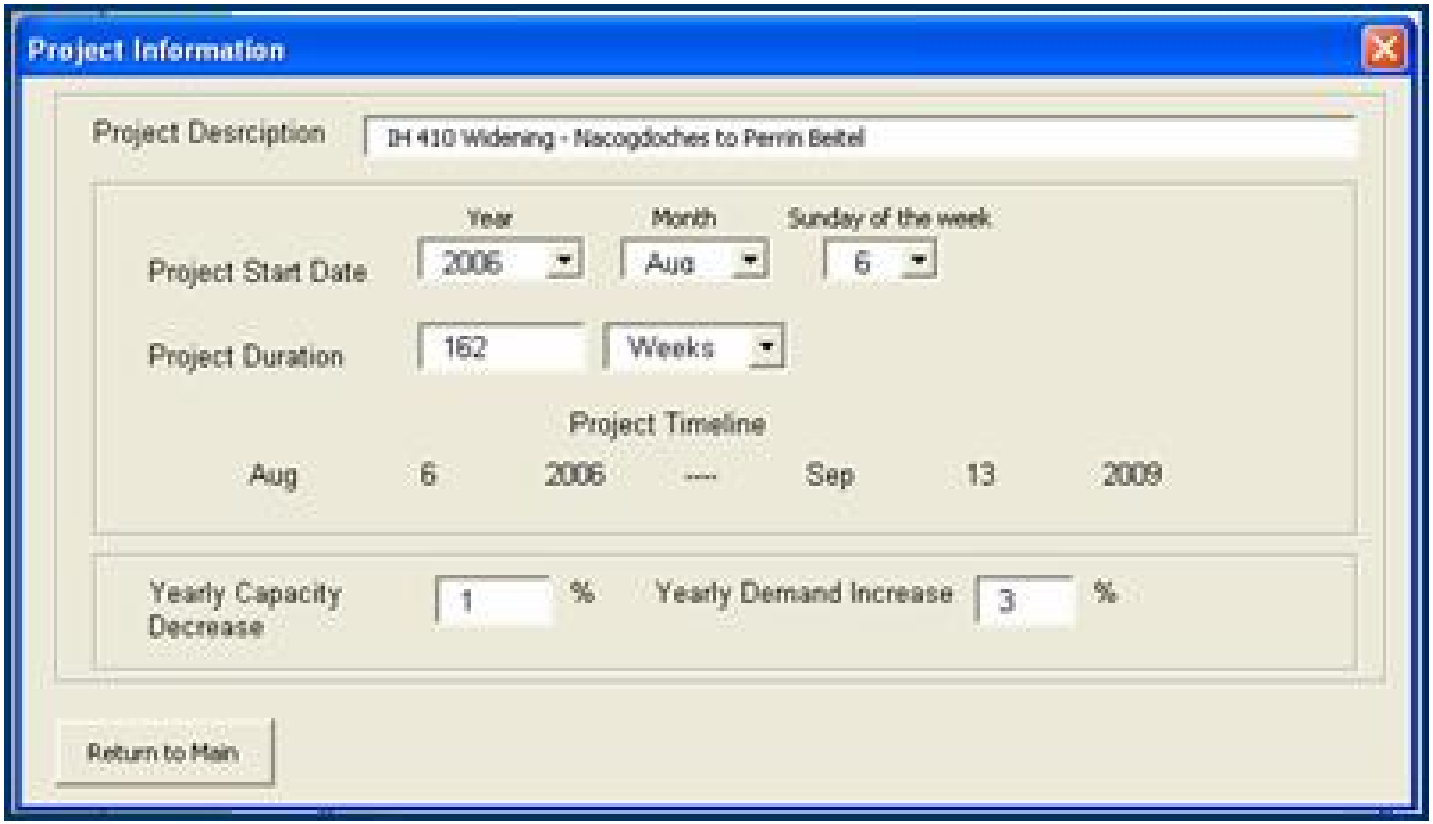
QuickZone MODEL

- Project Information Module



QuickZone MODEL

- Project information



QuickZone MODEL

- Sequencing plan

CAPACITY REDUCTION FOR RESTRICTED LANE WIDTH AND LATERAL CLEARANCE		
ADJUSTMENT CODE	***TYPICAL SECTION***	***CAPACITY REDUCTION*** [1]
AC-1	10-12-12-12-10	0
AC-2	1-12-12-12-10	129
AC-3	1-12-12-12-1	259
AC-4	10-10-11-10-10	588
AC-5	1-10-11-10-10	682
AC-6	1-10-11-10-1	987

AC-5

SLD	LN#1	LN#2	LN#3	SLD
1'	10'	11'	10'	10'

LN#1 - No Reduction = 0.860
LN#2 - No Reduction = 0.950
LN#3 - No Reduction = 0.900
Capacity Reduction = 682

IH 410 IMPROVEMENTS – NACOGDOCHES RD TO AUSTIN HWY
CSJ 0521-04-187

OUTLINE SEQUENCE OF CONSTRUCTION
November 2004

I. Phase 1

Shift EB and WB mainlane traffic to the outsides using 10'-11'-10' lane widths to allow construction of temporary shoulder pavement and construction of the median throughout the length of the project. Do not shift traffic until Phase 1 Stage 1 is complete.

A. Phase 1 Stage 1

1. Main Lanes
a) Close and reconstruct WBML outside shoulder with temporary pavement near sta. 1011+00 to east project limit.

2. Frontage Roads
a) Construct the various EB and WB frontage road widenings as shown in the plans.
b) Construct the WBFR low water crossing under traffic.
c) Construct the EBFR bridge over Salado Creek and approaches. Build proposed structure in two stages to avoid breaking back the existing structure.

3. Ramps
a) Keep existing WB ramps open during shoulder reconstruction. Widen ramp if needed to maintain taper in Phase 1 Stage 2.

B. Phase 1 Stage 2

1. Main Lanes
a) Shift traffic to Phase 1 configuration.
b) Construct temporary median pavement near sta. 905+00 to 917+00.
c) Construct permanent median pavement near sta. 917+00 to 930+00.
d) Construct permanent median pavement with SSCB near sta. 930+00 to 968+00.
e) Construct temporary median pavement near sta. 968+00 to 987+00.
f) Construct permanent median pavement near sta. 987+00 to 999+00.
g) Construct temporary median pavement near sta. 999+00 to 1011+00
h) Construct permanent median pavement near sta. 1011+00 to 1034+00.
i) Construct temporary median pavement near sta. 1034+00 to east limit.

2. Frontage Roads
a) Close the existing EBFR bridge over Salado Creek and divert traffic to the newly constructed bridge, one-lane phased structure.

3. Ramps
4. Starcrest Underpass Bridge

QuickZone MODEL

- Sequencing plan

Phase 1 Stage 2

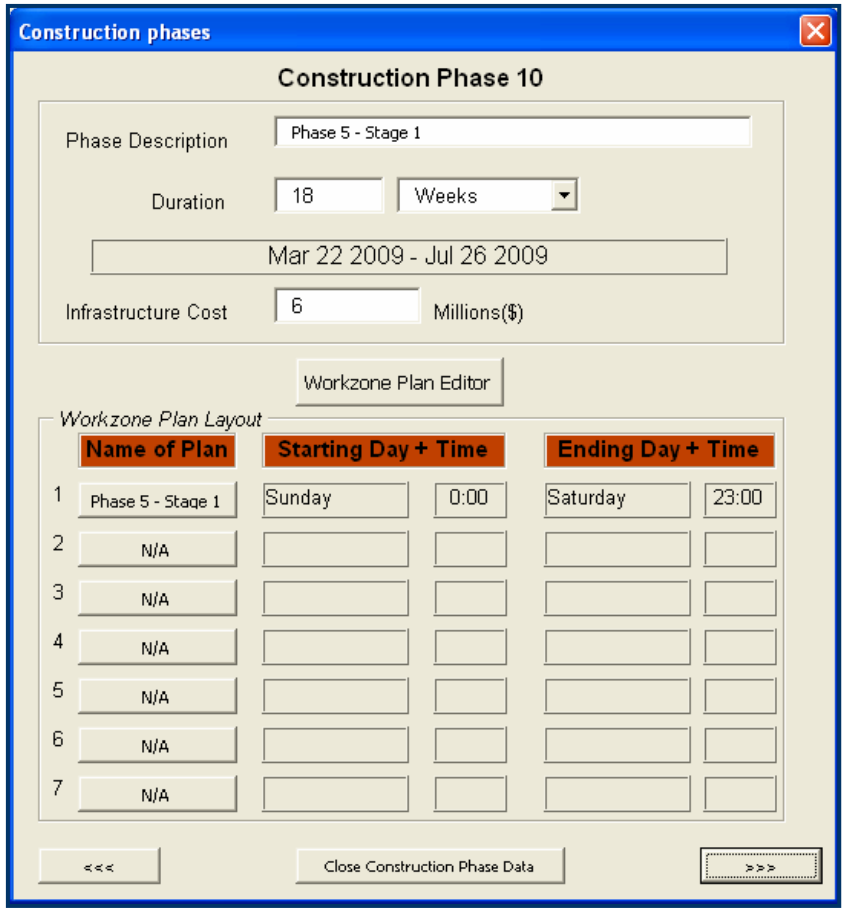
Begin Date: ***4***

Cost ($M): ***5***

	QUICKZONE LINK	***ADJUSTMENT CODE***	***CAPACITY DECREASE***
INBOUND WORKZONE LINKS	1	AC-2	129
	2	AC-5	682
	3	AC-5	682
	4	AC-5	682
	5	AC-5	682
	6	AC-5	682
	7	AC-5	682
	8	AC-5	682
	9	AC-5	682
	10	AC-5	682
	11	AC-5	682
	12	AC-5	682
	13	AC-5	682
	14	AC-4	588
OUTBOUND WORKZONE LINKS	24	AC-5	682
	25	AC-5	682
	26	AC-5	682
	27	AC-5	682
	28	AC-5	682
	29	AC-5	682
	30	AC-5	682
	31	AC-5	682
	32	AC-5	682
	33	AC-5	682
	34	AC-5	682
	35	AC-5	682
	36	AC-5	682
	37	AC-4	588

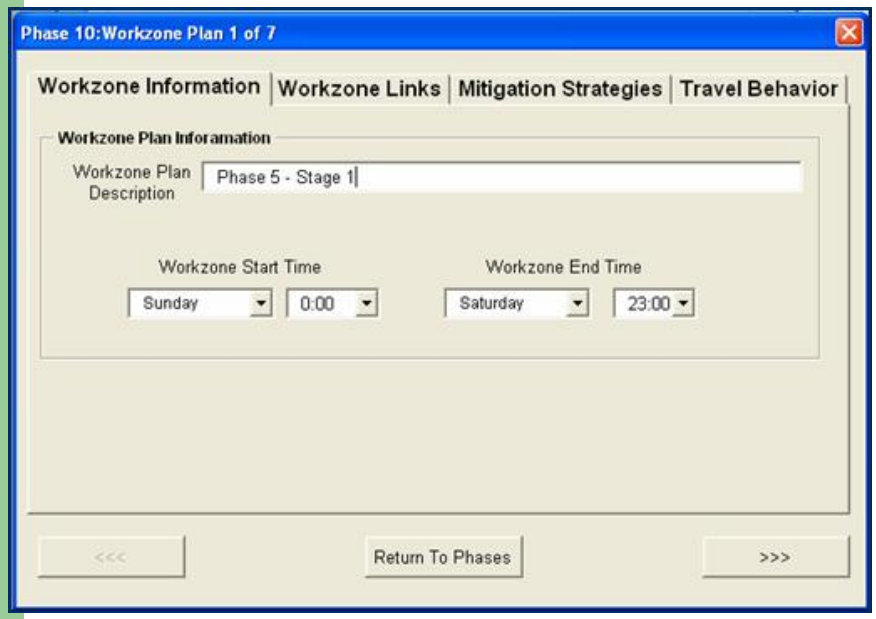
QuickZone MODEL

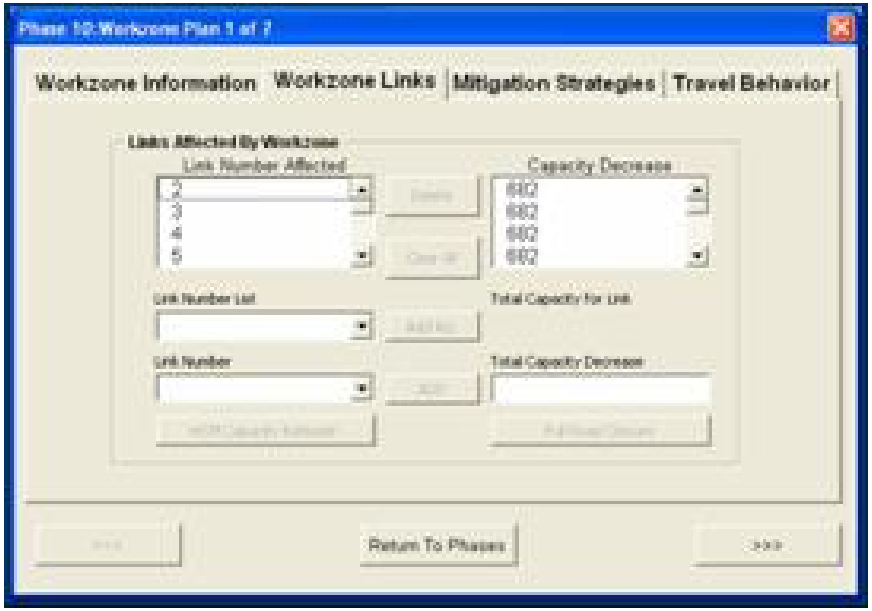
- Sequencing plan



QuickZone MODEL

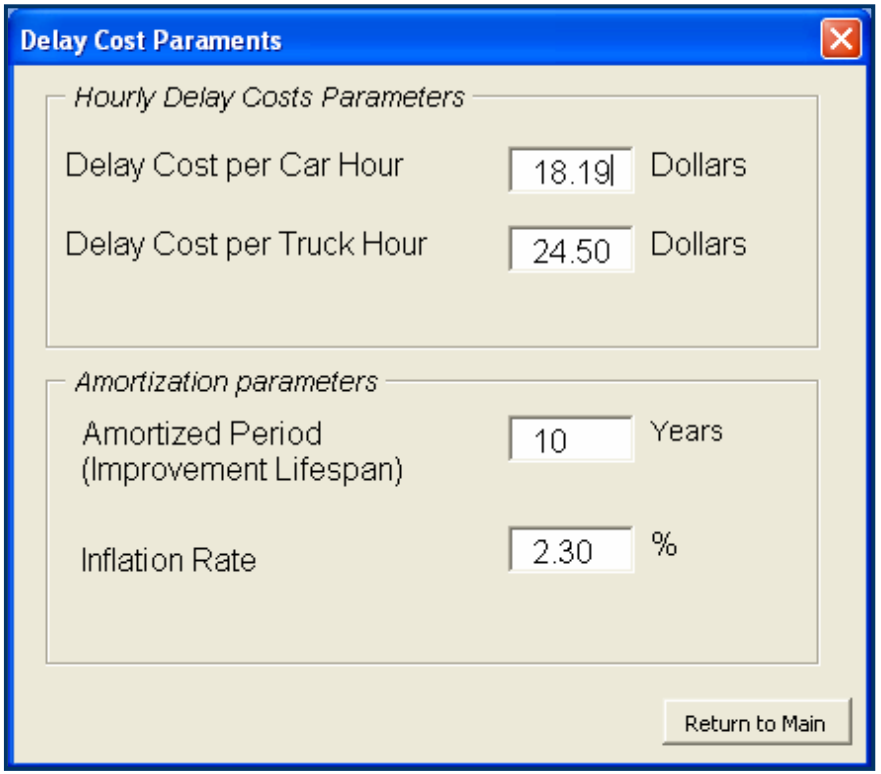
- Phase descriptions, capacity reductions





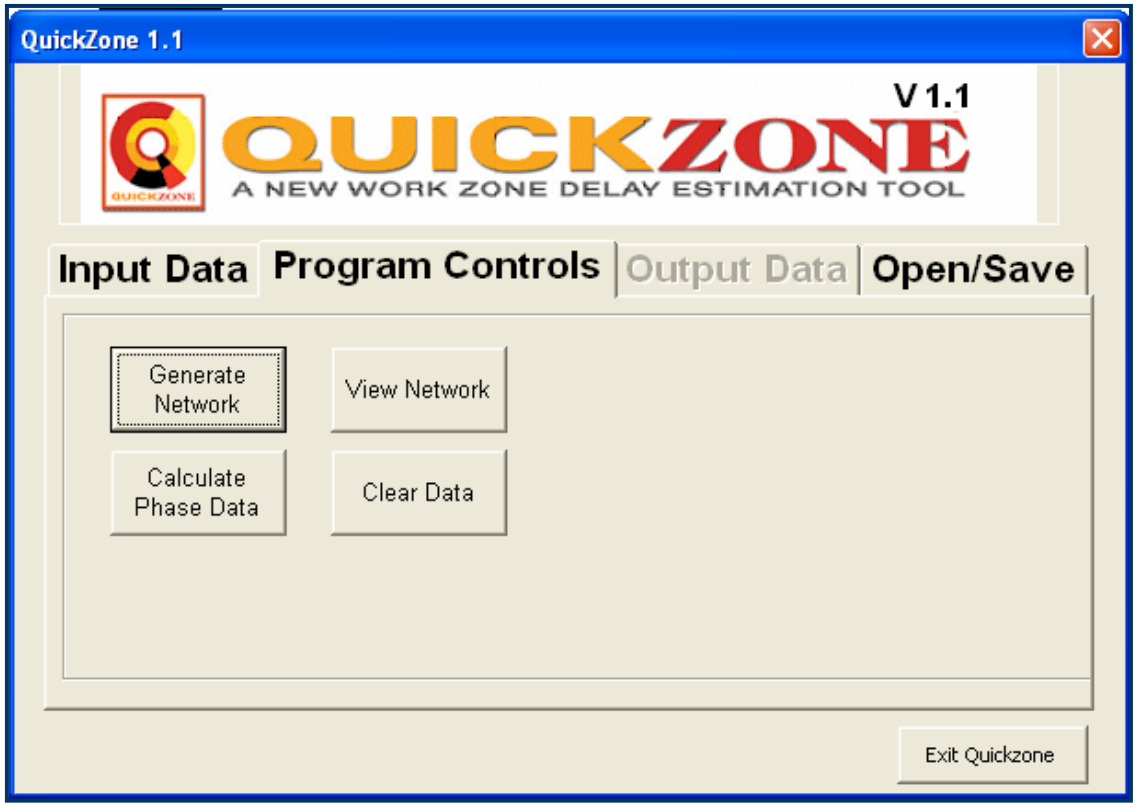
QuickZone MODEL

- Delay cost parameters
  - CPI-adjusted delay costs
  - OMB inflation rate projections



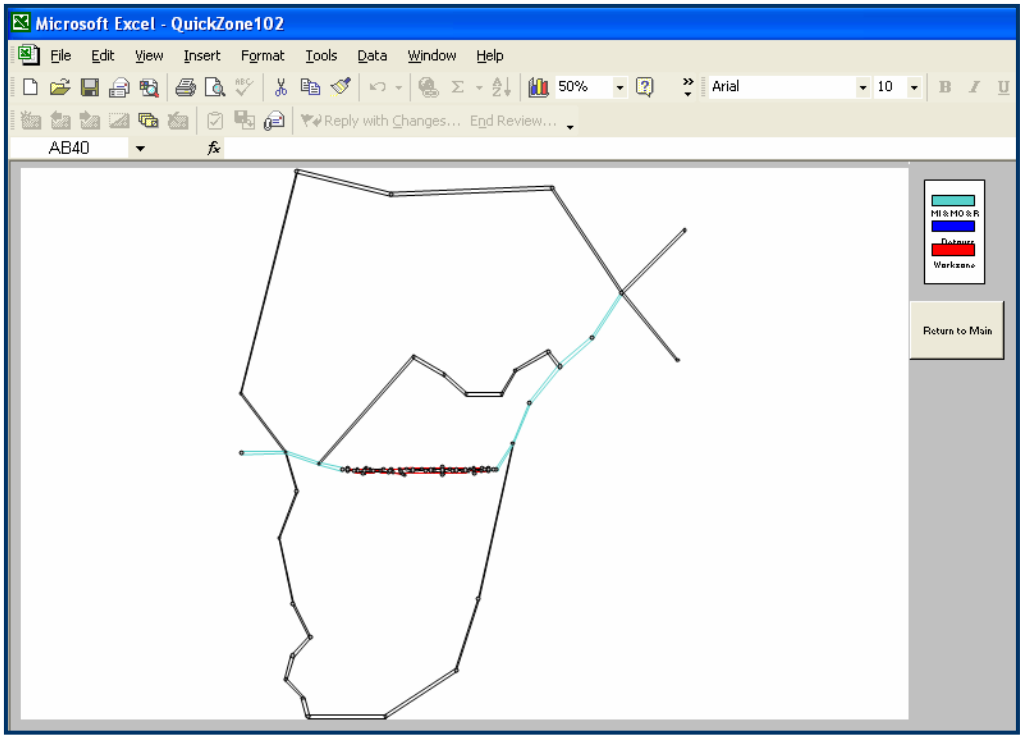
QuickZone MODEL

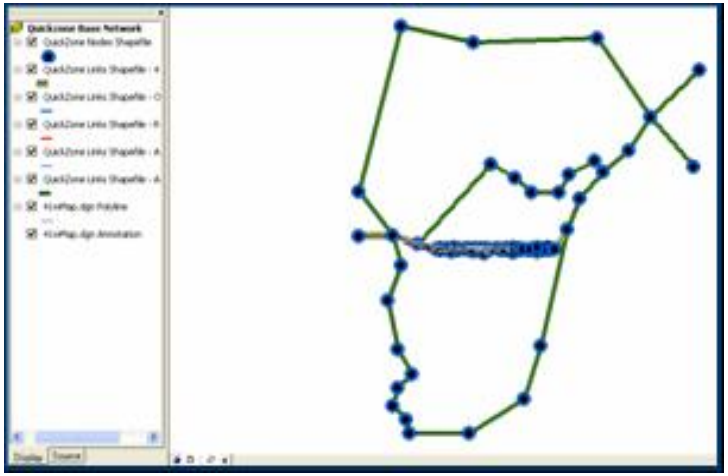
- Program controls



QuickZone MODEL

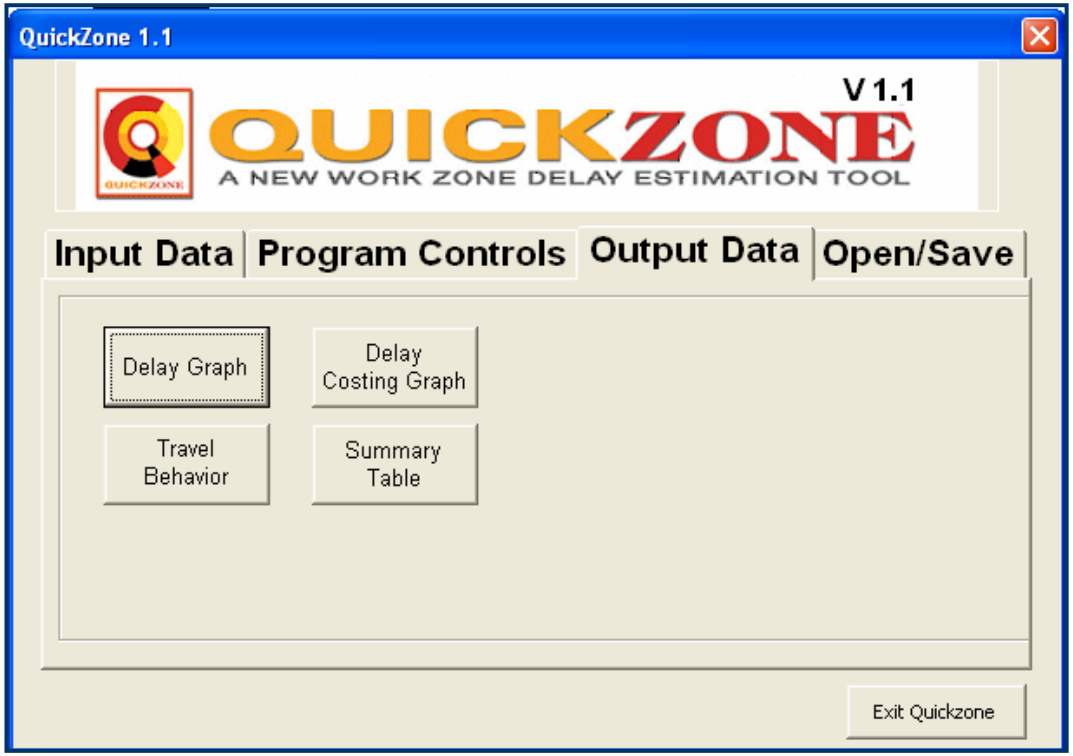
- Network generation





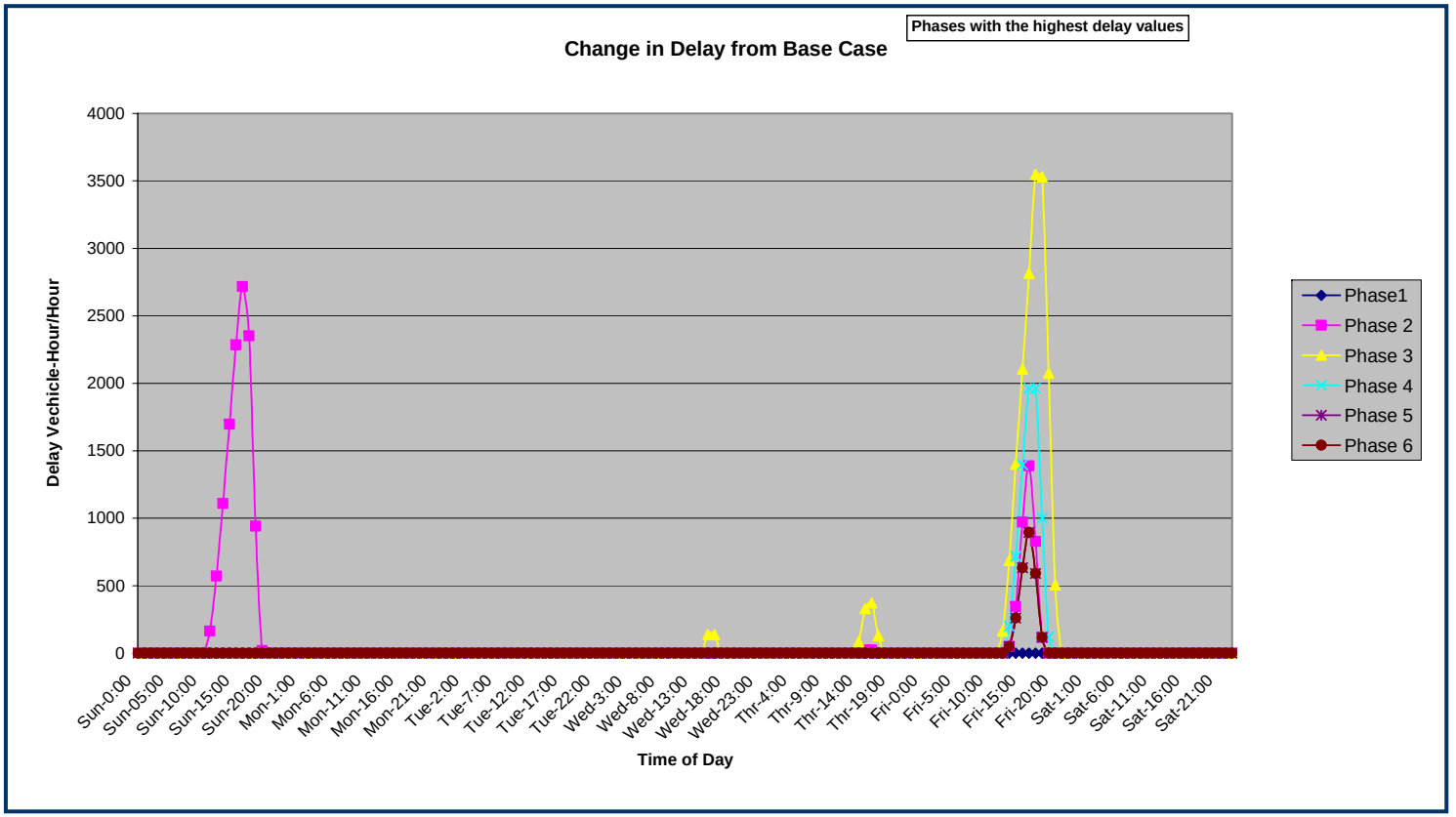
QuickZone MODEL

- Output data



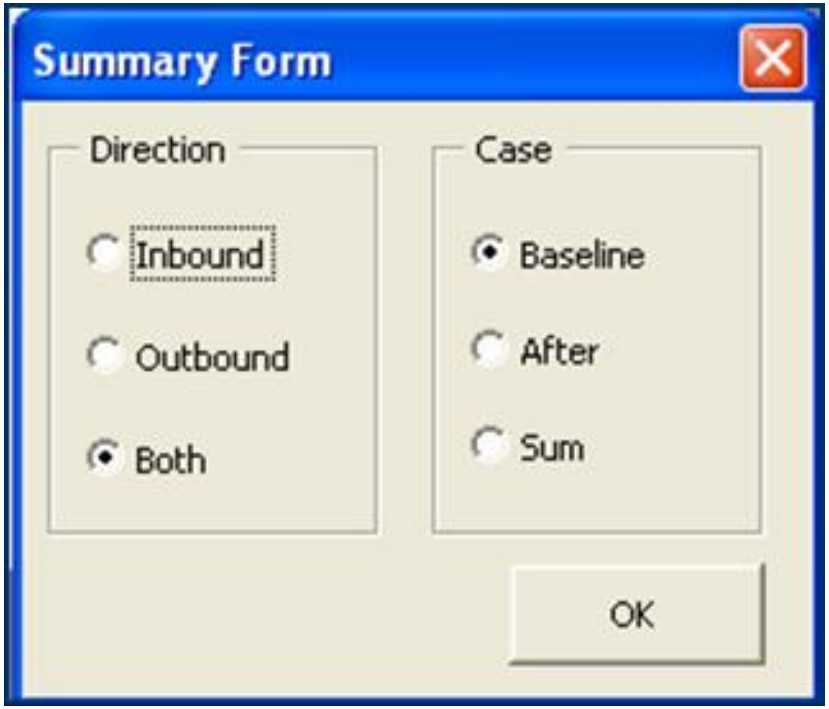
QuickZone MODEL

- Delay graph



QuickZone MODEL

- Summary of results
  - Unidirectional or both
  - Baseline (recurring)
  - After (work zone)
  - Sum



QuickZone MODEL

- Summary of results - baseline

IH 410 Widening - Nacogdoches to Perrin Beitel
Baseline Data

Option Form	Queue-Both		Delay-Both			Phase Travel Behavior (Weekly Inbound + Outbound)				Cost (millions $)-Both			
Title	Weekly Max (mi)	Weekly Total (mi)	Weekly User Max (min)	Weekly Total (VH)	Phase Total 1000 (VH)	Take Detour (V)	1 HR Shifting	Cancel Trip (V)	Mode Shift (V)	Infrastructure	Car	Delay Trucks	Total
Phase 1 - Stage 1	2.41	10.5	21.3	7889	71	0	0	0	0	3	1.29	0.13	1.42
Phase 1 - Stage 1	2.41	10.5	21.3	7889									
Phase 1 - Stage 2	0.42	0.8	2.7	570.6	10.3	0	0	0	0	5	0.19	0.02	0.21
Phase 1 - Stage 2	0.42	0.8	2.7	570.6									
Phase 2 - Stage 1	3.23	17.6	30.6	13213.8	476	0	0	0	0	12	8.65	0.88	9.53
Phase 2 - Stage 1	3.23	17.6	30.6	13213.8									
Phase 2 - Stage 2	0.42	0.8	2.7	570.6	2.3	0	0	0	0	4	0.04	0	0.05
Phase 2 - Stage 2	0.42	0.8	2.7	570.6									
Phase 2 - Stage 3	0.42	0.8	2.7	570.6	2.3	0	0	0	0	4	0.04	0	0.05
Phase 2 - Stage 3	0.42	0.8	2.7	570.6									
Phase 2 - Stage 4	0.42	0.8	2.7	570.6	2.3	0	0	0	0	3	0.04	0	0.05
Phase 2 - Stage 4	0.42	0.8	2.7	570.6									
Phase 3 - Stage 1	2.41	10.5	21.3	7889	174	0	0	0	0	8	3.16	0.32	3.48
Phase 3 - Stage 1	2.41	10.5	21.3	7889									
Phase 4 - Stage 1	2.41	10.5	21.3	7889	284	0	0	0	0	15	5.17	0.52	5.69
Phase 4 - Stage 1	2.41	10.5	21.3	7889									
Phase 4 - Stage 2	0.42	0.8	2.7	570.6	2.3	0	0	0	0	6	0.04	0	0.05
Phase 4 - Stage 2	0.42	0.8	2.7	570.6									
Phase 5 - Stage 1	4.38	29	43.7	21752.5	392	0	0	0	0	6	7.12	0.72	7.84
Phase 5 - Stage 1	4.38	29	43.7	21752.5									
Phase 5 - Stage 2	6.54	52.5	66.1	39355.3	157	0	0	0	0	4	2.86	0.29	3.15
Phase 5 - Stage 2	6.54	52.5	66.1	39355.3									
										70	28.6	2.88	31.52

QuickZone MODEL

- Summary of results – work zone

IH 410 Widening - Nacogdoches to Perrin Beitel

After Data

Option Form	Queue-Both		Delay-Both			Phase Travel Behavior (Weekly Inbound + Outbound)				Cost (millions $)-Both			
Title	Weekly Max (mi)	Weekly Total (mi)	Weekly User Max (min)	Weekly Total (VH)	Phase Total 1000 (VH)	Take Detour (V)	1 HR Shifting	Cancel Trip (V)	Mode Shift (V)	Infrastructure	Car	Delay Trucks	Total
Phase 1 - Stage 1	0	0	0	0	0	0	0	0	0	3	0	0	0
Phase 1 - Stage 1	0	0	0	0									
Phase 1 - Stage 2	3.81	20.8	32.4	15598.5	281	0	0	0	0	5	5.11	0.52	5.63
Phase 1 - Stage 2	3.81	20.8	32.4	15598.5									
Phase 2 - Stage 1	5.23	24	33.4	18025.6	649	0	0	0	0	12	11.8	1.2	13
Phase 2 - Stage 1	5.23	24	33.4	18025.6									
Phase 2 - Stage 2	2.89	9.8	18.4	7361.4	29.4	0	0	0	0	4	0.54	0.05	0.59
Phase 2 - Stage 2	2.89	9.8	18.4	7361.4									
Phase 2 - Stage 3	1.26	3.4	8.1	2545.7	10.2	0	0	0	0	4	0.19	0.02	0.2
Phase 2 - Stage 3	1.26	3.4	8.1	2545.7									
Phase 2 - Stage 4	1.26	3.4	8.1	2545.7	10.2	0	0	0	0	3	0.19	0.02	0.2
Phase 2 - Stage 4	1.26	3.4	8.1	2545.7									
Phase 3 - Stage 1	4.89	20.1	31.2	15057	331	0	0	0	0	8	6.03	0.61	6.64
Phase 3 - Stage 1	4.89	20.1	31.2	15057									
Phase 4 - Stage 1	4.89	27.5	42.3	20648	743	0	0	0	0	15	13.52	1.37	14.89
Phase 4 - Stage 1	4.89	27.5	42.3	20648									
Phase 4 - Stage 2	2.89	12.5	23.9	9379.1	37.5	0	0	0	0	6	0.68	0.07	0.75
Phase 4 - Stage 2	2.89	12.5	23.9	9379.1									
Phase 5 - Stage 1	2.95	12.5	18.8	9399.8	169	0	0	0	0	6	3.08	0.31	3.39
Phase 5 - Stage 1	2.95	12.5	18.8	9399.8									
Phase 5 - Stage 2	6.98	45.6	44.6	34221.5	137	0	0	0	0	4	2.49	0.25	2.74
Phase 5 - Stage 2	6.98	45.6	44.6	34221.5									
										70	43.63	4.42	48.03

ROAD USER COST REPORT

Milestone No.	Milestone Description	Average Road User Cost per Day	(1)Incentive /Disincentive Equivalence
1	Phase 2 – Stage 2	$17,143	$4,286
2	Phase 2 – Stage 3 **and** Phase 2 – Stage 4	$12,143	$3,036
3	Phase 5 – Stage 1 **and** Phase 5 – Stage 2	$104,286	$26,072
A+B	All Phases	$38,790	$9,698

Phase-Stage	Queue Weekly Max (mi)	Delay Weekly Max (min)	Cost Total ($Million)	Cost per day ($)
Phase 1 - Stage 1	0	0	0	$0
Phase 1 - Stage 2	3.81	32.4	4.58	$40,893
Phase 2 - Stage 1	5.23	33.4	10.58	$47,232
Phase 2 - Stage 2	2.89	18.4	0.48	$17,143
Phase 2 - Stage 3	1.26	8.1	0.17	$6,071
Phase 2 - Stage 4	1.26	8.1	0.17	$6,071
Phase 3 - Stage 1	4.89	31.2	5.4	$38,571
Phase 4 - Stage 1	4.89	42.3	12.12	$54,107
Phase 4 - Stage 2	2.89	23.9	0.61	$21,786
Phase 5 - Stage 1	2.95	18.8	2.76	$24,643
Phase 5 - Stage 2	6.98	44.6	2.23	$79,643
		TOTAL =	39.1	

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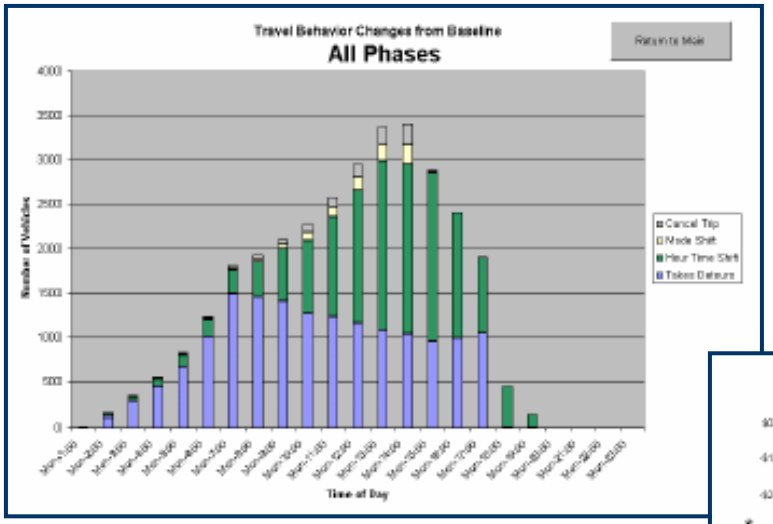
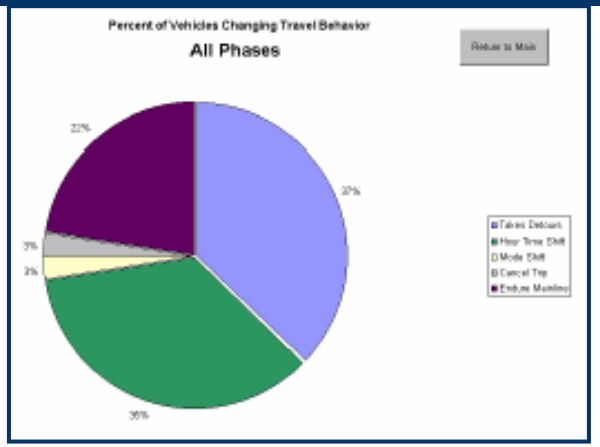
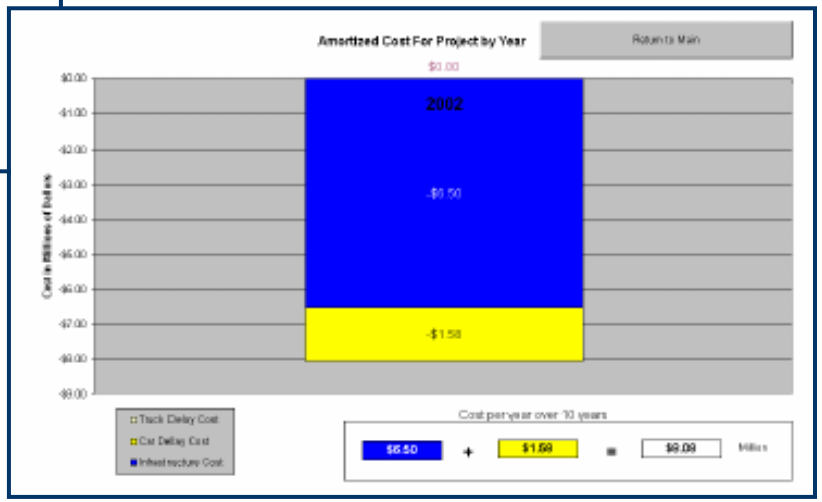
- Other tools

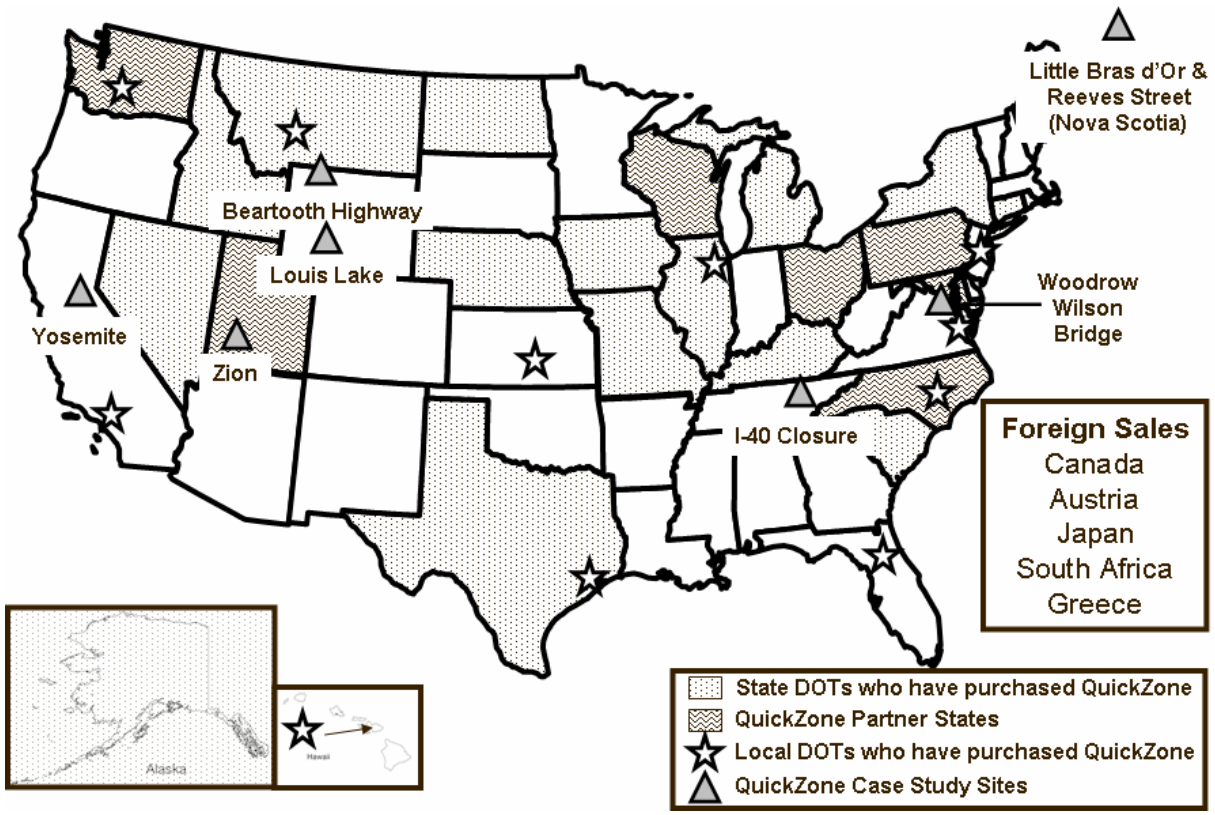






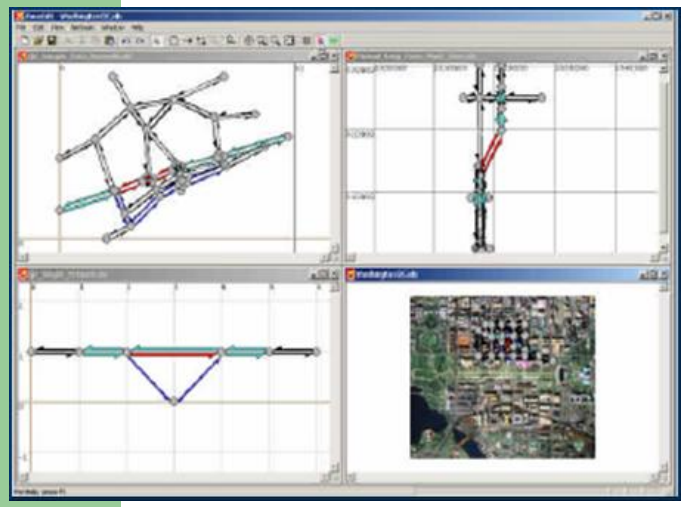
QuickZone

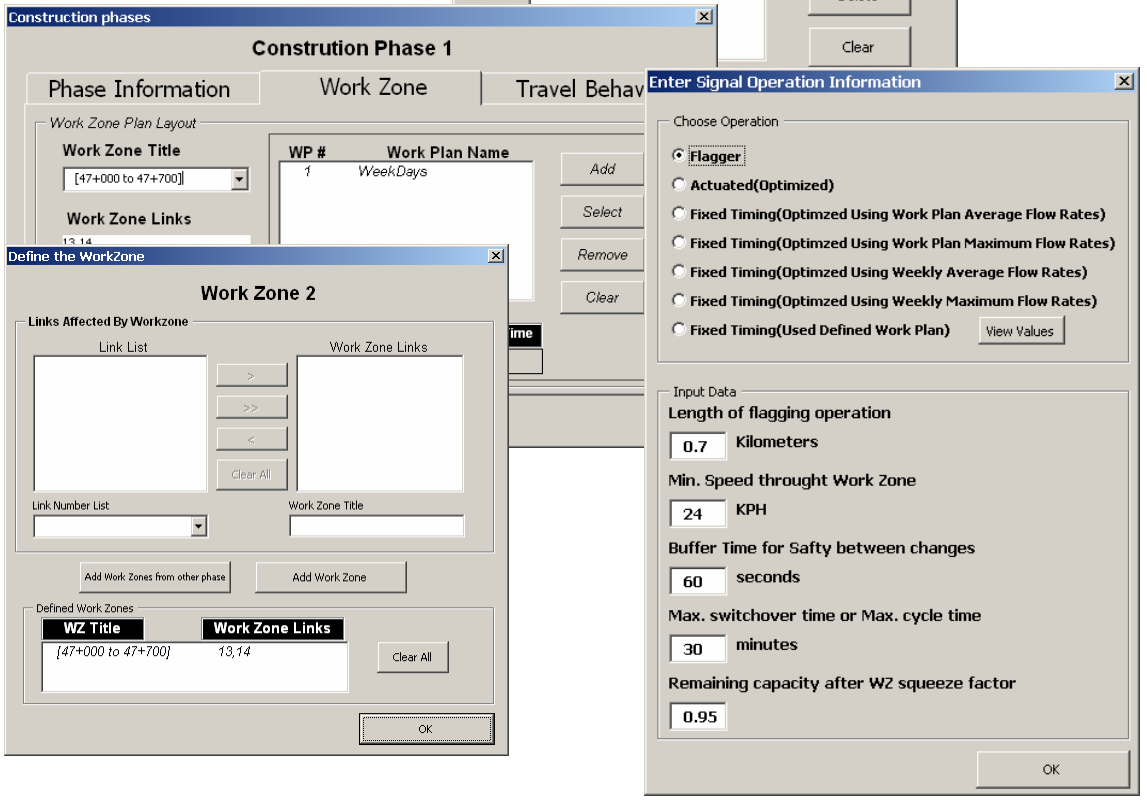
- Case studies



QuickZone

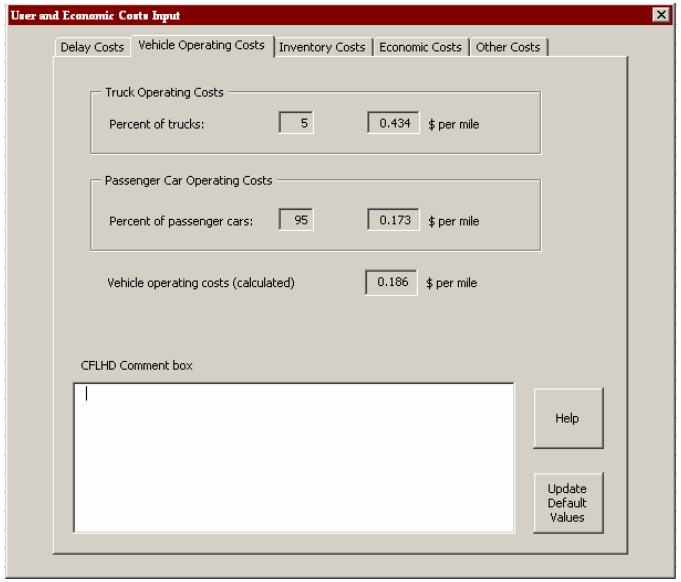
- Future enhancements

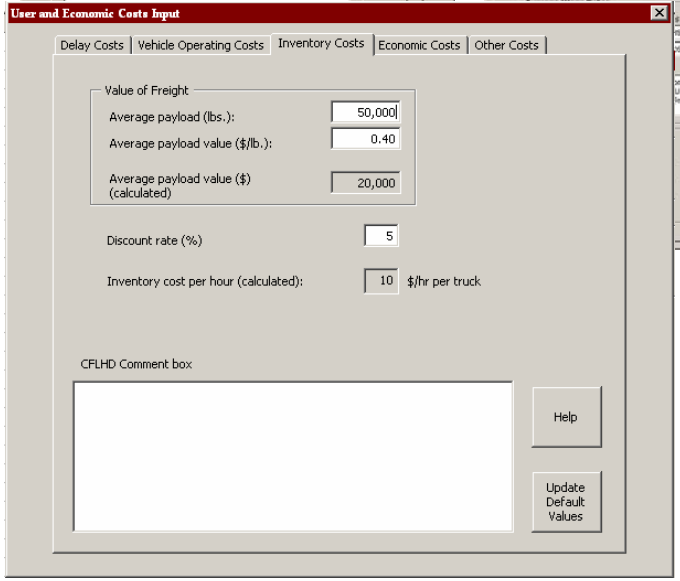




QuickZone

- Future enhancements





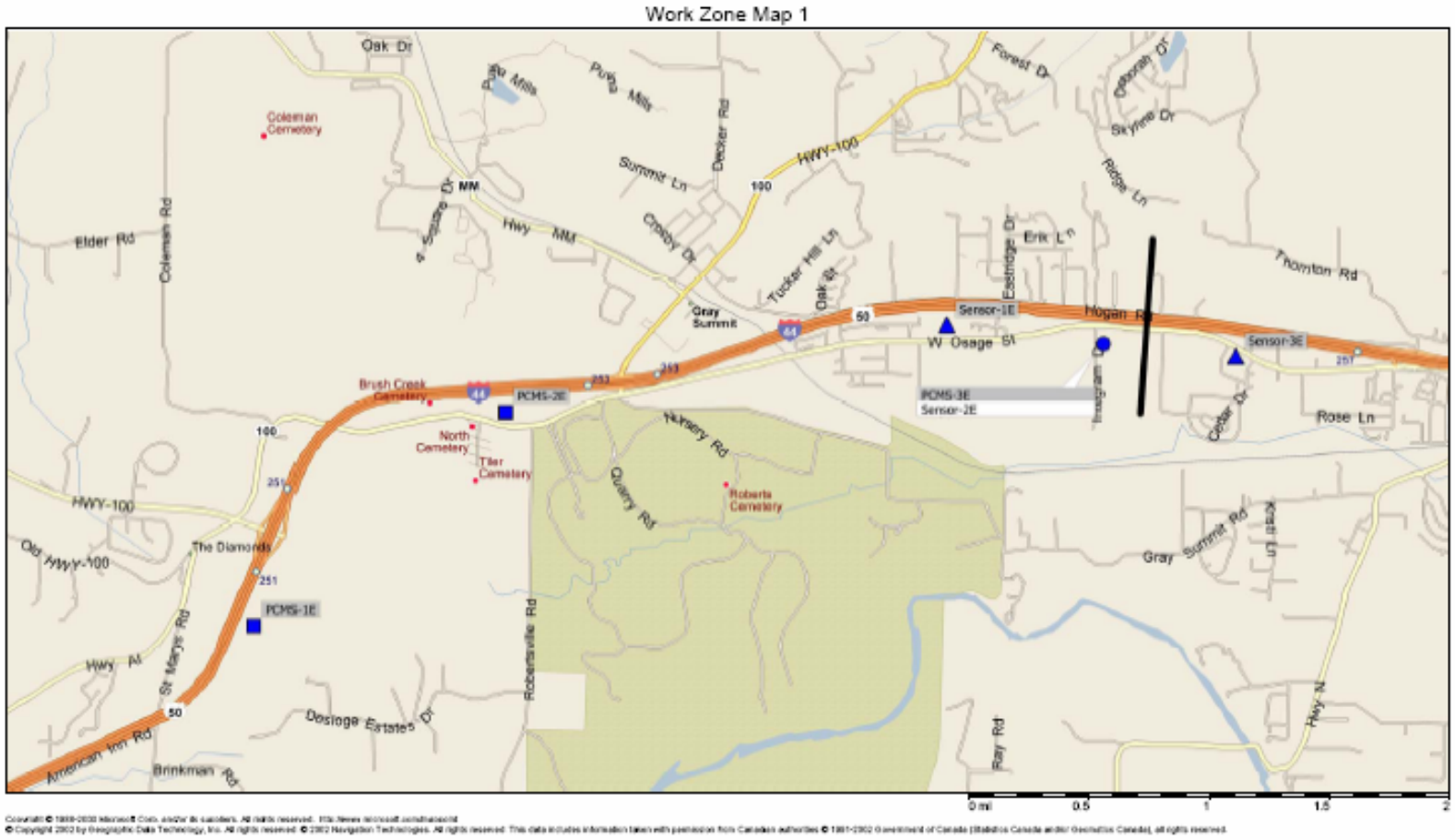
SMART WORK ZONE SYSTEM

- Provides Real Time Information
  - Travel time through work zone
  - Distance to the end of work zone
  - Decision making by local travelers

SMART WORK ZONE SYSTEM

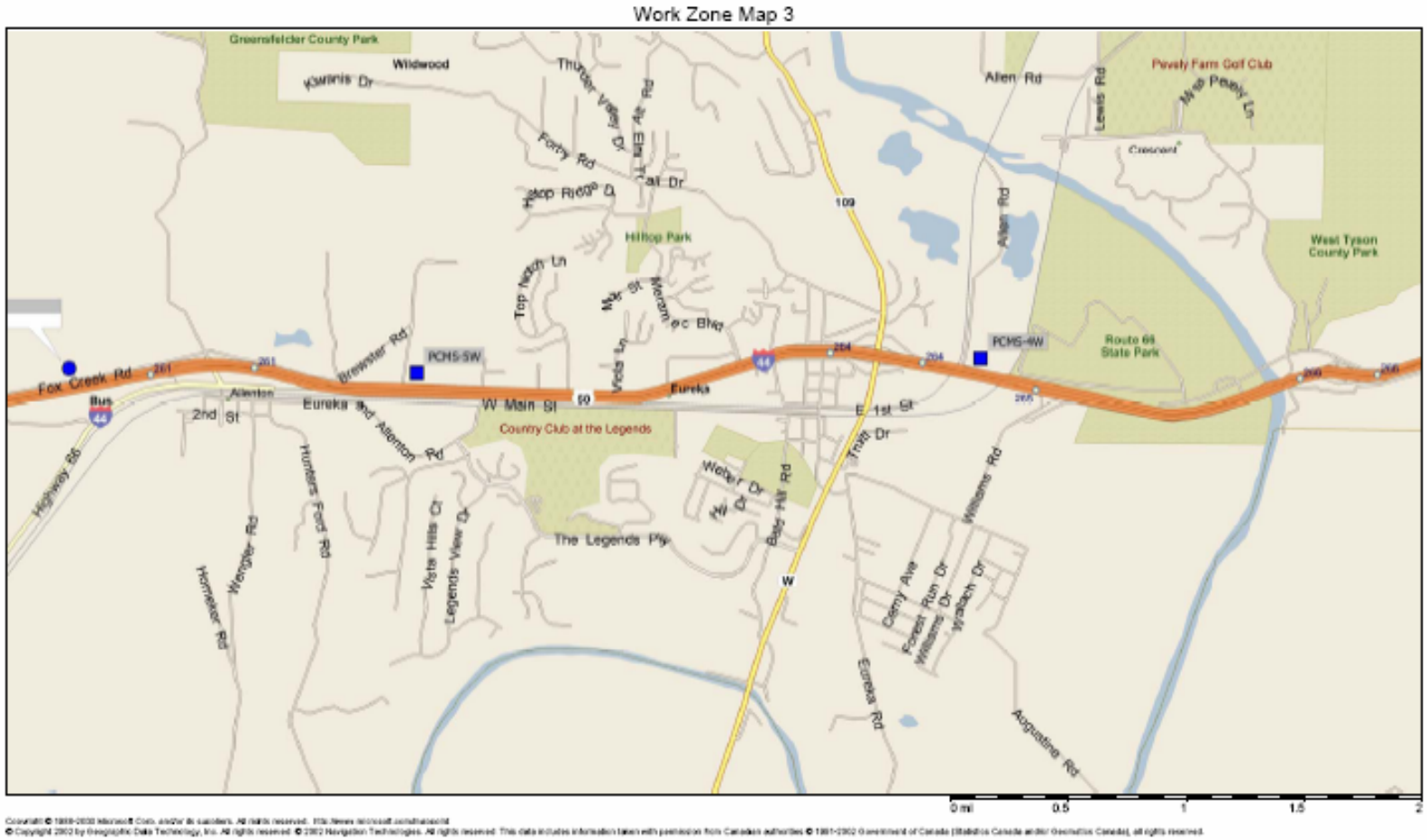
- Provides Work Zone Management Tool
  - Delay monitoring
  - Flexibility in Operations
  - Enhances Operations

SMART WORK ZONE SYSTEM



SMART WORK ZONE SYSTEM

SMART WORK ZONE SYSTEM



SMART WORK ZONE SYSTEM