Low-Cost Signal Improvement Program / Thoroughfare Assessment Program Phase 3.2

Executive Summary

Cities of Alvarado, Azle, Cleburne, Coppell, Dallas, Denton, Fort Worth, Grand Prairie, Hurst, Irving, Joshua, Lake Worth, Mesquite, North Richland Hills, Richland Hills, The Colony

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Submitted by:

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1. INTRODUCTION

BACKGROUND

Traffic signals impact the operational efficiency of arterials more than any other traffic control device. Efficient timing plans provide optimal splits to traffic movements at intersections and allow for the progressive movement of vehicular platoons along an arterial with minimal stops and delays. On the other hand, inefficient timing can essentially reduce the capacity of an arterial to zero during periods when the arterial is not being provided the correct percentage of the cycle required to serve the demand. Inefficient progression along an arterial increases stops and delays for vehicles moving through the corridor.

Recognizing the impact, the North Central Texas Council of Governments (NCTCOG) began funding improvements to signal hardware and the development of optimized timing plans in 1992. In 2003, NCTCOG committed additional Federal funds for a Traffic Signal Integration and Monitoring Project. Phase 3.2 of the Thoroughfare Assessment Program (TAP) targets improvements in the arterial transportation system in the DFW Non-attainment Area. The results of this phase are contained within this report.

STUDY PURPOSE

A team of consultants led by Teal Engineering Services, Inc., retimed 484 traffic signals at intersections operated by fourteen (14) different cities and two Districts of the Texas Department of Transportation (TxDOT). Data collection only services were provided to two (2) additional cities (Irving and Coppell) that performed traffic signal retiming using in-house staff. The intent of this report is to summarize the results of the Final Technical Memoranda (After Studies) in contrast with the Before Studies (existing conditions analysis) for all project corridors.

This report and its tables illustrate the difference in total delay, number of stops and total travel time by subtracting the "Before" values from the "After" values for all of these quantities. Hence, a negative value in the table indicates corridor improvements by an overall reduction of the total delay or travel time (in seconds) or the number of stops. Empirical data was obtained in the field from travel time runs (TTRs) using the "floating car method" described later in this report.

Additionally, each corridor is modeled using Synchro which also evaluates the existing system in contrast to an "After" system to estimate changes in total delay, the number of stops, the total travel time, gallons of fuel consumed, and kilograms of carbon monoxide (CO), nitrous oxides (NOx), and volatile organic compounds (VOC/HOC) emitted. A monetary value of daily user savings is calculated for the entire corridor by multiplying the absolute value of the total delay change by $12.50. This represents NCTCOG's current value per vehicle hour of delay as reflected in *Mobility 2030 - 2009 Amendment*. Where the total delay increases, this monetary value is negative and indicates a daily cost to the user.

The data evaluated falls under three general categories with regard to time of day: AM Peak, Off Peak, and PM Peak. In the case of Off Peak, two subcategories exist: AM Off Peak and PM Off Peak. For the cities of Hurst and North Richland Hills a Midday (MD) Peak is also studied.

The time periods are generally defined as follows:

- AM Peak Period – 6:30 AM to 8:30 AM
- AM Off Peak – 9:30 AM to 11:30AM
- MD Peak – 11:30 AM to 1:30 PM
- PM Off Peak – 1:30 PM to 3:30 PM
- PM Peak – 4:30 PM to 6:30 PM

Figure 1 illustrates the locations of the traffic signals retimed as part of TAP Phase 3.2.

2. CORRIDOR CHARACTERISTICS AND ANALYSIS

ARTERIAL AND INTERSECTION CHARACTERISTICS

All details regarding arterial and intersection characteristics are contained within the Before Studies and Final Technical Memoranda specific to the corridor or group in question.

TRAFFIC VOLUMES

Turning movement counts were made at each study intersection and 24-hour bi-directional counts were generally taken along each corridor. For the purposes of this Executive Summary, all volumes are taken from the data available in the Final Technical Memoranda for each corridor. Where a summary of the 7-day count is available, the maximum recorded Average Daily Traffic (ADT) is taken as the ADT for the tables. Where this data is not available, the 24-hour counts are used.

SIGNAL OPERATIONS

For all project corridors, new timing plans were developed for weekday AM, PM and Off peak traffic flow periods. After the new timing plans were implemented, extensive fine-tuning was done to improve or optimize traffic operations under actual field conditions. Details describing the signal operations for each corridor are contained within the Final Technical Memoranda

TRAVEL TIME RUNS

To assess the current traffic flow characteristics of each corridor the team conducted travel time runs (TTRs). Typically three or four runs were performed in each direction during the Peak (AM, midday and PM) and Off-Peak (AM and/or PM) times as needed. The "floating car method" was used. This study method requires a test car to be driven by one of the observers along the corridor such that the test car flows (or "floats") with the moving traffic. It is expected that the test car will pass the same number of vehicles that are passing it. The arithmetic mean of the runs is taken to be the recorded travel time, number of stops, and cumulative delay. Travel time runs were recorded before and after the implementation of new timing plans.

3. PROJECT RESULTS

BEFORE AND AFTER COMPARISON

All data contained within the tables evaluates the differences noted in the "After" travel time runs in contrast to those conducted before any changes were made to the signals. Similarly, the Synchro models compare the existing conditions to those implemented in the "After" scenario. In most cases, the TTR data collected matches the data presented in the Final Technical Memoranda; however, when conflicts do occur the data presented in this Executive Summary comes from the data collected in the travel time runs and not the Final Technical Memoranda. In the majority of corridors studied, the travel time runs reveal improvements made to the total delay experienced. In the events where travel time runs indicate delay has increased somewhat, Synchro frequently models a reduction in stops accompanied by lowered fuel consumption and vehicle emissions.

RESULTS AND CONCLUSIONS

Table 1 presents a summary of the project conclusions and benefits. For each study corridor or group, travel route statistics include: route limits, number of signals, average daily traffic volume, and corridor benefits (reductions in travel time, stops, and delay). Benefits derived from the Synchro model include reductions in total signal delay, stops, travel time, fuel consumed, and emissions. Daily user savings were based on reductions in total signal delay using a value of $12.50 per vehicle-hour of delay. For this project daily values were derived from two hours of benefit from the AM peak timing plans, two hours of benefit from the PM peak timing plan, and five hours of benefit from the off peak or mid-day timing plan.
Based on the results shown in Table 1, the following conclusions were drawn:

- Estimated user benefit is approximately $62,048 per weekday
- Assuming 248 weekdays per year, resulting annual savings is approximately $15.4M.
- Total Signal Delay was reduced by over 4,950 vehicle-hours per weekday; 16.2% reduction
- Total travel time was reduced by over 5,700 hours per weekday; 8.2% reduction
- Total stops were reduced by approximately 355,320 vehicle stops per weekday; 12.0% reduction
- Total fuel consumption was reduced by over 11,350 gallons per weekday

As indicated by the results shown in Table 1, positive benefits or improvements were realized for the majority of the corridors or groups included in this project. Of the 44 corridors or groups studied, only eight (8) were shown to result in negative benefits in terms of MOE's estimated by Synchro. In terms of intersections, this represents approximately 10% of the total number of project intersections. On average, positive benefits were achieved for approximately 90% of the project intersections.

The following provides brief explanations regarding the negative benefits:

- **SH 174 in Joshua:** The negative benefits for this corridor are mainly due to the increased cycle length required to accommodate left turn and side street signal phases at critical intersections. Although improvements (decreased intersection delay) were made for the AM and PM peak periods, these were offset by the increased delay during the Off peak periods. The timing plans developed for the Off peak periods improved progression along SH 174 but the higher cycle lengths (cycle lengths for coordinated plans versus "free" mode for existing or Before operations) caused more delay for non-coordinated movements.

- **Northwest Drive in Mesquite:** Based on the Synchro results, marginal improvements were made for the AM and PM peak periods but daily user savings were negated by the negative benefits realized during the off peak periods. The After study concluded that consideration be given to operating the corridor in a "free" mode during non-peak periods because of the relatively low traffic volumes that exist during the non-peak or off peak periods.

- **Oates Drive in Mesquite:** Probably the biggest factor contributing to the increase in travel time and delay was due to changing the phasing at the IH-635 diamond interchange from a 3-phase operation to a 4-phase operation. To accommodate the 4-phase operation, the effective cycle length for the system was increased. The main reason for changing to a 4-phase operation was to eliminate or reduce the potential for vehicles to form a queue on the frontage road approaches that would impact the ramps or freeway (mainlane) operations. Also, field observations during the Before conditions revealed that with the 3-phase operation at the diamond, internal storage capacity was often exceeded for internal left turning vehicles. Although the 4-phase operation appears to have increased overall travel time, it eliminated the internal storage problem which in peak flow periods could cause severe congestion and queues at the diamond interchange. Also, the reduction in the number of stops as reported by Synchro is consistent with the expected operation of a 4-phase scheme versus a 3-phase scheme at the diamond interchange.

- **Military Parkway/Scyene Road in Mesquite:** Field measured travel time runs showed a decrease in corridor travel times, stops, and delay when comparing Before to After conditions. However, the Synchro results show an increase in total signal delay. This is mainly due to the higher cycle lengths required to operate the complex diamond interchange at IH-635. The diamond interchange at the east end of the system is a "box-type" configuration in that Military and Scyene streets form a one-way pair through the interchange. The interchange is further complicated by a portion of the southbound frontage road being two-way. One of the main objectives of the retiming effort was to optimize traffic operations at the interchange to relieve the heavy congestion that was being experienced during peak traffic flow periods.

- **SH 183 in Richland Hills:** Based on the Synchro results, total travel time was reduced but total signal delay increased. This indicates that the new coordinated traffic signal timing plans improved travel time along the corridor but overall delay was increased at the intersections when comparing the coordinated system operations to allowing the intersections to operation in an isolated or "free" mode. The coordinated timing plans penalize locations, such as the intersections at Rufe Snow and at Booth Calloway, which have significant cross-street traffic. Green time is taken from the side street movements and given to the coordinated phases.

- **Bedford-Euless Road in Hurst:** The Bedford-Euless Road East Corridor was added to the Precinct Road coordinated system. The Precinct Road was the critical corridor and was used to determine the cycle length. The cycle lengths increased during the AM, Noon, and PM peak periods. During the AM-Off Peak the intersections went from running "free" to running in coordination. The increase in cycle length caused an overall increase in travel time, signal delay, and the number of stops for Bedford-Euless Road. However, the combined results of Bedford-Euless Road and Precinct Road were positive. The intersections of Bedford-Euless at Norwood and Bedford-Euless at Harwood were running in coordination during the Before Study. After reviewing travel patterns it was determined the intersections operations would improve if they were operating in "free" operation. They Synchro model did show a significant improvement in operations for the individual intersection, but no longer provided progression for the overall coordinated system and negatively impacted the system-wide MOE's.

- **Harwood Road in Hurst:** Field data showed a significant improvement in travel time for between the "before" and "after" travel runs, however, the improvement was not indicated by the MOE's reported by the Synchro analysis for the system-wide corridor. This is believed to be due to increased cycle lengths. The increased cycle lengths were necessary to meet pedestrian time requirements and clearance time intervals. The improvement in travel times indicate an improvement in coordination, however the increase in cycle lengths caused an increase in travel time, total delay, and the number of stops for overall signal operations.

- **SH 360 in Grand Prairie/Mansfield:** Results of the field measured travel time runs showed reductions in travel time, number of stops, and delay. The Synchro results indicated a small increase in total signal delay which resulted in a negative daily user savings. There are numerous factors that contributed to the overall negative benefits estimated by Synchro for this corridor when comparing Before versus After results. Some of the contributing factors include the following:
    - New signal timings were not implemented at Green Oaks Parkway, Camp Wisdom, or US 287. These intersections were left in a "free" mode based on decisions made by the operating agencies but were included in the overall evaluation. Additional information regarding the decisions made by the agencies is included in the After Study.

- Heritage Street is a stop sign controlled intersection.
- The Holland Road intersection was a stop sign controlled intersection in the Before conditions but was signalized in the After scenario.
- The intersection at Camp Wisdom operates at capacity. Future planned capacity improvements combined with improved signal timings are expected to have a significant positive impact.
- Based on a review of raw traffic data, it appears that there was a change in traffic patterns within the corridor between the time the Before Study was conducted and the completion of the After Study.

A detailed review of the Synchro output did reveal that improvements or positive benefits were achieved for the five (5) core intersections (from Webb Lynn Lane to Broad Street) of the system.

Figure 1: Thoroughfare Assessment Program (TAP) - Phase 3.2

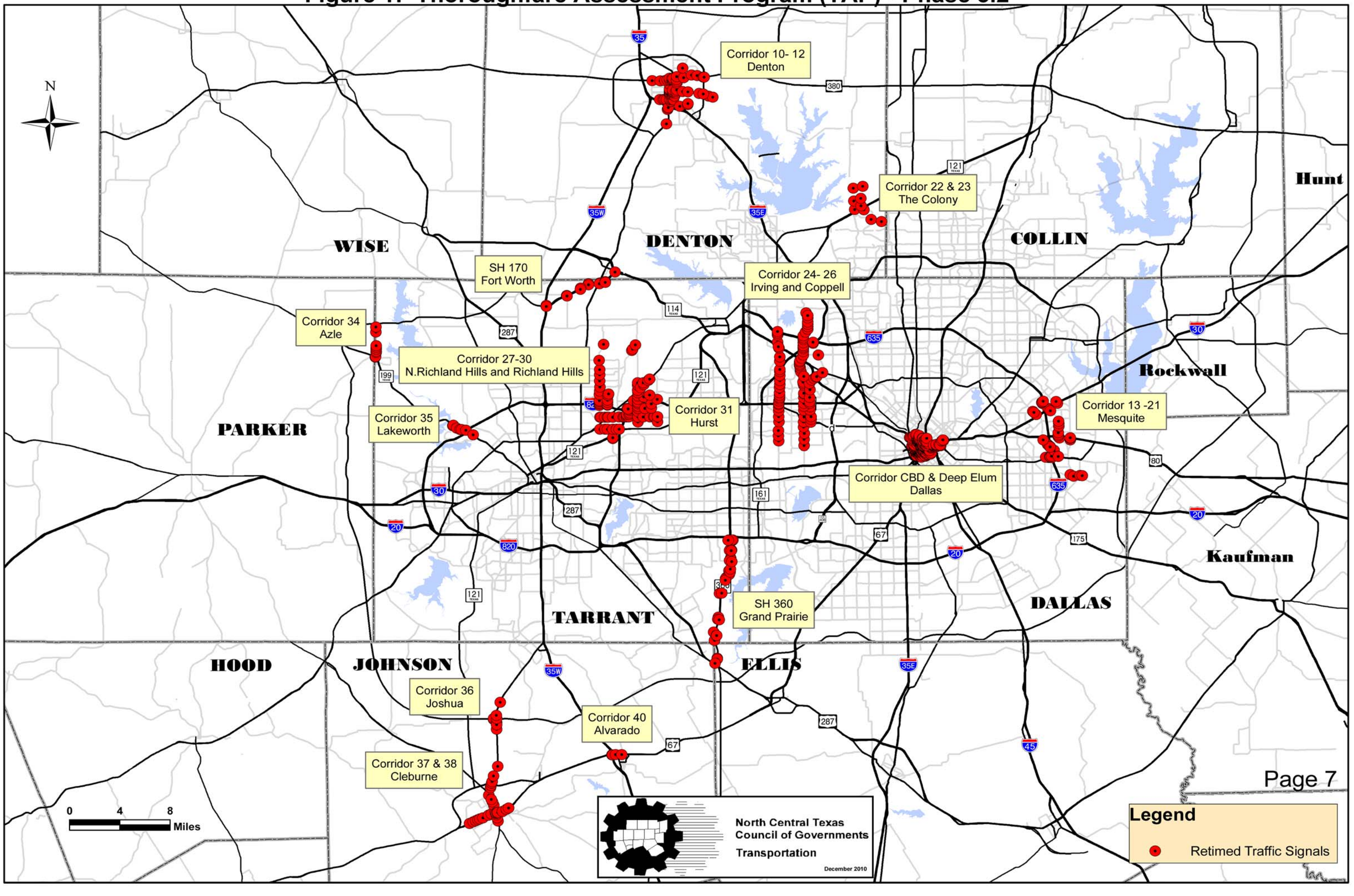

Table 1

SUMMARY OF PROJECT BENEFITS - TAP Phase 3.2

Corridor	City	From	To	Number of Signals in Corridor	Average Daily Traffic	Benefits											
						From Travel Time Runs[1]			From Synchro[1]							Daily User Savings[2]	
						Travel Time (seconds)	Stops	Delay (seconds)	Total Signal Delay (hours)	Stops	Total Travel Time (hours)	Fuel Consumed (gallons)	CO Emissions (kg)	NOx Emissions (kg)	VOC Emissions (kg)	Corridor Total	Per Intersection
US 67	Alvarado	IH35 SBFR	Cummings	4	30,791	-283.5	-2.5	-246.0	-475.8	-10609.0	-454.7	-329.6	-25.5	-1.8	-2.1	$5,948	$1,487
FM 730	Azle	SH 199	FM 1542	9	28,004	164.3	-2.6	59.5	-109.7	-18503.0	-104.9	-480.1	-80.3	-5.5	-1.4	$1,371	$152
US 67	Cleburne	Nolan River Rd	Brazos	13	17,544	-148.2	-3.1	-3.1	-101.8	-28220.0	-159.7	-265.9	-45.9	-4.6	-1.1	$1,273	$98
SH 171	Cleburne	FM 1718	Boone	8	14,204	-310.0	2.4	167.4	-140.9	-36001.0	-246.2	-461.5	-57.5	-5.7	-1.4	$1,761	$220
Bell Avenue	Denton	Eagle Drive	Chapel	8	8,100	133.7	-4.7	1053.6	-180.0	-14960.0	-374.0	-2382.0	-120.0	0.2	-0.4	$2,250	$281
Carroll	Denton	Fort Worth Drive	Sherman Drive	9	28,528	110.8	3.2	-627.0	-205.0	-2490.0	-240.0	-1185.0	-105.0	-0.7	-0.2	$2,563	$285
Eagle	Denton	Avenue C	Bell Avenue	6	18,224	-436.8	-34.2	11.2	-64.0	-1212.0	-90.0	-310.0	-23.0	-0.3	-0.2	$800	$133
Elm/Locust	Denton	Parkway Street	Sycamore Street	6	8,324	157.9	-8.2	173.1	-12.7	-786.0	-15.1	-38.4	0.0	0.0	0.0	$159	$26
Fort Worth	Denton	Country Club	IH 35 E NBFR	4	43,015	-158.5	-4.9	-155.7	-201.0	-5476.0	-242.0	-965.0	-37.2	-0.4	-0.1	$2,513	$628
McKinney Street	Denton	Bell Avenue	Ryan Way	7	20,589	921.9	26.0	924.6	-31.7	-2874.0	-52.3	-318.7	-35.3	-0.5	-0.2	$396	$57
Sherman	Denton	Carroll Drive	Windsor Drive	5	9,632	-268.3	-10.5	-835.0	-7.8	-1133.0	-13.4	-113.2	355.0	0.0	0.0	$98	$20
University	Denton	Bonnie Brae	Loop 288 NBFR	13	34,919	-242.6	-17.7	-1008.3	-4.1	903.0	11.2	75.4	-448.1	-0.1	0.0	$51	$4
SH 174	Joshua	Stadium	Country Club	6	35,156	-228.0	-8.6	-1.8	7.2	-7634.0	17.9	-106.3	-31.5	-2.3	-0.4	($90)	($15)
SH 199	Lake Worth	Hodgkins / Foster	Robert's Cut Off	7	46,581	65.1	7.9	-2.9	-242.6	-14061.5	-194.6	-230.4	-39.2	-2.8	-1.8	$3,032	$433
Belt Line Road	Mesquite	US 80 WBFR	Range Drive	3	21,060	-110.5	-5.1	-229.0	-19.1	-1623.5	-20.8	-42.1	-3.4	-0.2	-0.4	$239	$80
E Cartwright	Mesquite	Belt Line Rd.	Mesquite Valley Rd/Windsor Dr	4	20,000	-130.5	-1.5	-271.6	-30.3	-3651.5	-27.9	-72.5	-15.0	-0.8	-2.1	$379	$95
Galloway North	Mesquite	Barnes Bridge Rd	IH 30 WBFR	3	21,200	-170.6	-4.9	-351.0	-28.5	-4264.0	-35.9	-43.3	0.9	-0.3	-0.1	$356	$119
Galloway South	Mesquite	Ridgeview St	Town East Blvd.	8	30,227	-391.9	-7.6	-1287.8	-444.5	-16377.0	-465.8	-196.5	16.8	-0.1	-0.7	$5,556	$695
Gross Road	Mesquite	Sybil Drive	Hillcrest St.	6	21,005	122.1	-3.5	-522.0	-145.3	-9683.0	-142.1	-193.0	-28.1	-2.1	-0.6	$1,816	$303
Gus Thomason	Mesquite	Oates Drive	Live Oak Drive	3	24,500	-70.0	-4.3	-314.9	-4.7	-4085.5	-8.2	-52.8	-5.9	-0.6	-0.1	$58	$19
Northwest Drive	Mesquite	IH 30 EBFR	Wiggins Pkwy	3	10,000	26.6	-4.6	-248.6	4.2	-300.0	9.3	1.7	-2.9	-0.1	0.0	($53)	($18)
Oates	Mesquite	IH 635 SBFR at N Galloway Ave	IH 635 NBFR at Oates	4	21,128	110.5	2.6	-234.3	44.2	-1633.0	45.9	-0.8	-4.6	-0.2	0.0	($552)	($138)
Military/ Scyene	Mesquite	Peachtree Rd	IH 635 NBFR	4	15,316	-154.6	-8.1	-481.0	36.2	-2309.5	77.4	80.3	2.9	-0.1	0.1	($453)	($113)
SH 183	Richland Hills	Latham Drive	Booth Calloway	12	18,945	152.0	0.4	32.2	51.2	-4649.5	-32.3	-151.0	-22.6	-1.2	-0.4	($639)	($53)
Bedford-Euless Road East Corridor	Hurst	Irwin Drive	Norwood Drive	8	17,000	258.5	0.7	284.0	29.0	1999.0	31.5	46.5	3.1	0.6	0.7	($363)	($45)

1: The totals above are based on the following multipliers: 2 hours for AM Peak; 5 hours for Midday Peak; 2 hours for PM Peak.

2: Based on $12.50 per hour of Synchro Total Signal Delay.

Corridor	City	From	To	Number of Signals in Corridor	Average Daily Traffic	Benefits											
						From Travel Time Runs[1]			From Synchro[1]							Daily User Savings[2]	
						Travel Time (seconds)	Stops	Delay (seconds)	Total Signal Delay (hours)	Stops	Total Travel Time (hours)	Fuel Consumed (gallons)	CO Emissions (kg)	NOx Emissions (kg)	VOC Emissions (kg)	Corridor Total	Per Intersection
Pipeline Road East Corridor	Hurst	Precinct Line Road	Bellaire Drive	6	14,600	188.5	5.6	180.6	-55.5	-1041.0	-55.5	-48.0	-3.5	-0.7	-0.8	$694	$116
Harwood Road Corridor	Hurst	Campus Drive	Norwood Drive	4	18,800	-357.7	1.8	-320.0	56.5	1449.0	58.5	59.5	3.9	0.8	0.9	($706)	($177)
Precinct Line Road North Corridor	Hurst	Overhill Drive	Martin Drive	10	39,800	555.9	1.5	566.7	-116.0	-5984.5	-131.5	-145.0	-6.4	-0.2	0.0	$1,450	$145
Precinct Line Road South Corridor	Hurst	Oakwood Avenue	Bedford-Euless Road	4	21,600	0.4	3.8	18.4	-8.5	-2733.5	-9.0	-36.5	-2.4	-0.5	-0.5	$106	$27
SH 26 Corridor	Hurst	Precinct Line Road	Mid-Cities Boulevard	4	25,400	-289.1	-4.8	-276.4	-77.5	-608.0	-77.5	-73.5	-5.2	-0.7	-0.8	$969	$242
Pipeline Road West Corridor	Hurst	IH 820 (NBFR)	Melbourne Road	3	18,500	-282.8	-10.5	-281.0	-61.0	-12337.5	-61.0	-140.0	-9.8	-1.9	-2.0	$763	$254
Davis Boulevard	North Richland Hills	North Tarrant Parkway	Precinct Line Road	3	11,889	-216.4	-5.0	-50.0	-53.5	-2287.0	-43.8	-20.0	-26.2	-0.6	-0.3	$669	$223
Glenview Drive Corridor	North Richland Hills	Rufe Snow Drive	Grapevine Highway (SH 26)	3	6,013	-484.4	-3.4	-339.4	-17.1	-2008.0	-48.4	-70.3	-8.9	-0.7	-0.2	$214	$71
Holiday Lane	North Richland Hills	IH 820	Liberty Way	6	7,336	-341.0	-15.6	-501.0	-25.4	-3799.0	-74.8	-102.7	-15.8	-1.2	-0.4	$318	$53
Rufe Snow	North Richland Hills	Meadow Lakes Drive	Bursey Road	13	42,070	-1696.0	-51.6	-1589.0	-107.9	-8547.0	-153.6	-773.0	90.6	13.9	3.5	$1,349	$104
Blair Oaks Drive	The Colony	Memorial Drive	N. Colony Blvd.	3	5,974	-466.5	0.5	-189.5	-19.0	-295.0	-17.0	-12.5	-1.0	-0.2	-0.2	$238	$79
Paige Road	The Colony	Memorial Drive	N. Colony Blvd.	3	17,461	44.0	2.4	44.0	-6.0	-34.0	-6.0	-4.0	-0.3	-0.1	-0.1	$75	$25
Windhaven Parkway	The Colony	Plano Parkway	Saintsbury Drive	2	6,381	-19.0	-2.5	-90.0	-8.5	-241.5	-6.5	-6.0	-0.4	-0.1	-0.1	$106	$53
SH 170	Fort Worth	I-35	SH 114	7	19,594	24.8	-21.0	26.3	-233.0	-1051.0	-414.0	-286.0	-19.8	-5.5	-4.6	$2,913	$416
SH 360	Grand Prarie and Mansfield	US 287	Green Oaks Blvd.	8	33,262	-7373.9	-35.8	-2147.5	2.0	-3880.0	-158.0	13.0	0.9	0.1	0.2	($25)	($3)
Group 1	Dallas			106					-1271.0	-99982.0	-1334.0	-1425.0	-100.0	-19.0	-23.0	$15,888	$150
Group 2	Dallas			81					-542.0	-38885.0	-471.0	-738.0	-52.0	-10.0	-12.0	$6,775	$84
Group 3	Dallas			33					-69.0	-590.0	-78.0	-69.0	-5.0	-1.0	-1.0	$863	$26
Group 4	Dallas			22					-74.0	17170.0	89.0	259.0	18.0	3.0	4.0	$925	$42
Totals for TAP Phase 3.2				484					-4963.8	-355319.0	-5718.7	-11351.8	-895.2	-54.2	-50.5	$62,048	$128

1: The totals above are based on the following multipliers from TLS (Traffic Light Synchronization Program): 2 hours for AM Peak; 5 hours for Midday Peak; 2 hours for PM Peak.

2: From $12.50 per hour of Synchro Total Signal Delay.