Appendix A
Alternative Forecast Scenarios

Appendix A

ALTERNATIVE FORECAST SCENARIOS

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Appendix A
ALTERNATIVE FORECAST SCENARIOS

This appendix summarizes the alternative forecasts of enplaned passengers, air cargo, and total aircraft operations for IAH. In addition to the baseline forecasts of aviation demand presented in Chapter 3, *Aviation Forecasts*, two alternative scenarios are prepared for planning purposes and to use as tools to manage uncertainty and anticipate the facility requirements associated with higher levels of aviation activity compared with the baseline forecast.

A.1 ALTERNATIVE FORECAST SCENARIO ASSUMPTIONS

Two alternative forecast scenarios were developed based on the analysis of passenger and cargo activity presented in Chapter 3.

- Scenario 1 is a fast growth scenario reflecting faster regional economic growth than the projections used for the baseline forecasts, as measured by Houston MSA total personal income (in constant dollars) and GDP by international region (in constant dollars). In Scenario 1, total personal income in the Houston MSA is projected to increase an average of 3.7% per year between 2011 and 2035, compared with an average increase of 2.7% per year during the same period in the baseline forecast. Similarly, annual growth in GDP by international region is assumed to increase average of 1% per faster in Scenario 1 than in the baseline forecast.

- Scenario 2 is a slow growth scenario reflecting slower regional economic growth. In Scenario 2, total personal income in the Houston MSA is projected to increase an average of 1.7% per year between 2011 and 2035, compared with an average increase of 2.7% per year during the same period in the baseline forecast. Similarly, annual growth in GDP by international region is assumed to increase average of 1% per slower in Scenario 2 than in the baseline forecast.

All other assumptions used in the alternative forecast scenarios are unchanged from the baseline forecast, including the share of low cost carrier seats at IAH, average load factors, average seats per departure, and cargo carried per operation.

A.2 ENPLANED PASSENGER ALTERNATIVE FORECAST SCENARIOS

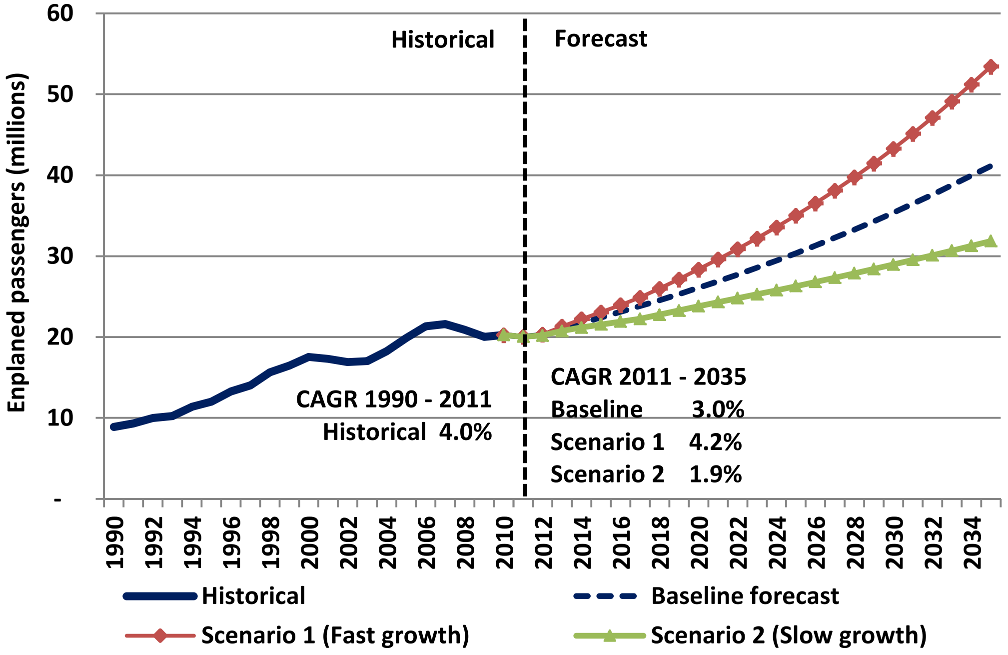
The enplaned passenger alternative forecast scenarios are presented in Tables A-1 and A-2. In Scenario 1, the number of enplaned passengers at IAH is forecast to increase an average of 4.2% per year between 2011 and 2035, from 20.05 million in 2011 to 53.42 million in 2035, as shown in Table A-1. In Scenario 2, the number of enplaned passengers at IAH is forecast to increase an average of 1.9% per year between 2011 and 2035, from 20.05 million in 2011 to 31.86 million in 2035, as shown in Table A-2.

Figure A-1 presents a comparison of the alternative forecast scenarios of enplaned passengers at IAH with the baseline forecast.

Figure A-1

HISTORICAL AND FORECAST ENPLANED PASSENGERS
ALTERNATIVE FORECAST SCENARIOS

George Bush Intercontinental Airport/Houston



Note: The forecasts presented in this figure were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

CAGR = Compound average annual growth rate

Source: Historical: Houston Airport System records.
Forecast: LeighFisher, June 2012.

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Table A-1

ENPLANED PASSENGER FORECASTS BY SECTOR AND MARKET – SCENARIO 1 (FAST GROWTH)

Master Plan Update
George Bush Intercontinental Airport/Houston
2011-2035
In millions

	Historical	Forecast					Compound average annual percent increase				
	2011	2012	2016	2021	2026	2035	2011-2016	2016-2021	2021-2026	2026-2035	2011-2035
Domestic	15.77	15.83	18.18	21.36	25.12	33.69	2.9%	3.3%	3.3%	3.3%	3.2%
International											
Mexico	1.49	1.56	2.03	2.97	4.13	6.99	6.5%	7.9%	6.8%	6.0%	6.7%
Latin America/Caribbean	1.30	1.40	1.95	3.04	4.48	8.29	8.4%	9.2%	8.1%	7.1%	8.0%
Europe	0.75	0.75	0.79	0.84	0.89	0.99	1.1%	1.2%	1.2%	1.1%	1.2%
Canada	0.41	0.42	0.49	0.59	0.70	0.96	3.9%	3.7%	3.5%	3.5%	3.6%
Middle East/Africa	0.21	0.23	0.34	0.56	0.89	1.96	10.3%	10.2%	9.7%	9.2%	9.7%
Asia	0.13	0.14	0.19	0.25	0.34	0.54	7.2%	6.4%	5.9%	5.4%	6.1%
International total	4.28	4.50	5.80	8.26	11.43	19.73	6.2%	7.3%	6.7%	6.3%	6.6%
Total Airport	20.05	20.33	23.97	29.61	36.54	53.42	3.6%	4.3%	4.3%	4.3%	4.2%
Percent domestic	78.6%	77.9%	75.8%	72.1%	68.7%	63.1%					
Percent international	21.4%	22.1%	24.2%	27.9%	31.3%	36.9%					
Revenue passengers											
Originating											
Domestic	6.83	6.92	7.99	9.44	11.15	15.06	3.2%	3.4%	3.4%	3.4%	3.4%
International	2.11	2.21	2.82	3.97	5.47	9.48	6.0%	7.1%	6.6%	6.3%	6.5%
Originating total	8.94	9.13	10.81	13.41	16.63	24.54	3.9%	4.4%	4.4%	4.4%	4.3%
Connecting											
Domestic	8.15	8.26	9.54	11.27	13.31	17.98	3.2%	3.4%	3.4%	3.4%	3.4%
International	2.07	2.18	2.86	4.17	5.85	10.14	6.7%	7.8%	7.0%	6.3%	6.9%
Connecting total	10.22	10.44	12.40	15.44	19.16	28.12	3.9%	4.5%	4.4%	4.4%	4.3%
Revenue passengers total	19.16	19.57	23.21	28.85	35.78	52.66	3.9%	4.4%	4.4%	4.4%	4.3%
Non-revenue passengers	0.89	0.76	0.76	0.76	0.76	0.76	(3.2%)	0.0%	0.0%	0.0%	(0.7%)
Total Airport	20.05	20.33	23.97	29.61	36.54	53.42	3.6%	4.3%	4.3%	4.3%	4.2%
Percent originating	46.7%	46.7%	46.6%	46.5%	46.5%	46.6%					
Percent connecting	53.3%	53.3%	53.4%	53.5%	53.5%	53.4%					

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Note: Mainline includes charter passengers.

Sources: Historical: Houston Airport System records.
Forecast: LeighFisher, June 2012.

Table A-2

ENPLANED PASSENGER FORECASTS BY SECTOR AND MARKET – SCENARIO 2 (SLOW GROWTH)

Master Plan Update
George Bush Intercontinental Airport/Houston
2011-2035
In millions

	Historical	Forecast					Compound average annual percent increase				
	2011	2012	2016	2021	2026	2035	2011-2016	2016-2021	2021-2026	2026-2035	2011-2035
Domestic	15.77	15.83	16.96	18.26	19.67	22.50	1.5%	1.5%	1.5%	1.5%	1.5%
International											
Mexico	1.49	1.50	1.66	2.06	2.39	3.03	2.3%	4.4%	3.1%	2.7%	3.0%
Latin America/Caribbean	1.30	1.36	1.66	2.22	2.82	4.10	4.9%	6.1%	4.9%	4.2%	4.9%
Europe	0.75	0.75	0.76	0.77	0.78	0.80	0.2%	0.3%	0.3%	0.2%	0.3%
Canada	0.41	0.41	0.44	0.48	0.51	0.58	1.7%	1.5%	1.4%	1.4%	1.5%
Middle East/Africa	0.21	0.21	0.26	0.32	0.39	0.53	4.4%	4.4%	3.9%	3.5%	4.0%
Asia	0.13	0.14	0.17	0.20	0.24	0.33	4.9%	4.2%	3.6%	3.2%	3.9%
International total	4.28	4.36	4.95	6.06	7.14	9.37	2.9%	4.1%	3.3%	3.1%	3.3%
Total Airport	20.05	20.19	21.91	24.32	26.81	31.86	1.8%	2.1%	2.0%	1.9%	1.9%
Percent domestic	78.6%	78.4%	77.4%	75.1%	73.4%	70.6%					
Percent international	21.4%	21.6%	22.6%	24.9%	26.6%	29.4%					
Revenue passengers											
Originating											
Domestic	6.83	6.92	7.44	8.03	8.67	9.96	1.7%	1.5%	1.6%	1.6%	1.6%
International	2.11	2.14	2.42	2.91	3.40	4.41	2.7%	3.8%	3.2%	2.9%	3.1%
Originating total	8.94	9.06	9.85	10.94	12.08	14.37	2.0%	2.1%	2.0%	2.0%	2.0%
Connecting											
Domestic	8.15	8.26	8.87	9.58	10.35	11.89	1.7%	1.5%	1.6%	1.6%	1.6%
International	2.07	2.11	2.42	3.03	3.63	4.85	3.2%	4.6%	3.6%	3.3%	3.6%
Connecting total	10.22	10.37	11.29	12.61	13.97	16.73	2.0%	2.2%	2.1%	2.0%	2.1%
Revenue passengers total	19.16	19.43	21.15	23.56	26.05	31.10	2.0%	2.2%	2.0%	2.0%	2.0%
Non-revenue passengers	0.89	0.76	0.76	0.76	0.76	0.76	(3.2%)	0.0%	0.0%	0.0%	(0.7%)
Total Airport	20.05	20.19	21.91	24.32	26.81	31.86	1.8%	2.1%	2.0%	1.9%	1.9%
Percent originating	46.7%	46.6%	46.6%	46.5%	46.4%	46.2%					
Percent connecting	53.3%	53.4%	53.4%	53.5%	53.6%	53.8%					

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Note: Mainline includes charter passengers.

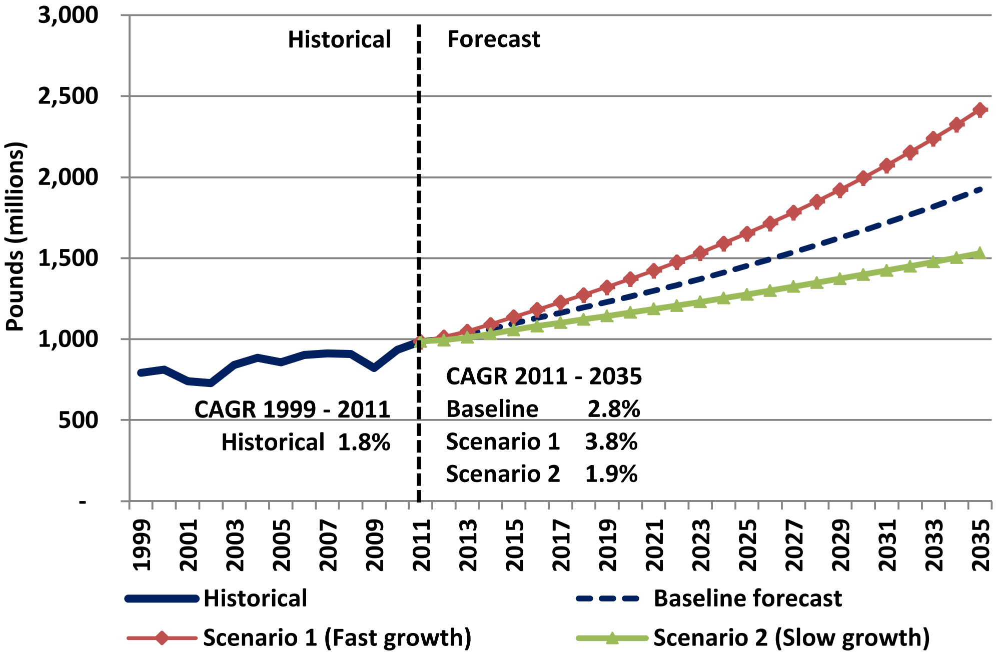
Sources: Historical: Houston Airport System records. Forecast: LeighFisher, June 2012.

Air Cargo Alternative Forecast Scenarios

The alternative air cargo forecast scenarios are presented in Tables A-3 and A-4. In Scenario 1, air cargo (air freight and mail) is forecast to increase an average of 3.8% per year between 2011 and 2035, from 985.5 million pounds in 2011 to 2,417.1 million pounds in 2035, as shown in Table A-3. In Scenario 2, air cargo tonnage is forecast to increase an average of 1.9% per year between 2011 and 2035, from 985.5 million pounds in 2011 to 1,531.4 million pounds in 2035, as shown in Table A-4.

Figure A-2 presents a comparison of the alternative forecast scenarios of air cargo at IAH with the baseline forecast.

Figure A-2
HISTORICAL AND FORECAST AIR CARGO ALTERNATIVE FORECAST SCENARIOS
George Bush Intercontinental Airport/Houston



Note: The forecasts presented in this figure were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

CAGR = Compound average annual growth rate

Source: Historical: Houston Airport System records.
Forecast: LeighFisher, June 2012.

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Table A-3
AIR CARGO FORECASTS BY SECTOR AND MARKET – SCENARIO 1 (FAST GROWTH)
Master Plan Update
George Bush Intercontinental Airport/Houston
2011-2035
In millions of pounds

	Historical	Forecast					Compound average annual percent increase				
	2011	2012	2016	2021	2026	2035	2011-2016	2016-2021	2021-2026	2026-2035	2011-2035
Freight											
Domestic	428.3	439.9	513.2	611.0	726.8	984.8	3.7%	3.6%	3.5%	3.4%	3.5%
International											
Europe	293.4	296.0	318.7	348.0	378.5	437.7	1.7%	1.8%	1.7%	1.6%	1.7%
Asia/Africa/Middle East	139.6	149.8	202.2	283.2	386.0	649.6	7.7%	7.0%	6.4%	6.0%	6.6%
Latin America/ Caribbean	42.8	45.6	62.4	90.2	128.5	237.7	7.8%	7.6%	7.3%	7.1%	7.4%
Mexico	5.7	5.8	6.5	7.4	8.4	10.6	2.8%	2.6%	2.6%	2.6%	2.6%
Canada	1.3	1.3	1.4	1.6	1.8	2.3	2.6%	2.5%	2.4%	2.4%	2.4%
International total	482.8	498.5	591.3	730.5	903.3	1,337.9	4.1%	4.3%	4.3%	4.5%	4.3%
Freight total	911.1	938.3	1,104.5	1,341.5	1,630.1	2,322.6	3.9%	4.0%	4.0%	4.0%	4.0%
Mail											
Domestic	67.4	68.1	70.9	74.5	78.3	85.6	1.0%	1.0%	1.0%	1.0%	1.0%
International	6.9	7.0	7.3	7.6	8.0	8.8	1.0%	1.0%	1.0%	1.0%	1.0%
Mail total	74.4	75.1	78.2	82.1	86.3	94.4	1.0%	1.0%	1.0%	1.0%	1.0%
Total cargo (freight and mail)											
Domestic	495.8	508.0	584.1	685.5	805.1	1,070.4	3.3%	3.3%	3.3%	3.2%	3.3%
International	489.7	505.5	598.6	738.1	911.3	1,346.7	4.1%	4.3%	4.3%	4.4%	4.3%
Total Airport	985.5	1,013.5	1,182.6	1,423.6	1,716.5	2,417.1	3.7%	3.8%	3.8%	3.9%	3.8%
Percent domestic	35.1%	50.1%	49.4%	48.2%	46.9%	44.3%					
Percent international	64.9%	49.9%	50.6%	51.8%	53.1%	55.7%					

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Note: Total cargo is the sum of enplaned and deplaned freight and mail.

Sources: Historical: Houston Airport System records. Forecast: LeighFisher, June 2012.

Table A-4
AIR CARGO FORECASTS BY SECTOR AND MARKET – SCENARIO 2 (SLOW GROWTH)
Master Plan Update
George Bush Intercontinental Airport/Houston
2011-2035
In millions of pounds

	Historical	Forecast					Compound average annual percent increase				
	2011	2012	2016	2021	2026	2035	2011-2016	2016-2021	2021-2026	2026-2035	2011-2035
Freight											
Domestic	428.3	429.4	463.2	500.4	540.7	618.0	1.6%	1.6%	1.6%	1.5%	1.5%
International											
Europe	293.4	292.1	298.3	305.1	311.0	320.9	0.3%	0.5%	0.4%	0.3%	0.4%
Asia/Africa/Middle East	139.6	146.1	179.1	222.3	268.9	365.8	5.1%	4.4%	3.9%	3.5%	4.1%
Latin America/ Caribbean	42.8	44.4	54.3	68.3	84.9	123.2	4.9%	4.7%	4.4%	4.2%	4.5%
Mexico	5.7	5.7	6.1	6.4	6.8	7.5	1.3%	1.1%	1.2%	1.1%	1.2%
Canada	1.3	1.3	1.3	1.4	1.5	1.6	1.1%	1.0%	0.9%	0.9%	1.0%
International total	482.8	489.5	539.0	603.6	673.1	819.0	2.2%	2.3%	2.2%	2.2%	2.2%
Freight total	911.1	918.9	1,002.2	1,103.9	1,213.8	1,437.0	1.9%	2.0%	1.9%	1.9%	1.9%
Mail											
Domestic	67.4	68.1	70.9	74.5	78.3	85.6	1.0%	1.0%	1.0%	1.0%	1.0%
International	6.9	7.0	7.3	7.6	8.0	8.8	1.0%	1.0%	1.0%	1.0%	1.0%
Mail total	74.4	75.1	78.2	82.1	86.3	94.4	1.0%	1.0%	1.0%	1.0%	1.0%
Total cargo (freight and mail)											
Domestic	495.8	497.5	534.1	574.8	619.0	703.6	1.5%	1.5%	1.5%	1.4%	1.5%
International	489.7	496.5	546.3	611.2	681.2	827.8	2.2%	2.3%	2.2%	2.2%	2.2%
Total Airport	985.5	994.0	1,080.4	1,186.1	1,300.1	1,531.4	1.9%	1.9%	1.9%	1.8%	1.9%
Percent domestic	35.1%	50.0%	49.4%	48.5%	47.6%	45.9%					
Percent international	64.9%	50.0%	50.6%	51.5%	52.4%	54.1%					

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Note: Total cargo is the sum of enplaned and deplaned freight and mail.

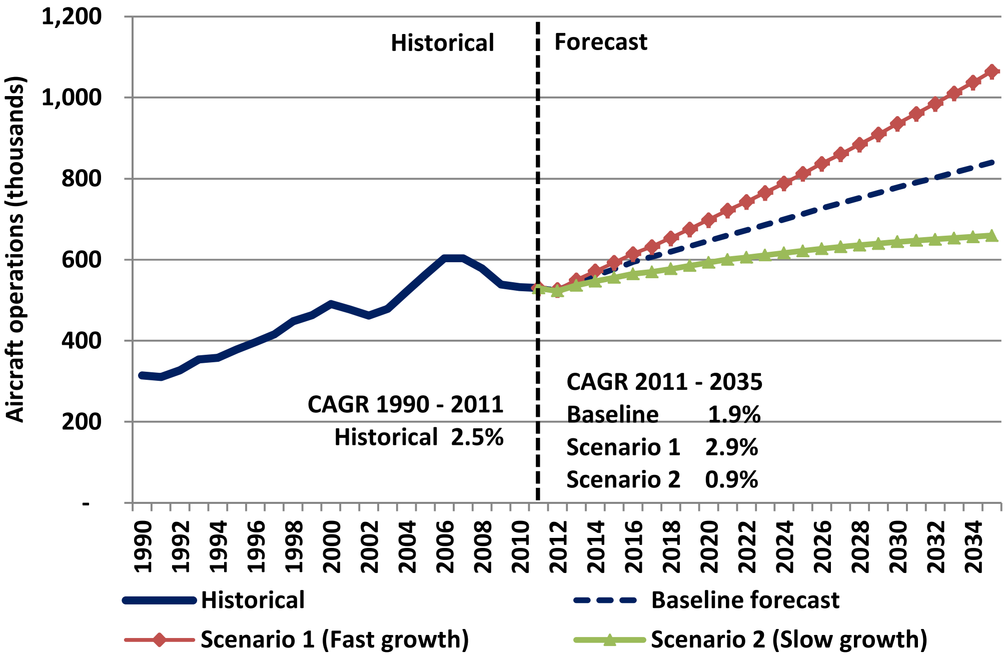
Sources: Historical: Houston Airport System records.
Forecast: LeighFisher, June 2012.

ALTERNATIVE AIRCRAFT OPERATIONS FORECASTS

Tables A-5 and A-6 provide aircraft operations forecasts for Scenarios 1 and 2. In Table A-5, the passenger and cargo airline operations are shown as derived from the enplaned passenger and air cargo tonnage totals associated with Scenario 1; Table A-6 provides the same for Scenario 2. In Scenario 1, total aircraft operations (passenger and cargo airlines, general aviation, and military) are forecast to increase an average of 2.9% per year between 2011 and 2035, from 530,000 in 2011 to 1,064,700 in 2035, as shown in Table A 5. In Scenario 2, total aircraft operations are forecast to increase an average of 0.9% per year between 2011 and 2035, from 530,000 in 2011 to 659,600 in 2035, as shown in Table A-6.

Figure A-3 presents a comparison of the alternative forecast scenarios of aircraft operations at IAH with the baseline forecast.

Figure A-3
HISTORICAL AND FORECAST AIRCRAFT OPERATIONS
ALTERNATIVE FORECAST SCENARIOS
George Bush Intercontinental Airport/Houston



Note: The forecasts presented in this figure were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

CAGR = Compound average annual growth rate

Source: Historical: Houston Airport System records.
Forecast: LeighFisher, June 2012.

Table A-5

AIRCRAFT OPERATIONS FORECASTS – SCENARIO 1 (FAST GROWTH)

Master Plan Update
George Bush Intercontinental Airport/Houston
2011-2035

	Historical	Forecast					Compound average annual percent increase				
	2011	2012	2016	2021	2026	2035	2011-2016	2016-2021	2021-2026	2026-2035	2011-2035
Air Carrier											
Passenger airlines											
Mainline	250.8	217.1	257.0	311.6	375.9	523.1	0.5%	3.9%	3.8%	3.7%	3.1%
Regional	22.8	27.3	32.5	39.6	48.0	67.6	7.4%	4.0%	3.9%	3.9%	4.6%
Passenger—total	273.6	244.4	289.5	351.2	423.9	590.8	1.1%	3.9%	3.8%	3.8%	3.3%
Cargo airlines	8.9	9.1	10.6	12.4	14.6	19.3	3.6%	3.2%	3.2%	3.2%	3.3%
Other	8.6	4.0	4.0	4.0	4.0	4.0	(14.3%)	0.0%	0.0%	0.0%	(3.2%)
Air Carrier total	291.1	257.5	304.1	367.6	442.4	614.0	0.9%	3.9%	3.8%	3.7%	3.2%
Air Taxi											
Passenger airlines	223.8	249.6	290.9	333.6	373.3	427.4	5.4%	2.8%	2.3%	1.5%	2.7%
Cargo airlines	1.3	1.3	1.5	1.7	2.0	2.6	2.5%	3.0%	3.0%	2.9%	2.9%
Other	1.3	5.0	5.0	5.0	5.0	5.0	31.4%	0.0%	0.0%	0.0%	5.9%
Air Taxi total	226.4	255.9	297.3	340.3	380.3	435.0	5.6%	2.7%	2.2%	1.5%	2.8%
General Aviation											
Itinerant	12.2	12.3	12.8	13.5	14.2	15.5	1.0%	1.0%	1.0%	1.0%	1.0%
Local	--	--	--	--	--	--	--	--	--	--	--
General Aviation total	12.2	12.3	12.8	13.5	14.2	15.5	1.0%	1.0%	1.0%	1.0%	1.0%
Military	0.2	0.2	0.2	0.2	0.2	0.2	(3.6%)	--	--	--	--
Total Airport	530.0	525.9	614.5	721.7	837.1	1,064.7	3.0%	3.3%	3.0%	2.7%	2.9%
Commercial aircraft operations											
Passenger airlines											
Air Carrier	273.6	244.4	289.5	351.2	423.9	590.8	1.1%	3.9%	3.8%	3.8%	3.3%
Air Taxi	223.8	249.6	290.9	333.6	373.3	427.4	5.4%	2.8%	2.3%	1.5%	2.7%
	497.4	494.0	580.4	684.8	797.2	1,018.2	3.1%	3.4%	3.1%	2.8%	3.0%
All-cargo airlines											
Air Carrier	8.9	9.1	10.6	12.4	14.6	19.3	3.6%	3.2%	3.2%	3.2%	3.3%
Air Taxi	1.3	1.3	1.5	1.7	2.0	2.6	2.5%	3.0%	3.0%	2.9%	2.9%
	10.2	10.3	12.1	14.1	16.5	21.8	3.4%	3.2%	3.2%	3.1%	3.2%
Total commercial operations	517.5	513.4	601.5	708.0	822.8	1,049.0	3.1%	3.3%	3.1%	2.7%	3.0%

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Note: Mainline includes charter passengers.

Sources: Historical: Houston Airport System records. Forecast: LeighFisher, June 2012.

Table A-6

AIRCRAFT OPERATIONS FORECASTS – SCENARIO 2 (SLOW GROWTH)

Master Plan Update
George Bush Intercontinental Airport/Houston
2011-2035

	Historical	Forecast					Compound average annual percent increase				
	2011	2012	2016	2021	2026	2035	2011-2016	2016-2021	2021-2026	2026-2035	2011-2035
Air Carrier											
Passenger airlines											
Mainline	250.8	215.4	234.1	255.0	275.1	313.5	(1.4%)	1.7%	1.5%	1.5%	0.9%
Regional	22.8	27.1	29.5	32.1	34.7	39.6	5.3%	1.7%	1.5%	1.5%	2.3%
Passenger—total	273.6	242.5	263.6	287.1	309.7	353.1	(0.7%)	1.7%	1.5%	1.5%	1.1%
Cargo airlines	8.9	8.9	9.6	10.2	10.8	12.0	1.5%	1.2%	1.2%	1.2%	1.3%
Other	8.6	4.0	4.0	4.0	4.0	4.0	(14.3%)	0.0%	0.0%	0.0%	(3.2%)
Air Carrier total	291.1	255.3	277.2	301.3	324.6	369.1	(1.0%)	1.7%	1.5%	1.4%	1.0%
Air Taxi											
Passenger airlines	223.8	248.7	268.3	279.0	282.1	268.1	3.7%	0.8%	0.2%	(0.6%)	0.8%
Cargo airlines	1.3	1.2	1.3	1.4	1.5	1.6	0.4%	1.0%	1.1%	1.0%	0.9%
Other	1.3	5.0	5.0	5.0	5.0	5.0	31.4%	0.0%	0.0%	0.0%	5.9%
Air Taxi total	226.4	255.0	274.6	285.4	288.5	274.7	3.9%	0.8%	0.2%	(0.5%)	0.8%
General Aviation											
Itinerant	12.2	12.3	12.8	13.5	14.2	15.5	1.0%	1.0%	1.0%	1.0%	1.0%
Local	--	--	--	--	--	--	--	--	--	--	--
General Aviation total	12.2	12.3	12.8	13.5	14.2	15.5	1.0%	1.0%	1.0%	1.0%	1.0%
Military	0.2	0.2	0.2	0.2	--	0.2	(3.6%)	--	--	--	--
Total Airport	530.0	522.9	564.9	600.4	627.3	659.6	1.3%	1.2%	0.9%	0.6%	0.9%
Commercial aircraft operations											
Passenger airlines											
Air Carrier	273.6	242.5	263.6	287.1	309.7	353.1	(0.7%)	1.7%	1.5%	1.5%	1.1%
Air Taxi	223.8	248.7	268.3	279.0	282.1	268.1	3.7%	0.8%	0.2%	(0.6%)	0.8%
	497.4	491.2	531.9	566.1	591.8	621.2	1.4%	1.3%	0.9%	0.5%	0.9%
All-cargo airlines											
Air Carrier	8.9	8.9	9.6	10.2	10.8	12.0	1.5%	1.2%	1.2%	1.2%	1.3%
Air Taxi	1.3	1.2	1.3	1.4	1.5	1.6	0.4%	1.0%	1.1%	1.0%	0.9%
	10.2	10.1	10.9	11.6	12.3	13.6	1.4%	1.2%	1.2%	1.1%	1.2%
Total commercial operations	517.5	510.3	551.9	586.7	613.1	643.9	1.3%	1.2%	0.9%	0.5%	0.9%

The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.

Note: Mainline includes charter passengers.

Sources: Historical: Houston Airport System records. Forecast: LeighFisher, June 2012.

Appendix B
Airfield and Airspace Simulation Assumptions

Appendix B

AIRFIELD AND AIRSPACE SIMULATION ASSUMPTIONS

Prepared by:

LeighFisher Inc.

Appendix B
AIRFIELD AND AIRSPACE SIMULATION ASSUMPTIONS

The major assumptions developed in the analysis are summarized below.

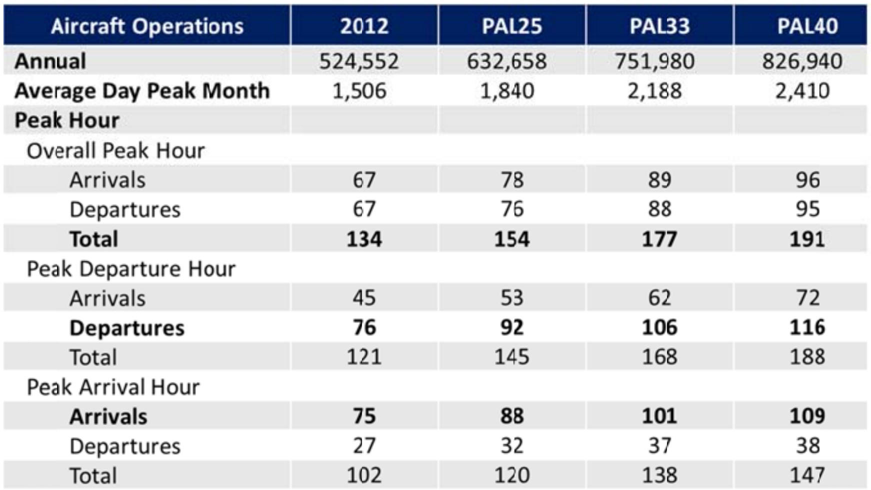
B.1 FORECAST DEMAND/FLIGHT SCHEDULE DEVELOPMENT

Aircraft flight schedules for the 2012, PAL25, PAL33, and PAL40 demand levels were developed using the annual activity forecasts. The flight schedules used in the simulation effort represent an "Average-Day-Peak-Month" (ADPM), (i.e. a flight schedule with a daily number of operations representing the total number of operations in July divided by 31). More details on the forecast and flight schedule development can be found in the forecast documentation, entitled, *Aviation Demand Forecast*, prepared by LeighFisher, June 20, 2012.

Table B-1 summarizes the ADPM demand levels that were simulated. Commercial passenger and cargo arrivals in the flight schedules were "linked" to subsequent departing flights to provide a matched flight schedule to facilitate the TAAM modeling of terminal gate occupancy and pushback operations.

Table B-1

AVERAGE-DAY-PEAK-MONTH (ADPM) ACTIVITY LEVELS

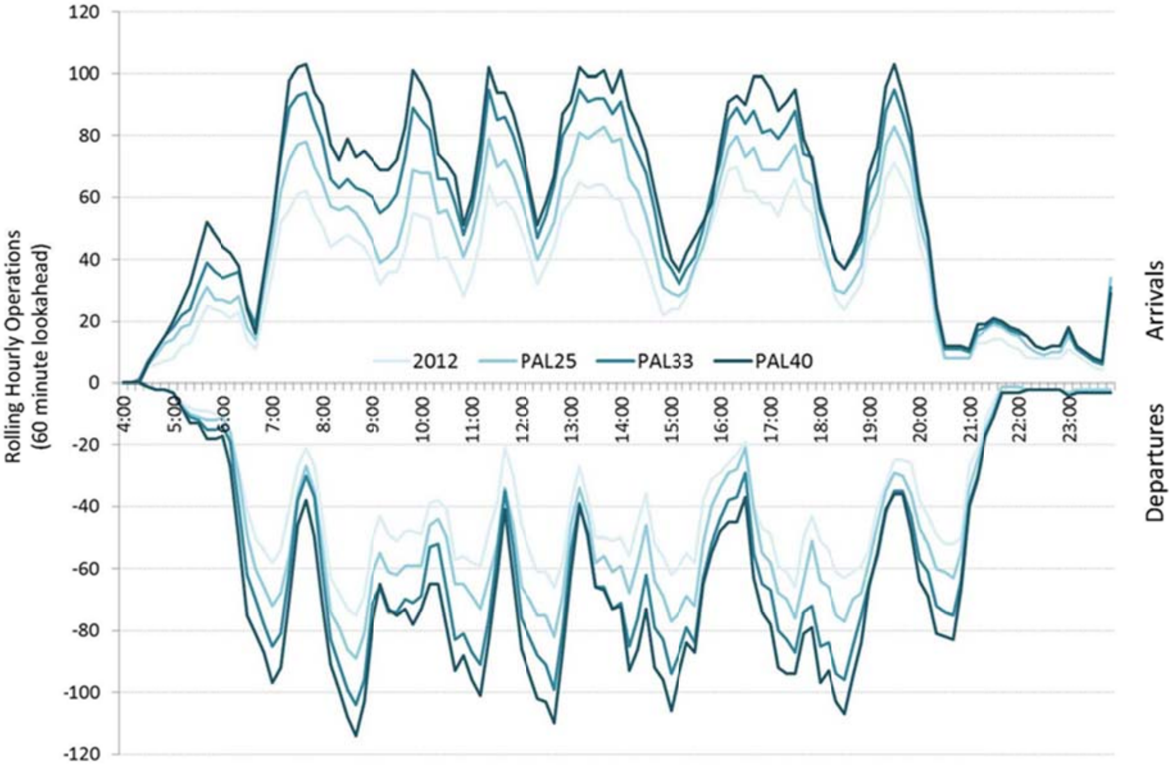


Aircraft Operations	2012	PAL25	PAL33	PAL40
Annual	524,552	632,658	751,980	826,940
Average Day Peak Month	1,506	1,840	2,188	2,410
Peak Hour				
Overall Peak Hour				
Arrivals	67	78	89	96
Departures	67	76	88	95
Total	**134**	**154**	**177**	**191**
Peak Departure Hour				
Arrivals	45	53	62	72
Departures	**76**	**92**	**106**	**116**
Total	121	145	168	188
Peak Arrival Hour				
Arrivals	**75**	**88**	**101**	**109**
Departures	27	32	37	38
Total	102	120	138	147

Source: LeighFisher, February 2013.

Figure B-1 shows the temporal distribution of the 2012, PAL25, PAL33, and PAL40 passenger flight schedules. This figure shows the number of passenger operations scheduled in 10-minute rolling hourly average. Arrivals are shown plotted upward on the positive vertical or y-axis, and departures are shown plotted downward on the negative y-axis.

Figure B-1
TEMPORAL DISTRIBUTION, PASSENGER OPERATIONS

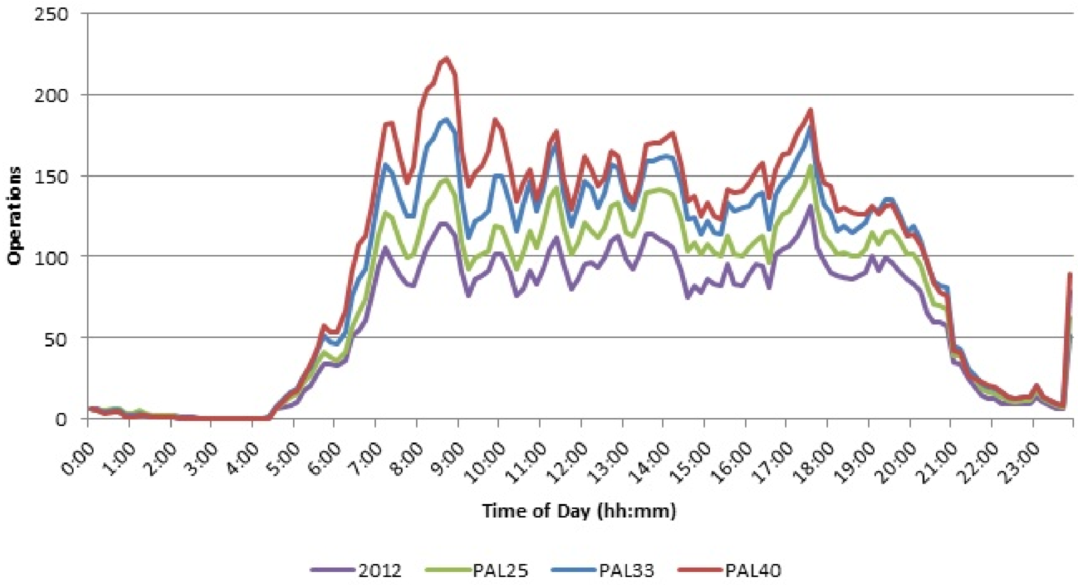


Source: LeighFisher, February 2013.

The historical peaking characteristic at the Airport shows approximately 9% of the daily arrivals occurring in the peak hour, and approximately 10% of the daily departures in the peak hour. In determining the forecast levels of peak hour operations it was assumed that the overall peak hour should not change but the total peak hour operations would not increase as quickly as the growth in total operations for the future activity demand levels, i.e. de-peaked. Part of the increase in peak hour operations is spread over other arrival and departure banks, as much of the future growth is expected to be in market frequency. The percentage of operations from the peak hour that are “spread-over” to the other arrival and departure banks were developed based on the mid-range elasticity assumptions from FAA and United Kingdom’s Civil Aviation Authority (CAA) forecast methodologies. The hourly operations for each activity level before and after de-peaking are shown in Figures B-2 and B-3. Tables B-2 and B-3 compare how the hourly arrivals and departures in each bank changed before and after de-peaking. The de-peaked flight schedules are used in this study.

Figure B-2

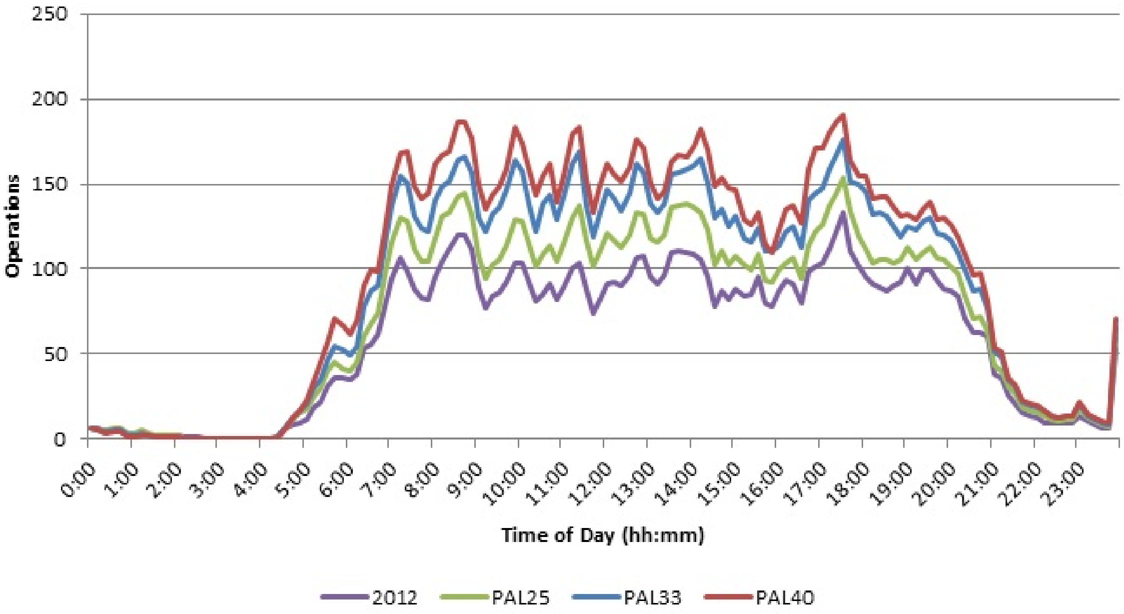
AVERAGE DAY PEAK MONTH ACTIVITY LEVELS – PRIOR TO DE-DEPEAKING



Source: LeighFisher, February 2013.

Figure B-3

AVERAGE DAY PEAK MONTH ACTIVITY LEVELS – AFTER DE-DEPEAKING



Source: LeighFisher, February 2013.

Table B-2

DEPARTURE BANKS (BEFORE AND AFTER DE-PEAKING)

	Original				Revised (De-peaked)			
Departure Banks	2012	PAL25	PAL33	PAL40	2012	PAL25	PAL33	PAL40
7:00	59	71	86	97	59	72	86	98
8:40 *(peak)*	75	94	123	145	75	91	104	114
11:10	56	76	93	97	56	71	91	101
12:40	64	80	97	104	64	81	98	109
14:10	54	71	84	90	54	66	85	93
15:00	64	78	87	93	64	79	94	106
17:30	66	78	95	103	66	76	87	94
18:30	62	72	77	87	62	77	95	106
21:40	55	62	71	66	55	64	77	85
Total Departures During Banks	555	682	813	882	555	677	817	906

Source: LeighFisher, February 2013.

Table B-3

ARRIVAL BANKS (BEFORE AND AFTER DE-PEAKING)

	Original				Revised (De-peaked)			
Arrival Banks	2012	PAL25	PAL33	PAL40	2012	PAL25	PAL33	PAL40
5:40	26	29	36	41	26	32	40	53
7:40	62	74	95	110	62	78	94	103
9:50	54	64	80	87	54	69	91	103
11:20	60	77	92	97	60	77	94	101
13:10	64	80	90	93	64	81	94	101
16:20 *(peak)*	69	85	101	116	69	80	89	93
17:30	67	78	85	87	67	78	89	96
19:30 *(peak)*	72	87	100	96	72	83	95	103
Total Arrivals During Banks	474	574	679	727	474	578	686	753

Source: LeighFisher, February 2013.

B.2 WEATHER AND WIND ANALYSIS

Weather conditions—namely cloud ceiling, visibility, and wind conditions—determine the air traffic control (ATC) procedures that can be used at the Airport at any given time, which in turn affect runway capacity and aircraft delay.

Based on discussions with representatives from FAA, as well as analysis of weather observation data available from the FAA Aviation System Performance Metrics (ASPM) we recommend that the following weather conditions to be analyzed in the simulation, as shown in Table B-4. Assumed runway use practices are described in the following section.

Table B-4
WEATHER CONDITIONS

Weather Condition	Ceiling (feet)	Visibility (miles)	Occurrence
VMC	5,000	5	75.8%
MVMC	1,000	3	17.9
IMC	<1,000	<3	6.3

Source: LeighFisher, based on analysis of Integrated Surface Hourly Data (TD-3505), January 1, 2002 through December 31, 2011, from the National Climatic Data Center.

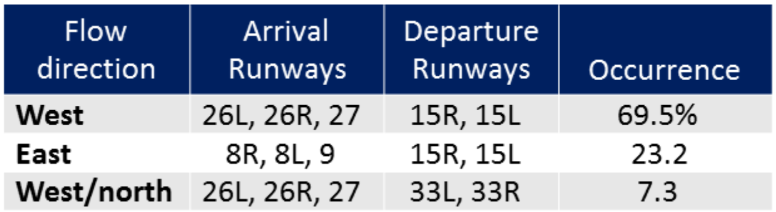
To limit the number of model runs to a reasonable set, two weather conditions were selected to model, VMC (Visual Meteorological Conditions) and IMC (Instrument Meteorological Conditions). MVMC was considered to be modeled as IMC for purpose of estimating average annual aircraft delays. For the purpose of annualization, the weather occurrence percentages are adjusted, resulting in VMC accounting for 75.8% and IMC (combined with MVMC) accounting for 24.2% of the time.

B.3 RUNWAY CONFIGURATIONS

Direction of air traffic flow is largely dictated by prevailing wind and weather conditions. Because the Airport's primary three runways are in an east-west orientation, the two primary runway operating configurations at the Airport are east flow and west flow. Data for 2007 through 2011 from ASPM were used to estimate the percent occurrence of differing flow configurations, summarized in Table B-5.

These annual percent occurrences were confirmed through discussions with Airport Stakeholders. The Airport also operates in west/north flow and other configurations for approximately 7.3% of the time. For purposes of the simulation modeling, east and west flow were considered the primary flow configurations, and their occurrences were normalized to 100%, resulting in 75.0% west flow and 25.0% east flow.

Table B-5
RUNWAY USE



Flow direction	Arrival Runways	Departure Runways	Occurrence
West	26L, 26R, 27	15R, 15L	69.5%
East	8R, 8L, 9	15R, 15L	23.2
West/north	26L, 26R, 27	33L, 33R	7.3

Source: LeighFisher, based on analysis of FAA ASPM database for 2007 through 2011 representing 95% of all hours.

The TAAM model dynamically balances runway use based on demand through the use of current rules such that the secondary arrival runways are used during arrival peaks, and secondary departure runways are used during departure peaks.

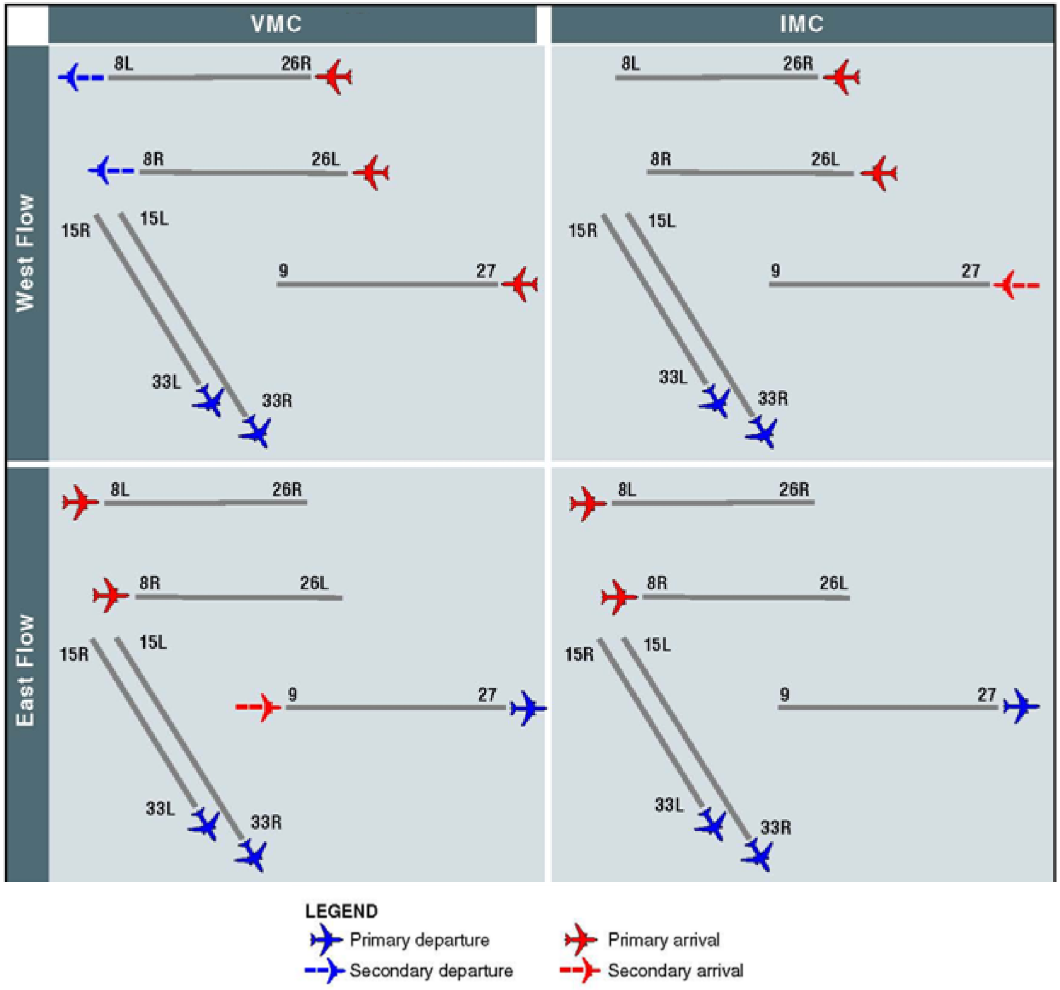
Typical east and west flow runway configurations are shown in Figure B-4. Runway use was simulated in accordance with these runway configurations. The primary arrival runways are 8R-26L, 8L-26R, and 9-27, while the primary departure runways are 15L and 15R.

B.4 EXPERIMENTAL DESIGN AND ANNUALIZATION

The experimental design specifies the characteristics of the individual TAAM simulation runs—or "experiments"—that were conducted in the baseline analysis. These characteristics include runway-use configuration, weather condition, and activity level for each scenario. Table B-6 outlines the runway use configuration, weather condition, and demand activity level of the simulation experiments that will be performed for this baseline analysis. Given the intricate dependencies of the other facility requirements (e.g., terminal location and sizing) on airfield requirements, the experiments for assessing performance of activity levels representing PAL33 and PAL40 will be conducted as part of the alternatives analysis.

Figure B-4

RUNWAY CONFIGURATIONS



Source: LeighFisher, based on discussions with IAH Airport Traffic Control Tower, December 2012.

Table B-6

TAAM EXPERIMENTAL DESIGN

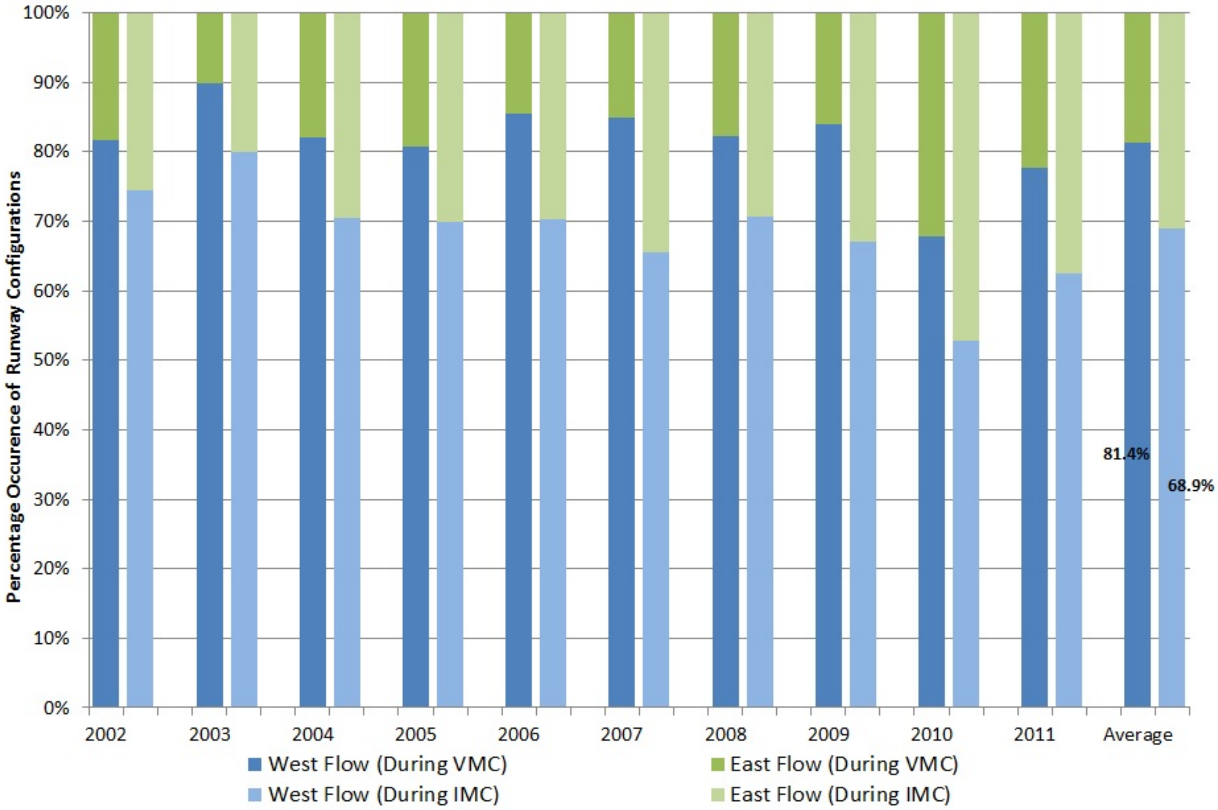
Experiment	Scenario	Runway use configuration	Activity level	Weather	Objective
1	Baseline	West flow	2012	VMC	Baseline models for comparison and calibration
2				IMC	
3		East flow		VMC	
4				IMC	

Source: LeighFisher, April 2013.

Results of the simulation such as taxiing time and delay for the individual experiments are multiplied by the estimated percent occurrence of their associated runway use configuration and weather condition to obtain an annualized total estimate. It is observed that west flow is operated more frequently during VMC than during IMC, as shown by FAA's ASPM data from 2002-2011 in Figure 5. The estimated percent occurrences reflecting such differences are shown in Table 7 and are used in the annualization of experimental results.

Figure B-5

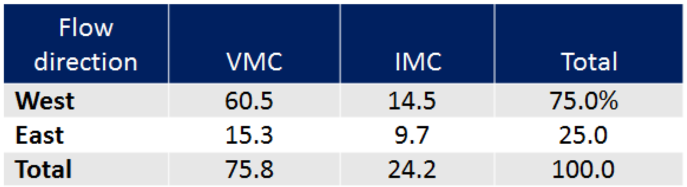
PERCENTAGE OCCURRENCE OF WEST/EAST FLOW DURING VMC/IMC



Source: LeighFisher analysis of FAA ASPM (Aviation System Performance Metrics) database for 2002 through 2011, April 2013.

Table B-7

ANNUALIZATION PERCENT OCCURRENCE



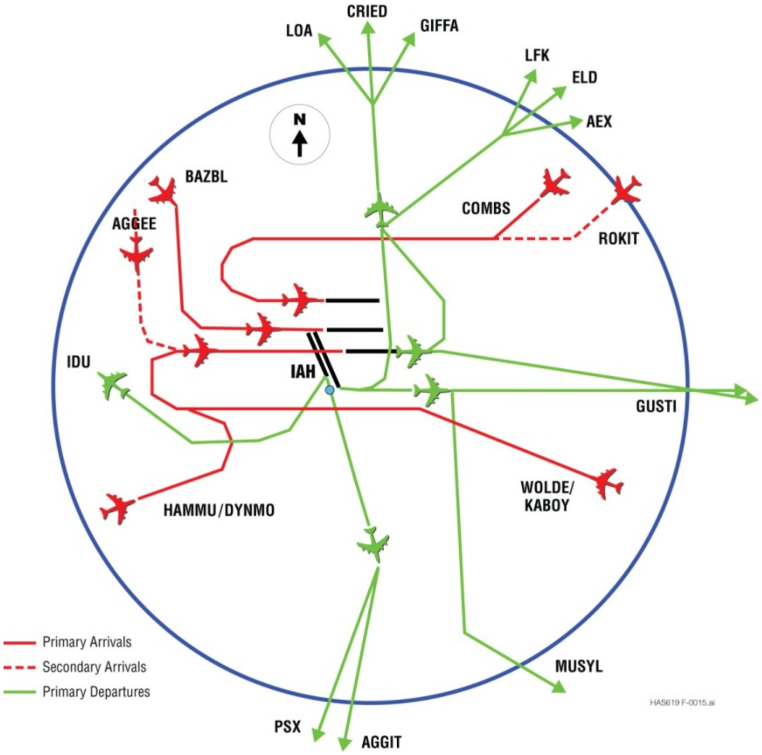
Flow direction	VMC	IMC	Total
West	60.5	14.5	75.0%
East	15.3	9.7	25.0
Total	75.8	24.2	100.0

Source: LeighFisher, April 2013.

B.5 AIRSPACE STRUCTURE AND FLIGHT PROCEDURES

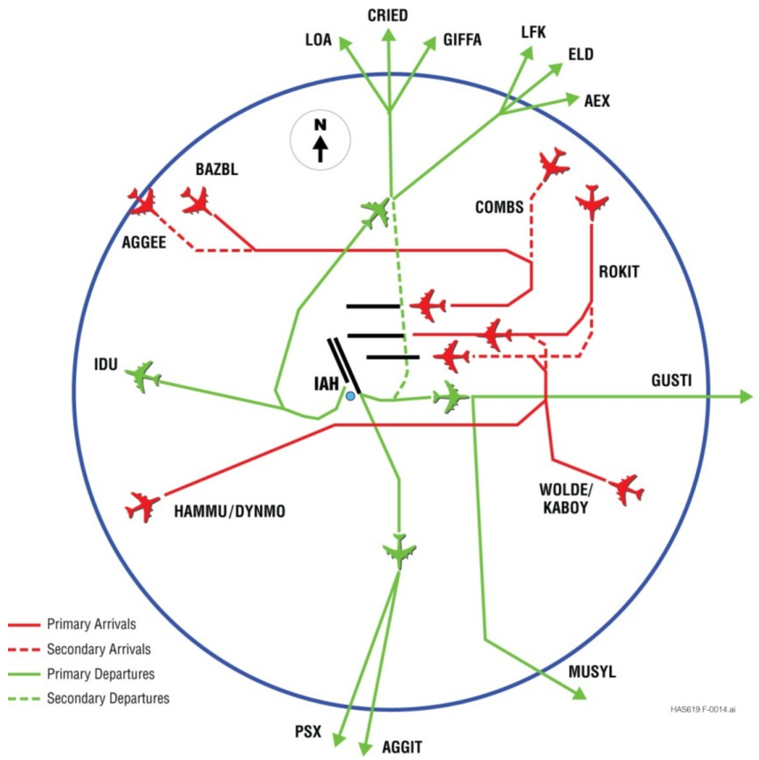
Developing the appropriate and accurate modeling assumptions of the airspace structure and flight procedures is important to establish representative runway assignments, and in turn representing the appropriate demands on the terminal gates and taxiway system. The airspace structure and flight procedures assumed in TAAM were developed from currently published Standard Terminal Arrival Routes (STARs) and Standard Instrument Departure Procedures (SIDs), Bush Intercontinental Airport Master Plan (December 2006), Existing Operating Conditions, Conway Consulting, Ltd. (January 20, 2011), the Local Operating Procedures at Houston Intercontinental Tower (IAH), with inputs from the FAA ATC personnel and airline representatives.

Figure B-6
GENERAL ARRIVAL/DEPARTURE FIX AIRSPACE STRUCTURE (EAST FLOW)



Source: LeighFisher, April 2013.

Figure B-7
GENERAL ARRIVAL/DEPARTURE FIX AIRSPACE STRUCTURE (WEST FLOW)



Source: LeighFisher, April 2013.

B.5.1 Arrival/Departure Fix Structure

Figures B-6 and B-7 illustrate the arrival and departure fix airspace structure simulated in the model. The close-in airspace structure was considered, out to approximately 40 nautical miles from the Airport. In both flows, arriving flights were assigned to arrive from one of the four directions, with dual arrival fixes in each direction: ROKIT and COMBS from the northeast; AGGEE and BAZBL from the northwest; WOLDE and KABOY from the southeast; and HAMMU and DYNMO from the southwest. Likewise, departing flights were assigned to depart via one of the departure gates to six directions: LFK, ELD, and AEX to the northeast; GIFFA, CRIED, and LOA to the northwest; IDU to the west; PSX and AGGIT to the southwest; MUSYL to the southeast; and GUSTI to the east.

Within the terminal airspace, STARs were defined between these arrival fix to the runway ends at the Airport while SIDs were defined between the runway ends to the departure gates, all in accordance with current air traffic procedures and input provided by the Airport.

B.5.2 Arrival/Departure Fix Assignment by Market

In all experiments, aircraft are assigned to the arrival and departure fixes on the basis of their origin or destination airports to minimize the amount of airborne crossing. The heading from IAH to the origin or destination airport is calculated, and the fix with the closest heading is selected. Example assignments of market to arrival and departure fixes are shown below:

Arrivals

- Northeast via DAS to EWR, MEM, ORD, etc.
- Northwest via RIICE to YVR, DEN, PDX, SEA, etc.
- Southwest via CARNE to ABQ, HNL, LAX, Mexico (MEX), etc.
- Southeast via WOLDE to FLL, SJU, Mexico (CUN), Europe, Africa, Asia, etc.

Departures

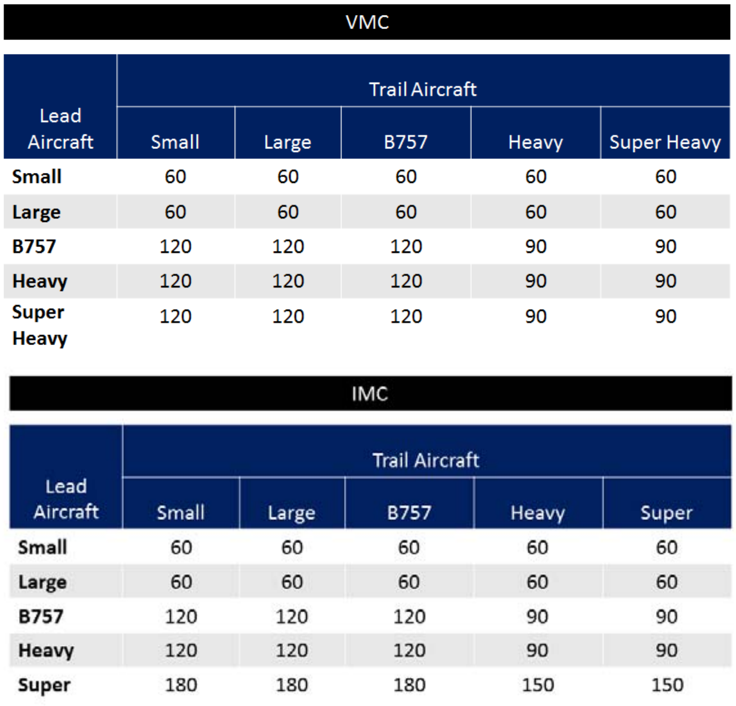
- East from EWR, ATK, YYZ, Europe, and Africa via GUSTI
- North from DFW, ORD, YEG, and STL via CRIED
- West from ABQ, COS, LAX, and YVR via IDU
- Southwest from South America and Mexico (MEX) via MUSYL
- Southeast from HNL and Mexico (CUN) via THX

B.5.3 Air Traffic Control Rules

With respect to air traffic control rules, separation requirements specified in FAA Order JO 7110.65T, Air Traffic Control, were applied, including wake turbulence and in-trail separation requirements. Wake turbulence governs the required separation between successive departures on same or dependent runways, whereas in-trail requirements govern separation between successive arrivals on same or dependent runways. These separation requirements vary depending on the difference in size between the leading aircraft and the trailing aircraft, which larger separations required behind heavier aircraft to protect for wake turbulence. The minimum separations specified in the FAA Order 7110.65, Air Traffic Control, were applied to the five aircraft classes, as shown in Tables B-8 and B-9.

Table B-8

ASSUMED MINIMUM DEPARTURE/DEPARTURE Separations (SECONDS)



VMC

Lead Aircraft	Trail Aircraft				
	Small	Large	B757	Heavy	Super Heavy
Small	60	60	60	60	60
Large	60	60	60	60	60
B757	120	120	120	90	90
Heavy	120	120	120	90	90
Super Heavy	120	120	120	90	90

IMC

Lead Aircraft	Trail Aircraft				
	Small	Large	B757	Heavy	Super
Small	60	60	60	60	60
Large	60	60	60	60	60
B757	120	120	120	90	90
Heavy	120	120	120	90	90
Super	180	180	180	150	150

Notes:

(1) Departure separations behind small/large aircraft are assumed to be 60 seconds instead of the 50 seconds minimum.

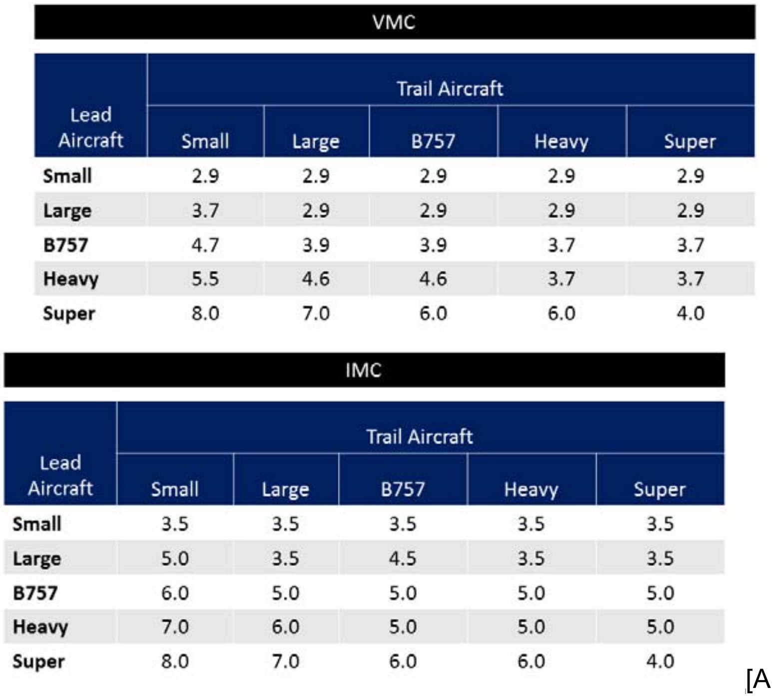
(2) FAA has classified the Boeing 747-8 and 787 aircraft as regular “Heavy” jets; “Super” refers to only the Airbus 380.

(3) Departures from Parallel runways less than 2,550 feet apart are considered as a single runway with regard to the Airbus 380 because of the possible effects of wake turbulence.

Sources: *FAA Order 7110.65M, Air Traffic Control; FAA Notice JO 7110.582, Procedures for Airbus A380-800 (A388) Flights (June 18, 2012);* and discussions with FAA IAH ATC personnel.

Table B-9

ASSUMED MINIMUM ARRIVAL/ARRIVAL In-Trail Separations (NAUTICAL MILES)



VMC

Lead Aircraft	Trail Aircraft				
	Small	Large	B757	Heavy	Super
Small	2.9	2.9	2.9	2.9	2.9
Large	3.7	2.9	2.9	2.9	2.9
B757	4.7	3.9	3.9	3.7	3.7
Heavy	5.5	4.6	4.6	3.7	3.7
Super	8.0	7.0	6.0	6.0	4.0

IMC

Lead Aircraft	Trail Aircraft				
	Small	Large	B757	Heavy	Super
Small	3.5	3.5	3.5	3.5	3.5
Large	5.0	3.5	4.5	3.5	3.5
B757	6.0	5.0	5.0	5.0	5.0
Heavy	7.0	6.0	5.0	5.0	5.0
Super	8.0	7.0	6.0	6.0	4.0

[AS1]

Note:

(1) FAA has classified the Boeing 747-8 and 787 aircraft as regular "Heavy" jets; "Super" refers to only the Airbus 380.

Sources: *FAA Order 7110.65M, Air Traffic Control; FAA EM-78-8A, Parameters of Future ATC Systems Relating to Airport Capacity/Delay, FAA Notice JO 7110.582*, Procedures for Airbus A380-800 (A388) Flights (June 18, 2012); and discussions with FAA IAH ATC personnel.

Additionally, the minimum separation requirements between visual approaches on final approach under VMC shown in Table 9 were obtained from the FAA report: Parameters of Future ATC Systems Relating to Airport Capacity/Delay, FAA Em-78-8A, which reflects the tendency for the separations between successive visual approaches to "compress" (i.e. reduced separation distances as successive aircraft decelerate on final approach). The model adds a buffer to reflect the accuracy with which controllers can deliver aircraft to the final approach (this buffer is usually on the order of one nautical mile) such that minimum separation distance standards are ensured not to be violated.

Please note that the FAA Notice N JO 7110.582, Procedures for Airbus A388 Flights, presents current FAA standards for separations behind the A380, which now agree with the current ICAO requirements. These rules require that the separations behind an A380 be 2.0 nautical miles greater than for heavy jets. So, instead of the "4-5-6" rule, the "6-7-8" rule is applied. In addition, ICAO specifies that the separation for an A388 behind an A388 is 4.0 miles (ICAO). FAA rules also require that 1.0 additional minute be added when applying separation criteria for terminal operations are defined in minutes.

In addition to the standard separation requirements, there are notable exceptions:

- During west flow in IMC, arrivals to Runway 27 are required to be 10 nautical miles in-trail.
- During east flow in both VMC and IMC, arrivals to Runway 9 are required to be 10 nautical miles in-trail.

Airspeed restrictions for arriving flights were specified in TAAM to reflect the restrictions that are currently used by air traffic controllers. On final approach, arrival speeds were reduced to 170 knots by the time aircraft reach the outer marker of the instrument landing system (ILS).

B.5.4 Runway Dependencies – VMC

In west flow, arrival Runways 26L, 26R, and 27 are operated independently since they are widely-spaced parallel runways. Departures from Runways 15L and 15R are independent in VMC, aside from requisite wake turbulence dependencies and spacing (as shown in Table 9).

In east flow, arrivals to Runways 8L, 8R, and 9 are operated independently, given that they are widely-spaced parallel runways. Departures from 15L and 15R are independent in VMC, aside from requisite wake turbulence dependencies and spacing. Departures from 15L and 15R are held when an arrival on final approach to Runway 9 is within 2.0 nautical miles of Runway 15R. Once an arrival to Runway 9 passes the centerline of Runways 15R, the departures can be released. Runway 9 arrivals are spaced at 10 NM to maintain departure throughput and are restricted to non-heavy aircraft. In addition, departure throughput is impacted by west and north bound aircraft requiring 15L due to length which cross over Runway 15R.

Mixed operations on a single runway are rarely used in either flow. During west flow, Runways 26L and 26R are operated as arrival-only runways during arrival banks and are typically only used for departures as an offload during departure banks. Similarly, during east flow, Runway 9 is operated as either an arrival-only or a departure-only runway.

Land-And-Hold-Short-Operations (LAHSO) is commonly used only during east flow under VMC for arrivals on Runway 8R who hold short of Taxiway NP to allow operations using Runway 8L to cross the runway freely. LAHSO for Runway 26L during west flow is seldom used because arrivals from Runway 26R destined to Terminals C-South and E are routed to Taxiway NP and do not use Taxiway NE frequently; therefore runway crossings are minimal.

B.5.5 Runway Dependencies—IMC

In west flow, arrival Runways 26L, 26R, and 27 operate independently as in VMC since they are widely-spaced parallel runways. Departures from Runways 15L and 15R are dependent as successive departures from either runway are conducted with 1.0 nautical mile spacing and 15-degree divergence. Departures from Runways 15L and 15R are held when an arrival to Runway 27 is within 2.0 nautical miles of landing.

In east flow, arrivals to Runways 8L, 8R, and 9 are operated independently, given that they are widely-spaced parallel runways. Departures from Runways 15L and 15R are independent in VMC, aside from requisite wake turbulence dependencies and spacing. Departures from Runways 15L and 15R are held when an arrival on final approach to Runway 9 is within the runway capture distance of 5.0 nautical miles of Runway 15R. Departures from Runways 15L and 15R commence their roll after Runway 9 arrivals cross the threshold of Runway 15R.

B.5.6 Runway Assignment

B.5.6.1 Runway Assignments by Fix and Offloading Strategies

The model assigns arrivals and departures to individual runways based on the arrival and departure fixes, except during periods of high demand where offloading strategies are employed by TAAM to dynamically adjusts runway assignments based on the arrival and departure demand at each runway.

In west flow, arrivals from the northeast use Runway 26L predominantly but offload to Runways 26R and 27 during high demand periods. Arrivals from the northwest predominantly use Runway 26R but can be offload to Runway 26L. Arrivals from the south use Runway 27 predominantly while Runway 26L is used for offloading. It is assumed that Runway 26R will not be used by arrivals from the south since the aircraft would have to crossover the final approach of Runway 26L. However, since the airport has more traffic originating from the northern markets, arrivals from the north are assumed to cross over to utilize the southern-most Runway 27 during peak arrival periods.

In west flow, departures to the northwest, west, and southwest are assigned to Runway 15R. Runway 15L is predominantly used for departures to the northeast, east, and southeast, and is the preferred runway for heavy aircraft for its longer runway length. The primary departure Runways 15L and 15R are used in VMC until the hourly departure queue reaches approximately 60 aircraft per hour at which time Runway 26L is used as an additional departure runway. When there is significant departure demand, eastbound departures are sometimes assigned to Runway 9 which must make an immediate 15-degree right turn.

In east flow, arrivals from the northeast use Runway 8L predominantly but are offloaded to Runway 8R and (on a limited basis) Runway 9. Arrivals from northwest use Runways 8R and 9 predominantly. Arrivals from the south use Runways 8R and 9.

In east flow, departures to the northwest, northeast, east, and southeast use Runway 15L. Runway 9 is used as an offload to departures destined to the northwest and northeast. Runway 15R is the predominant departure runway to the west and southwest.

B.5.6.2 Estimated Runway Use Percentages

The estimated percent of use of each runway within a runway use configuration is obtained from Aerobahn data, for the selected days in 2012 representing each flow and weather condition modeled. Aerobahn data is collected for all aircraft, including commercial, cargo, and general aviation operations. These runway use percentages for each flow and weather condition are shown in Table B-10.

These runway use percentages are used to calibrate the model such that the use of runways is reflected in the operation of the existing airfield. This form as a starting point for future operating assumptions for discussions with FAA ATC and HAS Airport personnel.

Table B-10
RUNWAY USE PERCENTAGES

		Arrivals			Departures			
Flow	Weather	26L	26R	27	15L	15R	26L	26R
West	**VMC**	46	4	51%	57	40	2	1%
	IMC	67	7	26	66	34	-	-
Flow	Weather	8R	8L	9	15L	15R	9	-
East	**VMC**	66	32	2	54	14	32	-
	IMC	34	64	2	50	5	45	-

Source: LeighFisher analysis of Aerobahn data for the selected days in 2012.

B.6 AIRFIELD LAYOUT/TAXIING PATTERNS

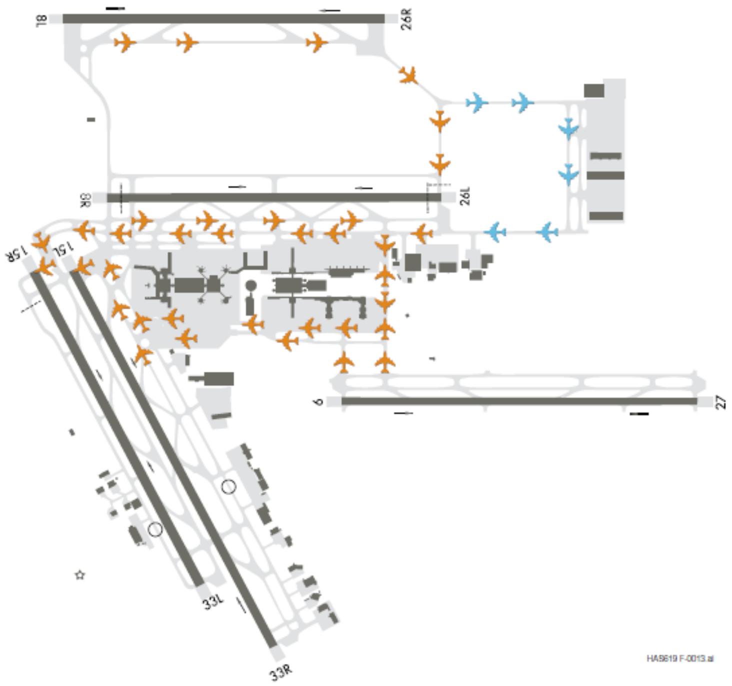
The aircraft taxiing patterns at the existing airfield layout assumed in TAAM were developed from: (1) Draft Technical Report – IAH Taxiway Comparison Study, HNTB, July 5, 2012; (2) Airfield Operations and Capacity Briefing, Conway Consulting, June 2010; (3) Taxiway Flows Crossfield Diagrams, Conway Consulting, 2010, (4) Delay Reduction Opportunities Using Existing Runways, Conway Consulting, April 2010; and (5) discussions with IAH ATC personnel.

B.6.1 General Taxiing Patterns

Bi-directional taxi flows on the north side of the terminal area are achieved by assigning eastbound aircraft to taxi via Taxiway NA and westbound aircraft to taxi via Taxiway NB when the Airport is operating in either west or east flow. In addition, the following taxiing routes are generally utilized and shown in Figure B-8:

- 15L departures use Taxiways RA and WA to Taxiway WW.
- 15R departures use Taxiways RB and WB to Taxiways NB, WP, and WC.
- Arrivals from 26R in west flow and 8L in east flow use Taxiways FH and NP. The "Beaumont" routing of Taxiways EE, EA, and NB are not frequently used in good weather due to the additional taxiing time. However, in poor weather conditions, the end-around taxiway route is used more frequently to avoid runway crossings of Runway 26L.
- Only arrivals from Runway 26L to Terminal A South in west flow use Taxiways NR and WB since Taxiways WA and WB are primarily used for departures on Runways 15L and 15R; all other arrivals (e.g. arrivals in west flow to Terminals B-South, C-South, and E, all arrivals from in east flow to south terminals) use Taxiway SF.
- North/south flows on the east side of the terminal area (e.g. Arrivals from Runway 27 to the north gates and arrivals from Runways 26L and 26R to the south gates) utilize Taxiway SF, resulting in bi-directional flows. A third independent taxi route is not available around the west end of the terminal complex.

Figure B-8
GENERAL TAXIING PATTERNS



Source: LeighFisher, February 2013.

B.6.2 Taxiway Restrictions

The majority of the taxiways can accommodate all existing aircraft in the fleet. Notable taxiway/taxilane restrictions listed below are assumed within the model:

- Taxiway WC (to and from the west general aviation parking) is limited to Boeing 737 or smaller aircraft (with wingspan of 118' and below)
- Taxiway NR between Taxiway WD and WB is restricted to Boeing 757 or smaller aircraft (with wingspan of 125' and below)
- Taxilane RC is restricted to Boeing 757W or smaller aircraft (with wingspan of 135' and below)

B.6.3 Assumed Terminal Layout/Gate Assignments

The model will assume the existing terminal layout, assuming the currently ongoing redevelopment of Terminal B-South is completed. Terminal B-South will include approximately 30 gates used for United Airline's regional domestic operations.

It is expected that even with these anticipated developments, the existing terminal layout will not be able to accommodate the forecast demand through PAL40. In particular, additional ADG V/VI gates will be required to accommodate the forecast demand by PAL25.

Gates for commercial aircraft are assigned based on the maximum aircraft size allowed by gate. In addition, remote parking positions are assumed at three locations: northwest of Terminal A-North, south of Terminal A-South, and north of Terminal D. Airline preferences are modeled in determining the appropriate gate to be used; these preferences can be summarized as follows:

- Terminals B, C, and E are used exclusively by United Airlines. Therefore, United Airlines is assumed to use Terminals B, C, and E first, overflowing onto Terminals A and D as needed.
- Foreign flag carriers are assumed to use Terminal D.
- Terminal E is used by United Airlines for both domestic and international operations.
- Non-United domestic carriers are assumed to have first priority on their leased gates in Terminal A.

The east cargo area is mainly used by UPS as well as most scheduled all cargo operators; the central cargo area is used by FedEx. General aviation parking is on the southwest side of the airfield, east of Taxiway WB and west of Taxiway WC.

Details of gate assignments and requirements can be found in Section C, Passenger Terminal Requirements.

B.7 CALIBRATION

Simulation validation is accomplished in three ways: (1) comparison of simulated average aircraft delay to FAA’s ASPM reported average aircraft delay, (2) comparison of simulated runway use percentages to estimated actual runway use percentages, and (4) via visual validation (i.e. observing the TAAM computer graphics display with IAH Tower staff).

B.7.1 Baseline Calibration

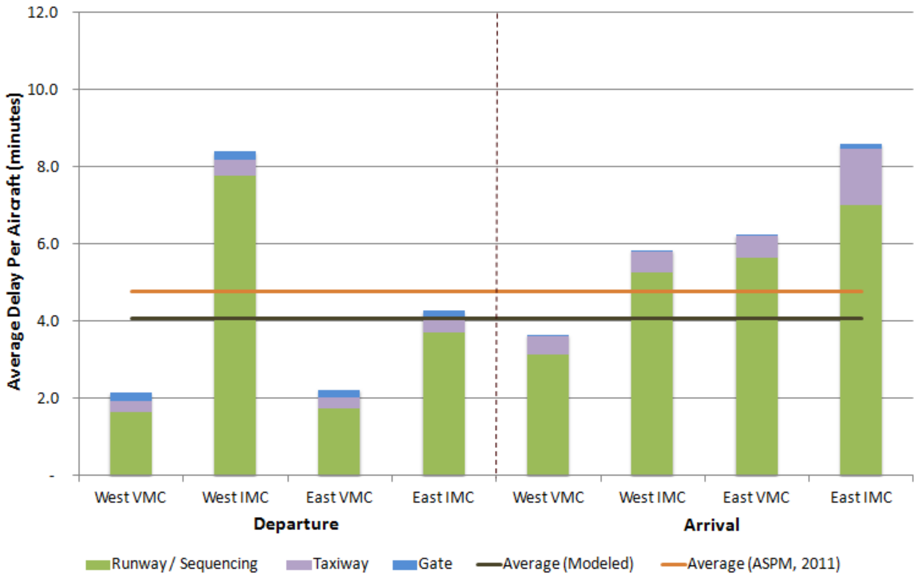
For purposes of calibrating the baseline model, two primary performance metrics – average aircraft delay and runway use percentages – are used. The first metric is computed by multiplying the four individual TAAM simulation experiments by the estimated percentage occurrence of their runway use configurations and weather conditions (refer to Table 7). The resulting delay, representing the overall delay of an average day, is compared with FAA’s ASPM reported average aircraft delay.

The second metric is comparing the simulated runway use percentages in each experiment with the actual runway use percentages as recorded in Aerobahn for the corresponding runway use configuration and weather condition. Results for the baseline model for the existing (2012) demand are presented in Figures B-9 and B-10.

The Airport currently operates with an average annual delay of 4.78 min/aircraft, as reported from FAA’s ASPM database for 2011. This is compared with the simulated annualized average delay of 4.07 min/aircraft, which includes all arrival and departure operations. When delays reach an average of approximately 7-8 minutes at an airport, the delays are considered to be unacceptable. The TAAM analysis estimates that the Airport only reaches this level of delay during IMC, and particularly only for departures in west flow and arrivals in east flow.

Figure B-9

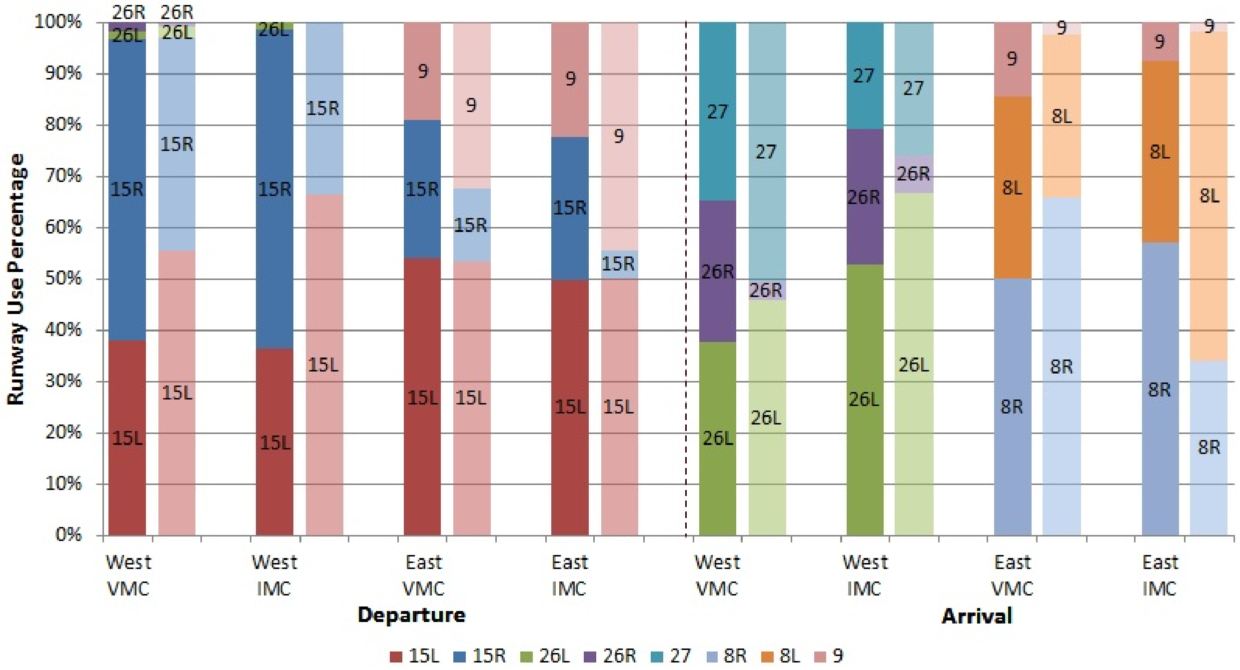
AVERAGE ANNUAL DELAY



Sources: LeighFisher TAAM analysis, April 2013; FAA ASPM database.

Another important operating assumption is the percent of use that each runway receives during each runway configuration and weather condition. Analysis of the Aerobahn data considers the use of each runway for the selected days representing each operating scenario, and is adjusted such that days where wind conditions dictate a certain runway to be used is not included. Figure 10 shows the simulated runway use percentages compared with the same metric analyzed from the Aerobahn data. The simulated runway use percentage for Runway 26R in west flow as an arrival runway is slightly lower than what is suggested from Aerobahn data because the Airport maintains a balance of arrival stream to both Runways 26L and 26R, rather than favoring Runway 26L significantly over 26R.

Figure B-10
RUNWAY USE PERCENTAGES – MODELED V.S. AEROBAHN



Note: Dark shades represent modeled runway use percentages from TAAM; Lighter shades represent runway use percentages based on Aerobahn data.

Source: LeighFisher TAAM analysis, April 2013; Aerobahn data for the selected days in 2012, February 2013.

Table B-11 summarizes the baseline TAAM analysis results for the existing (2012) demand. In addition to aircraft delay, average aircraft taxiing time and hourly runway throughput per individual runway for each operating scenario are presented.

Table B-11

TAAM RESULTS SUMMARY

	Baseline (2012)				
	West VMC (60.5%)	West IMC (14.5%)	East VMC (15.3%)	East IMC (9.7%)	Overall (100%)
Aircraft Delay (min/aircraft)					
Average Arrival Delay	3.64	5.83	6.22	8.61	4.83
Average Departure Delay	2.18	8.46	2.25	4.28	3.30
Average Delay	2.91	7.14	4.24	6.46	4.07
Aircraft Taxiing Time (min/aircraft)					
Average Taxi-in Time	9.20	10.60	9.40	10.25	9.54
Average Taxi-out Time	11.25	17.60	10.85	12.82	12.26
Average Taxi Time	10.23	14.10	10.13	11.53	10.90
Runway Throughput (aircraft/hour)					
West Flow – Arrival					
Runway 26L	30	37	--	--	--
Runway 26R	27	24	--	--	--
Runway 27	26	12	--	--	--
All Runways	74	67	--	--	--
West Flow – Departure					
Runway 15L	34	30	--	--	--
Runway 15R	42	45	--	--	--
All Runways	68	59	--	--	--
East Flow – Arrival					
Runway 8R	--	--	37	37	--
Runway 8L	--	--	29	30	--
Runway 9	--	--	8	15	--
All Runways	--	--	67	67	--
East Flow – Departure					
Runway 15L	--	--	39	35	--
Runway 15R	--	--	30	30	--
Runway 9	--	--	9	26	--
All Runways	--	--	66	73	--

Source: LeighFisher TAAM analysis, April 2013.

Appendix C
Master Plan Taxiway Recommendations

Appendix C

MASTER PLAN TAXIWAY RECOMMENDATIONS

Prepared by:

LeighFisher Inc.

MASTER PLAN TAXIWAY RECOMMENDATIONS

The master plan planning process and analysis determined that while the airfield has sufficient runway capacity for the next 20 years (out to about 2035 depending on the growth of aircraft operations), the flow of aircraft on the ground will become increasingly congested. One of the primary issues is the flow of aircraft around the terminal complex between the north and south airfields and the north and south terminal aprons. Bi-directional taxiways surrounding the terminal complex are required to accommodate the flow of traffic without incurring undue taxi time delays. In particular, nearly all aircraft arriving on the north airfield must use Taxiway SF to reach their gate on the south apron, regardless of whether they are gating at Terminals A, B, C or E, and regardless of the airfield flow direction (e.g. east flow, west flow). Similarly, all aircraft using Runway 9-27 to depart or arrive must use Taxiway SF if their parking position is on the north apron.

Taxiway SF is the only capable link between the north airfield and the south apron, which makes the efficient operation of the airfield particularly vulnerable. (Taxiways WA and WB on the west side of the terminal complex are used primarily by aircraft queueing for departure from the south apron.) Accordingly, the master plan makes two recommendations, one in the near-term and one in the long-term to address this vulnerability:

1. In the near-term, the extension of Taxiway NR to Taxiway RA on the west side of the terminal complex should be constructed to allow aircraft to taxi from the north airfield to the south apron concourses, particularly for aircraft destined for Terminals A and B. This taxiway should be constructed as soon as practical, depending on the timeframe to replace the three aircraft gates displaced by its construction.

2. In the long-term, a second crossfield taxiway, Taxiway SL, on the east side of the terminal complex should be constructed, especially in light of the fact that at some point Taxiway SF will be out of service for major rehabilitation. This taxiway should be operational around 2025.

The following sections address both recommendations in further detail.

NEAR-TERM RECOMMENDATION: TAXIWAY NR EXTENSION

Taxiway NR currently connects Taxiway CC north of Runway 8R-26L west of the terminal complex to Taxiway WB. An extension of Taxiway NR is proposed to (1) provide a shorter taxi route for aircraft arriving on Runways 8L-26R or 8R-26L to the south apron, and (2) upgrade Taxiway NR for use by larger aircraft.

A summary of the Taxiway NR project is described below:

- The portion of Taxiway NR to the west of the terminal complex is currently limited to aircraft with wingspans less than 125 feet. This project would upgrade this portion of the taxiway to accommodate Airplane Design Group (ADG) V aircraft, and extend Taxiway NR to Taxiway RA.

- Currently, the majority of arrivals from Runways 8L-26R destined for the south apron are routed via the east end of the terminal complex on Taxiway SF. This circuitous routing increases aircraft taxiing distances and times, and also increases conflicts on Taxiway SF leading to aircraft delays.

- An extension of Taxiway NR would provide a southbound route to the south apron, primarily for aircraft parking at the south concourses of Terminals A and B\, which would not conflict with existing flows of aircraft using Taxiways WA and WB northbound to taxi to Runways 15L or 15R for departure.

- The estimated cost of the Taxiway NR extension is $17 million. This cost estimate excludes the cost to replace three gates on the south concourse of Terminal A which would be demolished to make space for the taxiway extension.

- The Taxiway NR extension is estimated to save between $2.0 and $3.5 million per year in direct aircraft operating costs.

Project description

Currently, Taxiway NR dead-ends into Taxiway WB in the vicinity of the Terminal A south apron. The utility of the west side of the airfield to serve crossfield taxiing operations is limited since both Taxiways WA and WB are used in a northbound direction for departures to Runways 15L and 15R, and any aircraft using Taxiway NR southbound would conflict with traffic on Taxiway WB. Also, the portion of Taxiway NR between Taxiways WD and WB is limited to aircraft with wingspans of 125 feet or less.

A proposed extension to Taxiway NR is shown on Figure 1. An extension of Taxiway NR would provide redundancy in crossfield taxiing capability since Taxiway SF provides the only existing crossfield connection between north and south airfields. Additionally, the provision of Taxiway NR would reduce taxiing times for those aircraft using it, as well as reduce overall taxiing times due to reduced occurrence of head-to-head taxiing on Taxiway SF.

This taxiway extension would be used largely in a southbound direction, as shown in Figure 2, providing a taxi route around the west end of the terminal complex for arriving aircraft from Runways 8R-26L and 8L-26R to the south concourses of Terminals A and B via Taxiway NE, instead of the circuitous taxi route around the east end of the terminal complex Taxiway FH to Taxiways NP and SF.

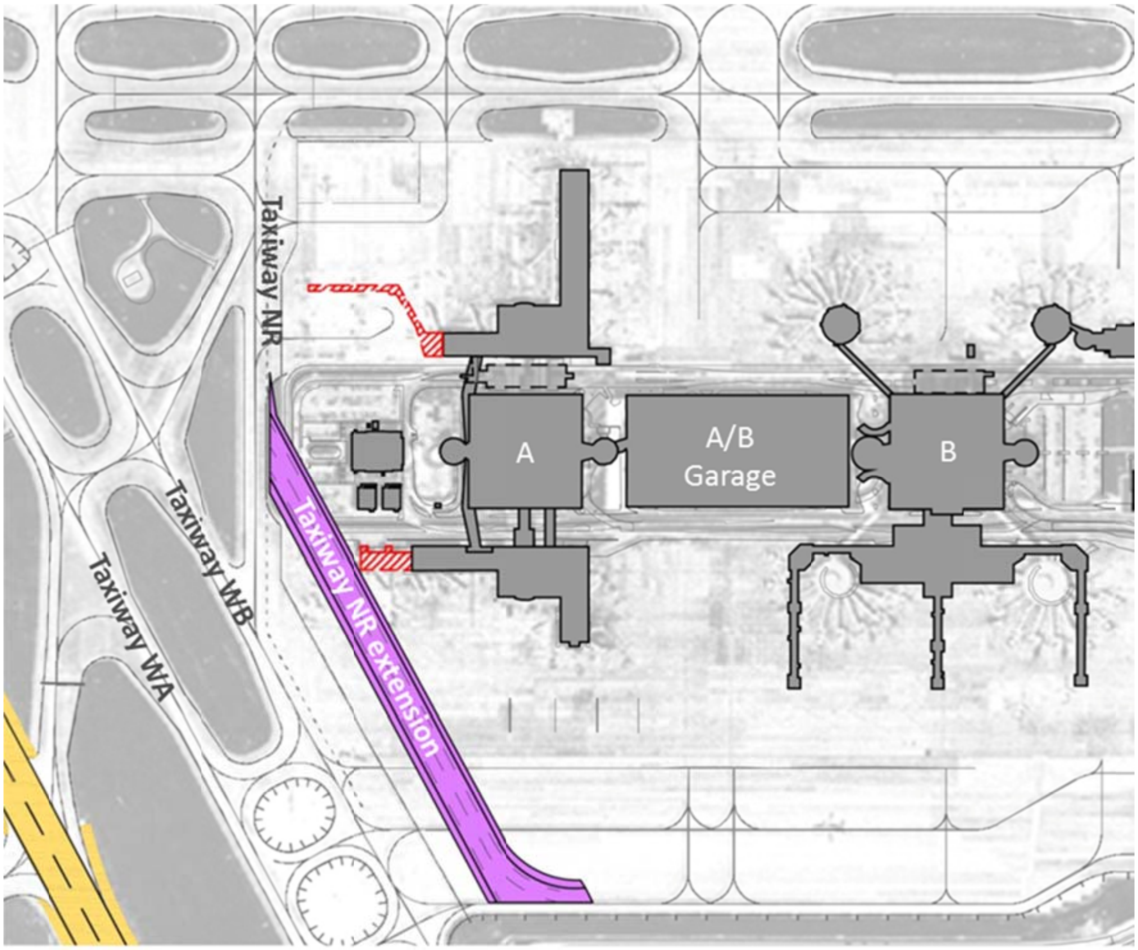
The proposed taxiway extension would extend Taxiway NR through to Taxiway RA, and upgrade the existing portion of Taxiway NR to the west of the terminal complex to accommodate larger wingspans. The Taxiway NR extension would meet ADG V and Taxiway Design Group (TDG) 6 standards, in particular:

- 324 feet centerline-to-centerline separation from ADG VI Taxiway WB

- 160 feet from centerline to fixed object (Terminal A South gates)

- 75-foot width with shoulders of 35 feet shoulders

Figure 1
PROPOSED TAXIWAY NR EXTENSION



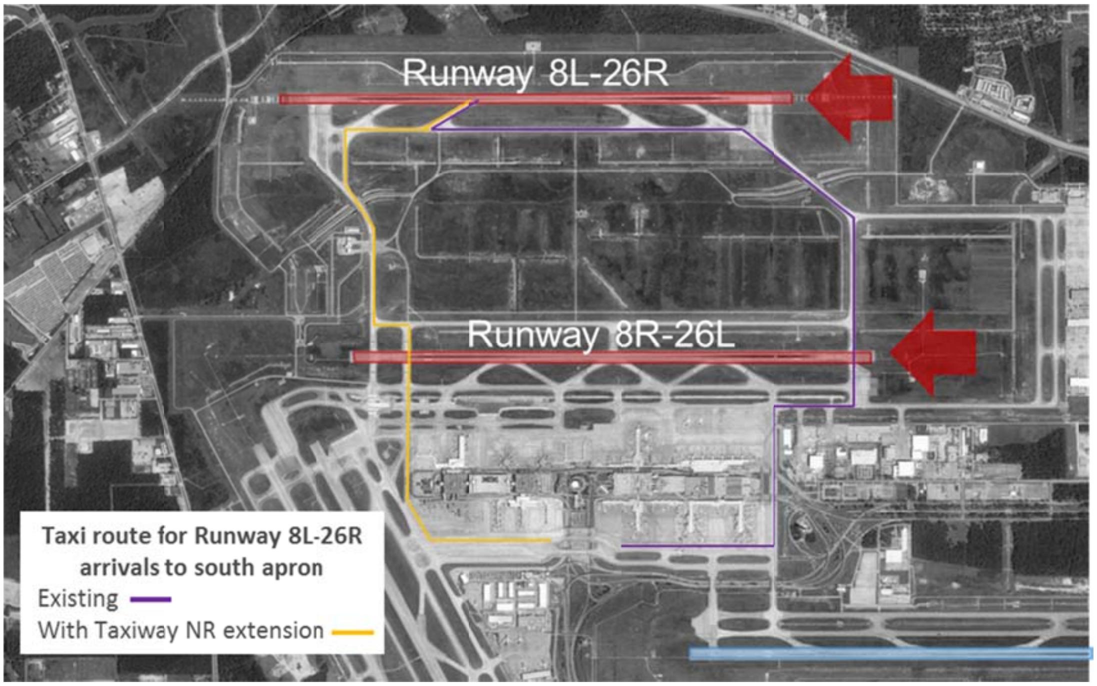
Source: LeighFisher, January 2015.

Enabling projects and cost estimate

The extension of Taxiway NR would require removal and replacement of three gates on Terminal A South, shown in Figure 3. In the future, one additional gate could be removed to upgrade Taxiway NR for ADG VI operations, if needed. The three gates would be replaced on the south side of Terminal A as shown in Figure 3. The taxiway extension would also eliminate one remote aircraft parking position, but additional apron for aircraft parking may be provided on the north apron at the time of the Taxiway NR extension. The unused “icehouse” portion of Terminal A North and the former site of the FAA ATCT/TRACON would need to be removed to provide ADG V wingtip clearances on the existing portion of Taxiway NR south of Taxiway NC.

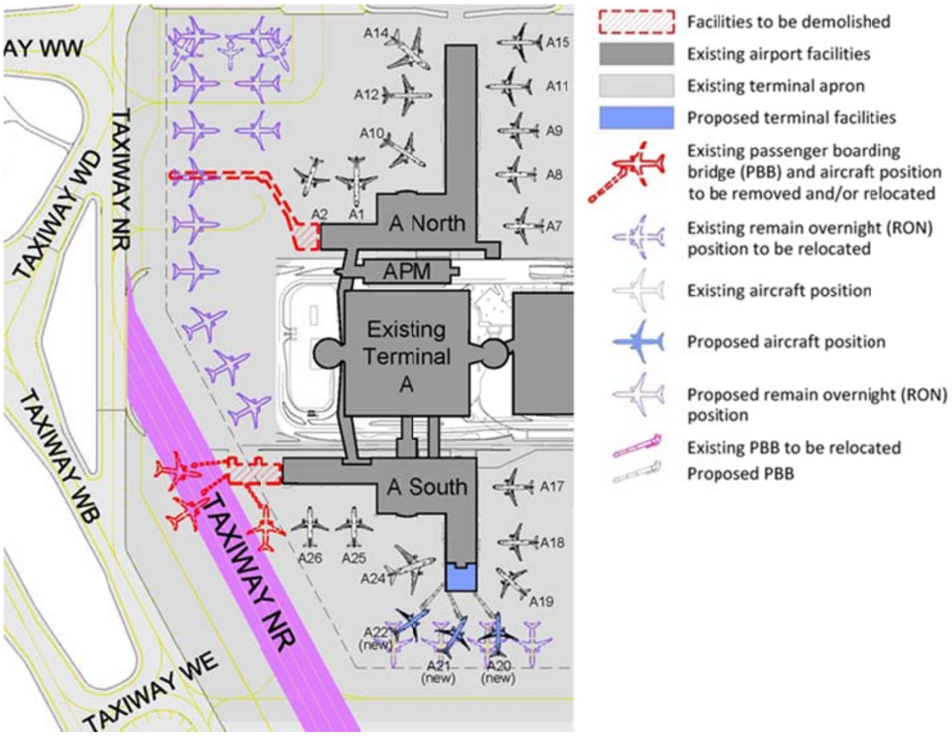
An order-of-magnitude cost estimate for the extension of Taxiway NR is $17 million, including capital and soft costs. The replacement of three gates on Terminal A is excluded from this estimate.

Figure 2
AIRCRAFT TAXI PATHS WITH TAXIWAY NR EXTENSION



Source: LeighFisher, January 2015.

Figure 3
TERMINAL A RECONFIGURATION



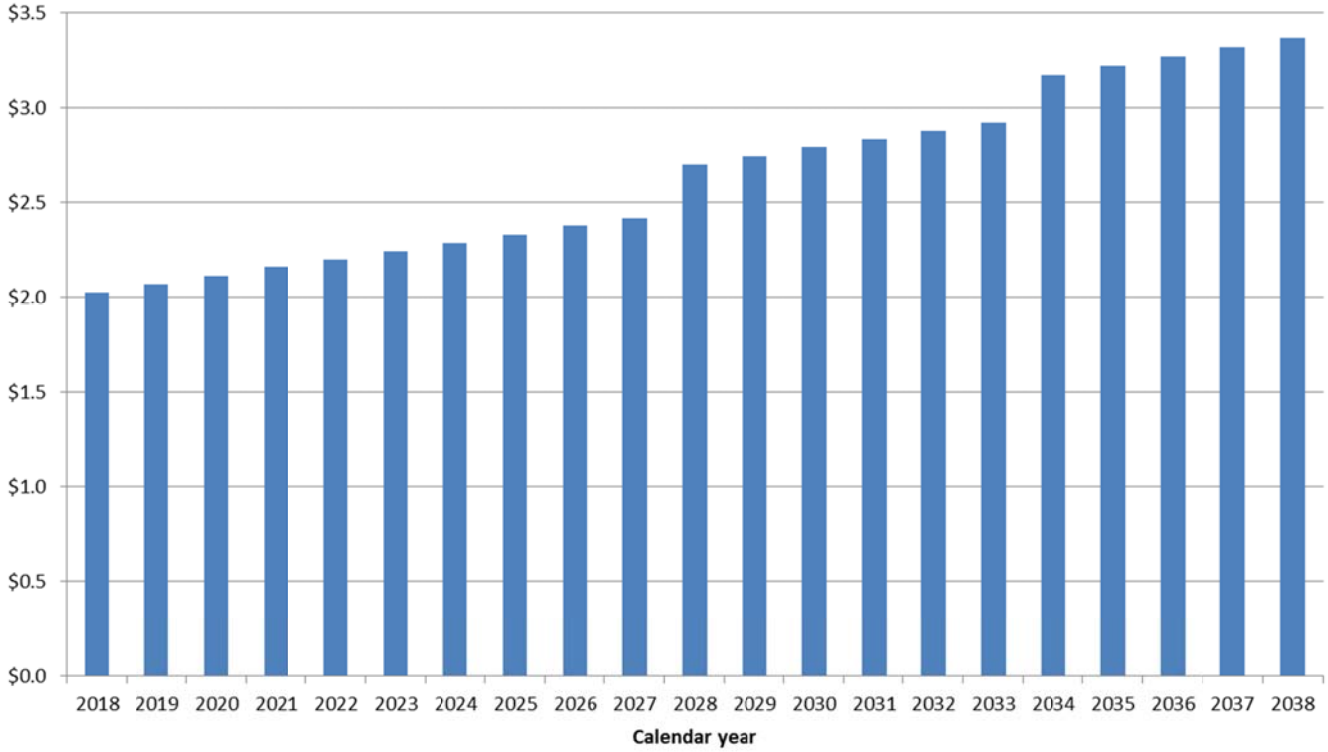
Source: LeighFisher, January 2015.

Economic justification

The level of savings in aircraft operating time with the Taxiway NR extension as compared to the existing airfield layout was estimated using Total Airspace and Airport Modeler (TAAM) simulations. The extension of Taxiway NR is estimated to save 0.17 minutes of aircraft taxiing time and delay per operation at the Planning Activity Level (PAL) 25 demand level. PAL25 represents the level of activity associated with 25 million annual enplanements and 630,000 annual aircraft operations.

Using a unit ground aircraft direct operating cost of between $19.22 and $22.53 per minute, and the Master Plan forecast of annual aircraft operations, Taxiway NR would save between $2.0 and $3.5 million per year in aircraft operating costs. Figure 4 shows the annual levels of estimated aircraft operating cost savings, assuming the taxiway extension opens in 2018 and has a 20-year useful life.

Figure 4
AIRCRAFT DIRECT OPERATING COST SAVINGS—TAXIWAY NR EXTENSION



Source: LeighFisher, January 2015.

Assuming Taxiway NR is open in 2018, over a 20-year planning period the present value of benefits is between $79 and $94 million (the low end corresponding to the FAA Terminal Area Forecast of aircraft operations and the high end corresponding to the Master Plan forecast). Accordingly, the benefits justify an investment of between $97 and $115 million in current 2014 dollars, assuming the costs would be incurred in 2017 (the year before the taxiway is open). This investment level is determined assuming that the costs are exactly equal the benefits, or a benefit-cost ratio of one.

LONG TERM RECOMMENDATION: TAXIWAY SL

Crossfield taxiway alternatives were considered to provide (1) a second crossfield taxiway, eliminating Taxiway SF as a single point of failure for airfield circulation, and (2) bi-directional northbound and southbound aircraft movement, reducing aircraft taxiing delay associated with conflicts on existing Taxiway SF.

In the next 15 to 20 years, Taxiway SF will be required to be out of service for a number of months while its bridges over Will Clayton Parkway, North Terminal Road, and South Terminal Road are reconstructed. Further, it is possible that the taxiway will be unavailable during shorter periods of time because of more routine maintenance or a disabled aircraft. In the event that the taxiway is unavailable, taxi time delays would be untenable and air traffic control workload would be increased.

While Taxiway SF is out of service, all crossfield aircraft movements would need to be routed around the west side of the terminal complex. Aircraft destined for the gates on the south apron of Terminals A, B, C and E from the north airfield, or aircraft destined to or from Runway 9-27 from the north apron would taxi around the west side of the terminal complex. The proposed construction of Taxiway NR would provide some crossfield capability in the case that Taxiway SF is out of service. However, aircraft arriving in east flow would have to "back-taxi" the length of Runways 8R and 8L to reach Taxiway NR, and operations between the north apron and Runway 9-27 would face a similar circuitous taxi route. Further, there would be head-to-head congestion created to the north, west, and south of the terminal complex due to the circuitous routings and conflicts between existing taxi patterns and re-routed crossfield movements.

With regard to air traffic controller workload, if Taxiway SF were unavailable, aircraft would likely need to be assigned their arrival or departure runway based on their assigned gate or parking position. This level of coordination between air traffic control and the airlines would lead to severely reduced operational efficiency of the airfield, major delays, and likely flight cancellations.

It should be noted that a primary use of crossfield Taxiway SF is to provide access between the north airfield complex and aircraft gates on the south side, predominantly for the aircraft operations of United Airlines. In addition to the single point of failure issue, having a single crossfield taxiway makes bi-directional flow between the north and south aprons and the north and south airfield complex challenging, given the need for Taxiway SF to serve both northbound and southbound aircraft movements.

Given these considerations, the master plan evaluated several alternative locations for the second crossfield Taxiway SL.

Analysis Summary

The primary findings of the alternatives analysis are:

- Alternatives located further east than the end of Runway 26L provide little or no reduction in aircraft operating time due to increases in taxi distances.
- To ensure future flexibility in use, a second crossfield taxiway must allow for a connection to the south apron, requiring the extension of Taxiways RA and RB. Given this requirement, the reconstruction of the Will Clayton Parkway/John F. Kennedy Boulevard (WCP/JFK) interchange would be required for all alternatives at some point in time.
- Alternative B is the preferred crossfield taxiway alternative because it maximizes aircraft delay reduction with a minimal increase in taxi time, providing the maximum reduction in aircraft operating time of any alternative.

- The estimated cost of Alternative B is $303 million, of which up to 75% would be eligible for federal funding under the Federal Aviation Administration's Airport Improvement Program.
- Taxiway SL is needed around the time when annual aircraft operations reach 633,000. Under the FAA Terminal Area Forecast (TAF) or low growth forecast from the Master Plan, this level of activity is projected to occur sometime between 2025 and 2028.
- Alternative B is estimated to save $4 to $7 million per year in direct aircraft operating costs.
- Following the FAA benefit-cost analysis guidance to estimate future benefits, the net present value of the aircraft operating cost and passenger time savings is -$9.3 million, assuming a 20 year planning period, discount rate of 7%, and growth in annual operations and passengers consistent with the FAA TAF, resulting in a benefit-cost ratio of 0.93, meaning that the benefits are nearly equivalent to the costs. Notably, this benefit cost ratio would exceed 1.0, if one were to assume operations grow in accordance with the Master Plan baseline forecast. The costs and benefits associated with the taxiway should be studied in more detail at the time of detailed design and environmental review. Detailed design would enable the refinement of the cost estimate for the taxiway.

Introduction

Taxiway SF currently provides the single connection for aircraft between the north and south airfield. Depending on runway configuration, between 20% and 30% of all aircraft operations at the Airport use Taxiway SF, which represents an approximate range of between 275 and 415 operations per day. Taxiways on the west side of the complex serve aircraft traveling from the south apron to depart Runways 15L and 15R, and are not typically used for crossfield movement. An additional crossfield taxiway is needed because:

- Taxiway SF is used in a northbound and southbound direction in all runway use configurations, causing aircraft taxiing delays. During peak arrival periods, northbound and southbound aircraft incur delays as they must be "platooned" to use the taxiway to avoid head-to-head taxiing situations.
- Taxiway SF is a single point of failure for efficient airfield circulation. In the event Taxiway SF were to be unavailable (e.g., disabled aircraft, pavement maintenance, or structural failure or rehabilitation), aircraft would likely need to be assigned an arrival runway based on their assigned gate or parking position. These assignments would lead to severely reduced operational efficiency of the airfield, major delays, and likely flight cancellations.
- Runway assignments are made based on arrival or departure fix on the basis of their origin or destination airports to minimize the amount of airborne crossing, and not based on aircraft parking location. Therefore, crossing is done on the ground and an additional crossfield taxiway is needed to increase efficiency of ground movements while allowing flexible use of the runways.
- Taxiway SF has two bridges which do not have the necessary shoulder width or structural strength to accommodate the fleet mix at the Airport. At a design width of 100 feet, the bridges do not meet taxiway safety area standards for Airplane Design Group IV or larger aircraft. (ADG IV standards require a taxiway width of 75 feet with 25 foot shoulders.)

A range of alternatives was evaluated that could provide redundant crossfield capability and improve airfield efficiency.

Planning Principles

All taxiway alternatives assume that Taxiway SF remains in place in its current location. Development needs that would trigger the removal of Taxiway SF, including expansion of the terminal platform to the east and/or extension of the automated people mover are not expected to materialize within the master planning period. Therefore the crossfield taxiway alternatives include one additional taxiway and the retention of Taxiway SF. The location of a second new taxiway is considered to inform the location of the first proposed taxiway and in the case that the need arises to remove Taxiway SF after the planning period.

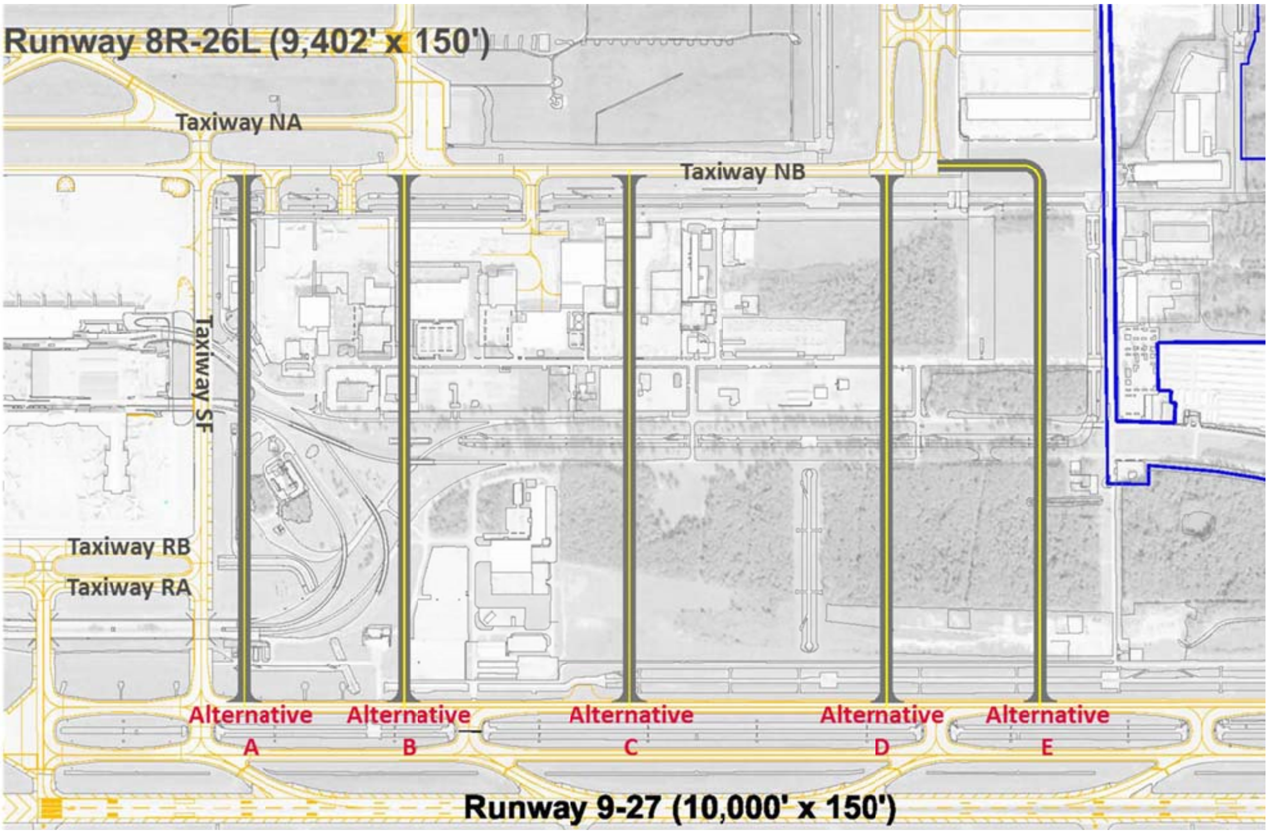
All taxiway alternatives meet the following design standards for the Airbus A380: Taxiway Design Group (TDG) 7 and ADG VI:

- Taxiway width = 82 feet (TDG 7)
- Taxiway shoulder width = 40 feet (TDG 7)
- Taxiway centerline to fixed or moveable object = 193 feet (ADG VI)
- Taxiway centerline to parallel taxiway centerline = 324 feet (ADG VI)
- Taxiway safety area = 262 feet (ADG VI)

Taxiway Alternatives

Five alternatives for providing secondary crossfield taxiway capability were considered and evaluated, described in the following sections. The alternatives are depicted on Figure 5. Note that Figure 5 does not depict the ultimate extensions to Taxiways RA and RB which would be necessary for each of the alternatives to function most efficiently.

Figure 5
CROSSFIELD TAXIWAY ALTERNATIVES



Source: LeighFisher, January 2015.

Alternative A

Alternative A provides the minimum ADG VI centerline spacing of 324 feet from existing Taxiway SF. It would require reconstruction of the WCP/JFK interchange. Additionally, the taxiway and its object free areas would require displacement of the United Airlines mail sort facility and the entry roadways to the FAA Air Traffic Control Tower (ATCT). Additionally, due to the object free area requirements, a portion of the apron surrounding United Airlines' Hangar B would not be useable.

Alternative B

Alternative B is aligned with the end of Runway 26L and Taxiway NP, and is located at 1,525 feet centerline spacing from existing Taxiway SF. It would require demolition and reconstruction of the interchange between WCP/JFK. Additionally, the taxiway and its object free areas would require demolition of the ground service equipment maintenance building, Chelsea flight kitchen #2/#3, United Airlines flight training facility, and Aircraft Rescue Fire Fighting Station 92.

Alternative C

Alternative C is located at 3,225 feet centerline spacing from existing Taxiway SF so that the western edge of the taxiway object free area aligns with the United Airlines warehouse and shop. This alternative would not require the relocation of any facilities, although it would require a bridge over WCP.

Alternative D

Alternative D is aligned with Taxiway EA, and is located at 5,162 feet centerline spacing from existing Taxiway SF. This alternative would not require the relocation of any facilities, although it would require a bridge over WCP.

Alternative E

Alternative E is located at the eastern edge of the property line at 6,316 feet centerline spacing from existing Taxiway SF. This alternative allows for the maximum contiguous area for site development, including a potential East Terminal in the long-term. This alternative would not require the relocation of any facilities, although it would require a bridge over WCP.

Operational Use

The existing taxi flows for east and west flow are shown on Figures 6 and 7. Head-to-head conflicts occur on Taxiway SF in both a northbound and southbound direction to/from the east-west runways and the apron areas.

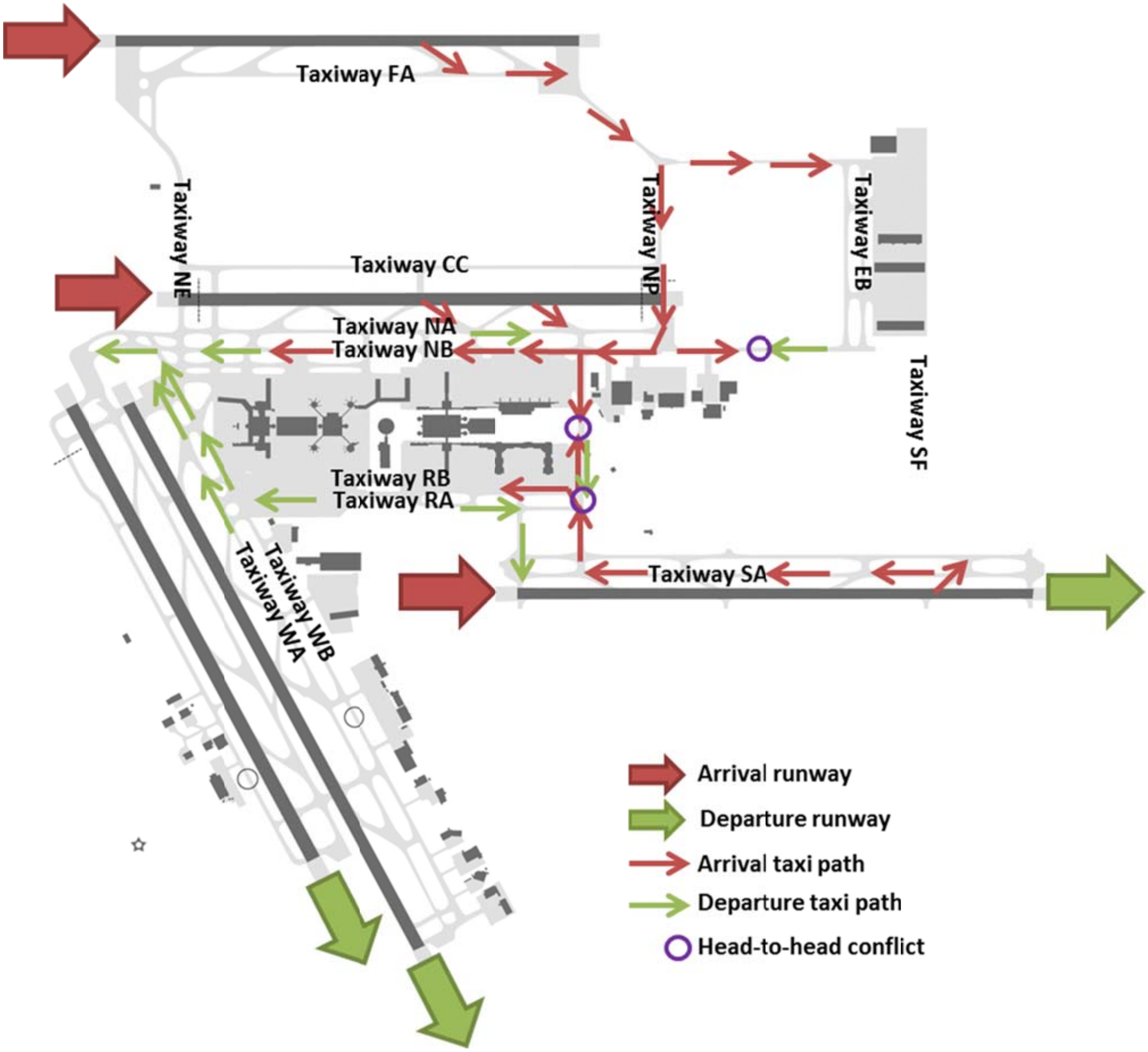
Taxi flows for each proposed crossfield taxiway alternative were developed based on the following assumptions:

- Taxiway SF and a proposed crossfield taxiway would be operated as a bi-directional pair (i.e., one northbound and one southbound).
- Taxiway directions would be assigned to minimize taxi distance for the predominant flow direction.
- In east flow, the primary flow direction is southbound, and the resulting assumptions about taxiway use are as follows:
    - Southbound traffic assigned to Taxiway SF (arrivals on Runways 8L and 8R destined for a gate on the south apron, departures on Runway 9 traveling from the north apron)
    - Northbound traffic would be assigned to the proposed taxiway (arrivals on Runway 9 destined for the north apron)
- In west flow, the primary flow direction is southbound, and the resulting assumptions about taxiway use are as follows:
    - Southbound traffic assigned to Taxiway SF (arrivals on Runways 26L and 26R destined for the south apron)
    - Northbound traffic assigned to proposed taxiway (arrivals on Runway 27 traveling to the north apron)

The future taxiway routes with the proposed taxiway for east and west flow, using the assumptions described above, are depicted on Figures 8 through 13. On Figures 8 and 9, Alternative B is shown to represent the operation of Alternatives A and B. Figure 10 and 11 depicts the taxiway routes for Alternative C. On Figures 12 and 13, Alternative D is used to represent the operation of Alternatives D and E.

Figure 6

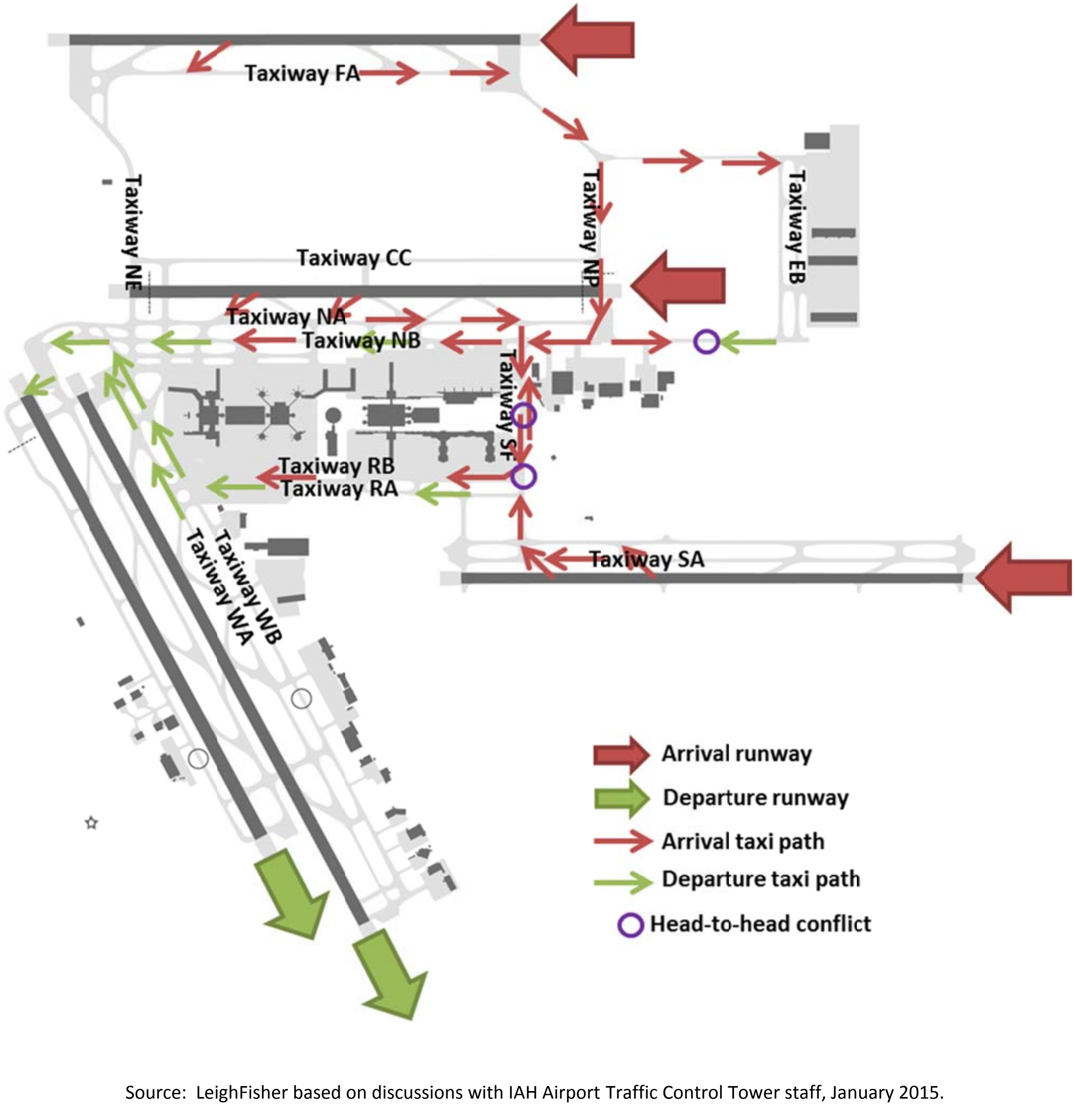
TAXI FLOWS—EXISTING EAST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Figure 7

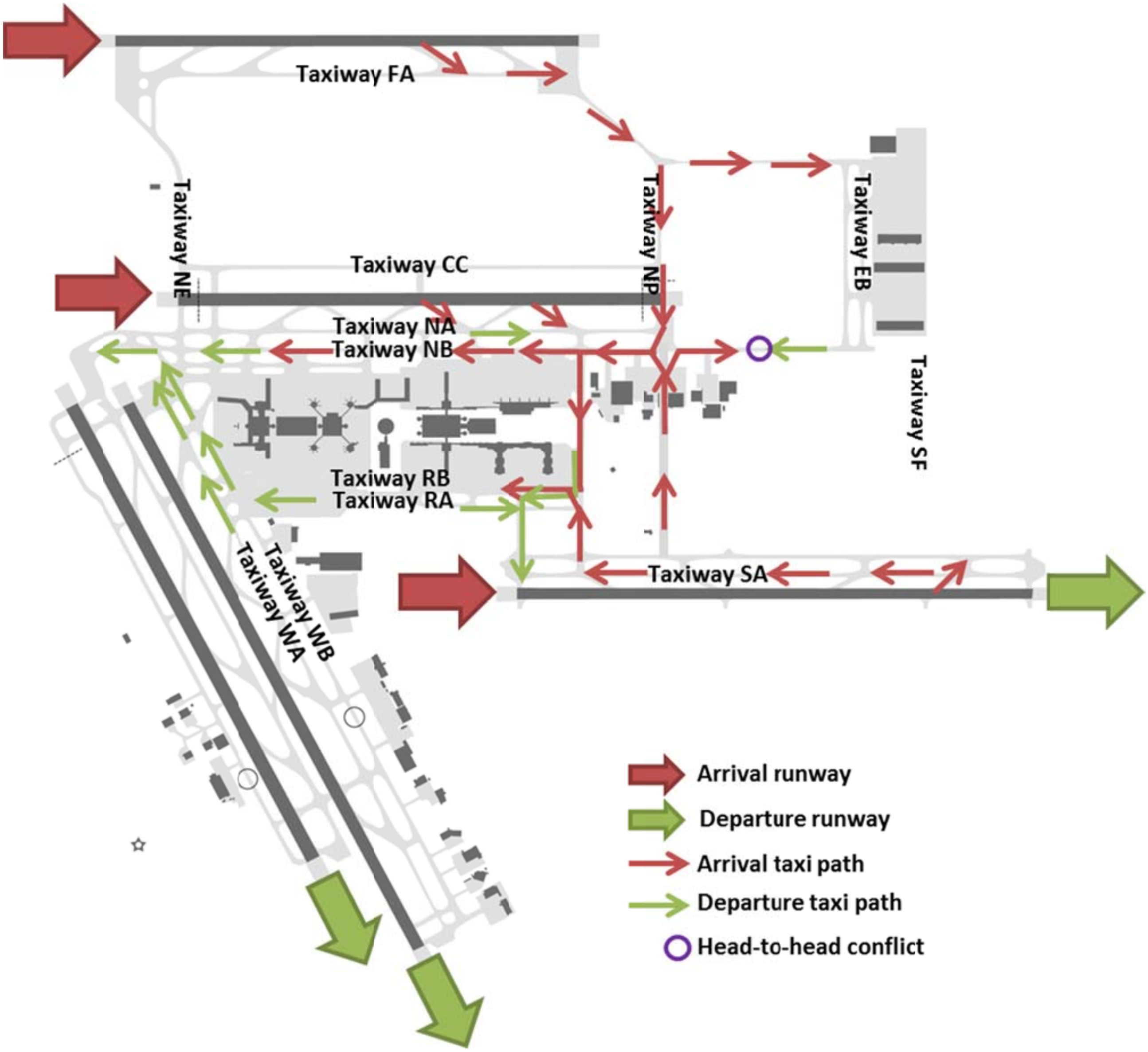
TAXI FLOWS—EXISTING WEST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Figure 8

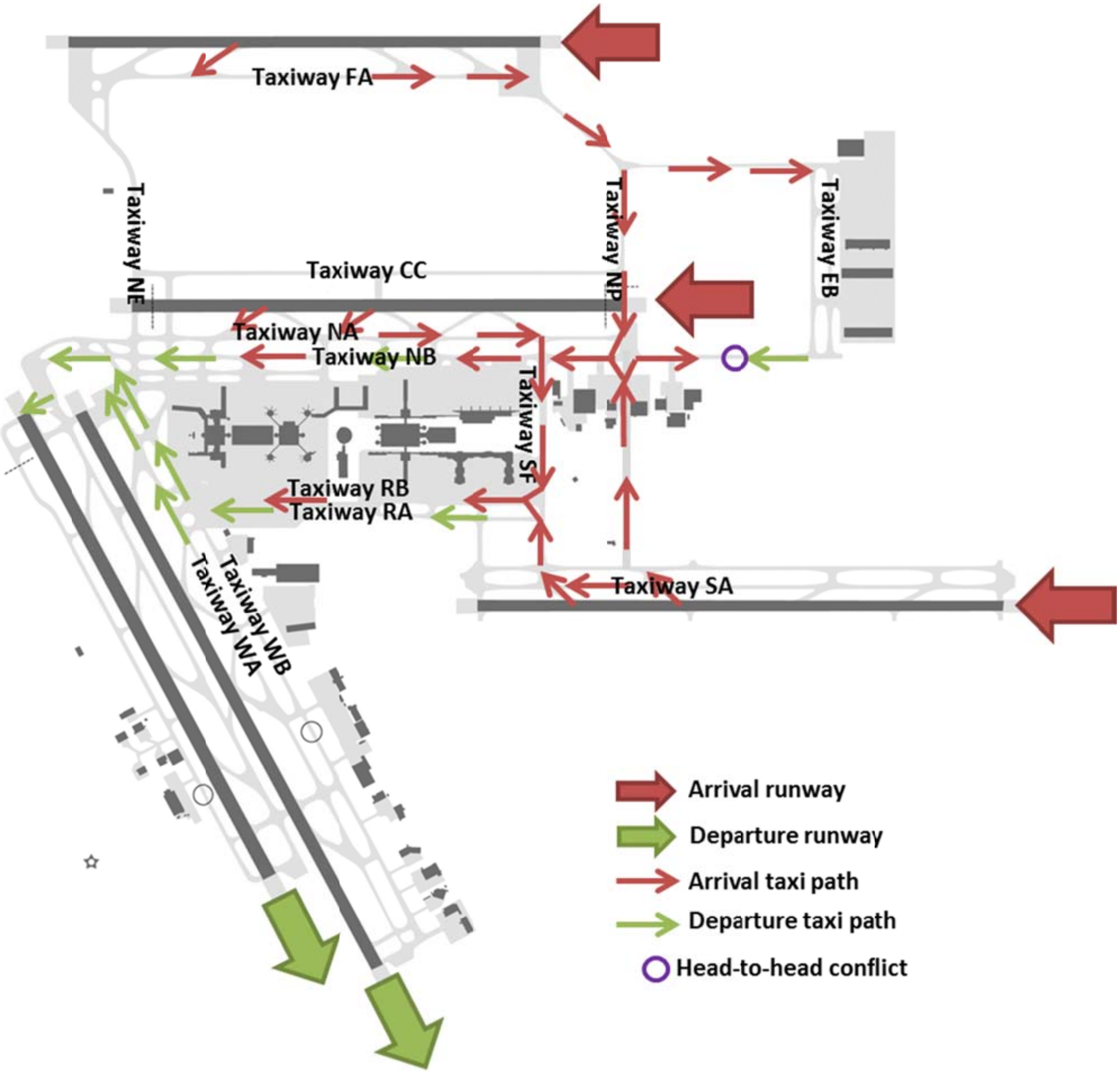
TAXI FLOWS—ALTERNATIVE A/B EAST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Figure 9

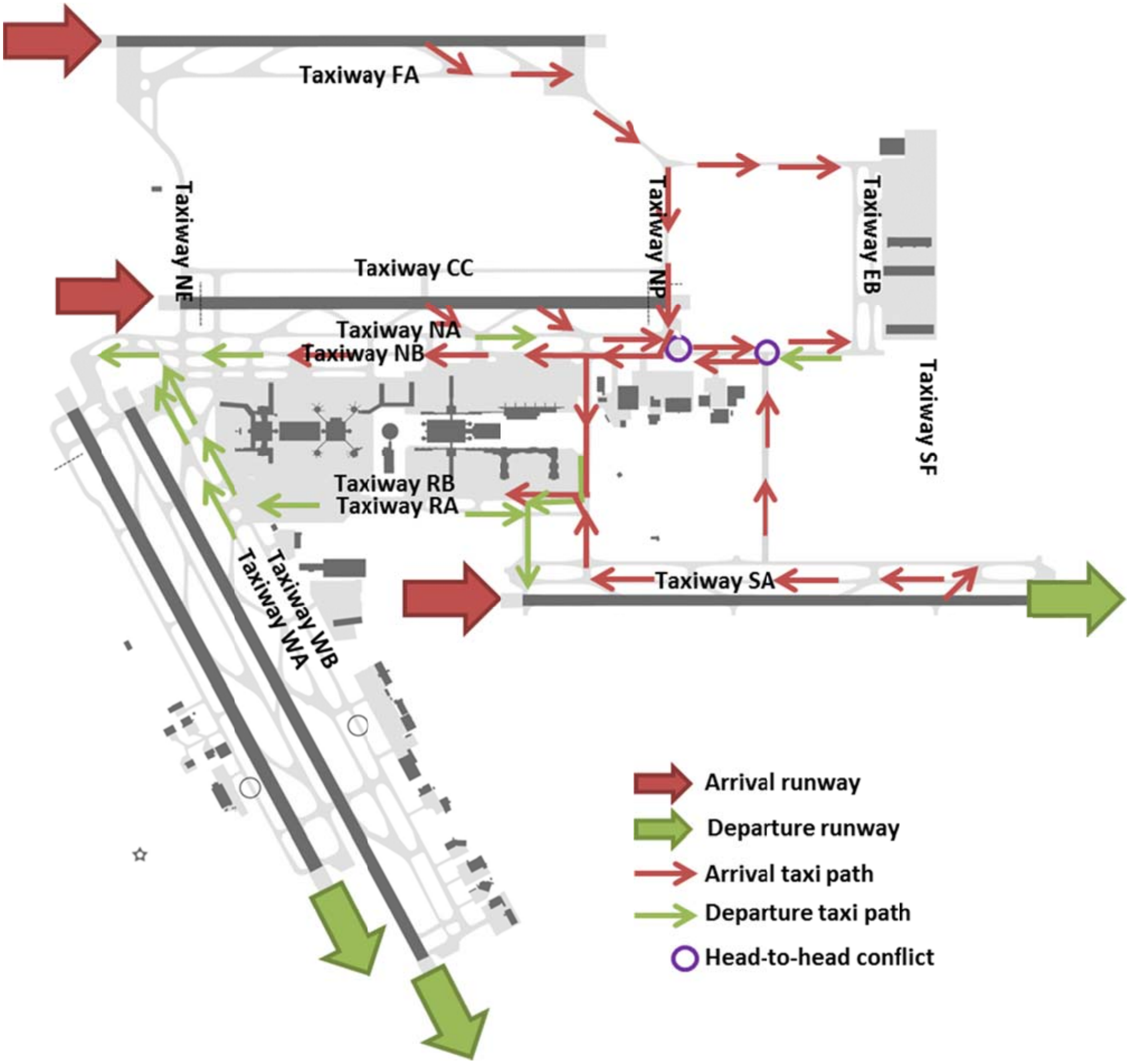
TAXI FLOWS—ALTERNATIVE A/B WEST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Figure 10

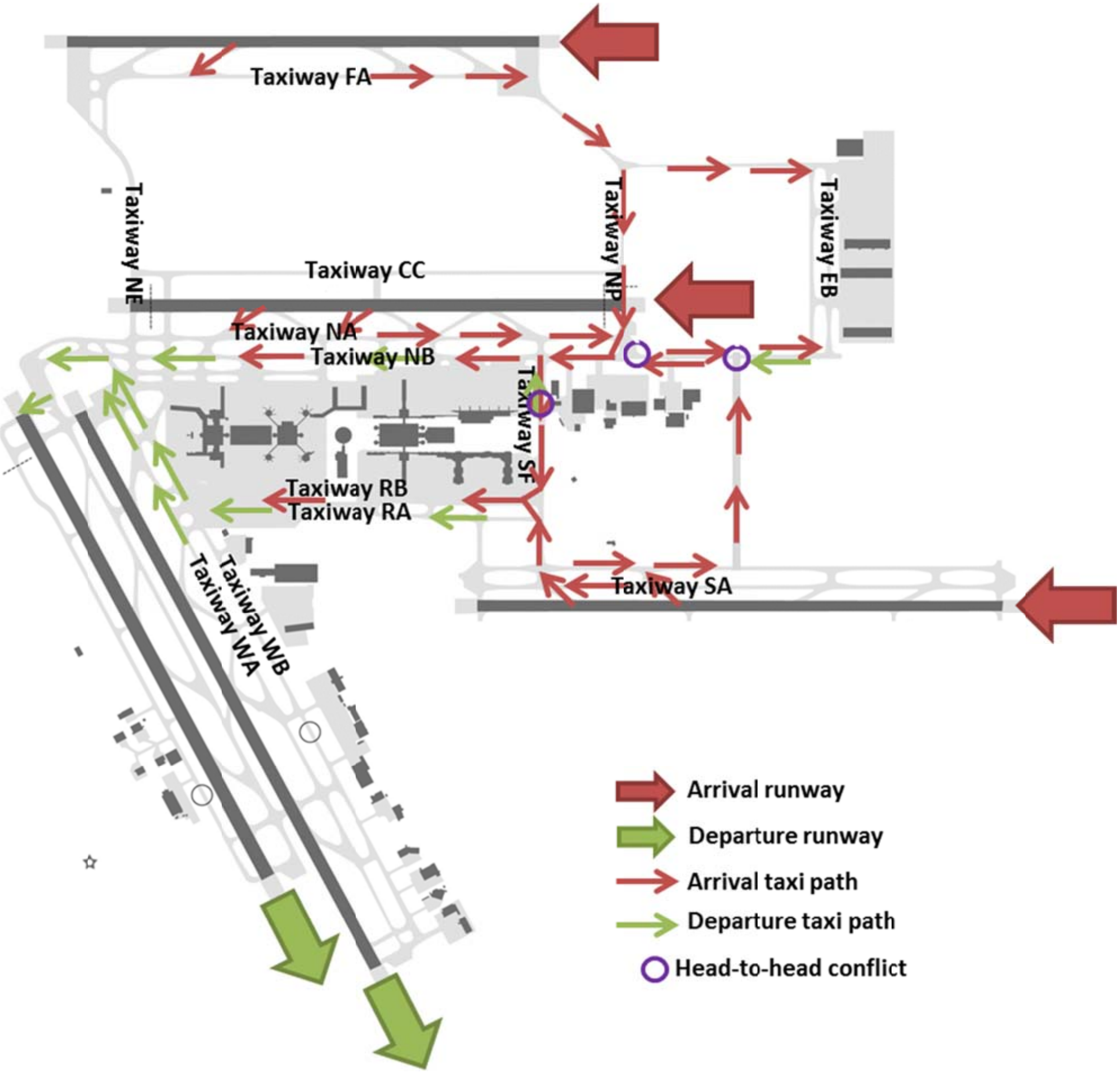
TAXI FLOWS—ALTERNATIVE C EAST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Figure 11

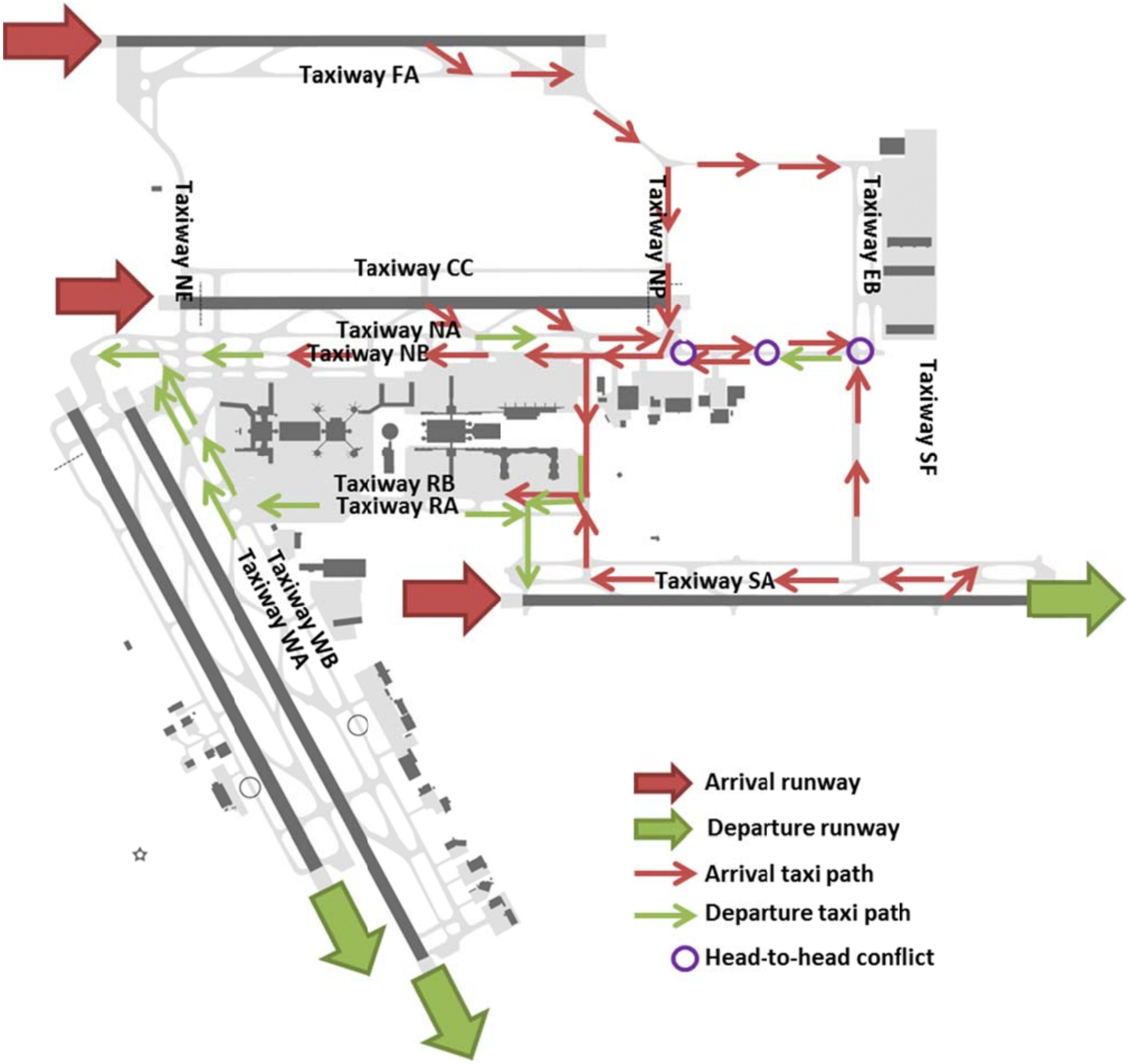
TAXI FLOWS—ALTERNATIVE C WEST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Figure 12

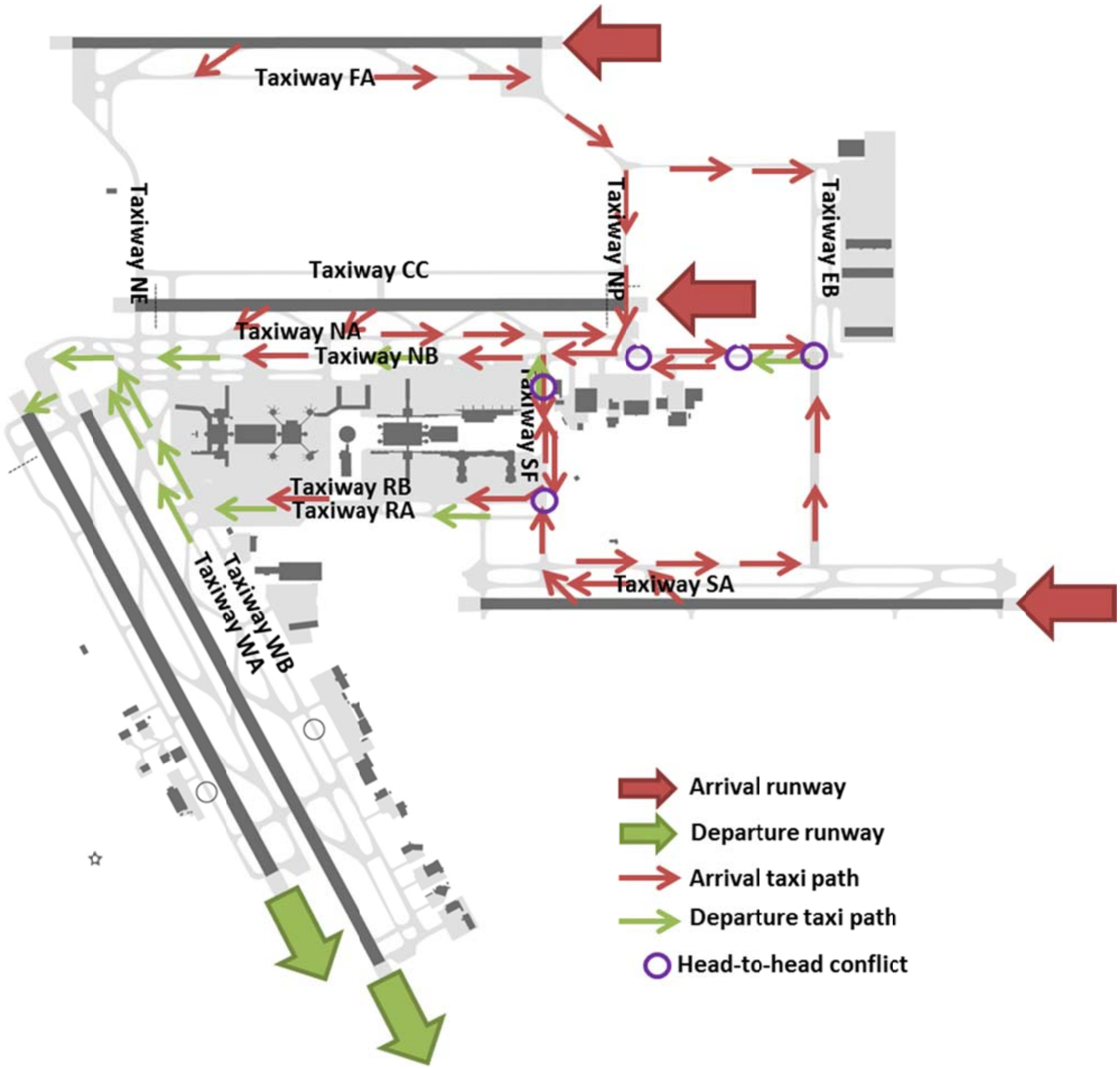
TAXI FLOWS—ALTERNATIVE D/E EAST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Figure 13

TAXI FLOWS—ALTERNATIVE D/E WEST FLOW



Source: LeighFisher based on discussions with IAH Airport Traffic Control Tower staff, January 2015.

Alternatives Evaluation

The five alternatives were reviewed with respect to several criteria to identify the preferred alternative. The scoring of each alternative is summarized in Table 1.

Financial evaluation

Order-of-magnitude cost estimates were prepared for each of the alternatives. These cost estimates include construction of the taxiway and any enabling projects, inclusive of facility and roadway relocations. Allowances for soft costs are included.

Alternatives A and B are the most costly because they include significant facility relocation and the reconstruction of the WCP/JFK interchange. For purposes of the evaluation, the cost estimates do not include the cost of extending Taxiways RA and RB, which will be needed for ultimate ground movement efficiency. If the costs for these taxiway extensions were included, the cost of Alternatives C, D, and E would be much greater given the reconstruction of the WCP/JFK interchange would be required for those alternatives as well.

Operational evaluation

The operational criteria included aircraft operating time, construction time and phasing, and impact on land use, summarized in Table 1. The most important operational criteria are aircraft operating time, estimated construction time, and the future option to construct Taxiway RA and RB extensions, as described below.

Aircraft operating time. Impacts to aircraft operating time were assessed using TAAM simulation software. Aircraft operating time is defined as unimpeded taxi time plus delay. This metric is used since a strict comparison of delay would not account for changes in taxi distance, and therefore taxi time, for some alternatives. Two demand levels were simulated, 2012 (1,506 daily aircraft operations) and PAL25 (1,840 daily aircraft operations), for the existing airfield using the most frequently occurring mode of operation (instrument approaches and independent departures). The resulting average aircraft operating time and change from the baseline condition (Taxiway SF as the only crossfield taxiway) are shown in Table 2.

As shown in Table 2, Alternatives A and B offer the greatest benefit in terms of total aircraft operating time because they do not increase taxi time while providing reductions in delay. This is logical, given that they are closer to the terminal complex than the other alternatives. Alternative C offers minimal reduction in total aircraft operating time, with the increases in aircraft taxiing time essentially offsetting any delay savings from the taxiway. Alternatives D and E result in an increase in total aircraft operating time since delay savings are not offset by increases in taxi time with taxi routes that require back-taxiing.

Estimated construction time. Also of note in the operational evaluation is the construction time and phasing. Alternative A would take the longest time to construct because of the complexity in reconstructing the WCP/JFK interchange more or less in the same location as the existing interchange, requiring as many as 23 phases. Alternative B takes less time to construct because the new interchange can be constructed to the east of the existing interchange, requiring only 9 phases. Alternatives C, D, and E could be constructed the fastest because they do not require reconstruction of the interchange in the initial build.

Table 1

CROSSFIELD TAXIWAY EVALUATION MATRIX

Criteria	Alternative				
	A	B	C	D	E
FINANCIAL					
Total project cost ($M)	320	303	64	59	63
Construction cost ($M)					
Crossfield taxiway	44	44	28	28	30
Facility demolition and relocation	37	70	4	-	-
Roadway construction	68	51	-	-	-
Drainage and utility	38	12	5	6	7
OPERATIONAL					
PAL 25 change in average aircraft operating time (minutes/operation)	-0.25	-0.25	-0.04	+0.02	+0.02
Estimated construction time (years)	5	3	1.5	1.5	1.5
Complexity of construction phasing	Poor	Fair	Good	Good	Good
Access traffic impacts during construction	Yes	Yes	No	No	No
ATCT line of sight	Poor	Fair	Good	Good	Good
Future option for RA/RB extensions	Yes	Yes	No	No	No
Developable area remaining	Contiguous	Contiguous	Bisected	Contiguous	Contiguous
Allows for expansion of terminal complex platform	No	Some	Yes	Yes	Yes
Allows for development of East Terminal	Yes	Yes	No	No	Yes
ENVIRONMENTAL AND SOCIAL					
Relocation or modification to public roadways	Significant	Significant	Minor	Minor	Minor
Increase in impervious surface area	Minor	Minor	Significant	Significant	Significant
Impact on wetlands	None	None	None	Minor	Minor
Impact on floodplains	None	None	Significant	Significant	Significant
Level of community/political controversy	Possible	Possible	None	None	None

Source: LeighFisher, January 2015.

Table 2

AVERAGE TOTAL AIRCRAFT OPERATING TIME

Demand	**Baseline**	**Alt A/B**	**Alt C**	**Alt D/E**
Annualized average total aircraft operating time: unimpeded taxi time + delay (minutes per operation)				
2012	13.08	12.98	13.07	13.20
PAL25	16.81	16.57	16.77	16.83
Change from baseline (minutes per operation)				
2012	N/A	-0.10	-0.01	+0.12
PAL25	N/A	-0.25	-0.04	+0.02

Source: LeighFisher, January 2015.

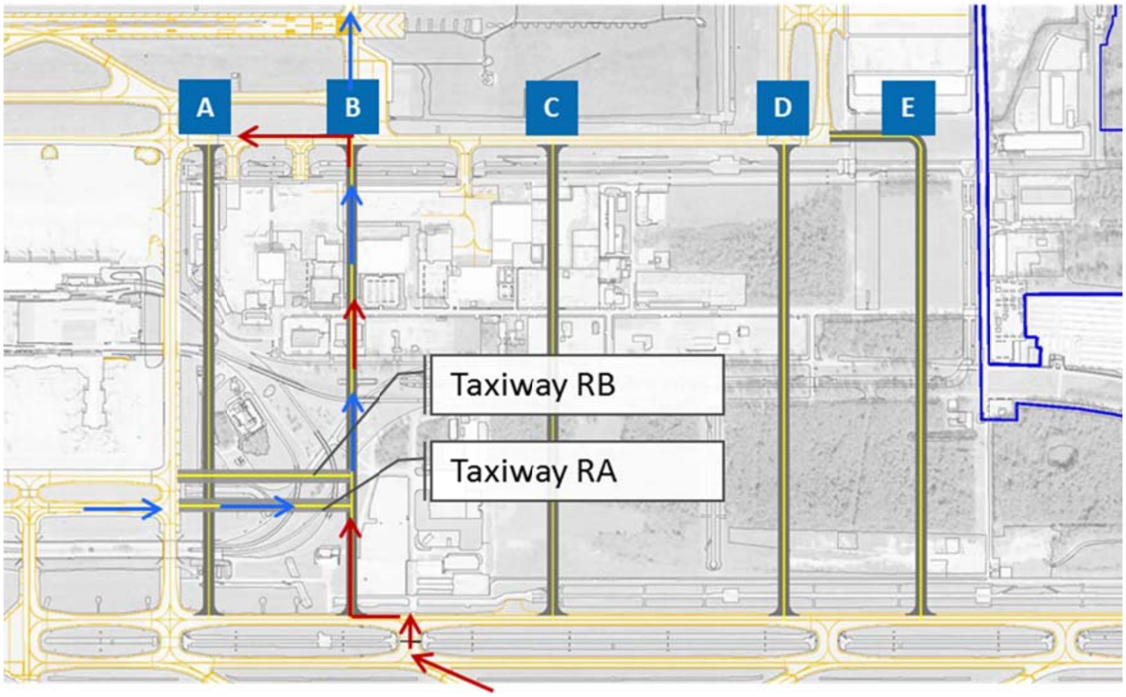
Future option for RA/RB extensions. A connection between the south apron and the new crossfield taxiway will be required to allow flexibility in the use of the taxiways and runways, and to enable access to a new north runway when built. For purposes of reducing initial cost, it is assumed that the extensions to Taxiway RA and RB be constructed in a later phase to coincide with the construction of the proposed Runway 8C-26C. Runway 8C-26C is anticipated to be required to be operational around the year 2035, depending on the realized growth of aircraft operations. Figure 14 shows how the taxiway extensions to RA and RB would serve aircraft departing from the south concourses of the terminal complex would taxi to Runway 8C-26C for departure.

While the extensions to Taxiways RA and RB are not required to alleviate congestion on Taxiway SF in the initial build of Taxiway SL, they could be built sooner if the Airport and FAA deems them to be useful or needed.

Environmental and Social. Alternatives A and B involve significant impacts to existing public roadways, but do not have significant environmental impacts otherwise. Alternatives C, D, and E would result in an increase in impervious surface since they would largely be on undeveloped land area. Also, these alternatives would reside in the floodplain.

Figure 14

TAXIWAY FLOW FROM SOUTH APRON TO PROPOSED RUNWAY 8C-26C



Source: LeighFisher, January 2015.

Preferred Alternative

Alternative B was recommended as the preferred alternative.

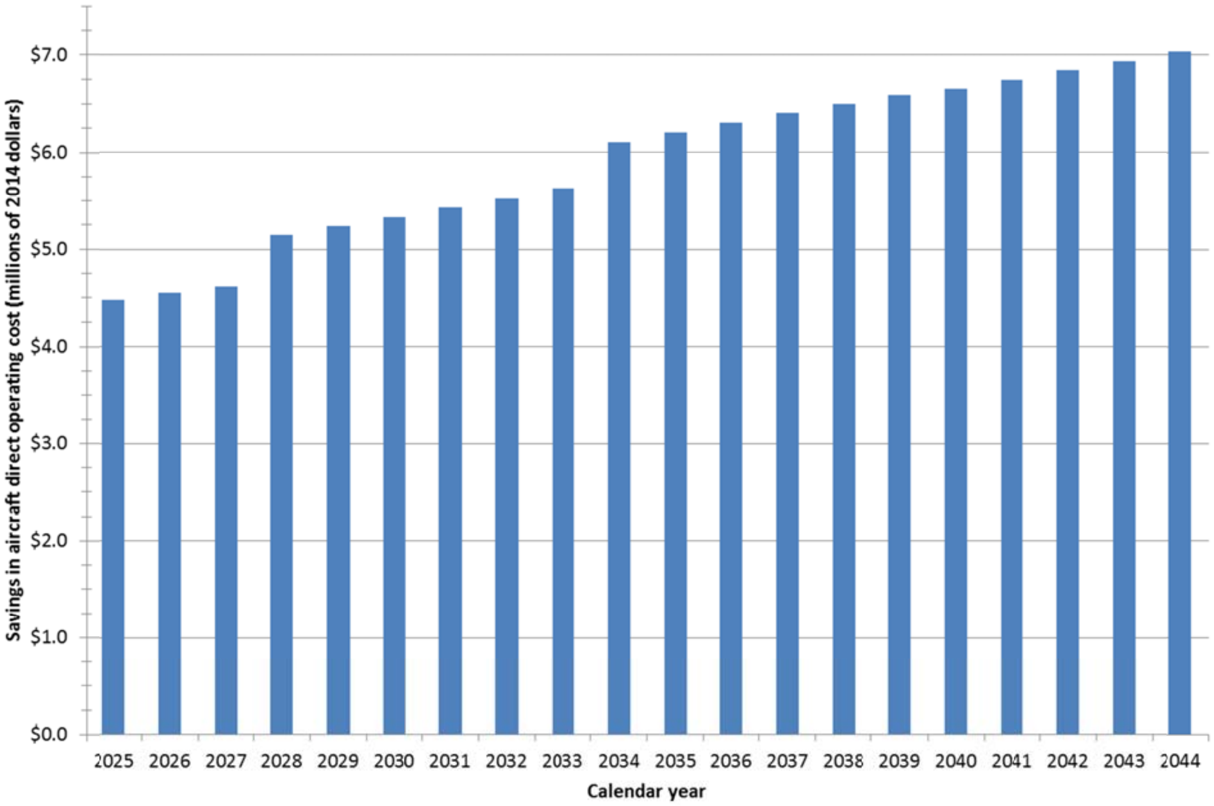
Alternatives D and E were are not favorable because they would require back-taxiing, resulting in an increase in aircraft operating time, meaning that the reduction in aircraft delay with these alternatives would not offset the increase in aircraft taxi time. Alternative C was not recommended because the savings in aircraft operating time are minimal, and although initially less costly than Alternatives A and B, it would not enable extension of Taxiways RA and RB without undertaking relocation of the WCP/JFK interchange. If Taxiways RA and RB were extended, Alternative C would result in a similar cost to Alternatives A or B. Alternative A was eliminated from consideration because of the construction time and cost implications of rebuilding the WCP/JFK interchange atop the existing interchange, while not providing for future expansion of the existing terminal platform.

The taxiway is expected to be needed at the PAL25 level of activity, corresponding to approximately 633,000 annual aircraft operations. Per the baseline master plan forecast, this level of activity is expected to occur in 2019. However, actual growth in aircraft operations has been slower than projected in the master plan baseline forecast. The FAA TAF forecasts expects reaching 633,000 annual aircraft operations in 2025, and the master plan slow growth forecast expects reaching 633,000 annual aircraft operations in 2028. For purposes of an informal analysis of economic justification, the FAA TAF forecast is assumed to be a reasonable projection of future passengers and aircraft operations at the Airport. Therefore, for the purposes of the benefit cost analysis (BCA) the taxiway is assumed to be operational in 2025, and benefits are accrued for 20 years through 2044.

Using a unit ground aircraft direct operating cost of between $19.22 and $22.53 per minute, and the FAA TAF estimated annual aircraft operations, Alternative B would save between $4 and $7 million per year in aircraft operating costs. Figure 15 shows the annual levels of estimated aircraft operating cost savings for each year in the assumed 20-year planning period.

Figure 15

AIRCRAFT DIRECT OPERATING COST SAVINGS



Source: LeighFisher, January 2015.

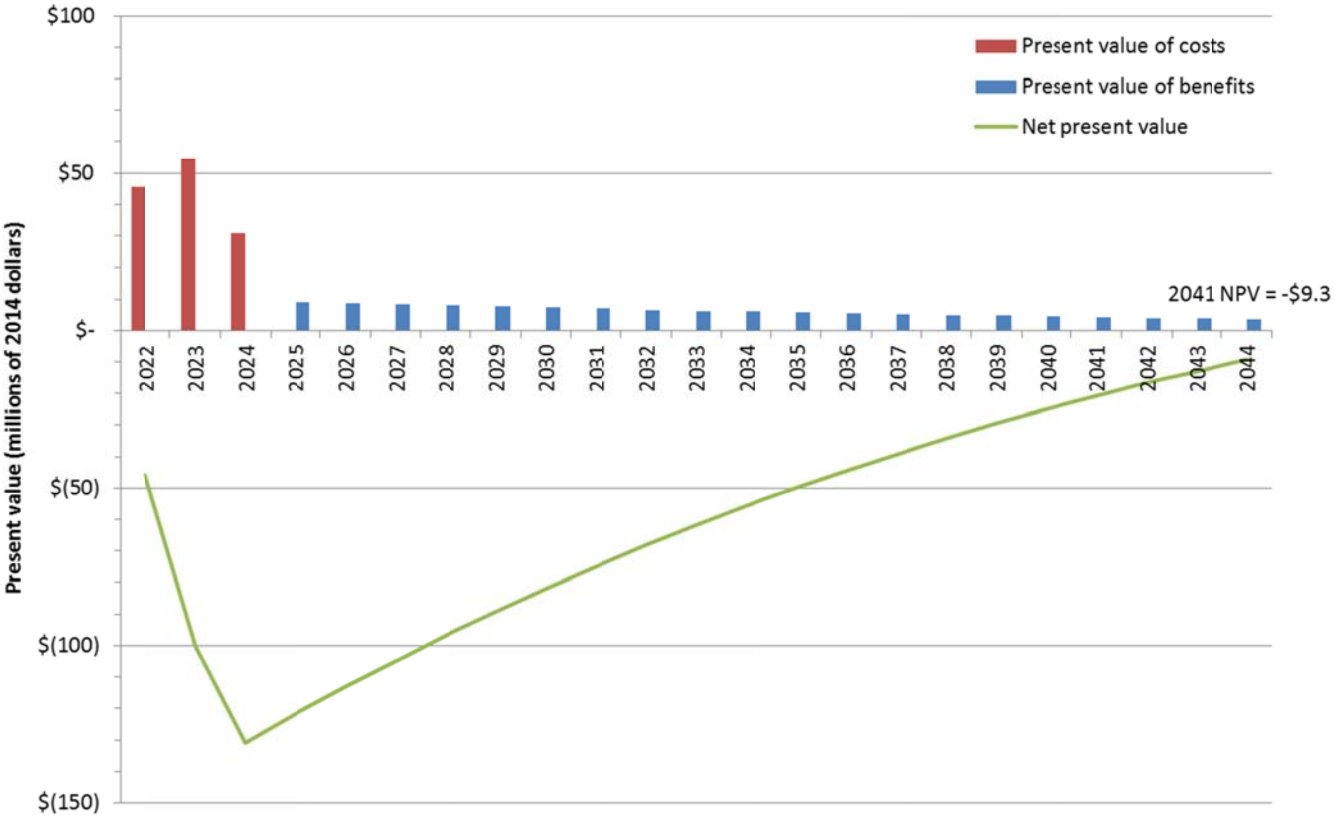
Using a FAA BCA approach to estimating future benefits, the net present value of the aircraft operating time savings and passenger savings is -$9.3 million over a 20-year planning period, resulting in a benefit-cost ratio of 0.93 using the following assumptions.

- The proposed taxiway opens in 2025 and benefits are accrued through 2044
- The existing airfield infrastructure (e.g. excludes the implementation of Taxiway NR which could erode the benefit)
- Base year of 2014
- Discount rate of 7%

- Annual aircraft operations and passengers grow in accordance with the FAA TAF
- Average unit ground aircraft direct operating cost of between $19.22 and $22.53 per minute, based on US Department of Transportation Form-41 filings for the Airport's existing and future fleet mix
- Passenger value of time of $47.96 per hour
- Airport-specific system wide multiplier of 1.46
- The Base Case (the course of action the Airport would take if it were unable to undertake Alternative B) assumes that the Airport would need to build a taxiway for the purposes of redundancy and to enable future maintenance of Taxiway SF. It is assumed that construction of Alternative C is the Base Case.

The present value of the costs and benefits using the FAA BCA guidance, as well as the resulting net present value year-by-year is shown in Figure 16.

Figure 16
PRESENT VALUE OF COSTS AND BENEFITS



Source: LeighFisher, January 2015.

The benefit-cost ratio of nearly one signifies that the project benefits approximately offset the project costs. As annual aircraft operations grow towards levels which would trigger implementation of Taxiway SL, further study is recommended including:

- Structural and pavement evaluation of Taxiway SF to determine when major maintenance will require its temporary closure;
- Planning for the event that Taxiway SF is unavailable, including consideration of alternate taxiway routes, assignment of aircraft to runways based on their aircraft gate, timing of the closure for maintenance, and potentially aircraft flight schedule changes; and
- Refinement of the BCA to: (a) include the assessment of additional benefits, include those hard to quantify; (b) refinement of the cost estimate based on more detailed planning or preliminary design, with reduced contingencies; (c) assessment of the impact of Taxiway SF temporary closure; (d) and refined construction schedule.

Appendix D
Roadway Technical Analysis

Appendix D

ROADWAY TECHNICAL ANALYSIS

Prepared by:

Gunda Corporation

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Engineers, Planners & Managers
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MEMORANDUM

Date: November 21, 2014

To: Mr. Peter Mandle, Director, LeighFisher

From: GUNDA Corporation

Re: Houston George Bush Intercontinental Airport (IAH) – Traffic Analysis

Project No.: 12017-00

This memorandum presents the data collection procedures, analysis, and results of the existing and future conditions traffic analysis conducted for John F. Kennedy Boulevard and Will Clayton Parkway, which are the primary roadways that provide direct access to Houston George Bush Intercontinental Airport. A Level of Service (LOS) analysis was conducted using existing, Year 2018, Year 2023, and Year 2033 traffic volumes. The list of roadway improvement projects which are required to be implemented in order to properly accommodate the future traffic volumes at an acceptable LOS are also presented in this memorandum.

1.0 Existing Condition

George Bush Intercontinental Airport (hereafter referred to as IAH) is located within the City of Houston, approximately twenty miles north of downtown Houston. IAH covers 51,251 acres and is located north of Beltway 8, between IH-45 and US 59. Access to the airport is provided by Will Clayton Parkway, John F. Kennedy Blvd, and Hardy Toll Road Airport Connector. The vicinity map of the Airport is presented in Figure 1.

1.0.1 Existing Roadway System

WILL CLAYTON PARKWAY

Will Clayton Parkway is an east-west directional roadway which commences at IAH in the west and ends at West Lake Houston Parkway in the east. Will Clayton Parkway is a four to six lane divided street in the study area. The posted speed limit on Will Clayton Parkway is 50 MPH in the study area. There are six (6) signalized intersections in the study limits.

JOHN F. KENNEDY BOULEVARD

JFK Boulevard is a north-south roadway which commences at IAH in the north and ends at Aldine Mail Route Road in the south. JFK Boulevard is a four to six lane divided street in the study area. There is a posted speed limit of 45-50 MPH in the study area. There are three (3) signalized intersections in the study limits.

HARDY TOLL ROAD AIRPORT CONNECTOR

The Hardy Toll Road Airport Connector is a three mile roadway which commences at Hardy Toll Road in the west and merges into JFK Boulevard north of Greens Road. The Hardy Toll Road Airport Connector is a four lane divided roadway with a posted speed limit of 55 MPH in the study area.

1.1 Data Collection

A comprehensive field investigation was conducted at all the study intersections by observing traffic operations, during the weekday AM, Mid-Day, and PM peak periods. The existing roadway geometrics of the study intersections, including number of traffic lanes, intersection signal phasing etc. were observed. The existing signal timing data was obtained from City of Houston Traffic Operations Division.

1.1.1 Turning Movement Counts & 24-Hour Traffic Counts

Gunda Corporation conducted peak period turning movement counts for the study intersections during the month of December 2013. Also, the bi-directional 24-hour traffic counts were collected on two days (March 7-8, 2013) at five (5) locations along primary roadways within the study area. The 24-Hour traffic counts for the locations are summarized in Table 1. The traffic count reports for all the locations are provided under Attachment A of this memorandum.

The locations of study intersections are presented in Figure 2. The existing AM, Mid-Day, and PM peak hour turning movement counts for the study intersections are illustrated in Figure 3, Figure 4, and Figure 5, respectively.

Table 1 - 24-Hour Traffic Counts
Existing Conditions Traffic Analysis
Houston George Bush Intercontinental Airport Master Plan 2035

Location	24-Hour Traffic Volume	
	Day 1	Day 2
JFK Blvd. @ World Houston Pkwy.	61,341	62,686
JFK Blvd. @ Hardy Toll Rd.	53,459	55,328
Eastbound Will Clayton Pkwy. @ Lee Dr.	10,827	7,383
Will Clayton Pkwy. @ McKay Rd.	38,833	40,370
Greens Rd. east of JFK Blvd.	11,007	10,803
Hardy Toll Rd. @ Waverly Dr.	15,418	15,858
Lee Rd. @ South of Will Clayton Pkwy.	3,224	3,218

MASTER PLAN 2035
GEORGE BUSH INTERCONTINENTAL AIRPORT/HOUSTON

Source: LeighFisher, December 2012
Prepared by: LeighFisher, December 2012

Leigh|Fisher

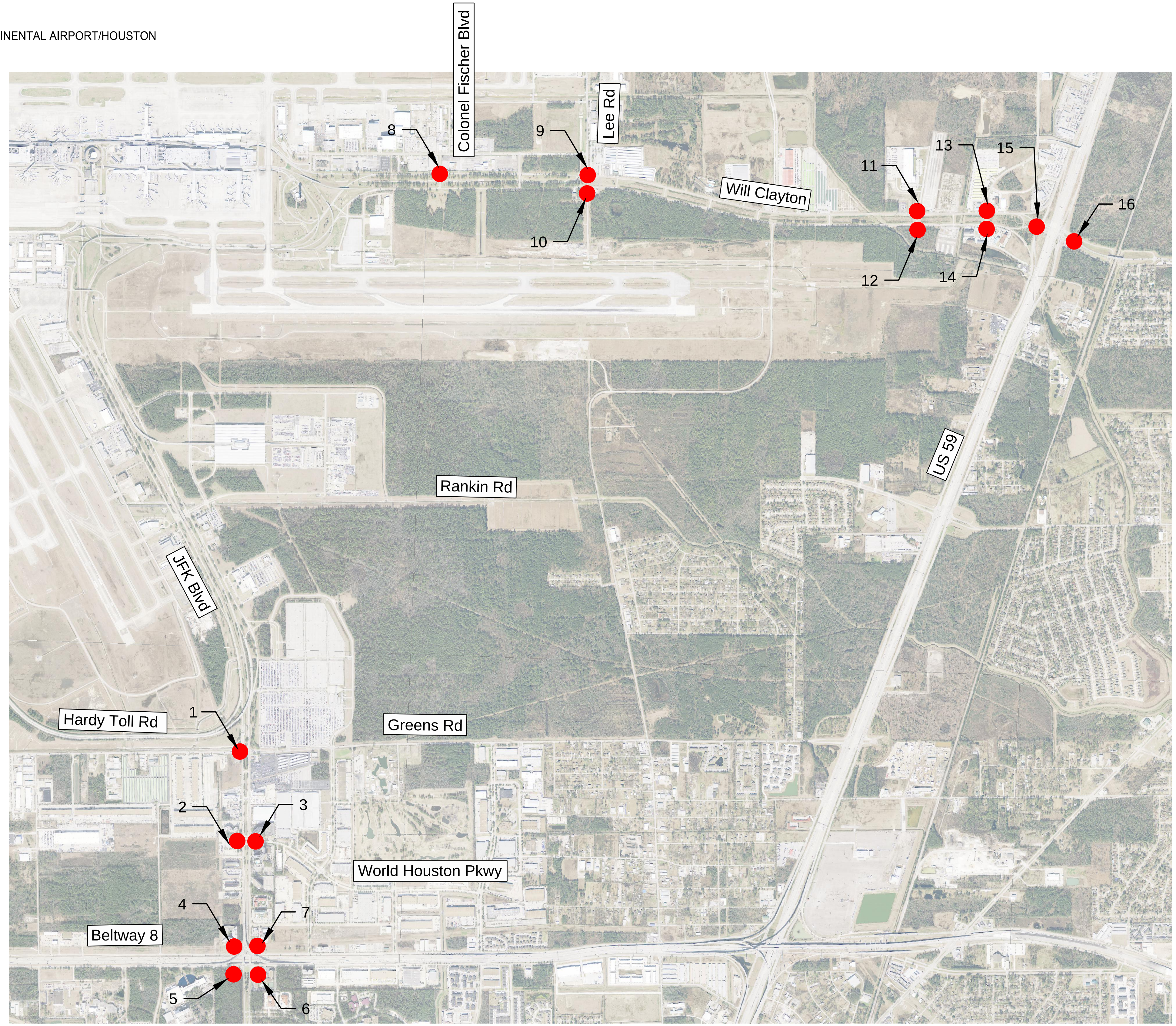
LEGEND

- ▨ Urban areas
- –·– County boundary
- ═ Major highway
- ═ Toll highway

N

4 0 4 8
Graphic Scale in Miles

Figure 1
Airport Vicinity Map



INTERCESSION DESCRIPTION:

1. JFK Boulevard & Greens Road
2. JFK Boulevard SB & World Houston Parkway
3. JFK Boulevard NB & World Houston Parkway
4. JFK Boulevard SB & BW 8 WB
5. JFK Boulevard SB & BW 8 EB
6. JFK Boulevard NB & BW 8 EB
7. JFK Boulevard NB & BW 8 WB
8. Will Clayton Parkway WB & Colonel Fischer Boulevard
9. Will Clayton Parkway EB & Lee Road
10. Will Clayton Parkway WB & Lee Road
11. Will Clayton Parkway EB & Humble Parkway
12. Will Clayton Parkway WB & Humble Parkway
13. Will Clayton Parkway EB & McKay Boulevard
14. Will Clayton Parkway WB & McKay Boulevard
15. Will Clayton Parkway & US 59 SB
16. Will Clayton Parkway & US 59 NB

Source: Jacobs, September 2014
Prepared by: Gunda Corporation, September 2014

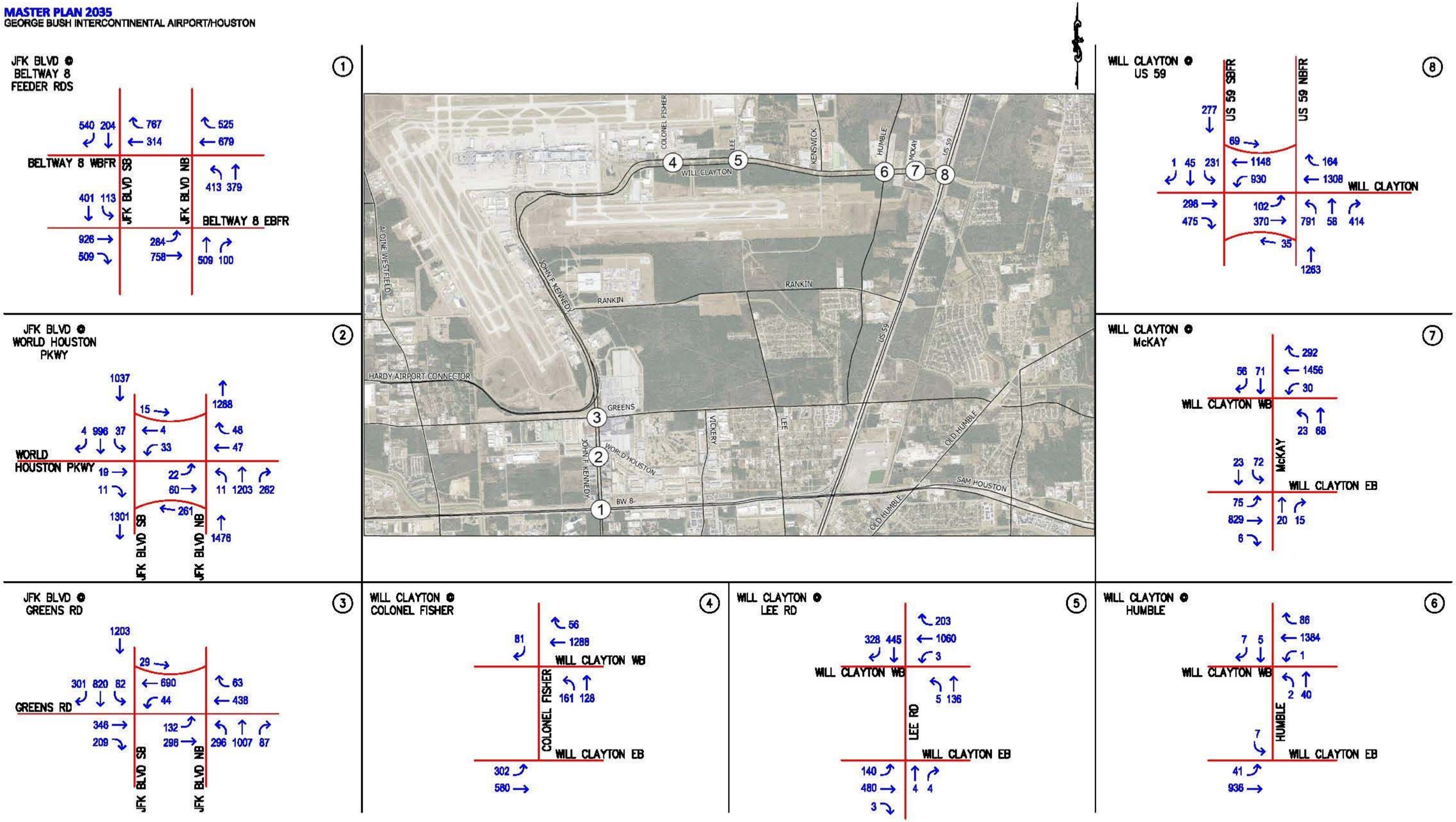
Leigh|Fisher

0 1250 2500

N

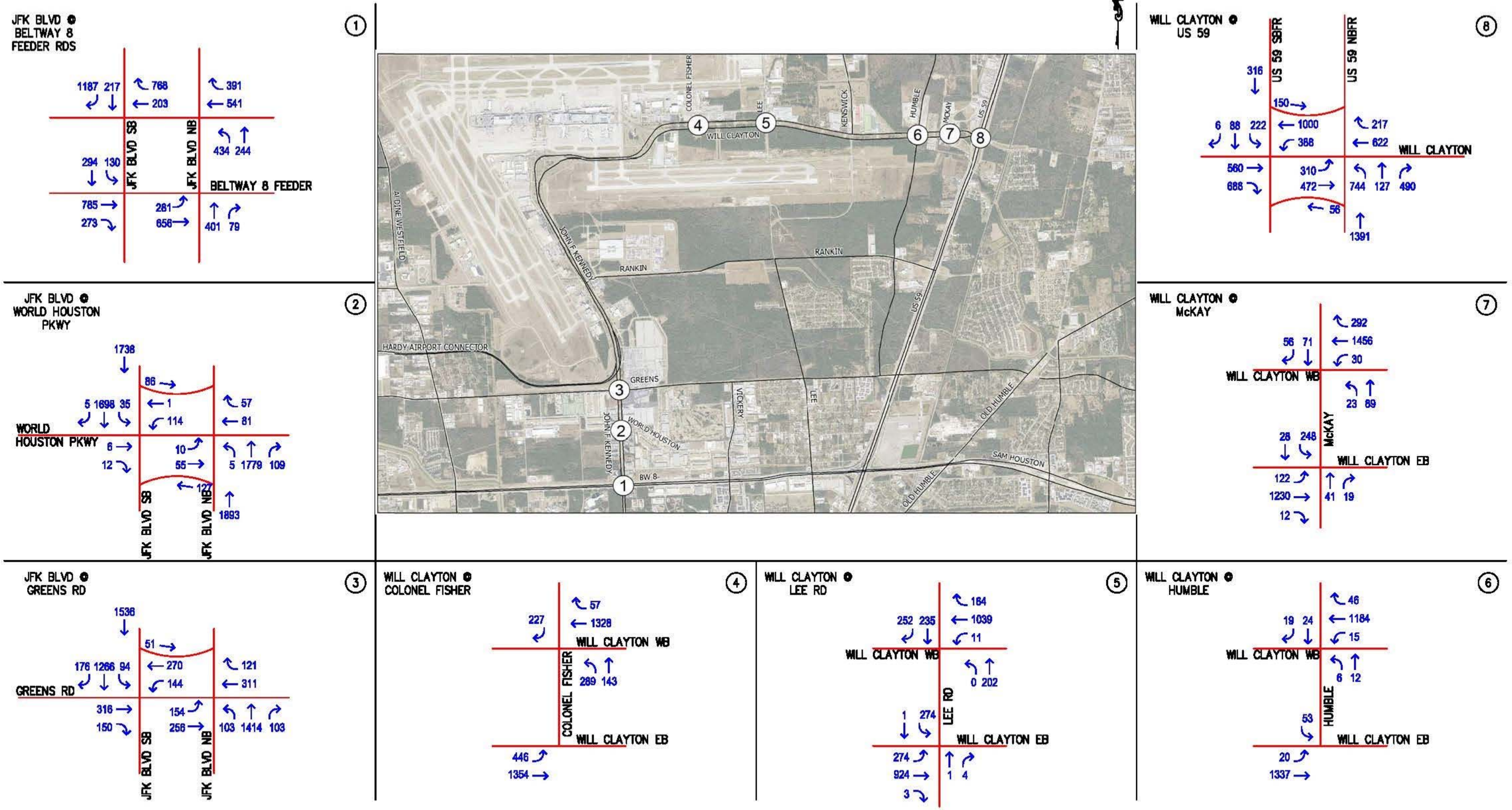
Figure 2

Study Intersections



Source: Gunda Corporation, January 2014
Prepared by: Gunda Corporation, January 2014

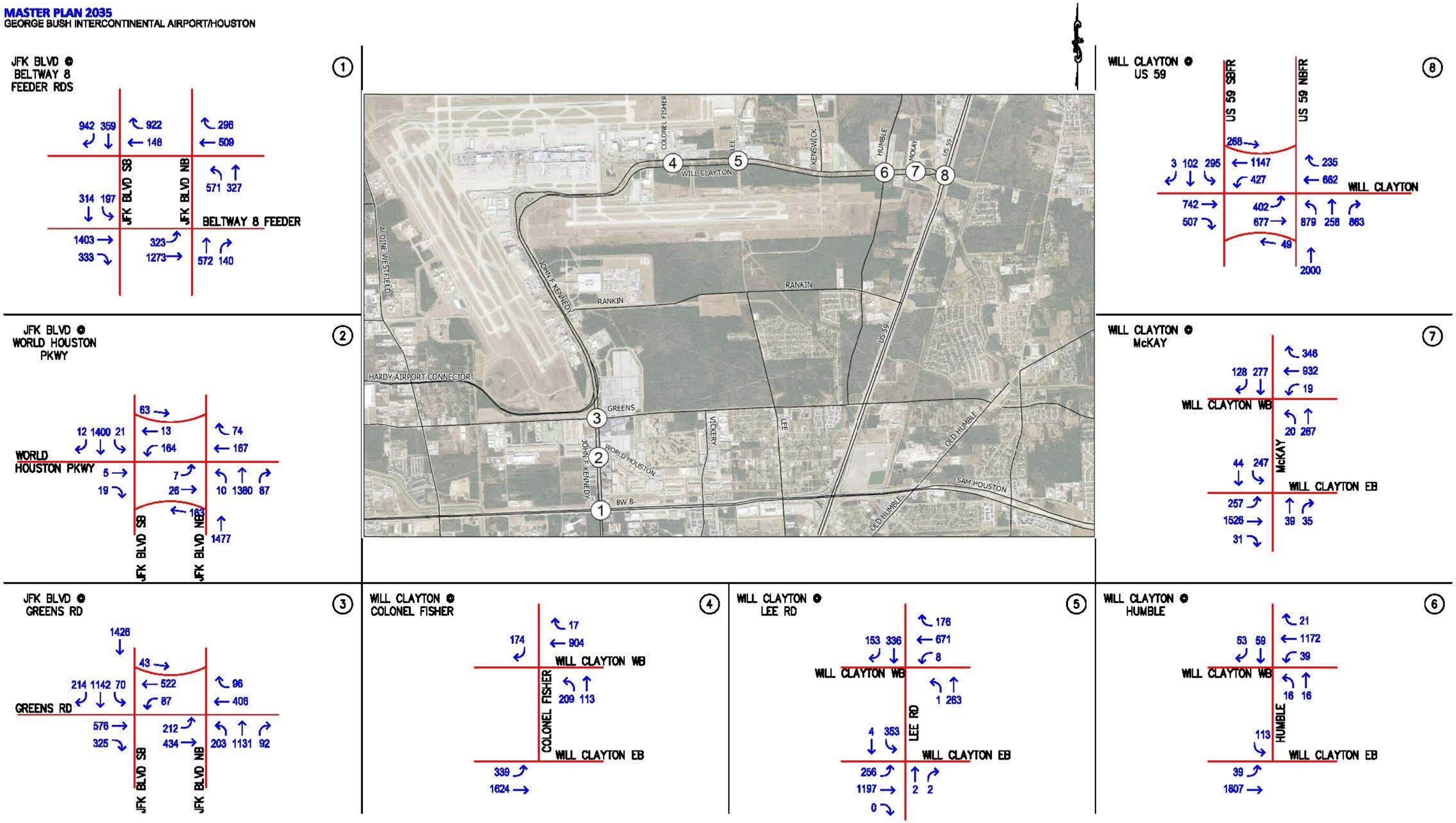
Figure 3
TRAFFIC TURNING MOVEMENT COUNTS - AM PEAK HOUR



Source: Gunda Corporation, December 2012
Prepared by: Gunda Corporation, December 2012

Leigh|Fisher

Figure 4
TRAFFIC TURNING MOVEMENT COUNTS - MID-DAY PEAK HOUR



Source: Gunda Corporation, December 2012
Prepared by: Gunda Corporation, December 2012

LeighFisher

Figure 5

TRAFFIC TURNING MOVEMENT COUNTS - PM PEAK HOUR

1.2 Summary of Field Observations

Observations were made for each intersection during both AM and PM peak periods.

JOHN F. KENNEDY BLVD

- **Beltway 8 & John F. Kennedy Blvd.**
  - During AM peak period, north and southbound traffic on John F. Kennedy Blvd. creates a queue on overpass segment.
  - During the PM peak hour, EB traffic on Beltway 8 has a queue, especially the right turn lane. SB has heavy traffic. Near the intersection there is a police officer directing traffic for office building in SB direction. Some queuing on all approaches.

- **World Houston Pkwy. & John F. Kennedy Blvd.**
  - During AM peak period, no queues were observed.
  - Traffic running smoothly. Heavier traffic in SB direction during PM peak.

- **Greens Rd. & John F. Kennedy Blvd.**
  - During AM peak hour, there were heavy delays on Greens Rd. in the WB direction.
  - During PM peak, there significant delay travelling EB on Greens. The through vehicles are blocking the left turn lane so that it does not fill. NB and WB left turn lanes are also backed up at the intersection. SB traffic is much heavier than NB.

WILL CLAYTON PKWY

- **US 59 & Will Clayton Pkwy.**
  - During AM peak period, WB thru traffic has large amount of queuing.
  - Toward end of AM peak period, NB and SB US 59 Feeder Roads have queuing. Also, EB and WB Will Clayton began to have heavier delays as well, spilling back to McKay Blvd.
  - EB traffic spilling back to McKay and Humble intersections during PM peak period. Other directions (especially NB and SB) have some queuing.

- **McKay Blvd. & Will Clayton Pkwy.**
  - During AM peak period, some delay spilling back from EB US 59 intersection. No delay in other directions.
  - EB backed up from US 59 during PM peak period. Other directions moving smoothly.

- **Humble Pkwy. & Will Clayton Pkwy.**
    - During AM peak period, traffic running smoothly.
    - During PM peak period, cars backed up to just past intersection in EB direction from US 59. Other directions moving smoothly.

- **Lee Rd. & Will Clayton Pkwy**.
    - During AM peak hour, WB vehicles queue up onto Will Clayton.
    - Some vehicles backed up on middle segment on Lee during PM peak period.

- **Colonel Fischer Dr. & Will Clayton Pkwy.**
    - WB had slight delay on Will Clayton during AM peak period.
    - Vehicles travelling NB on Colonel Fischer between EB and WB Will Clayton are filling segment.

1.3 Transportation System Analysis

PEDESTRIAN ACCESS

Sidewalks are present along JFK Boulevard and Will Clayton Parkway in the study area; however, they are discontinuous. The most signalized study intersections have pedestrian pushbuttons and pedestrian signal heads. Will Clayton Parkway at Lee Road and Colonel Fischer Drive do not have pedestrian pushbuttons or signal heads.

BICYCLE ACCESS

It was observed that none of the major streets in the study area have bike routes.

TRANSIT SERVICE

METRO bus routes are serviced in the study area. IAH is connected to Greenspoint Transit Center via Route 102. From the transit center, Routes 56 (to Downtown) and 86 (Crosstown to FM 1960) can be accessed.

1.4 Existing Condition Traffic Analysis

Intersection level of service analyses were performed in accordance with the procedures set forth and recommended by the Transportation Research Board’s Highway Capacity Manual (HCM) level of service methodologies for evaluation of signalized intersections. Traffic analysis software SYNCHRO, which incorporates HCM methodologies, was used to evaluate the operation of the study intersections. The Level of Service criteria for signalized and unsignalized intersections is based on average delay per vehicle and is listed below in Table 2. Level of Service "A" is considered as free flowing and "F" is considered as failing condition.

Table 2: Level of Service (LOS) Criteria for Intersections
George Bush Intercontinental Airport Master Plan Update

LOS	SIGNALIZED INTERSECION	UNSIGNALIZED INTERSECION
	DELAY (SEC/VEH)	DELAY (SEC/VEH)
A	0-10	0-10
B	>10-20	>10-15
C	>20-35	>15-25
D	>35-55	>25-35
E	>55-80	>35-50
F	>80	>50

PREPARED BY: GUNDA CORPORATION, 2014

Existing AM, Mid-Day, and PM weekday peak hour levels of service for the study intersections were evaluated based on existing traffic volumes, lane configuration, and timing. The existing AM, Mid-Day, and PM peak hour levels of service of the analysis intersections are summarized in Table 3, while detailed level of service analysis are included in Appendix B of this report. As presented in Table 3, several intersections are operating at level of service D during AM, Mid-Day and PM peak hours, under the existing conditions. There are also several intersections operating at LOS E during one or more peak period including: SB JFK Blvd. at Beltway 8 WBFR, NB JFK Blvd. at World Houston Parkway, JFK Blvd. at Greens Rd. Two intersections are currently operating at LOS F during both AM and PM peak hours: JFK Blvd. at Greens and Will Clayton at US 59 Northbound Frontage Rd.

Table 3: Intersections Level of Service – Existing Condition
George Bush Intercontinental Airport Master Plan Update

INTERSECTIONS	AM PEAK HOUR		MID-DAY PEAK HOUR		PM PEAK HOUR	
	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]
JFK Blvd. NB at Beltway 8 EBFR	D	38.7	C	20.7	D	47.5
JFK Blvd. SB at Beltway 8 EBFR	C	24.5	C	26.9	C	24.5
JFK Blvd. NB at Beltway 8 WBFR	C	22.0	D	40.8	D	39.3
JFK Blvd. SB at Beltway 8 WBFR	C	24.8	E	57.3	E	57.7
JFK Blvd. NB at World Houston Pkwy.	E	69.3	C	27.9	D	40.9
JFK Blvd. SB at World Houston Pkwy	C	27.3	C	20.9	D	43.3
JFK Blvd. at Greens Rd.	F	98.0	F	186.8	F	109.8
Will Clayton Pkwy. WB at Cl. Fischer Dr.	B	14.2	B	19.6	A	9.8
Will Clayton Pkwy. WB at Lee Road	C	26.8	C	26.3	C	21.7
Will Clayton Pkwy. EB at Lee Road	B	11.1	B	10.8	B	13.0
Will Clayton Pkwy. WB at Humble Dr.	A	6.6	A	6.3	B	10.3
Will Clayton Pkwy. EB at Humble Dr.	A	2.0	B	16.0	B	12.4
Will Clayton Pkwy. WB at McKay Ave.	B	11.4	B	10.1	B	14.5
Will Clayton Pkwy. EB at McKay Ave.	A	5.3	B	14.1	A	7.3
Will Clayton Pkwy. at US 59 SBFR	C	31.9	D	41.9	F	95.5
Will Clayton Pkwy. at US 59 NBFR	F	87.9	E	65.1	F	110.2

NOTES:
LOS – LEVEL OF SERVICE
[1] DEALY IS PRESENTED IN SECONDS PER VEHICLE
PREPARED BY: GUNDA CORPORATION, LLC., 2014

1.5 Findings

Based on the results of the traffic analysis conducted to evaluate the traffic operations along Will Clayton Parkway and John F. Kennedy Blvd. in the vicinity of the Houston George Bush Intercontinental Airport, the following observations have been made:

The following intersections are operating at LOS D or better during AM, PM and Mid-Day peak hour traffic conditions:

- JFK Blvd. SB & Beltway 8 EBFR
- JFK Blvd. NB & Beltway 8 WBFR
- JFK Blvd. & World Houston Pkwy.
- Will Clayton Pkwy. (WB) & Cl. Fischer Dr.
- Will Clayton Pkwy. & Lee Road
- Will Clayton Pkwy. & Humble Dr.
- Will Clayton Pkwy. & McKay Ave.

The following intersections are operating at LOS E or F during at least one of the AM, PM and Mid-Day peak hour traffic conditions:

- JFK Blvd. NB & Beltway 8 EBFR
- JFK Blvd. SB & Beltway 8 WBFR
- JFK Blvd. & Greens Road
- Will Clayton Pkwy. & US 59 SBFR
- Will Clayton Pkwy. & US 59 NBFR

The travel time along direct/preferred route (Beltway 8 main lanes to US 59 north main lanes) is approximately 18% less than the travel time along the primary cut-through route during the PM peak period.

2.0 Traffic Volume Projections

The existing (2013) traffic volumes at the study intersections along Will Clayton Parkway and JFK Boulevard were projected to future years (FY) 2018, 2023 and 2023. Based on the projected airline passenger growth rate provided by Leigh Fisher (2014) it was estimated that the airport traffic will grow at an annual rate of 3.1%. The non-airport traffic growth rate was estimated by comparing the Year 2010 and Year 2040 household population data for the census tracts in the vicinity of the Airport. The population data was obtained from Houston-Galveston Area Council (H-GAC). The annual non-airport traffic growth rate was estimated to be 1.98%. The exhibits illustrating existing and projected future traffic volumes are attached in Appendix A for reference.

3.0 Future Conditions Traffic Analysis

The same procedure used to conduct the existing condition Level of Service analysis was used in the future conditions analysis. The following study area intersections were analyzed as a part of the Future Conditions Analysis.

1. JFK Boulevard & Greens Road
2. JFK Boulevard SB & World Houston Parkway
3. JFK Boulevard NB & World Houston Parkway
4. JFK Boulevard SB & BW 8 WB
5. JFK Boulevard SB & BW 8 EB
6. JFK Boulevard NB & BW 8 EB
7. JFK Boulevard NB & BW 8 WB
8. Will Clayton Parkway WB & Colonel Fischer Drive
9. Will Clayton Parkway EB & Lee Road
10. Will Clayton Parkway WB & Lee Road
11. Will Clayton Parkway EB & Humble Parkway
12. Will Clayton Parkway WB & Humble Parkway
13. Will Clayton Parkway EB & McKay Boulevard
14. Will Clayton Parkway WB & McKay Boulevard
15. Will Clayton Parkway & US 59 SB
16. Will Clayton Parkway & US 59 NB

3.1 Future Conditions - No Build Scenario

The existing traffic volumes were projected to Year 2018, Year 2023 and Year 2033 using the growth rates presented in the traffic volume projections section (2.0). No Build conditions AM, Mid-Day, and PM weekday peak hour levels of service for the study intersections were evaluated based on projected traffic volumes, lane configuration, and signal timing. The future AM, Mid-day, and PM peak hour levels of service of the analysis intersections are summarized in Appendix B.

As presented in Appendix B, without improvements, several intersections will operate at level of service E or F during AM, Mid-Day and PM peak hours, under the future conditions.

Intersections operating below LOS D during AM, Mid-Day, or PM peak hours, without improvements, for each future conditions scenario are listed below:

The following intersections are projected to operate at level of service E or F in 2018 future conditions:

1. JFK Boulevard & Greens Road
2. JFK Boulevard SB & World Houston Parkway
3. JFK Boulevard NB & World Houston Parkway
4. JFK Boulevard SB & BW 8 WB
5. JFK Boulevard SB & BW 8 EB
6. Will Clayton Parkway WB & McKay Boulevard
7. Will Clayton Parkway & US 59 SB
8. Will Clayton Parkway & US 59 NB

In addition to the intersections listed above for 2018, the following intersection is projected to operate at level of service E or F in 2023 future conditions:

1. Will Clayton Parkway WB & Lee Road

In addition to the intersections listed above for 2018 and 2023, the following intersections are projected to operate at level of service E or F in 2033 future conditions:

1. JFK Boulevard NB & BW 8 EB
2. JFK Boulevard NB & BW 8 WB
3. Will Clayton Parkway WB & Colonel Fischer Drive
4. Will Clayton Parkway EB & Lee Road
5. Will Clayton Parkway WB & Humble Parkway
6. Will Clayton Parkway EB & McKay Boulevard

3.2 Recommended Roadway Improvements

Roadway improvements were developed for future conditions for three scenarios, 2018, 2023, and 2023. A summary of results and improvement recommendations for each year are listed below:

3.2.1 Year 2018 Traffic Analysis

The following section lists roadway improvements that are recommended to improve traffic operations occurring in 2018 at the study intersections along Will Clayton Parkway and John F. Kennedy Boulevard. These improvements are graphically depicted in Appendix B for reference.

- **JFK Boulevard & Greens Road (Figure B-1, Inset A)**
    - Add an exclusive eastbound right-turn lane (R.O.W. needed).

  - Provide channelization for southbound right-turn lane (R.O.W. available).

- **JFK Boulevard SB & Beltway 8 WB Frontage Road (Figure B-1, Inset B)**
  - Add an exclusive southbound right-turn lane.
  - Relocate driveway on BW 8 WB Frontage Road further west to provide sufficient distance for new free-flow southbound right-turn acceleration lane.

- **JFK Boulevard SB & Beltway 8 EB Frontage Road (Figure B-1, Inset B)**
  - Add an exclusive eastbound right-turn lane.

- **JFK Boulevard NB & Beltway 8 EB Frontage Road (Figure B-1, Inset B)**
  - Add an exclusive northbound right-turn lane.

- **Will Clayton Parkway & US 59 SB Frontage Road (Figure B-2, Inset A)**
  - Reconfigure the southbound approach of US 59 SB frontage road to provide two left turn lanes and one through/right shared lane.
  - Add an additional through lane on westbound approach of Will Clayton Parkway.

- **Will Clayton Parkway & US 59 NB Frontage Road (Figure B-2, Insets B & C)**
  - Add 3rd westbound through lane. This improvement was already identified in the City of Houston's Transportation Improvement Plan (TIP).
  - Add an additional eastbound left turn lane.
  - Reconfigure northbound approach to include 2 northbound left-turn lanes, 1 northbound through lane and, 1 northbound right-turn lane with channelization.
  - Close gas station driveway in the southeast corner of the intersection

The AM, Mid-Day and PM peak hour levels of service for the study intersections were evaluated by modeling the above mentioned roadway improvements. The level of service and delay information for the 2018 future scenario with and without the above improvements are shown in Table 4, below.

Table 4: FUTURE YEAR (2018) WITHOUT IMPROVEMENTS VS. WITH IMPROVEMENTS

INTERSECTION	AM PEAK HOUR				MID-DAY PEAK HOUR				PM PEAK HOUR			
	WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS		WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS		WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS	
	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)
JFK Boulevard & Greens Road	F	135.9	D	44.0	F	114.1	D	45.8	F	166.6	D	44.4
JFK Boulevard SB & World Houston Parkway	C	33.1	B	14.6	C	27.2	B	19.1	F	93.2	D	35.1
JFK Boulevard NB & World Houston Parkway	F	128.5	C	23.1	E	71.5	D	52.7	E	75.9	C	26.8
JFK Boulevard SB & BW 8 WB	D	36.2	B	12.5	E	76.0	B	14.2	F	84.5	B	13.2
JFK Boulevard SB & BW 8 EB	C	34.7	B	15.7	C	31.3	B	16.6	E	64.4	B	16.2
JFK Boulevard NB & BW 8 EB	D	46.2	B	10.8	D	47.0	A	8.8	D	50.4	B	12.6
JFK Boulevard NB & BW 8 WB	D	41.4	C	29.1	D	41.3	C	21.6	D	40.7	C	31.9
Will Clayton Parkway WB & Colonel Fischer Drive	B	17.8	B	11.3	C	22.0	B	16.9	B	12.7	B	13.1
Will Clayton Parkway EB & Lee Road	B	12.2	B	10.4	B	12.9	B	12.8	B	16.1	C	23.3
Will Clayton Parkway WB & Lee Road	D	41.4	D	37.1	C	30.2	C	27.9	C	21.2	B	16.8
Will Clayton Parkway EB & Humble	A	3.2	A	4.6	B	19.7	B	10.5	B	16.4	C	21.5
Will Clayton Parkway WB & Humble	A	7.8	A	9.2	A	8.2	B	10.8	B	11.6	B	12.8
Will Clayton Parkway EB & McKay Boulevard	A	5.7	A	7.4	B	16.2	B	12.0	B	10.5	B	18.8
Will Clayton Parkway WB & McKay Boulevard	B	12.5	A	9.1	B	12.1	B	11.7	F	252.4	B	13.5
Will Clayton Parkway & US 59 SB	E	63.7	C	30.6	E	77.9	C	26.6	F	148.6	D	48.3
Will Clayton Parkway & US 59 NB	F	134.0	D	51.5	F	100.1	D	50.2	F	167.4	D	52.9

4.2.2 Year 2023 Traffic Analysis

The following section lists roadway improvements that are recommended to improve the traffic operations occurring in 2023 at the study intersections along Will Clayton Parkway and John F. Kennedy Boulevard. These improvements are graphically depicted in Appendix C for reference. In addition to the 2018 improvements, the following improvements are recommended for 2023:

- **JFK Boulevard NB & World Houston Parkway (Figure C-1, Inset A)**
  - Add an exclusive northbound left-turn lane and an exclusive northbound right-turn lane.

- **Will Clayton Parkway & US 59 SB Frontage Road (Figure C-2)**
  - Relocate the existing entry ramp south approximately 1,200 feet from the existing entry ramp location.

The AM, Mid-Day and PM peak hour levels of service for the study intersections were evaluated by modeling the above mentioned roadway improvements. The level of service and delay information for the 2023 future scenario with and without the above improvements are shown in Table 5, below.

Table 5: FUTURE YEAR (2023) WITHOUT IMPROVEMENTS VS. WITH IMPROVEMENTS

INTERSECTION	AM PEAK HOUR				MID-DAY PEAK HOUR				PM PEAK HOUR			
	WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS		WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS		WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS	
	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)
JFK Boulevard & Greens Road	F	192.0	D	41.4	F	186.1	D	48.8	F	236.4	D	54.5
JFK Boulevard SB & World Houston Parkway	E	61.2	B	15.3	E	68.8	C	24.3	F	165.6	C	24.7
JFK Boulevard NB & World Houston Parkway	F	203.2	C	22.7	F	114.4	D	43.5	F	139.2	C	20.4
JFK Boulevard SB & BW 8 WB	E	61.0	B	13.8	F	122.1	D	35.9	F	121.1	D	35.4
JFK Boulevard SB & BW 8 EB	E	63.5	B	16.2	D	52.5	B	16.7	E	75.0	C	23.3
JFK Boulevard NB & BW 8 EB	D	49.2	B	12.0	D	51.1	B	10.1	D	52.3	B	15.3
JFK Boulevard NB & BW 8 WB	D	53.2	C	30.9	D	44.9	C	31.3	D	45.5	D	40.9
Will Clayton Parkway WB & Colonel Fischer Drive	C	21.2	B	14.3	C	24.8	C	23.8	B	16.0	B	14.0
Will Clayton Parkway EB & Lee Road	B	13.6	B	11.5	B	17.1	B	14.2	C	23.1	C	21.9
Will Clayton Parkway WB & Lee Road	F	95.7	D	52.4	D	41.1	D	36.1	C	24.6	C	26.5
Will Clayton Parkway EB & Humble	A	3.9	A	4.6	C	25.4	B	11.3	C	27.8	D	37.7
Will Clayton Parkway WB & Humble	A	9.5	B	11.5	A	8.3	B	12.1	A	9.9	B	13.9
Will Clayton Parkway EB & McKay Boulevard	A	5.7	A	6.6	B	15.1	B	15.0	B	11.7	C	32.8
Will Clayton Parkway WB & McKay Boulevard	B	14.9	B	10.8	B	13.2	B	14.4	B	17.5	B	15.8
Will Clayton Parkway & US 59 SB	F	117.4	D	36.3	F	124.1	C	24.3	F	212.7	D	47.1
Will Clayton Parkway & US 59 NB	F	184.8	D	47.0	F	117.6	D	40.8	F	212.0	D	46.0

4.2.3 Year 2033 Traffic Analysis

The following roadway improvements are recommended to improve the traffic operations at the study intersections along Will Clayton Parkway and John F. Kennedy Boulevard during the Year 2033. In addition to the short-term/mid-term operational improvements identified in the year 2018 and 2023 for the study area intersections, the following long-term improvements are recommended. These improvements are graphically depicted in Appendix D for reference.

JFK Boulevard: (Figure D-1)

- Construct an elevated four-lane divided roadway from Beltway 8 to North of Greens Road with entry and exit ramps on JFK Boulevard.
- Construct a direct connector to Beltway 8 Westbound from new elevated four lane divided roadway on JFK Boulevard.

Will Clayton Parkway: (Figures D-2, D-3, & D-4)

- Construct an elevated four-lane divided roadway from US 59 to west of Lee Road with Entrance and Exit ramps on Will Clayton Parkway.
- Option 1 - At the intersection of Will Clayton Parkway & US 59 SB Frontage Road, consolidate the two existing eastbound right-turn lanes to one wide channelized right-turn lane.
- Relocate the existing southbound entry ramp to further south.
- Also, the southbound exit-ramp for Rankin Road needs to be relocated north to current location of southbound Will Clayton Parkway entry ramp.
- Option 2 – Option 1+ Direct Connectors to US 59 from the new elevated four lane roadway on Will Clayton Parkway. This will introduce a second southbound entry ramp to US 59 Southbound and second northbound exit ramp from US 59 northbound.
- Option 3 – Option 2 + two westbound exit ramps on the new elevated four-lane roadway. One exit ramp located west of Lee Road and the second exit ramp west of Colonel Fischer Drive.
- An eastbound entry ramp east of Colonel Fischer Drive. This improvement was considered given the proposed parking lot improvements, from a previous study, at the intersection of Will Clayton Parkway & Colonel Fischer Drive.
- Widen Will Clayton Parkway WB at Colonel Fischer Drive to accommodate the exit ramp volume

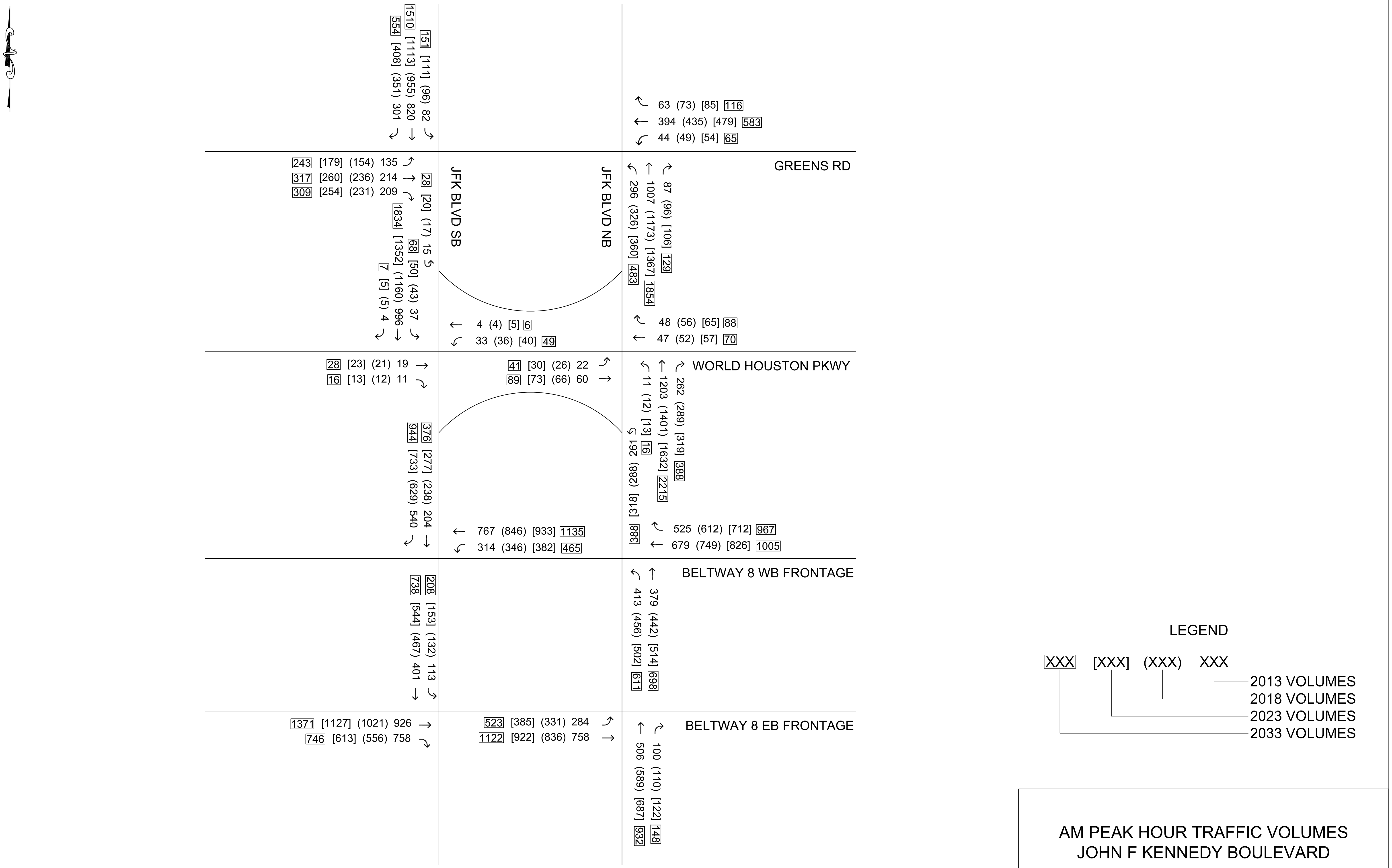
The AM, Mid-Day and PM peak hour levels of service for the study intersections were evaluated by modeling the above mentioned roadway improvements. The level of service and delay information for the 2033 future scenario with and without the above improvements are shown in Table 6, below.

Table 6: FUTURE YEAR (2033) WITHOUT IMPROVEMENTS VS. WITH IMPROVEMENTS

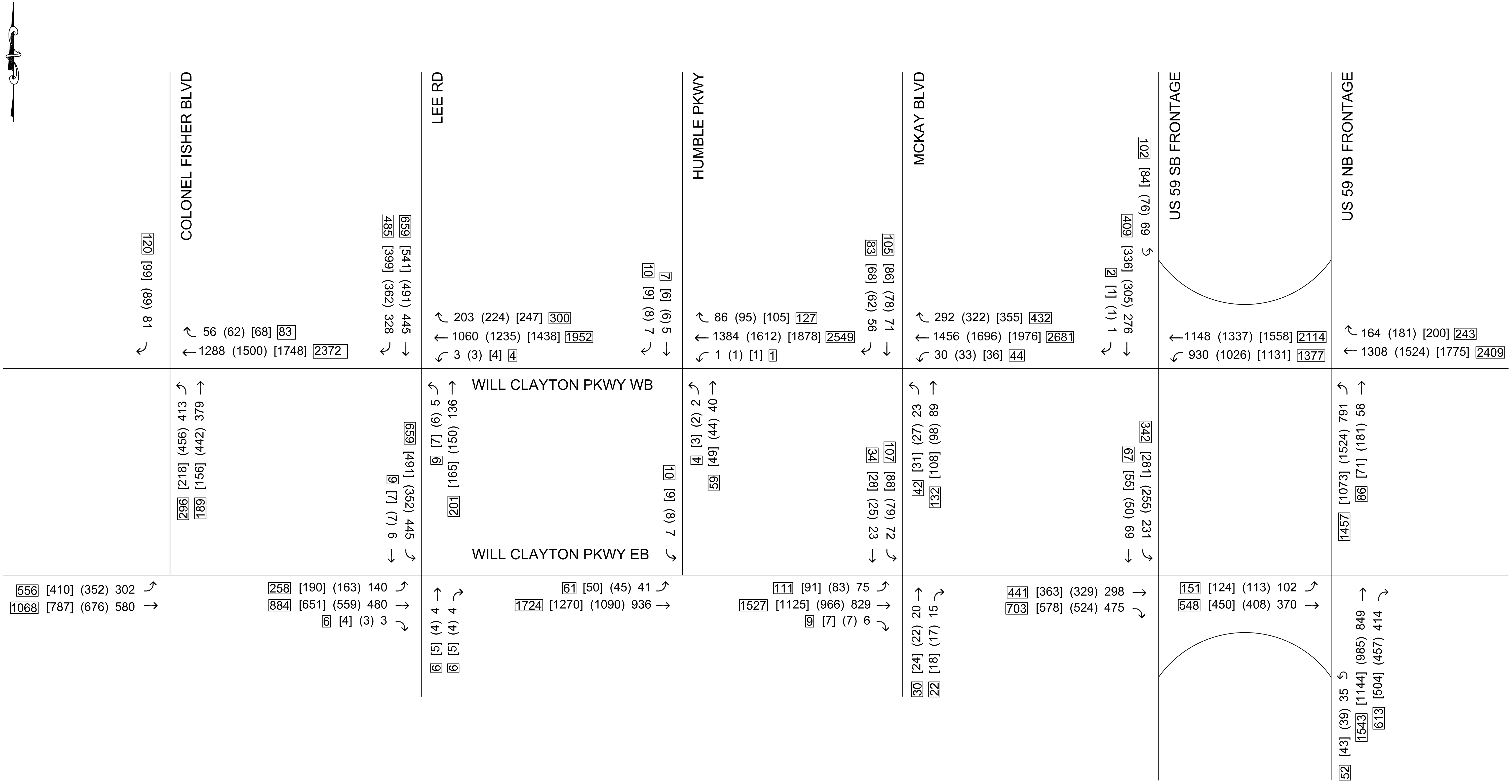
INTERSECTION	AM PEAK HOUR				MID-DAY PEAK HOUR				PM PEAK HOUR			
	WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS		WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS		WITHOUT IMPROVEMENTS		WITH IMPROVEMENTS	
	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)	LOS	Delay (v/s)
JFK Boulevard & Greens Road	F	350.8	D	43.8	F	386.5	D	48.7	F	422.4	D	39.7
JFK Boulevard SB & World Houston Parkway	F	225.8	C	29.3	F	207.8	C	31.7	F	357.5	C	31.1
JFK Boulevard NB & World Houston Parkway	F	392.5	C	29.3	F	282.4	D	36.0	F	305.8	C	24.8
JFK Boulevard SB & BW 8 WB	F	134.6	D	53.8	F	251.0	D	49.2	F	252.3	D	49.1
JFK Boulevard SB & BW 8 EB	F	89.8	C	31.2	F	90.5	B	17.3	F	127.5	C	24.9
JFK Boulevard NB & BW 8 EB	E	78.2	B	16.1	F	84.5	B	13.5	F	110.3	D	51.9
JFK Boulevard NB & BW 8 WB	F	117.1	C	33.6	E	76.8	C	34.8	E	75.3	C	32.5
Will Clayton Parkway WB & Colonel Fischer Drive	E	63.0	A	7.9	F	97.7	A	9.2	C	23.6	A	7.1
Will Clayton Parkway EB & Lee Road	B	17.4	B	14.3	F	81.8	B	14.7	F	146.9	B	13.8
Will Clayton Parkway WB & Lee Road	F	260.9	B	18.0	F	174.8	B	12.8	C	34.9	B	19.6
Will Clayton Parkway EB & Humble	A	4.9	A	4.6	F	98.7	A	9.1	F	186.6	B	10.4
Will Clayton Parkway WB & Humble	B	14.9	A	6.6	B	11.8	A	9.6	B	10.4	B	12.3
Will Clayton Parkway EB & McKay Boulevard	A	7.5	A	9.8	C	30.7	B	13.6	E	59.3	B	12.1
Will Clayton Parkway WB & McKay Boulevard	E	58.6	A	9.5	C	24.4	A	9.6	D	40.0	B	15.6
Will Clayton Parkway & US 59 SB	F	258.0	D	53.6	F	288.1	D	35.8	F	371.7	D	54.6
Will Clayton Parkway & US 59 NB	F	371.0	D	53.7	F	311.1	C	23.8	F	421.8	C	22.1

APPENDIX A

TRAFFIC VOLUME FIGURES



AM PEAK HOUR TRAFFIC VOLUMES
JOHN F KENNEDY BOULEVARD

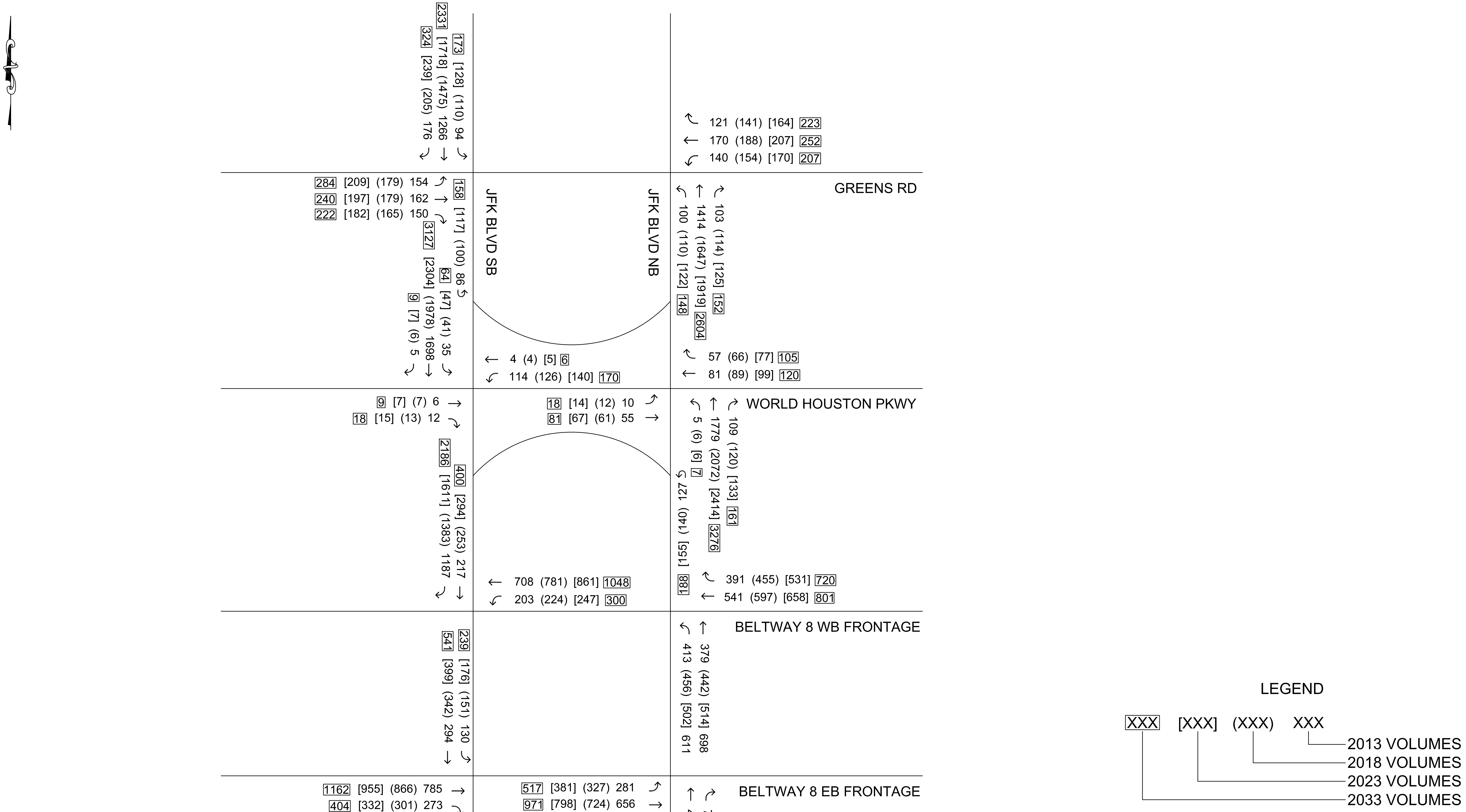


LEGEND

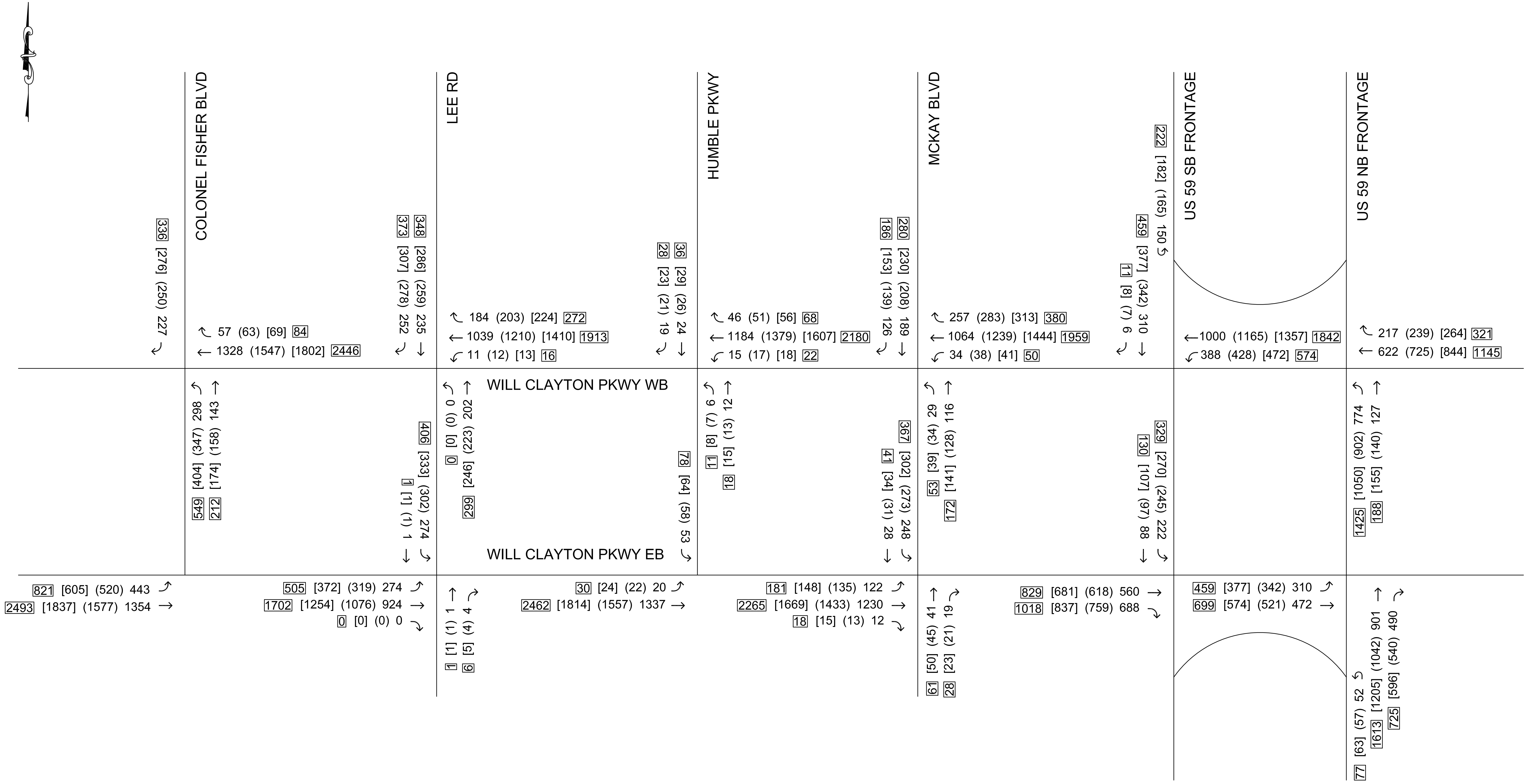
XXX [XXX] (XXX) XXX

XXX — 2013 VOLUMES
(XXX) — 2018 VOLUMES
[XXX] — 2023 VOLUMES
XXX (boxed) — 2033 VOLUMES

AM PEAK HOUR TRAFFIC VOLUMES
WILL CLAYTON PARKWAY



MIDDAY PEAK HOUR TRAFFIC VOLUMES
JOHN F KENNEDY BOULEVARD



LEGEND

XXX [XXX] (XXX) XXX

XXX – 2013 VOLUMES
(XXX) – 2018 VOLUMES
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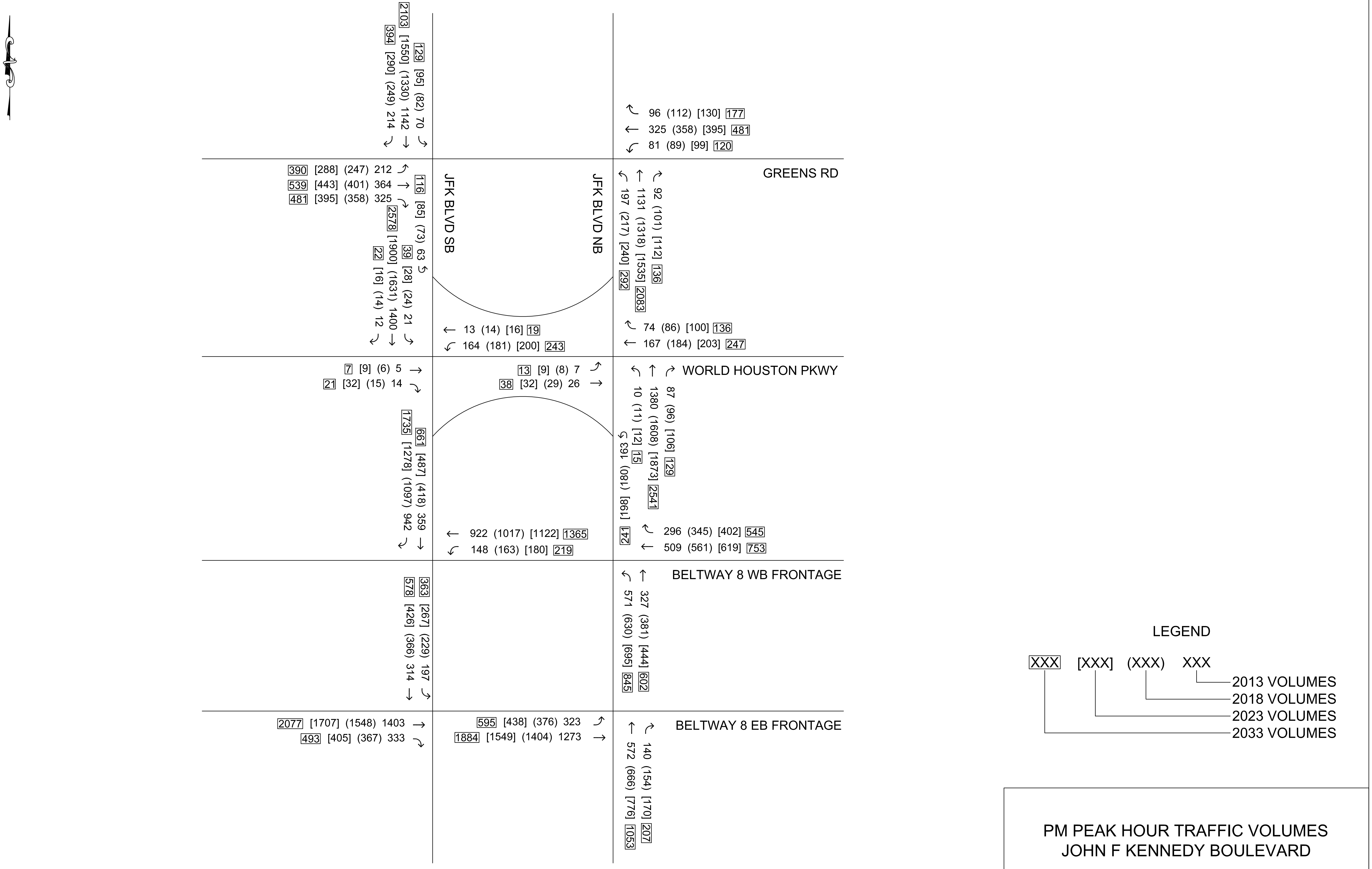
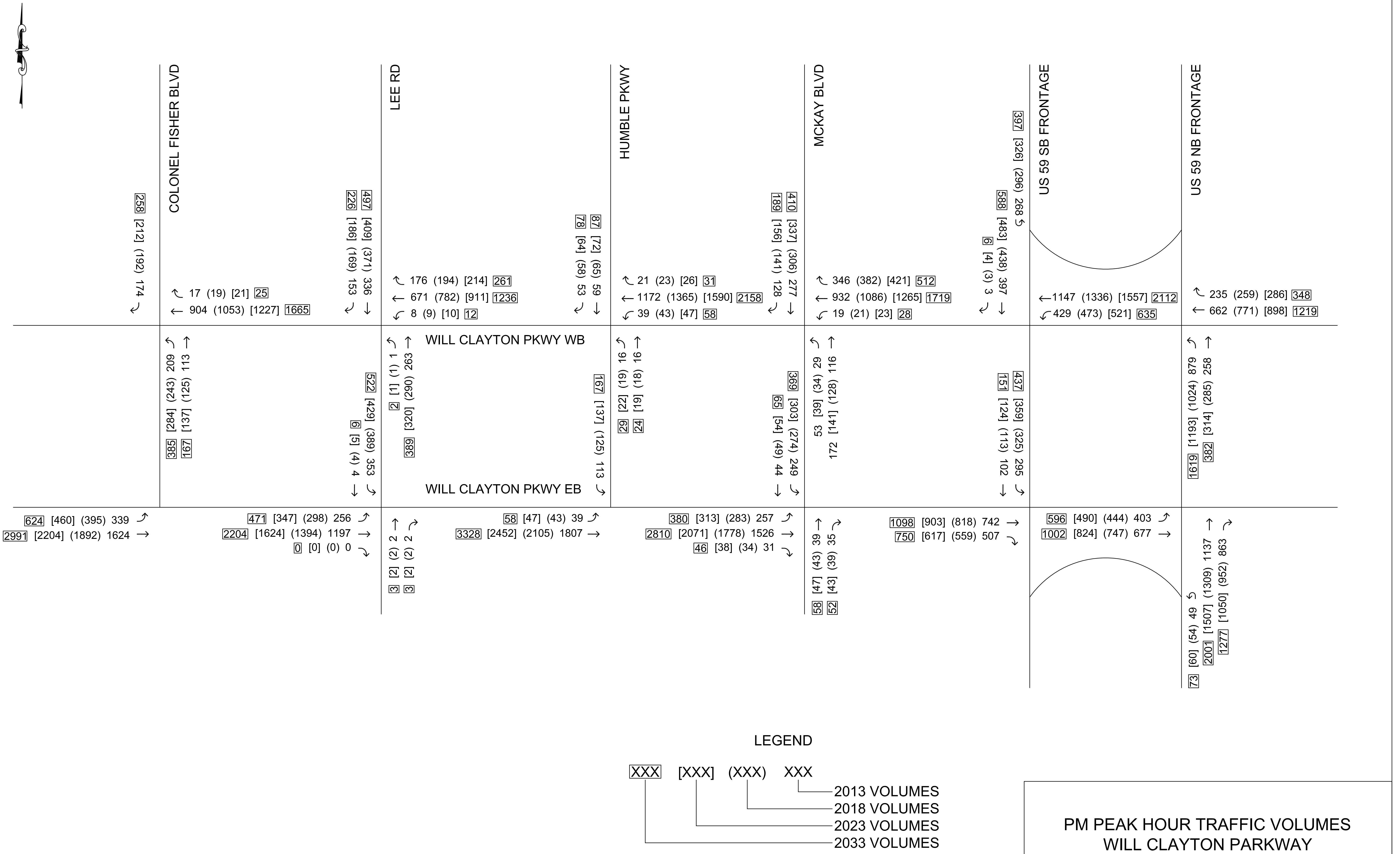
$\boxed{XXX}$ – 2033 VOLUMES

MIDDAY PEAK HOUR TRAFFIC VOLUMES
WILL CLAYTON PARKWAY



PM PEAK HOUR TRAFFIC VOLUMES
JOHN F KENNEDY BOULEVARD



PM PEAK HOUR TRAFFIC VOLUMES
WILL CLAYTON PARKWAY

2013 - AM PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road		132	214	209		44	394	63		296	1,007	87		82	820	301
JFK Boulevard SB & World Houston Parkway			19	11		33	4						15	37	996	4
JFK Boulevard NB & World Houston Parkway		22	60				47	48	261	11	1,203	262				
JFK Boulevard SB & BW 8 WB						314	767								204	540
JFK Boulevard SB & BW 8 EB			926	504										113	401	
JFK Boulevard NB & BW 8 EB		284	758								506	100				
JFK Boulevard NB & BW 8 WB							679	525		413	379					
Will Clayon Parkway EB & Colonel Fischer Boulevard		302	580													
Will Clayon Parkway WB & Colonel Fischer Boulevard							1,288	56		161	128					81
Will Clayton Parkway EB & Lee Road		140	480	3							4	4		445	6	
Will Clayton Parkway WB & Lee Road						3	1,060	203		5	136				445	328
Will Clayton Parkway EB & Humble		41	936											7		
Will Clayton Parkway WB & Humble						1	1,384	86		2	40				5	7
Will Clayton Parkway EB & McKay Boulevard		75	829	6							20	15			72	23
Will Clayton Parkway WB & McKay Boulevard						30	1,456	292		23	89				71	56
Will Clayton Parkway& US 59 SB			298	475		930	1,148						69	231	45	1
Will Clayton Parkway& US 59 NB		102	370				1,308	164	35	791	58	414				

2013 - MID-DAY PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road		154	162	150		140	170	121		100	1,414	103		94	1,266	176
JFK Boulevard SB & World Houston Parkway			6	12	1	114	4						86	35	1,698	5
JFK Boulevard NB & World Houston Parkway		10	55				81	57	127	5	1,779	109				
JFK Boulevard SB & BW 8 WB						203	708								217	1,187
JFK Boulevard SB & BW 8 EB			785	273										130	294	
JFK Boulevard NB & BW 8 EB		281	656								401	79				
JFK Boulevard NB & BW 8 WB							541	391		434	244					
Will Clayon Parkway EB & Colonel Fischer Boulevard		446	1,354													
Will Clayon Parkway WB & Colonel Fischer Boulevard							1,328	57		298	143					227
Will Clayton Parkway EB & Lee Road		274	924	36							1	4		274	1	
Will Clayton Parkway WB & Lee Road						11	1,039	184			202				235	252
Will Clayton Parkway EB & Humble		20	1,337											53		
Will Clayton Parkway WB & Humble						15	1,184	46		6	12				24	19
Will Clayton Parkway EB & McKay Boulevard		122	1,230	12							41	19	3	245	28	
Will Clayton Parkway WB & McKay Boulevard						34	1,064	257		29	116				189	126
Will Clayton Parkway& US 59 SB			560	688		388	1,000						150	222	88	6
Will Clayton Parkway& US 59 NB	2	308	472				622	217	52	774	127	490				

2013 - PM PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road		212	364	325		81	325	96		197	1,131	92		70	1,142	214
JFK Boulevard SB & World Houston Parkway			5	14		164	13						63	21	1,400	12
JFK Boulevard NB & World Houston Parkway		7	26				167	74	163	10	1,380	87				
JFK Boulevard SB & BW 8 WB						148	922								359	942
JFK Boulevard SB & BW 8 EB			1,403	333										197	314	
JFK Boulevard NB & BW 8 EB		323	1,273								572	140				
JFK Boulevard NB & BW 8 WB							509	296		571	327					
Will Clayon Parkway EB & Colonel Fischer Boulevard		339	1,624													
Will Clayon Parkway WB & Colonel Fischer Boulevard							904	17		209	113					174
Will Clayton Parkway EB & Lee Road		256	1,197								2	2		353	4	
Will Clayton Parkway WB & Lee Road						8	671	176		1	263				336	153
Will Clayton Parkway EB & Humble		39	1,807											113		
Will Clayton Parkway WB & Humble						39	1,172	21		16	16				59	53
Will Clayton Parkway EB & McKay Boulevard		257	1,526	31							39	35	2	247	44	
Will Clayton Parkway WB & McKay Boulevard						19	932	346		20	267				277	128
Will Clayton Parkway& US 59 SB			742	507	2	427	1,147						268	295	102	3
Will Clayton Parkway& US 59 NB	1	402	677				662	235	49	879	258	863				

2018 - AM PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	154	236	231	0	49	435	73	0	326	1,173	96	0	96	955	351
JFK Boulevard SB & World Houston Parkway	0	0	21	12	0	36	4	0	0	0	0	0	17	43	1,160	5
JFK Boulevard NB & World Houston Parkway	0	26	66	0	0	0	52	56	288	12	1,401	289	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	346	846	0	0	0	0	0	0	0	238	629
JFK Boulevard SB & BW 8 EB	0	0	1,021	556	0	0	0	0	0	0	0	0	0	132	467	0
JFK Boulevard NB & BW 8 EB	0	331	836	0	0	0	0	0	0	0	589	110	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	749	612	0	456	442	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	352	676	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	1,500	62	0	188	141	0	0	0	0	89
Will Clayton Parkway EB & Lee Road	0	163	559	3	0	0	0	0	0	0	4	4	0	491	7	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	3	1,235	224	0	6	150	0	0	0	491	362
Will Clayton Parkway EB & Humble	0	45	1,090	0	0	0	0	0	0	0	0	0	0	8	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	1	1,612	95	0	2	44	0	0	0	6	8
Will Clayton Parkway EB & McKay Boulevard	0	83	966	7	0	0	0	0	0	0	22	17	0	0	79	25
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	33	1,696	322	0	27	98	0	0	0	78	62
Will Clayton Parkway& US 59 SB	0	0	329	524	0	1,026	1,337	0	0	0	0	0	76	255	50	1
Will Clayton Parkway& US 59 NB	0	113	408	0	0	0	1,524	181	39	921	64	457	0	0	0	0

2018 - MID-DAY PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	179	179	165	0	154	188	141	0	110	1,647	114	0	110	1,475	205
JFK Boulevard SB & World Houston Parkway	0	0	7	13	1	126	4	0	0	0	0	0	100	41	1,978	6
JFK Boulevard NB & World Houston Parkway	0	12	61	0	0	0	89	66	140	6	2,072	120	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	224	781	0	0	0	0	0	0	0	253	1,383
JFK Boulevard SB & BW 8 EB	0	0	866	301	0	0	0	0	0	0	0	0	0	151	342	0
JFK Boulevard NB & BW 8 EB	0	327	724	0	0	0	0	0	0	0	467	87	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	597	455	0	479	284	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	520	1,577	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	1,547	63	0	347	158	0	0	0	0	250
Will Clayton Parkway EB & Lee Road	0	319	1,076	42	0	0	0	0	0	0	1	4	0	302	1	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	12	1,210	203	0	0	223	0	0	0	259	278
Will Clayton Parkway EB & Humble	0	22	1,557	0	0	0	0	0	0	0	0	0	0	58	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	17	1,379	51	0	7	13	0	0	0	26	21
Will Clayton Parkway EB & McKay Boulevard	0	135	1,433	13	0	0	0	0	0	0	45	21	3	270	31	0
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	38	1,239	283	0	34	128	0	0	0	208	139
Will Clayton Parkway& US 59 SB	0	0	618	759	0	428	1,165	0	0	0	0	0	165	245	97	7
Will Clayton Parkway& US 59 NB	2	340	521	0	0	0	725	239	57	902	140	540	0	0	0	0

2018 - PM PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	247	401	358	0	89	358	112	0	217	1,318	101	0	82	1,330	249
JFK Boulevard SB & World Houston Parkway	0	0	6	15	0	181	14	0	0	0	0	0	73	24	1,631	14
JFK Boulevard NB & World Houston Parkway	0	8	29	0	0	0	184	86	180	11	1,608	96	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	163	1,017	0	0	0	0	0	0	0	418	1,097
JFK Boulevard SB & BW 8 EB	0	0	1,548	367	0	0	0	0	0	0	0	0	0	229	366	0
JFK Boulevard NB & BW 8 EB	0	376	1,404	0	0	0	0	0	0	0	666	154	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	561	345	0	630	381	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	395	1,892	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	1,053	19	0	243	125	0	0	0	0	192
Will Clayton Parkway EB & Lee Road	0	298	1,394	0	0	0	0	0	0	0	2	2	0	389	4	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	9	782	194	0	1	290	0	0	0	371	169
Will Clayton Parkway EB & Humble	0	43	2,105	0	0	0	0	0	0	0	0	0	0	125	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	43	1,365	23	0	19	18	0	0	0	65	58
Will Clayton Parkway EB & McKay Boulevard	0	283	1,778	34	0	0	0	0	0	0	43	39	2	272	49	0
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	21	1,086	382	0	23	295	0	0	0	306	141
Will Clayton Parkway& US 59 SB	0	0	818	559	2	471	1,336	0	0	0	0	0	296	325	113	3
Will Clayton Parkway& US 59 NB	1	443	747	0	0	0	771	259	54	1,024	285	952	0	0	0	0

2023 - AM PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	179	260	254	0	54	479	85	0	360	1,367	106	0	111	1,113	408
JFK Boulevard SB & World Houston Parkway	0	0	23	13	0	40	5	0	0	0	0	0	20	50	1,352	5
JFK Boulevard NB & World Houston Parkway	0	30	73	0	0	0	57	65	318	13	1,632	319	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	382	933	0	0	0	0	0	0	0	277	733
JFK Boulevard SB & BW 8 EB	0	0	1,127	613	0	0	0	0	0	0	0	0	0	153	544	0
JFK Boulevard NB & BW 8 EB	0	385	922	0	0	0	0	0	0	0	687	122	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	826	712	0	502	514	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	410	787	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	1,748	68	0	218	156	0	0	0	0	99
Will Clayton Parkway EB & Lee Road	0	190	651	4	0	0	0	0	0	0	5	5	0	541	7	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	4	1,438	247	0	7	165	0	0	0	541	399
Will Clayton Parkway EB & Humble	0	50	1,270	0	0	0	0	0	0	0	0	0	0	9	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	1	1,878	105	0	3	49	0	0	0	6	9
Will Clayton Parkway EB & McKay Boulevard	0	91	1,125	7	0	0	0	0	0	0	24	18	0	0	88	28
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	36	1,976	355	0	31	108	0	0	0	86	68
Will Clayton Parkway& US 59 SB	0	0	363	578	0	1,131	1,558	0	0	0	0	0	84	281	55	1
Will Clayton Parkway& US 59 NB	0	124	450	0	0	0	1,775	200	43	1,073	71	504	0	0	0	0

2023 - MID-DAY PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	209	197	182	0	170	207	164	0	122	1,919	125	0	128	1,718	239
JFK Boulevard SB & World Houston Parkway	0	0	7	15	1	139	5	0	0	0	0	0	117	47	2,304	7
JFK Boulevard NB & World Houston Parkway	0	14	67	0	0	0	99	77	155	6	2,414	133	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	247	861	0	0	0	0	0	0	0	294	1,611
JFK Boulevard SB & BW 8 EB	0	0	955	332	0	0	0	0	0	0	0	0	0	176	399	0
JFK Boulevard NB & BW 8 EB	0	381	798	0	0	0	0	0	0	0	544	96	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	658	531	0	528	331	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	605	1,837	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	1,802	69	0	404	174	0	0	0	0	276
Will Clayton Parkway EB & Lee Road	0	372	1,254	49	0	0	0	0	0	0	1	5	0	333	1	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	13	1,410	224	0	0	246	0	0	0	286	307
Will Clayton Parkway EB & Humble	0	24	1,814	0	0	0	0	0	0	0	0	0	0	64	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	18	1,607	56	0	8	15	0	0	0	29	23
Will Clayton Parkway EB & McKay Boulevard	0	148	1,669	15	0	0	0	0	0	0	50	23	4	298	34	0
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	41	1,444	313	0	39	141	0	0	0	230	153
Will Clayton Parkway& US 59 SB	0	0	681	837	0	472	1,357	0	0	0	0	0	182	270	107	8
Will Clayton Parkway& US 59 NB	2	375	574	0	0	0	844	264	63	798	155	596	0	0	0	0

2023 - PM PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	288	443	395	0	99	395	130	0	240	1,535	112	0	95	1,550	290
JFK Boulevard SB & World Houston Parkway	0	0	6	17	0	200	16	0	0	0	0	0	85	28	1,900	16
JFK Boulevard NB & World Houston Parkway	0	9	32	0	0	0	203	100	198	12	1,873	106	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	180	1,122	0	0	0	0	0	0	0	487	1,278
JFK Boulevard SB & BW 8 EB	0	0	1,707	405	0	0	0	0	0	0	0	0	0	267	426	0
JFK Boulevard NB & BW 8 EB	0	438	1,549	0	0	0	0	0	0	0	776	170	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	619	402	0	695	444	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	460	2,204	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	1,227	21	0	284	137	0	0	0	0	212
Will Clayton Parkway EB & Lee Road	0	347	1,624	0	0	0	0	0	0	0	2	2	0	429	5	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	10	911	214	0	1	320	0	0	0	409	186
Will Clayton Parkway EB & Humble	0	47	2,452	0	0	0	0	0	0	0	0	0	0	137	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	47	1,590	26	0	22	19	0	0	0	72	64
Will Clayton Parkway EB & McKay Boulevard	0	313	2,071	38	0	0	0	0	0	0	47	43	2	301	54	0
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	23	1,265	421	0	27	325	0	0	0	337	156
Will Clayton Parkway& US 59 SB	0	0	903	617	2	519	1,557	0	0	0	0	0	326	359	124	4
Will Clayton Parkway& US 59 NB	1	489	824	0	0	0	898	286	60	907	314	1,050	0	0	0	0

2033 - AM PEAK HOUR

Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	243	317	309	0	65	583	116	0	438	1,854	129	0	151	1,510	554
JFK Boulevard SB & World Houston Parkway	0	0	28	16	0	49	6	0	0	0	0	0	28	68	1,834	7
JFK Boulevard NB & World Houston Parkway	0	41	89	0	0	0	70	88	386	16	2,215	388	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	465	1,135	0	0	0	0	0	0	0	376	994
JFK Boulevard SB & BW 8 EB	0	0	1,371	746	0	0	0	0	0	0	0	0	0	208	738	0
JFK Boulevard NB & BW 8 EB	0	523	1,122	0	0	0	0	0	0	0	932	148	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	1,005	967	0	611	698	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	556	1,068	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	2,372	83	0	296	189	0	0	0	0	120
Will Clayton Parkway EB & Lee Road	0	258	884	6	0	0	0	0	0	0	6	6	0	659	9	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	4	1,952	300	0	9	201	0	0	0	659	485
Will Clayton Parkway EB & Humble	0	61	1,724	0	0	0	0	0	0	0	0	0	0	10	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	1	2,549	127	0	4	59	0	0	0	7	10
Will Clayton Parkway EB & McKay Boulevard	0	111	1,527	9	0	0	0	0	0	0	30	22	0	0	107	34
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	44	2,681	432	0	42	132	0	0	0	105	83
Will Clayton Parkway& US 59 SB	0	0	441	703	0	1,377	2,114	0	0	0	0	0	102	342	67	2
Will Clayton Parkway& US 59 NB	0	151	548	0	0	0	2,409	243	52	1,457	86	613	0	0	0	0

2033 - MID-DAY PEAK HOUR

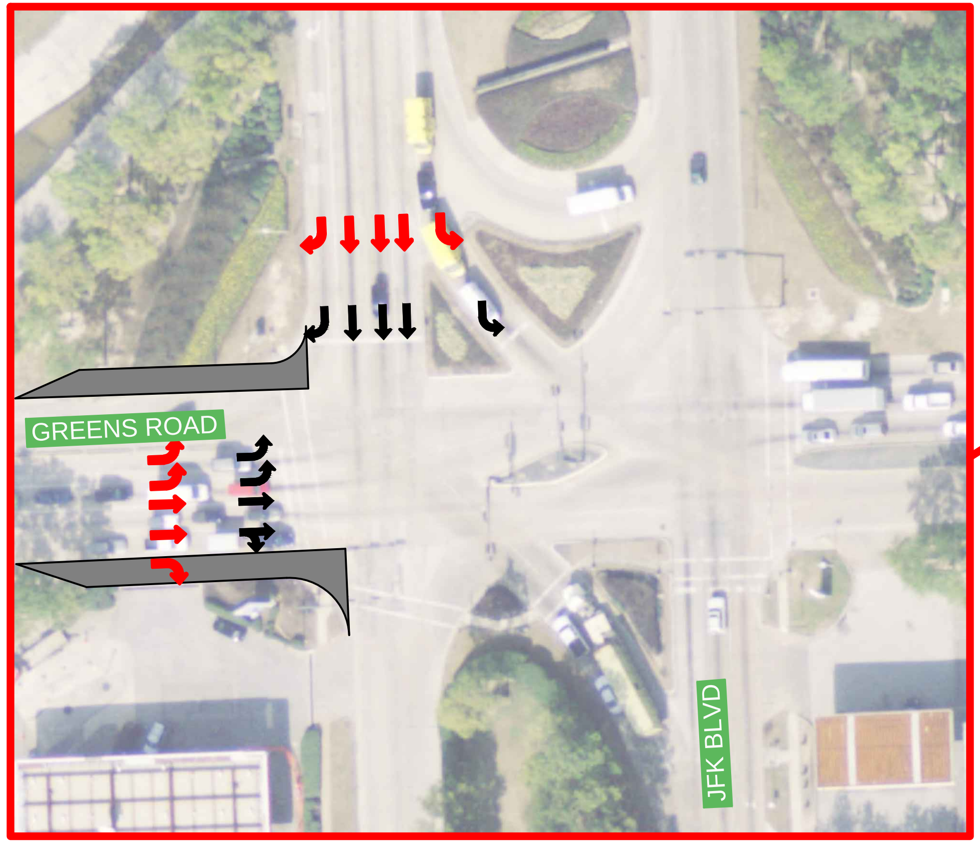
Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	284	240	222	0	207	252	223	0	148	2,604	152	0	173	2,331	324
JFK Boulevard SB & World Houston Parkway	0	0	9	18	1	169	6	0	0	0	0	0	158	64	3,127	9
JFK Boulevard NB & World Houston Parkway	0	18	81	0	0	0	120	105	188	7	3,276	161	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	300	1,048	0	0	0	0	0	0	0	400	2,186
JFK Boulevard SB & BW 8 EB	0	0	1,162	404	0	0	0	0	0	0	0	0	0	239	541	0
JFK Boulevard NB & BW 8 EB	0	517	971	0	0	0	0	0	0	0	738	117	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	801	720	0	642	449	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	821	2,493	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	2,446	84	0	549	212	0	0	0	0	336
Will Clayton Parkway EB & Lee Road	0	505	1,702	66	0	0	0	0	0	0	1	6	0	406	1	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	16	1,913	272	0	0	299	0	0	0	348	373
Will Clayton Parkway EB & Humble	0	30	2,462	0	0	0	0	0	0	0	0	0	0	78	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	22	2,180	68	0	11	18	0	0	0	36	28
Will Clayton Parkway EB & McKay Boulevard	0	181	2,265	18	0	0	0	0	0	0	61	28	4	363	41	0
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	50	1,959	380	0	53	172	0	0	0	280	186
Will Clayton Parkway& US 59 SB	0	0	829	1,018	0	574	1,842	0	0	0	0	0	222	329	130	11
Will Clayton Parkway& US 59 NB	3	456	699	0	0	0	1,145	321	77	1,425	188	725	0	0	0	0

2033 - PM PEAK HOUR

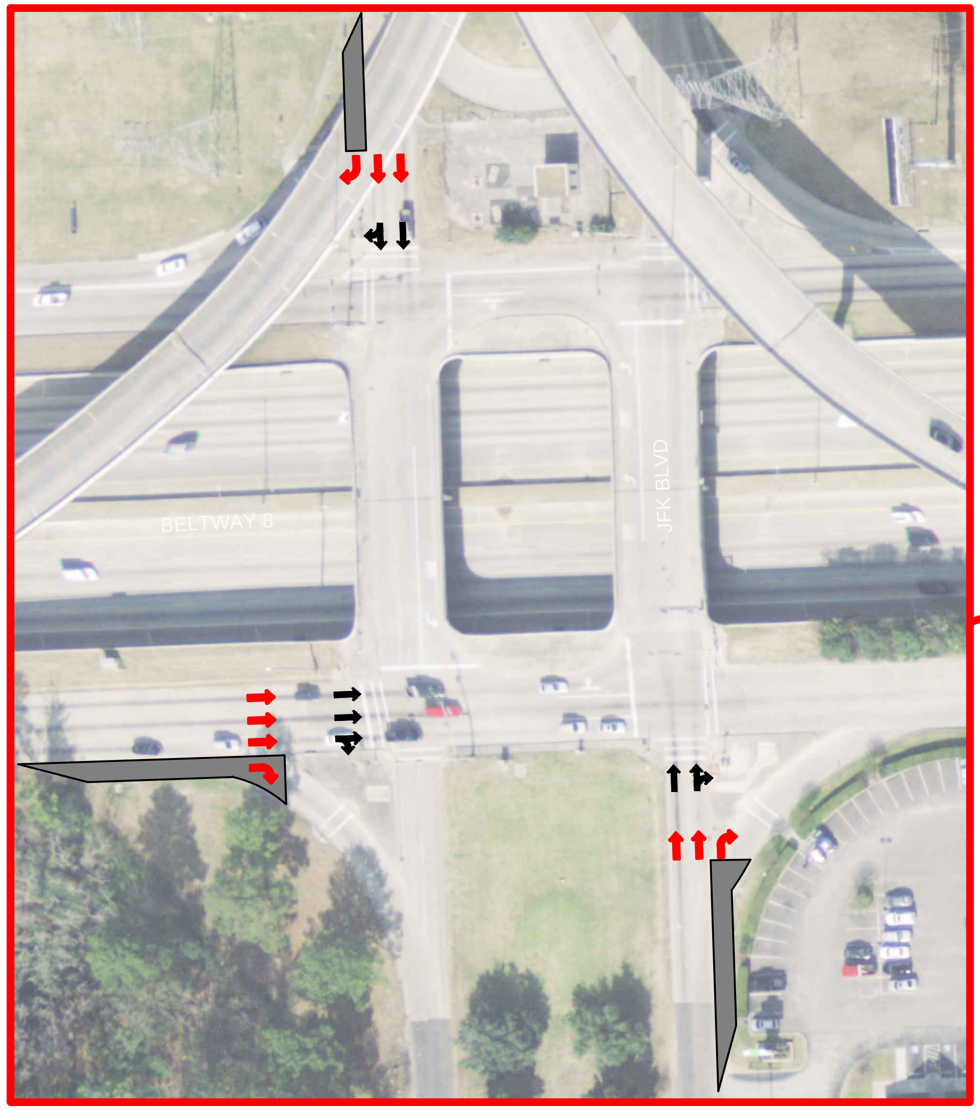
Intersection	EBU	EBL	EBT	EBR	WBU	WBL	WBT	WBR	NBU	NBL	NBT	NBR	SBU	SBL	SBT	SBR
JFK Bouleavrd & Greens Road	0	390	539	481	0	120	481	177	0	292	2,083	136	0	129	2,103	394
JFK Boulevard SB & World Houston Parkway	0	0	7	21	0	243	19	0	0	0	0	0	116	39	2,578	22
JFK Boulevard NB & World Houston Parkway	0	13	38	0	0	0	247	136	241	15	2,541	129	0	0	0	0
JFK Boulevard SB & BW 8 WB	0	0	0	0	0	219	1,365	0	0	0	0	0	0	0	661	1,735
JFK Boulevard SB & BW 8 EB	0	0	2,077	493	0	0	0	0	0	0	0	0	0	363	578	0
JFK Boulevard NB & BW 8 EB	0	595	1,884	0	0	0	0	0	0	0	1,053	207	0	0	0	0
JFK Boulevard NB & BW 8 WB	0	0	0	0	0	0	753	545	0	845	602	0	0	0	0	0
Will Clayon Parkway EB & Colonel Fischer Boulevard	0	624	2,991	0	0	0	0	0	0	0	0	0	0	0	0	0
Will Clayon Parkway WB & Colonel Fischer Boulevard	0	0	0	0	0	0	1,665	25	0	385	167	0	0	0	0	258
Will Clayton Parkway EB & Lee Road	0	471	2,204	0	0	0	0	0	0	0	3	3	0	522	6	0
Will Clayton Parkway WB & Lee Road	0	0	0	0	0	12	1,236	261	0	2	389	0	0	0	497	226
Will Clayton Parkway EB & Humble	0	58	3,328	0	0	0	0	0	0	0	0	0	0	167	0	0
Will Clayton Parkway WB & Humble	0	0	0	0	0	58	2,158	31	0	29	24	0	0	0	87	78
Will Clayton Parkway EB & McKay Boulevard	0	380	2,810	46	0	0	0	0	0	0	58	52	3	366	65	0
Will Clayton Parkway WB & McKay Boulevard	0	0	0	0	0	28	1,716	512	0	37	395	0	0	0	410	189
Will Clayton Parkway& US 59 SB	0	0	1,098	750	3	632	2,112	0	0	0	0	0	397	437	151	6
Will Clayton Parkway& US 59 NB	1	595	1,002	0	0	0	1,219	348	73	1,619	382	1,277	0	0	0	0

APPENDIX .

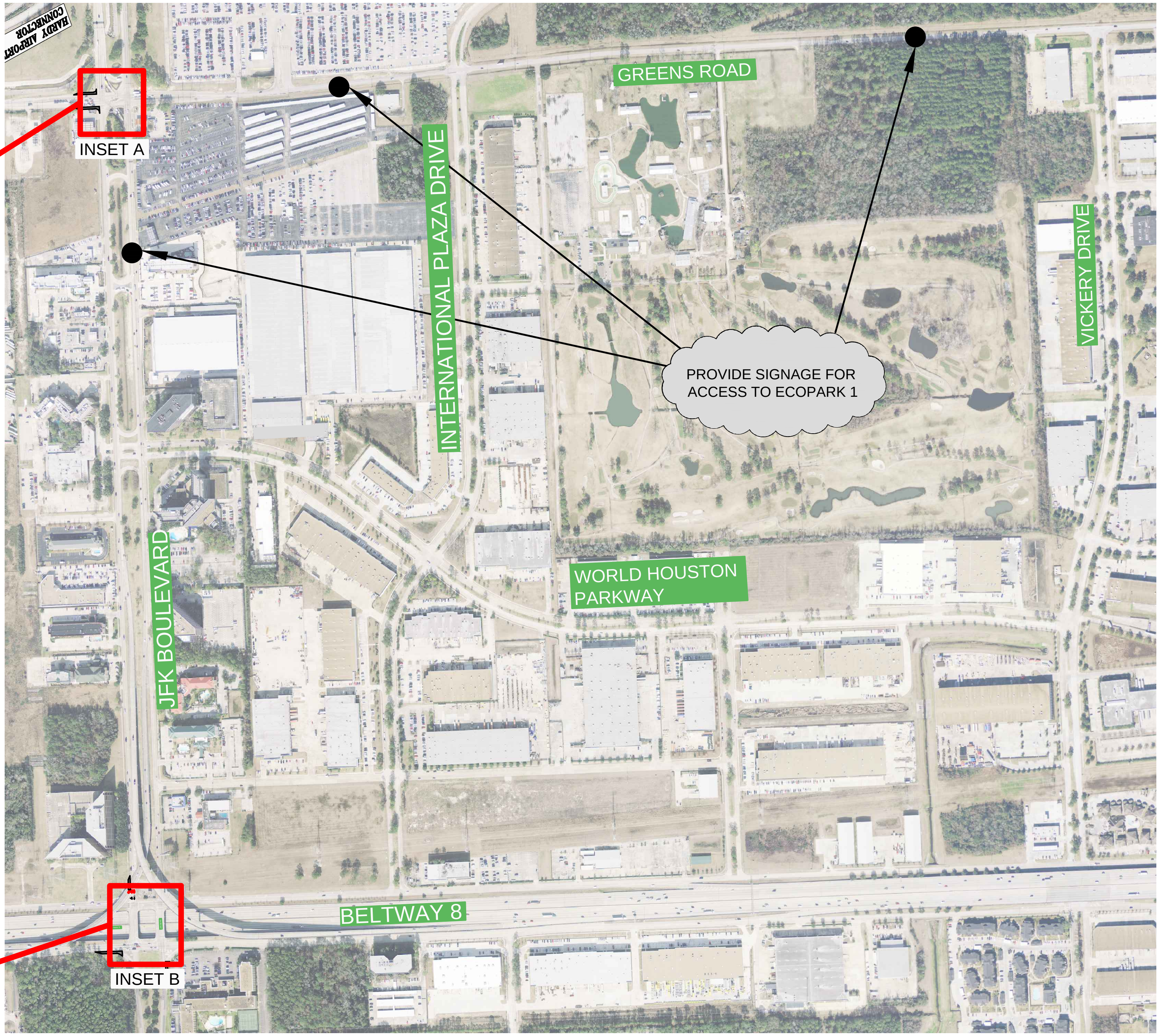
FY 2018 IMPROVEMENT RECCOMMENDATIONS



INSET A



INSET B



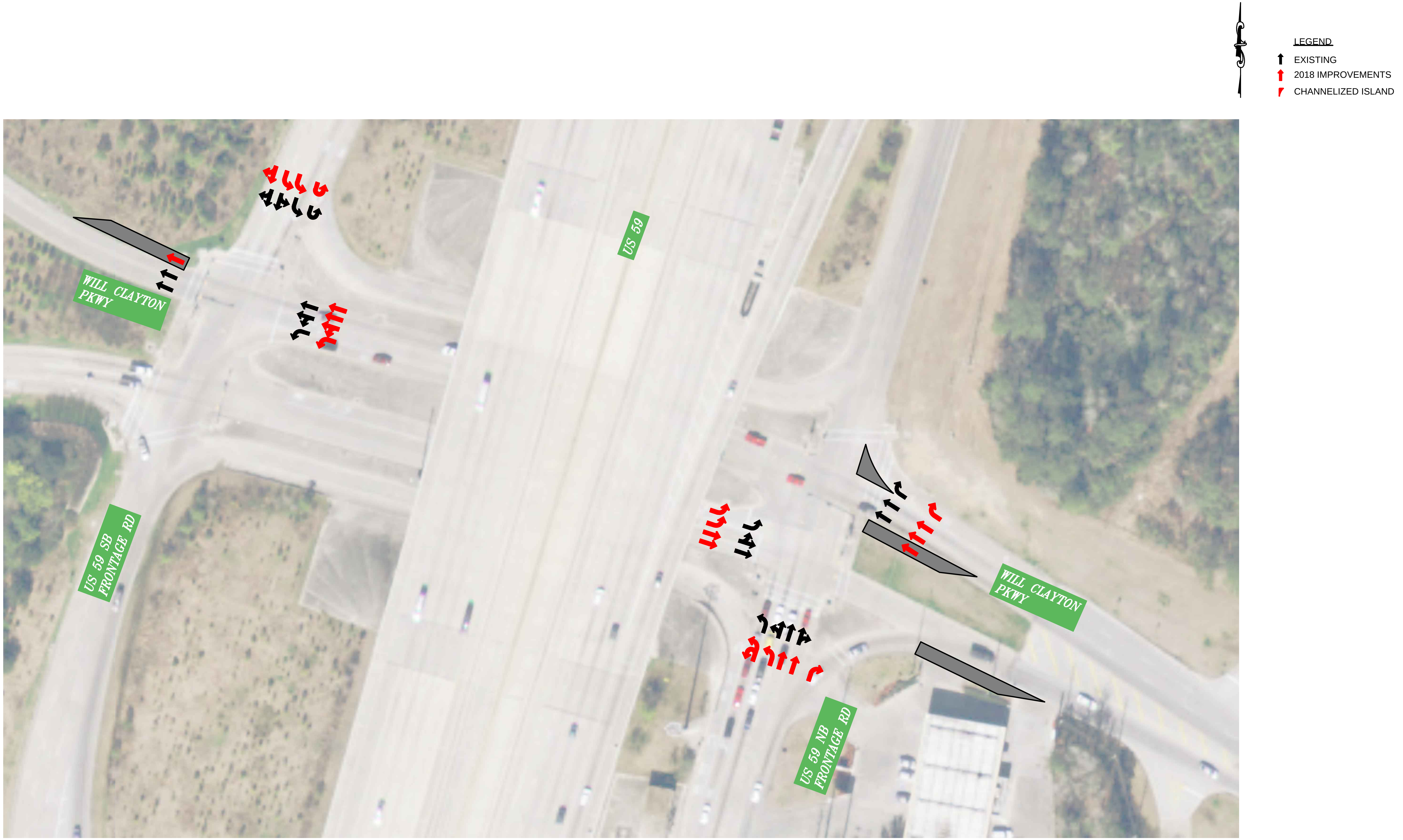
LEGEND

↑ EXISTING

↑ 2018 IMPROVEMENTS

IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

FIGURE B-1
JFK BOULEVARD 2018 IMPROVEMENTS

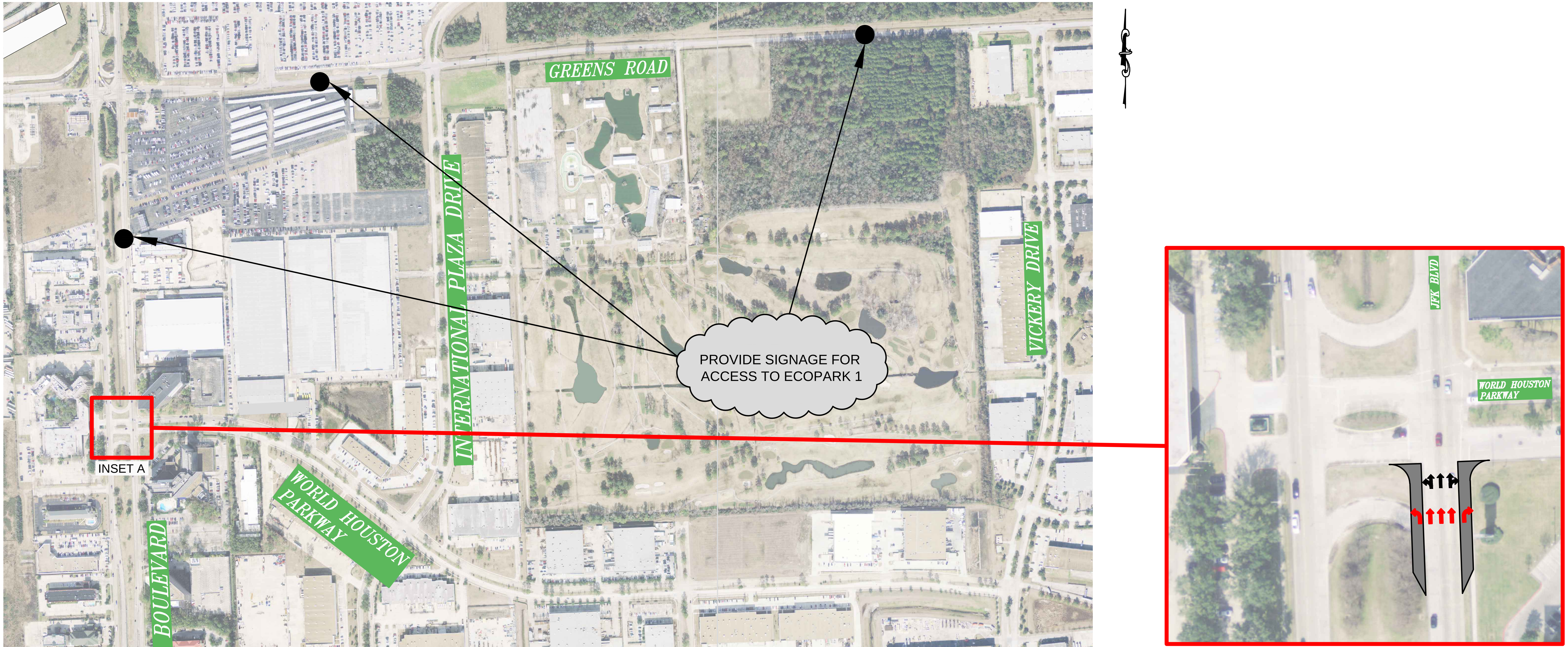


IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

FIGURE B-2
WILL CLAYTON PARKWAY 2018 IMPROVEMENTS

APPENDIX *I*

FY 2023 IMPROVEMENT RECCOMMENDATIONS



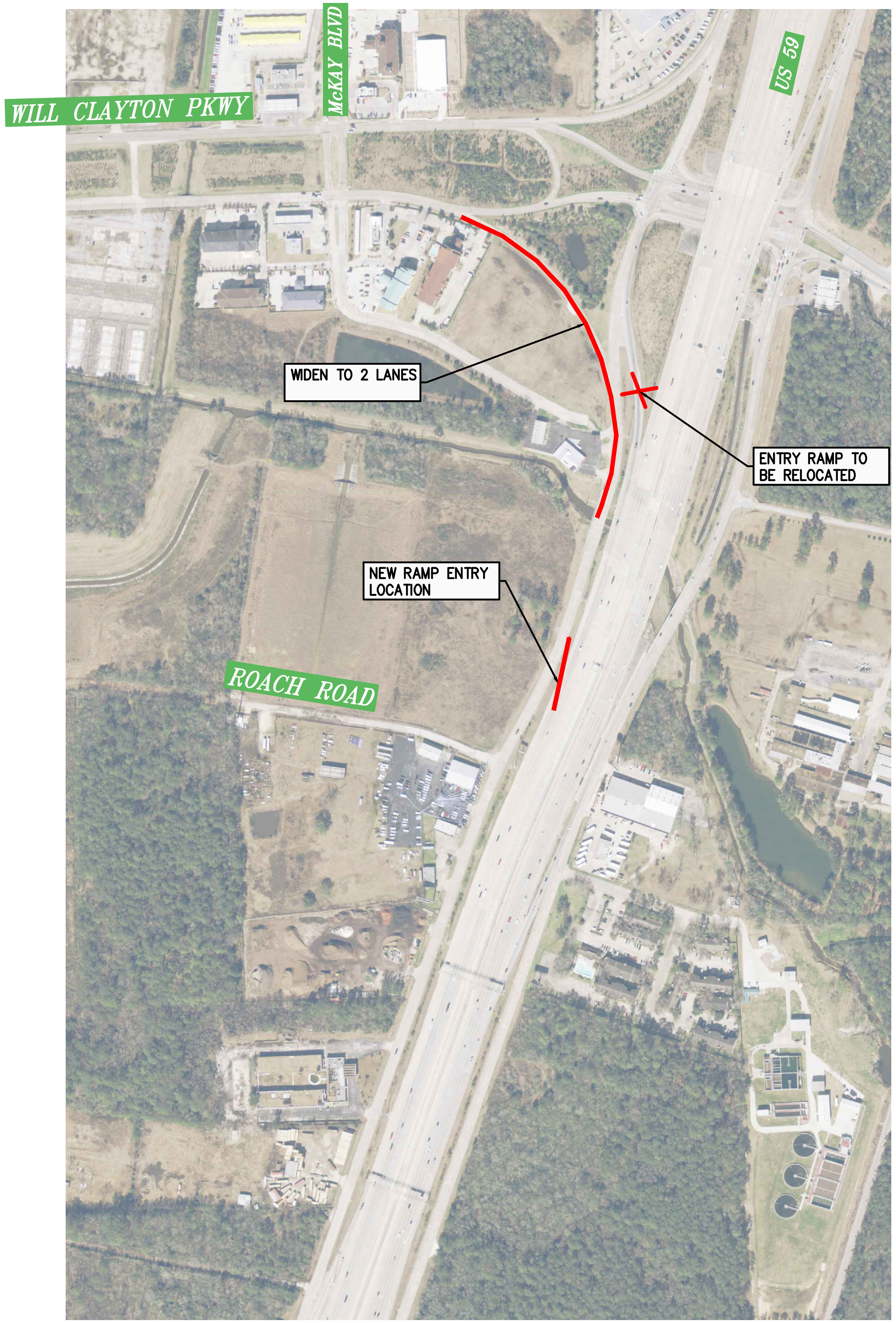
INSET A

LEGEND

- ⬆ EXISTING
- 🡅 2023 IMPROVEMENTS
- ◤ CHANNELIZED ISLAND

IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

FIGURE C-1
JFK BOULEVARD 2023 IMPROVEMENTS



LEGEND

↑ EXISTING

| 2023 IMPROVEMENTS

◤ CHANNELIZED ISLAND

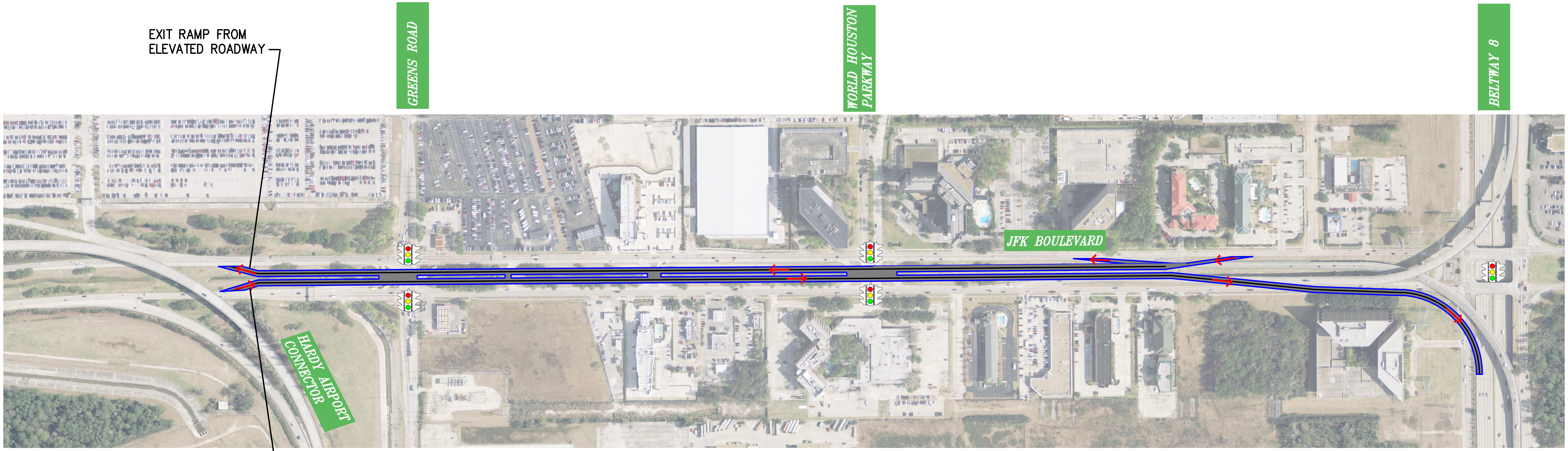
IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

FIGURE C-2
WILL CLAYTON PARKWAY 2023 IMPROVEMENTS

APPENDIX 5

FY 2033 IMPROVEMENT RECOMMENDATIONS

EXIT RAMP FROM
ELEVATED ROADWAY



ENTRY RAMP FROM
ELEVATED ROADWAY

FY 2033 LONG TERM IMPROVEMENTS

LEGEND

🚦 EXISTING SIGNAL

→ DIRECTIONAL ARROW

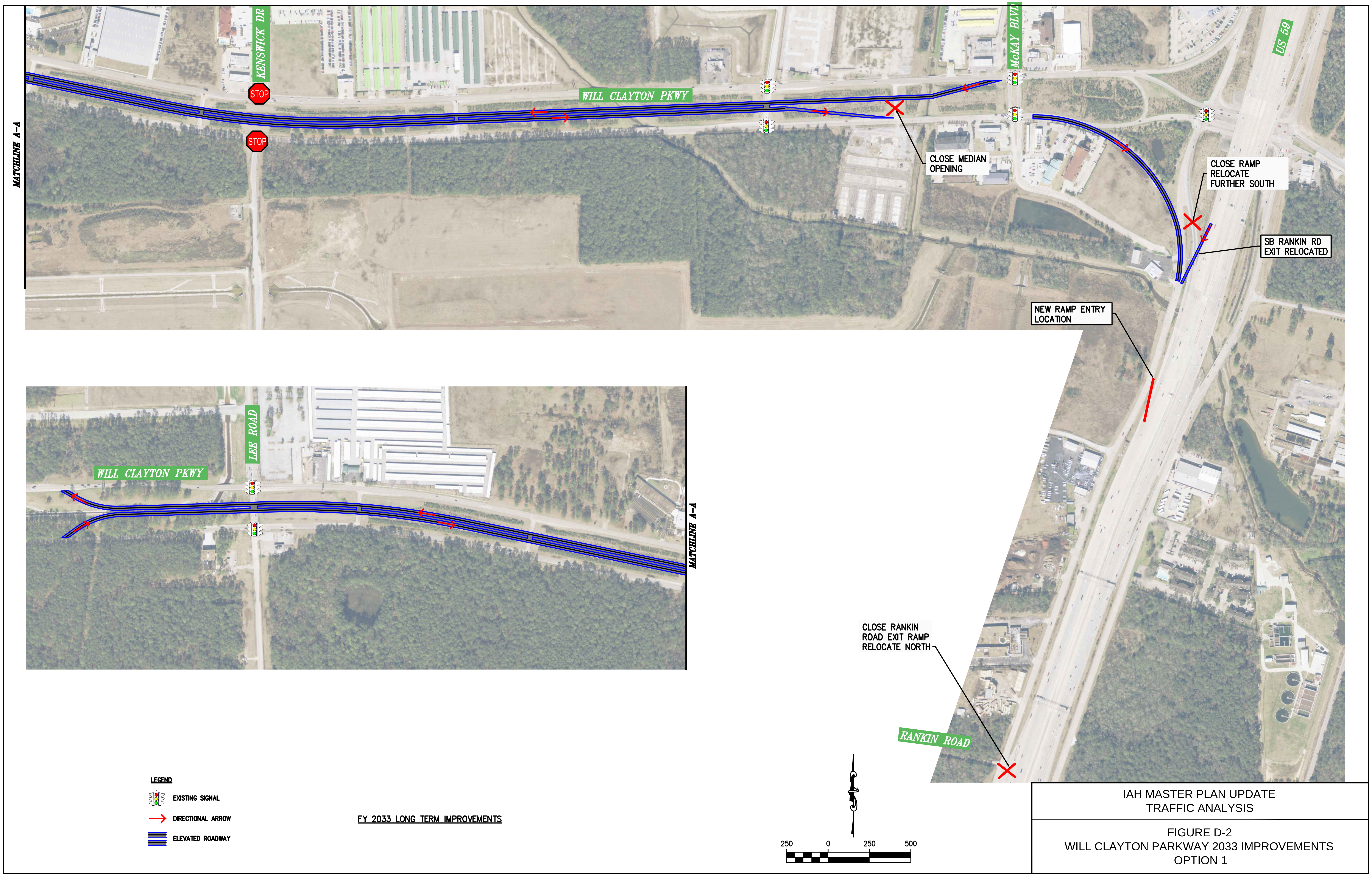
▤ ELEVATED ROADWAY

▤ AT GRADE IMPROVEMENT

200 0 200 400

IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

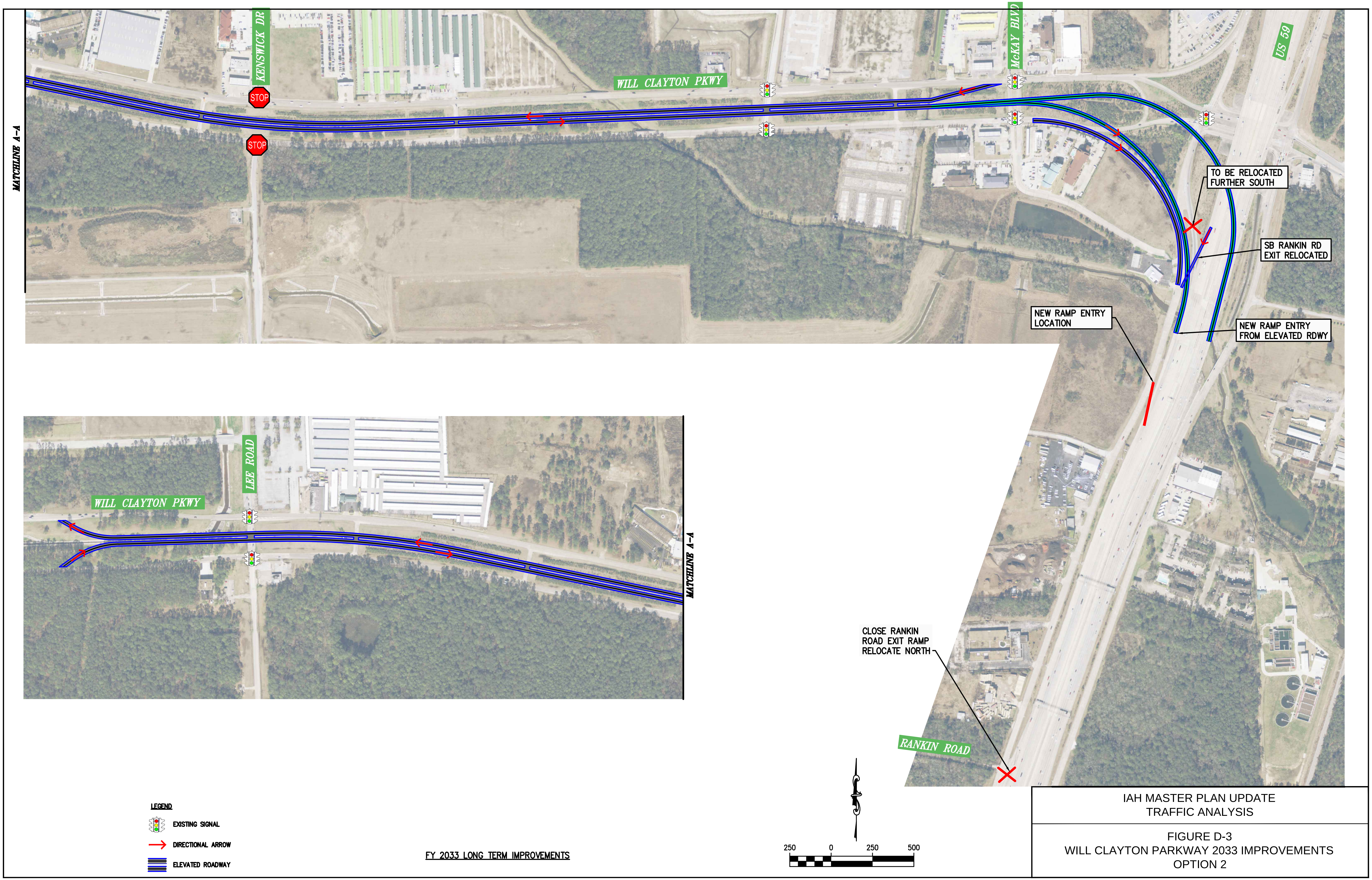
FIGURE D-1
JFK BOULEVARD 2033 IMPROVEMENTS



FY 2033 LONG TERM IMPROVEMENTS

IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

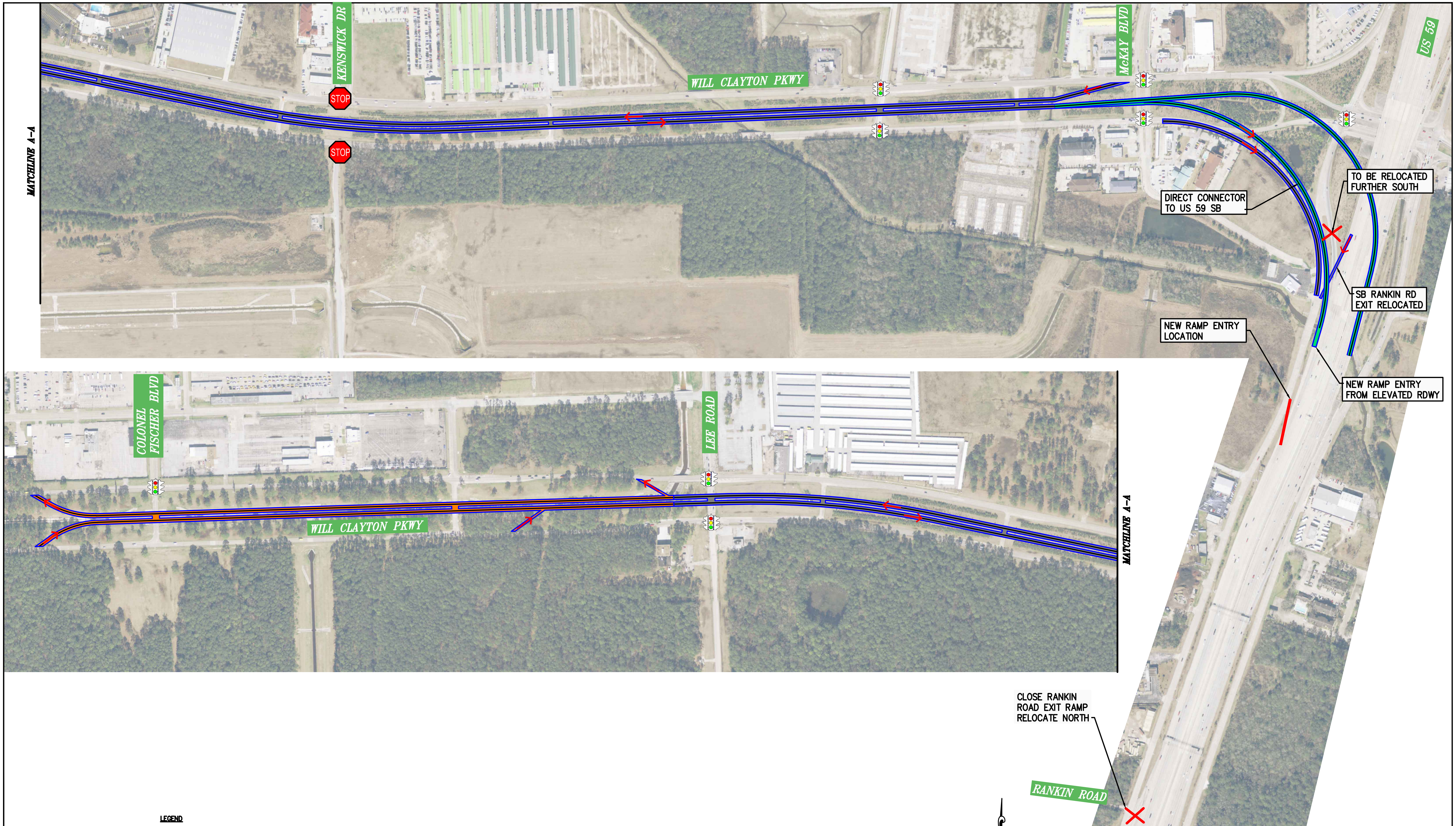
FIGURE D-2
WILL CLAYTON PARKWAY 2033 IMPROVEMENTS
OPTION 1



FY 2033 LONG TERM IMPROVEMENTS

IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

FIGURE D-3
WILL CLAYTON PARKWAY 2033 IMPROVEMENTS
OPTION 2



LEGEND

🚦 PROPOSED SIGNAL

🚦 EXISTING SIGNAL

→ DIRECTIONAL ARROW

▤ ELEVATED ROADWAY

FY 2033 LONG TERM IMPROVEMENTS

250 0 250 500

IAH MASTER PLAN UPDATE
TRAFFIC ANALYSIS

FIGURE D-4
WILL CLAYTON PARKWAY 2033 IMPROVEMENTS
OPTION 3

Appendix E
Parking Overview

Appendix E

PARKING OVERVIEW

Prepared by:

LeighFisher Inc.

Appendix E
PARKING OVERVIEW

This appendix provides an overview of the methodology for development of the parking requirements and alternatives and a timeline for implementation of the recommended parking projects. It also provides a comparison of the projected demand versus the capacity provided for both terminal area facilities and overall on-airport facilities at each planning activity level to facilitate review of the future parking needs.

E.1 METHODOLOGY

The public parking requirements were developed to serve a typical busy day during the peak month. During a few days of the year (e.g., Thanksgiving), public parking demands will likely exceeds those occurring on a typical busy day. However most airport operators do not provide structured parking for these few days because the revenue generated does not justify the additional costs of constructing and operating these extra spaces. Instead most airport operators provide surface “overflow” parking. Such overflow parking would be in addition to the requirements described in this report.

The Airport currently has an estimated 54% of the market share of public parking. Of the Airport’s current on-airport demand, 78% is for close-in terminal area parking and 22% for remote parking (EcoPark). In preparing the future demand forecasts, it was assumed that the existing off-airport demand would remain constant, with the Airport’s market share increasing to accommodate any additional growth to ensure adequate space is reserved for future parking needs. It was also assumed that the current split between demand for close-in and remote parking would remain constant.

Public parking demand was grown proportionately to projected O&D passenger growth, while employee parking demand was grown proportionately to projected aircraft operations. The public parking space requirements have been increased by a 10% “circulation factor” to allow for improperly parked vehicles, the inability of motorists to find the last empty space in a very large surface lot or structure, and to provide the desired level of customer service. These parking requirements assume that the existing propensity to parking (i.e., the proportion of airline passengers driving to the airport and parking for the duration of their trip) will continue during the planning period, and there will be no significant changes in access modes, parking durations, or parking patterns.

In calculating capacity, facilities currently designated as public parking and those designated as employee parking facilities were counted together. For example, the 3,500 spaces adjacent to the public EcoPark lot currently designated as United Airlines employee parking were counted as part of the EcoPark lot beginning in PAL25. Table E-1 summarizes the total on-airport parking demand, broken down by terminal area pubic parking, remote public parking, and employee parking.

Table E-1

AIRPORT PARKING SUMMARY

	Existing Capacity	Baseline Demand	PAL25	PAL33	PAL40
Total On-Airport Parking Demand	**27,840**	**20,110**	**28,160**	**40,420**	**50,400**
Terminal Area Public Parking	13,190	11,490	16,891	25,500	32,680
Remote Public Parking	8,550	3,250	4,770	7,200	9,230
Employee Parking	6,100	5,370	6,500	7,720	8,490
Existing Terminal Area Public Parking					
A/B Garage	4,260		4,260	2,840	0
C West Garage	4,620		4,620	4,620	4,620
D/E Garage	4,310		4,310	4,310	4,310
Existing Terminal Area Employee Parking					
Terminal A	700		700	700	0
Terminal B	700		700	0	0
East of Terminal B	500		500	0	0
South of Hotel	500		500	0	0
Terminal C West	200		200	200	200
New Terminal Area Facilities					
Public parking garage at FIS	--		1,000	1,000	1,000
Employee parking facility at FIS	--		240	240	240
C-West Expansion	--		2,000	2,000	2,000
Garage B	--		--	3,200	3,200
Garage H (South of Marriott)	--		--	1,800	1,800
Garage A	--		--	--	4,900
Total Terminal Area Facilities	**15,790**		**19,030**	**20,910**	**22,270**
Existing Remote Facilities					
EcoPark Surface Lot	8,550		8,550	7,180	5,850
United EcoPark (with EcoPark in PAL25-40)	3,500				
New Remote Facilities					
EcoPark2	--		2,200	2,200	2,200
EcoPark garage	--		--	10,300	10,300
EcoPark garage expansion	--		--	--	10,000
Total Remote Facilities	**12,050**		**10,750**	**19,680**	**28,350**
Total On-Airport Parking Facilities	**27,840**		**29,780**	**40,590**	**50,620**

-- Facility not yet built
Source: LeighFisher, 2015

E.2 RECOMMENDED DEVELOPMENT PLAN

By PAL25, the demand for public terminal area parking exceeds capacity of all existing terminal area parking facilities, whether currently designated for the public or for employees. The construction of a new seven level parking garage by the proposed FIS would add approximately 1,000 public parking spaces and 240 employee spaces. Expansion of the C-West Garage to add an additional 2,000 spaces over seven levels would bring the terminal area parking capacity above the projected PAL25 demand level. EcoPark2 would also be constructed to provide an additional 2,200 remote spaces.

In PAL33, the proposed consolidation of Terminals A and B into a single processor would require the closure of a portion of the existing Garage A/B, resulting in a loss of approximately 1,420 public parking spaces and 700 employee spaces. The existing employee parking lot east of Terminal B (500 spaces) would be replaced with a new eight-level parking facility (Garage B) providing 3,200 spaces. With no remaining sites in the core terminal area for additional parking facilities, the parking facility south of the hotel would be replaced with an eight-level, 1,800 space garage (Garage H). To access the terminals from this facility, passengers would use the inter-terminal train in the hotel. Thus, this facility would likely be a separate parking product from the close-in terminal area garages, priced accordingly. As shown in Figure E-1, with the addition of Garage B and Garage H, the demand for close-in parking in PAL33 still exceeds capacity. It will need to be a future policy decision to determine how the limited terminal area parking facilities are allocated among the public and employees. In developing parking alternatives, the excess terminal area demand was accommodated in the remote demand for PAL33 and PAL40. Figure E-2 shows that the proposed parking development plan provides sufficient on-airport capacity to exceed demand at all four planning activity levels.

Figure E-1
TERMINAL AREA PARKING

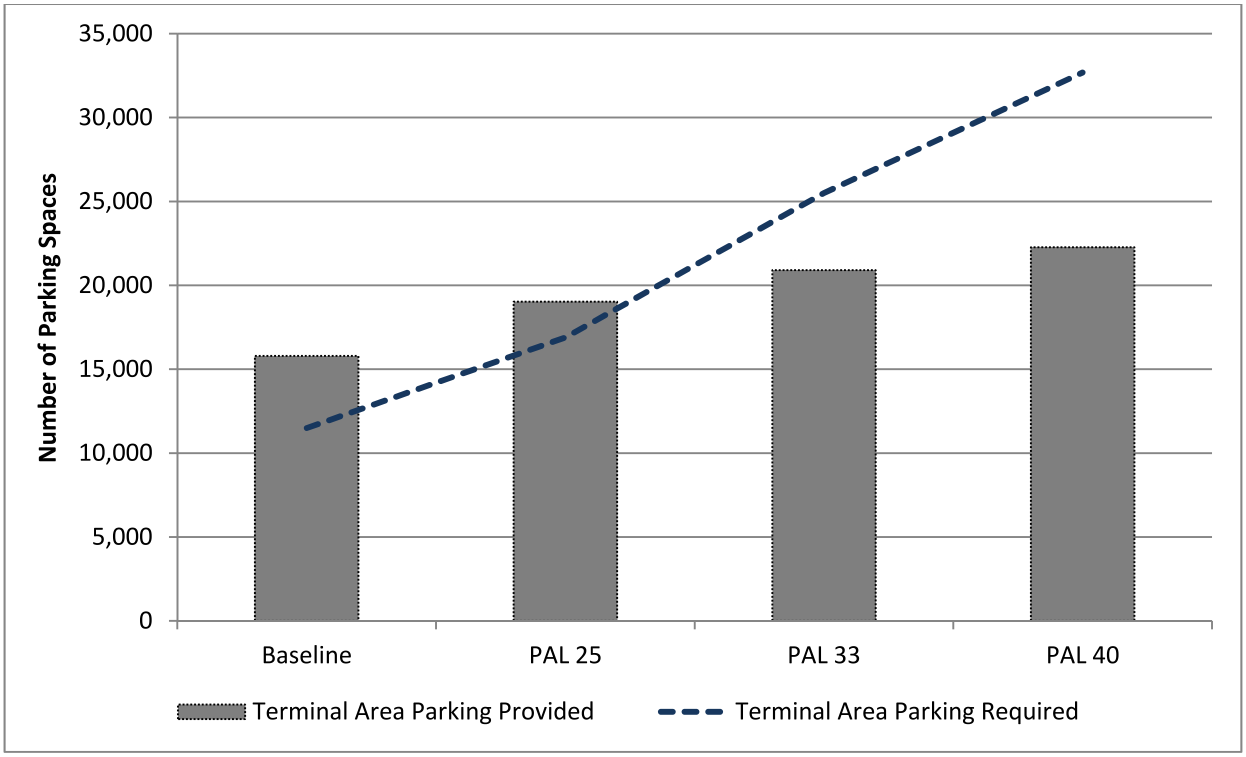
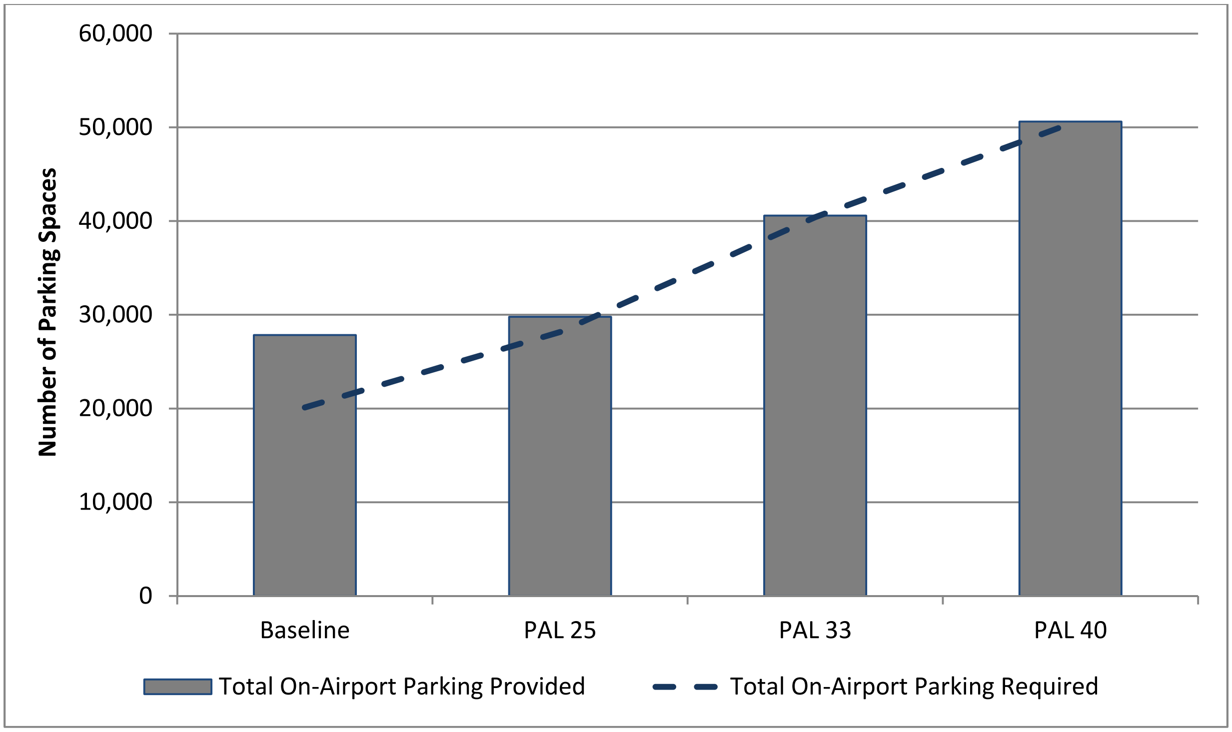


Figure E-2

ON-AIRPORT PARKING



Due to the large number of remote spaces required when the excess terminal demand is added, a remote garage (EcoPark Garage) is proposed rather than further expansion of the surface parking lots. This garage was recommended as the construction of 10,000 additional surface lot spaces to meet the PAL33 demand would require significant land that could otherwise be reserved for other purposes, operating costs of busing would be high, and customer service levels would be lower as passengers would need to circulate among large areas to find empty spaces and either walk further or take a longer bus route. The construction of a garage minimizes the required land area, improves busing efficiency as one stop can serve the entire garage, and improves passenger wayfinding and overall customer service levels. The new eight-level EcoPark Garage would displace approximately 1,370 EcoPark surface lot spaces, providing 10,300 new parking spaces, sufficient to meet the PAL33 on-airport parking demand.

In PAL40, the completion of the consolidated Terminal A/B processor would require the closure of the remaining portion of Garage A/B, resulting in a loss of 2,840 public parking spaces and 700 employee parking spaces. A new eight-level parking garage would be built on the site of existing Terminal A and provide approximately 4,900 spaces. As with PAL33, the PAL40 demand for terminal area spaces is expected to exceed the available terminal area parking capacity. To provide for this additional demand on-airport, the EcoPark Garage built in PAL33 would be expanded by an additional 10,000 spaces, bringing the total on-airport parking facilities to approximately 50,620 spaces, with 22,270 terminal area and 28,350 remote spaces to be allocated among the public and employees.

Appendix F
Cost Estimates

Appendix F
COST ESTIMATES

Prepared by:

Sunland Group, Inc.