Canadian Natural

Kirby Expansion Transportation Impact Assessment

Prepared by:

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Project Number:

60220860

Date:

October 2011

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October 05, 2011

Jennifer Bidlake Schroeder
Environmental Coordinator
Canadian Natural
Suite 2500, 855 – 2nd Street SW
Calgary, AB T2P 4J8

Dear Jennifer:

Project No: 60220860
Regarding: Kirby Expansion Transportation Impact Assessment

AECOM is pleased to submit this Transportation Impact Assessment presenting our analysis of the impacts of the Kirby Expansion future development on the surrounding transportation network and any recommendations for infrastructure improvements.

Should you have any questions or concerns relating to this study, please contact Irini Akhnoukh at 403.270.9110. We have enjoyed this opportunity to work with the Canadian Natural and look forward to future collaborations.

Sincerely,
AECOM Canada Ltd.

Irini Akhnoukh, P.Eng., PTOE
Transportation Engineer
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IA: hl
Encl.

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
A	HL	October 05, 2011	Revised per Client Comments

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1. Project Background

1.1 Project Location

Canadian Natural is a Calgary-based energy company focused on oil and natural gas exploration, development and production. Canadian Natural is proposing the expansion of two currently approved in situ oil sands project sites, located approximately 10 km south of Conklin, AB as shown in **Figure 1.1**.

The site is currently accessed via Highway 881; this will continue to be the only access point to the site from the external road network, and will service the full expanded site area. The intersection of the site access and Highway 881 will be the focus of this study.

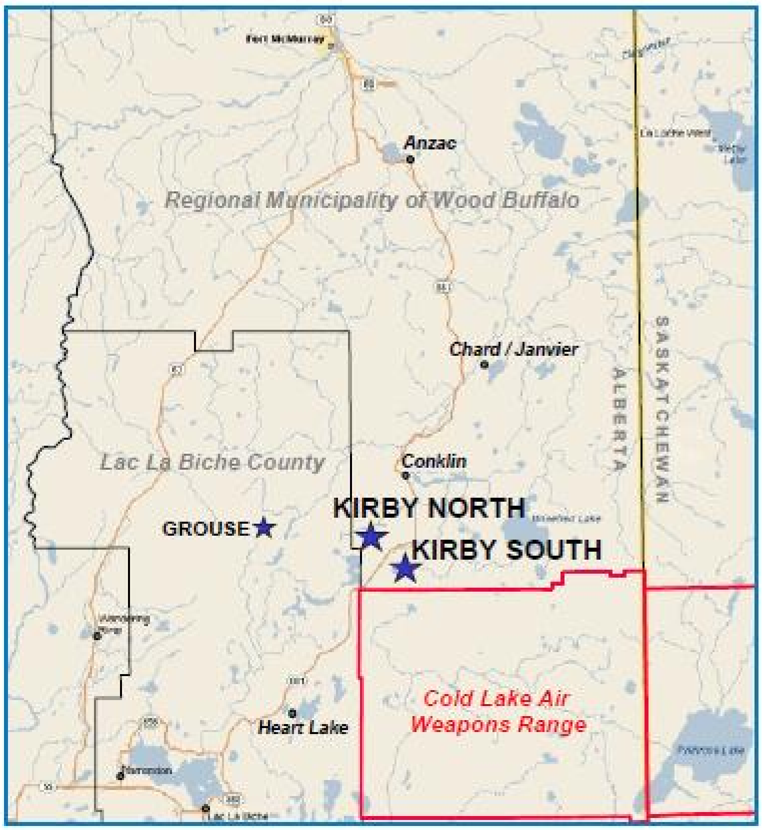

Figure 1.1: Regional Project Location

Source: Canadian Natural Kirby Expansion Plain Language Project Summary, May 2011, Pg. 4

1.2 Project Development

The Kirby Expansion Project involves the expansion of two recently approved in situ oil sands projects, Kirby South and Kirby North. Kirby South is currently approved for the development and production of 45,000 bbl/d (7,155 m^3/d) of bitumen and is already under construction. Kirby North is currently approved for the development and production of 10,000 bbl/d (1,590 m^3/d) of bitumen. The locations of Kirby North and South are shown on **Figure 1.2**.

The Kirby Expansion Project will increase the combined approved 55,000 bbl/d Kirby North and South bitumen production by 85,000 bbl/d for a total of 140,000 bbl/d of bitumen production.

Canadian Natural has established a three phase development plan for the expansion, which when completed will produce 140,000 bbl/d over an estimated 30 year time period. Kirby South Phase 1 is currently under construction and consists of the original Kirby South production capacity of 45,000 bbl/d. Based on information provided by Canadian Natural, it is expected that the peak construction horizon will occur in 2015.

AECOM was retained by Canadian Natural to complete a TIA to identify the impacts of traffic generated by both construction traffic at the peak construction period and post-construction operations traffic on the external road network.

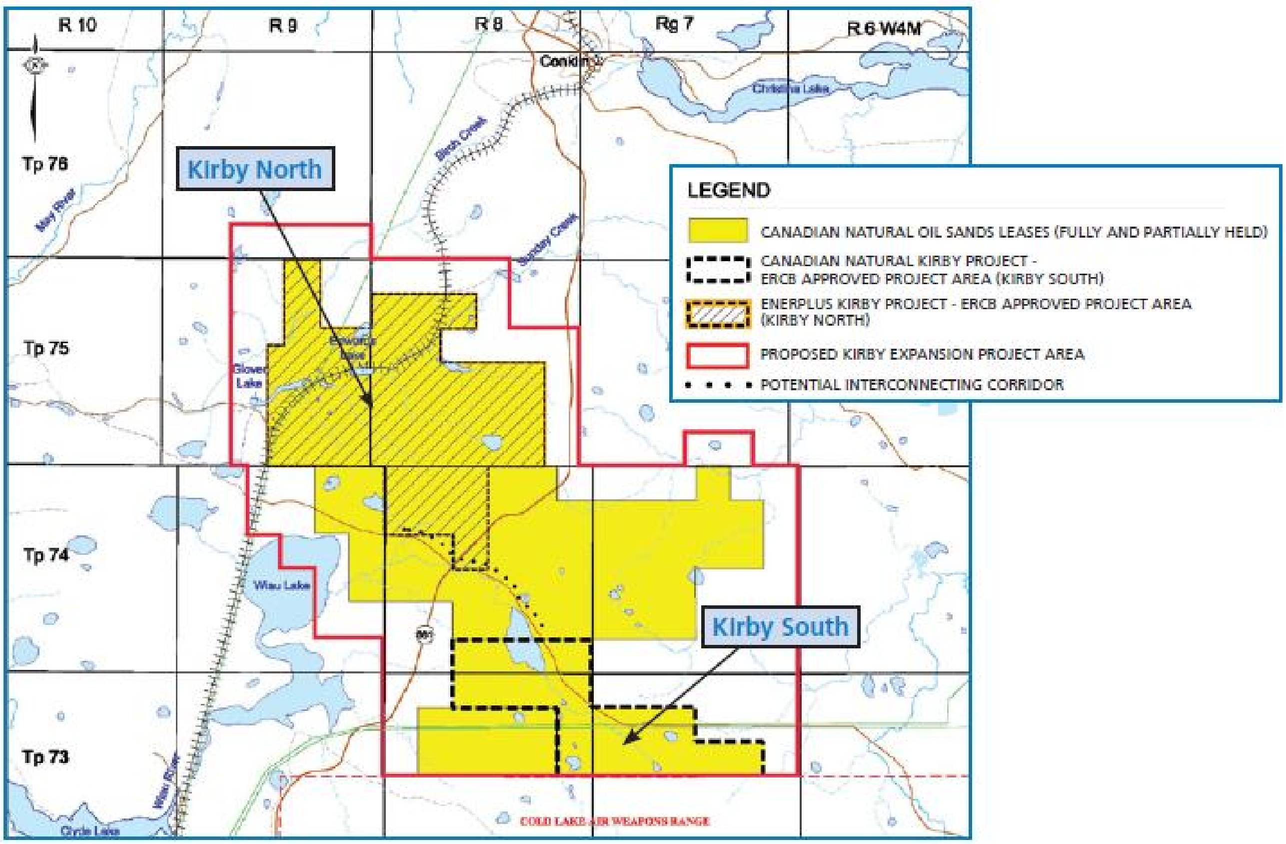

Figure 1.2: Kirby Expansion Project Area

Source: Canadian Natural Kirby Expansion Plain Language Project Summary, May 2011, Pg. 4

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2. Traffic Volumes

To create an accurate representation of the phased Canadian Natural development, three time horizons were analyzed to capture construction and operation traffic associated with each phase, as follows:

- Existing – 2011
- Peak Construction Horizon – 2015
- Operations Horizon – 2035

The year 2035 was selected to provide an analysis at full operations of the site, as well as a 20-year horizon as per Alberta Transportation TIA guidelines.

2.1 Background Traffic Volumes

To determine the existing traffic conditions and improve the accuracy of future traffic volume projections, AECOM conducted a 12-hour continuous traffic count at the intersection of Highway 881 and the Kirby Project site access. The count was performed between the hours of 06:00 and 18:00 on Thursday, August 11, 2011 and is included in **Appendix A**. A Thursday was selected to coincide with what is expected to be the day of the week with the highest number of trips generated by the site. The morning, noon and evening peak hours as determined from the 12 hour continuous count are as follows:

- AM peak: 10:15 to 11:15
- Noon peak: 12:45 to 13:45
- PM peak: 16:45 to 17:45

The PM peak hour coincides with expected shift change patterns and was therefore considered to be the critical peak hour, as it will combine peak site generated traffic with peak background traffic volumes. Although the AM peak hour for background traffic does not coincide with the expected AM peak hour for site generated volumes, analysis of the AM site-generated peak hour was also conducted, which occurs from 07:00 to 08:00.

To determine the average annual daily traffic volumes (AADT) for the intersection approaches, a Design Hourly Volume (DHV) factor 'K' is required. AADT is defined as the total yearly traffic volume divided by 365 days, in units of vehicles per day. The typical DHV factor used for Alberta highways is 0.15. Existing volume data for the area was reviewed to determine the specific DHV factor for Highway 881 near the access road intersection. The 2010 AADT volumes on Highway 881 north of Alpac "K" road and south of the Conklin access are 1340 and 1000 with PM peak hour volumes of 196 and 139, respectively.

The Design Hourly Volume factor is calculated using the following formula:

$$K = DHV/AADT$$

Using the 2010 data along Highway 881, the average DHV factor for the area is 0.14. Applying this factor to the PM peak hour volume collected at the access road intersection, however, results in 2011 AADT volumes which are lower than the 12-hour count totals. As such, the available traffic volume information along the corridor was examined to identify a more accurate factor. Using 12-hour count data on Highway 881 at the locations specified above, the following relationship to AADT can be identified:

N of Alpac "k" Road:	12-hr = 690 AADT = 980 k = 0.704	S of Conklin Access:	12-hr = 538 AADT = 820 k = 0.656

Average: k = 0.68

The average k-factor can be applied to the 12-hour count data collected at the access road intersection to determine the 2011 AADT.

To determine the base volumes in 2015 and 2035, a linear growth rate for Highway 881 was estimated based on historical AADT volumes. There have been major spikes in recent years in the AADT of Highway 881 due to traffic generated by construction and other bitumen related developments in the area, resulting in unrealistic linear growth rates. To resolve this issue, an annual linear growth rate of **3.1%** was developed through correspondence with Alberta Transportation (P. Kilburn, pers. comm. 22/08/2011., see **Appendix B**).

The linear growth rate was applied to the 2011 AADT and AM and PM peak hour volumes to develop 2015 and 2035 background turning movement and AADT volumes.

As the Kirby site access from Highway 881 forms the east leg of a 4-legged intersection and the west leg provides access to another Canadian Natural proposed oil sands development, the background volumes were then adjusted for the 2015 and 2035 horizons to account for traffic generated by the Grouse In-Situ Oil Sands Development. Details pertaining to Grouse-generated traffic volumes can be found in the *Grouse In-Situ Oil Sands Project Traffic Impact Assessment*, conducted by AECOM in 2011.

The resulting background traffic volumes for 2011, 2015 and 2035 are show in **Figures 2.1 to 2.3**.

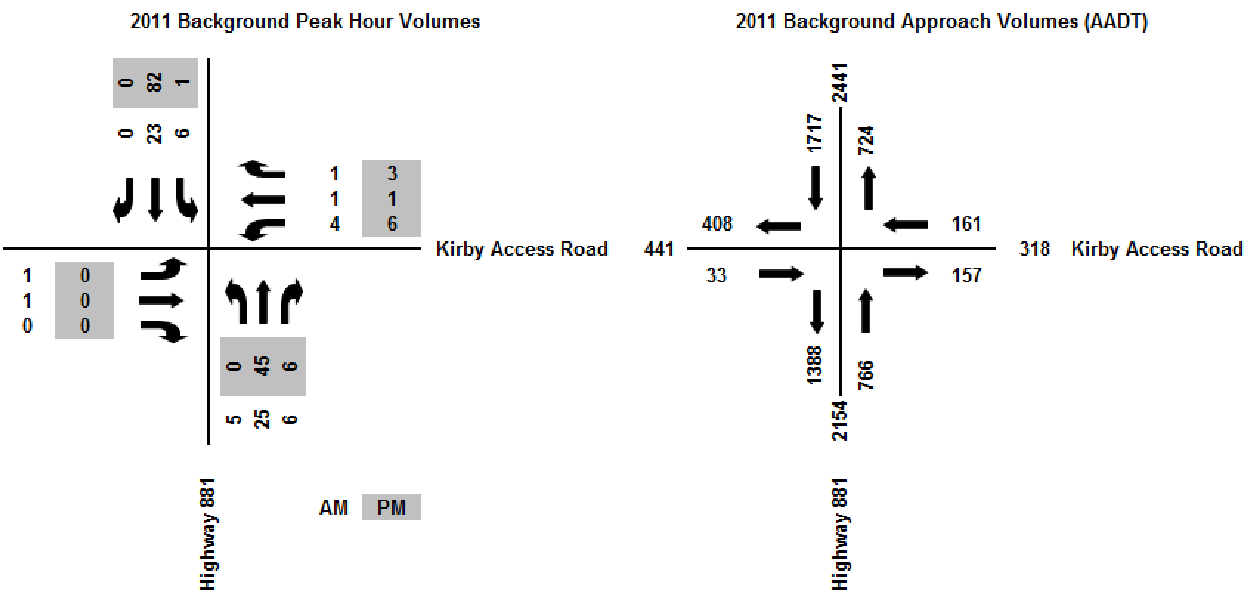

Figure 2.1: 2011 Background Traffic Volumes – AM & PM Peak Hour and AADT by Approach

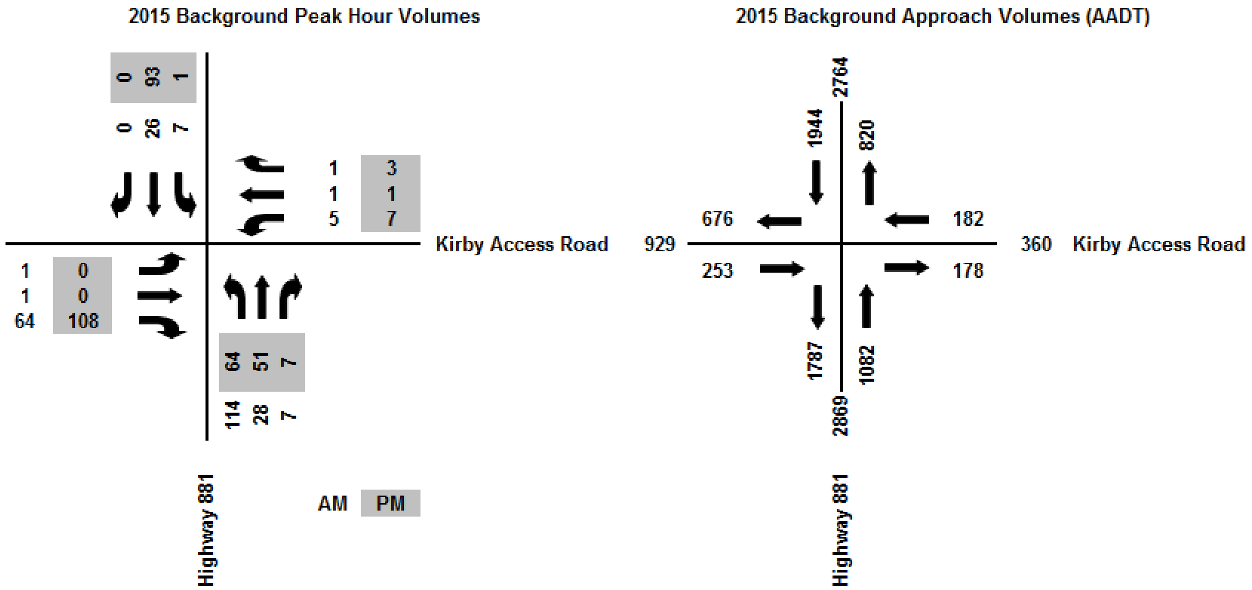

Figure 2.2: 2015 Background Traffic Volumes – AM & PM Peak Hour and AADT by Approach

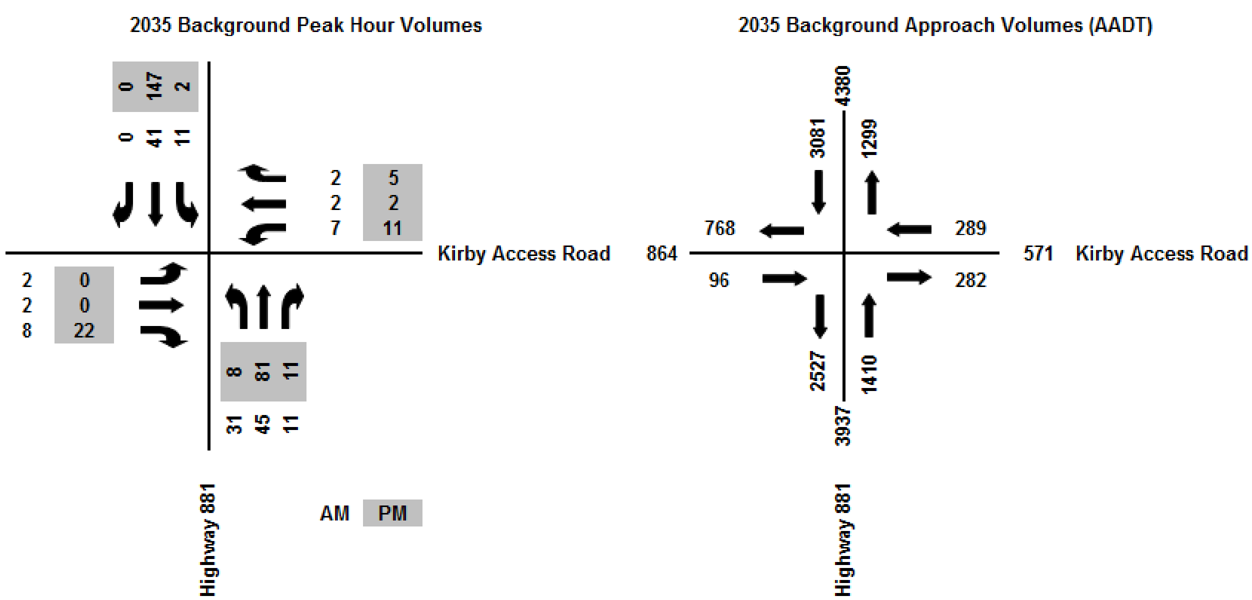

Figure 2.3: 2035 Background Traffic Volumes – AM & PM Peak Hour and AADT by Approach

2.2 Site Traffic Volumes

Expected site traffic volumes for the peak construction and operations phases were determined through discussions with Canadian Natural staff.

2.2.1 2015 Construction Phase

The total site-generated traffic during the peak construction phase will be 430 trips per day; this includes heavy vehicles, buses, and passenger vehicles. The peak travel periods are expected to be between 06:00 and 08:00, and 16:00 and 18:00. 90% of the total construction workers for the site will be transported to and from the project site on buses from Lac La Biche, the balance of the workers will travel to and from the site in passenger vehicles. The inbound and outbound splits were taken from the previous Kirby TIA which was completed in 2008 by Earth Tech (now AECOM). To determine the morning and afternoon peak hour traffic generation and vehicle classifications, the following assumptions were used:

- 80% of daily trips will be made during the two peak hours, 20% will be during off-peak hours
- Peak hour trips are split equally between AM and PM peak hours (e.g., 40% of daily trips in both AM and PM)
- AM peak hour trips: 62.5% inbound, 37.5% outbound
- PM peak hour trips: 37.5% inbound, 62.5% outbound
- All trips will be to/from south of the intersection
- 90% of all vehicles will be heavy vehicles (buses) and 10% will be passenger vehicles

Based on these assumptions, **Figure 2.4** illustrates the 2015 peak construction horizon site-generated traffic volumes for the AM and PM peak hours.

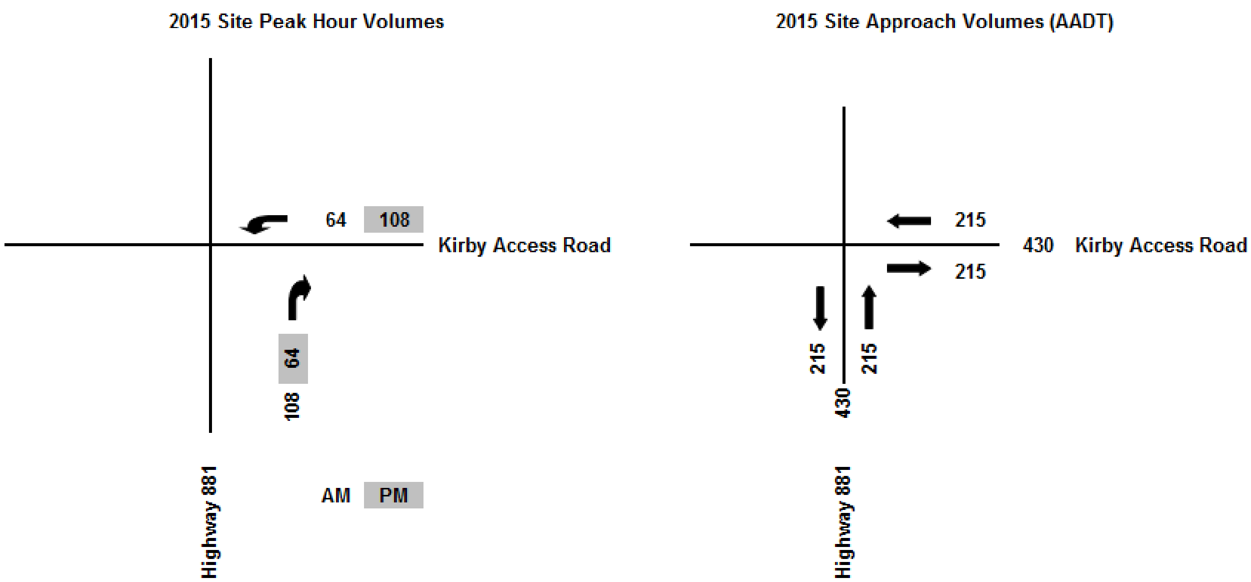

Figure 2.4: 2015 Construction Phase Site Generated Volumes – AM & PM Peak Hour and AADT by Approach

2.2.2 2035 Operations Phase

The total site generated traffic during the peak operations phase will be 72 trips per day; this includes heavy vehicles and passenger vehicles. The peak travel periods are expected to be between 06:00 and 08:00, and 16:00 and 18:00. The inbound and outbound splits were taken from the previous Kirby TIA which was completed in 2008 by Earth Tech (now AECOM). To determine the morning and afternoon peak hour traffic generation and vehicle classifications, the following assumptions were used:

- 80% of daily trips will be made during the two peak hours, 20% will be during off-peak hours
- Peak hour trips are split equally between AM and PM peak hours (e.g., 40% of daily trips in both AM and PM)
- AM peak hour trips: 75% inbound, 25% outbound
- PM peak hour trips: 25% inbound, 75% outbound
- All trips will be to/from south of the intersection
- 90% of all vehicles will be heavy vehicles (buses) and 10% will be passenger vehicles

Based on these assumptions, **Figure 2.5** illustrates the 2035 operations horizon site-generated traffic volumes for the AM and PM peak hours.

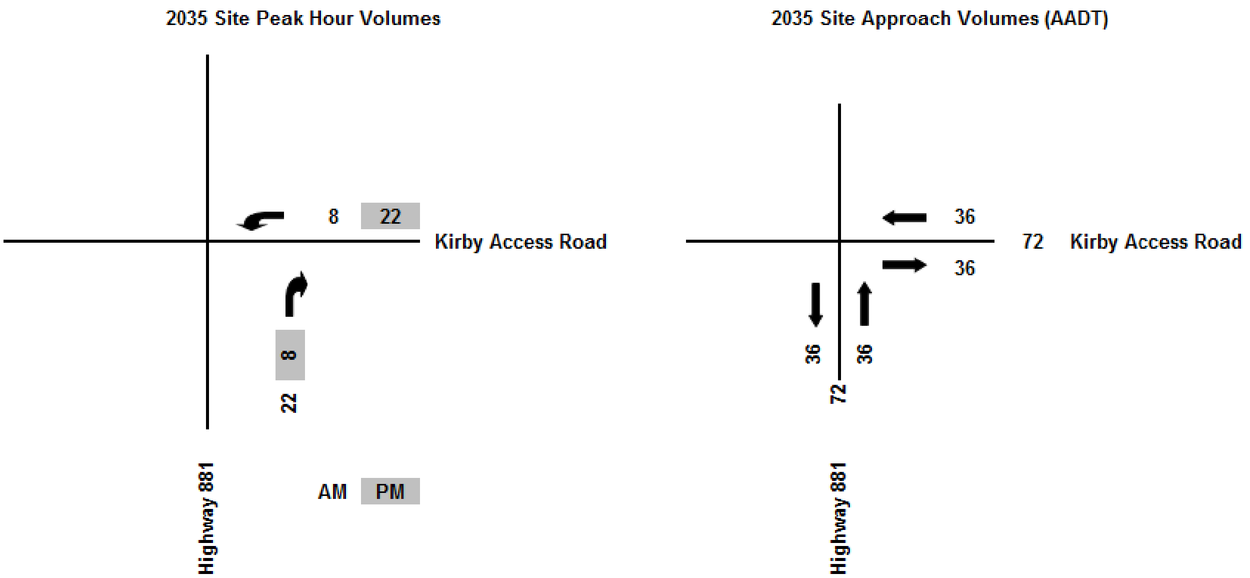

Figure 2.5: 2035 Operations Phase Site Generated Volumes – AM & PM Peak Hour and AADT by Approach

2.3 Combined Traffic Volumes

Combined traffic volumes were determined by superimposing site generated traffic on background traffic volumes for each horizon and time period. **Figures 2.6 and 2.7** illustrate the 2015 and 2015 combined traffic volumes, respectively.

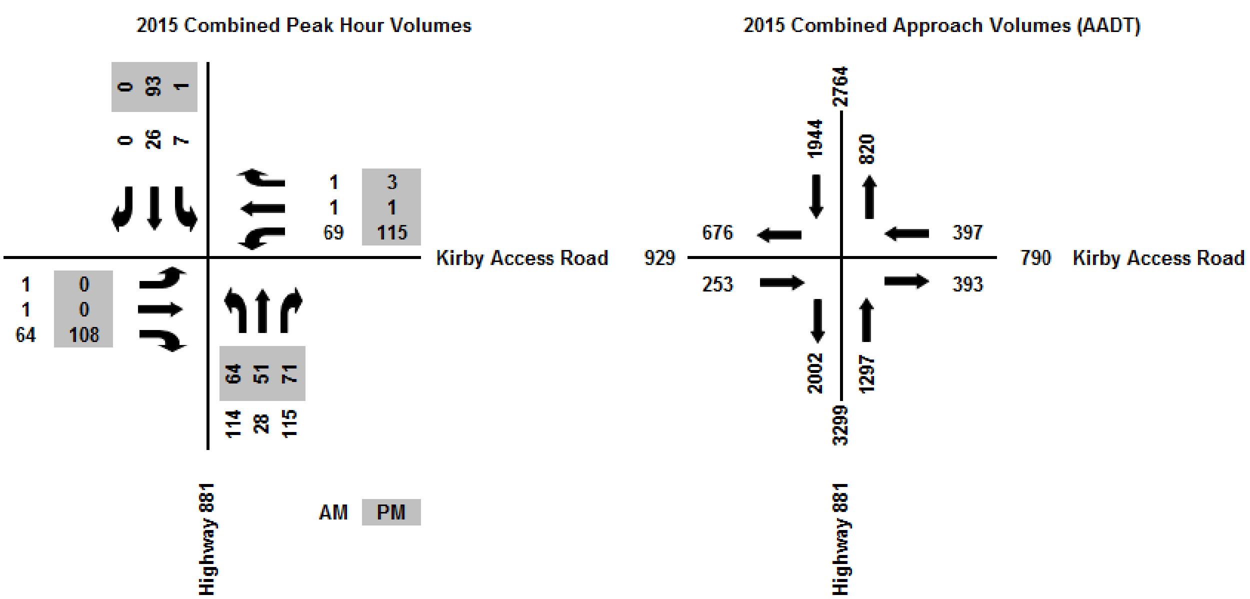

Figure 2.6: 2015 Construction Phase Combined Volumes – AM & PM Peak Hour and AADT by Approach

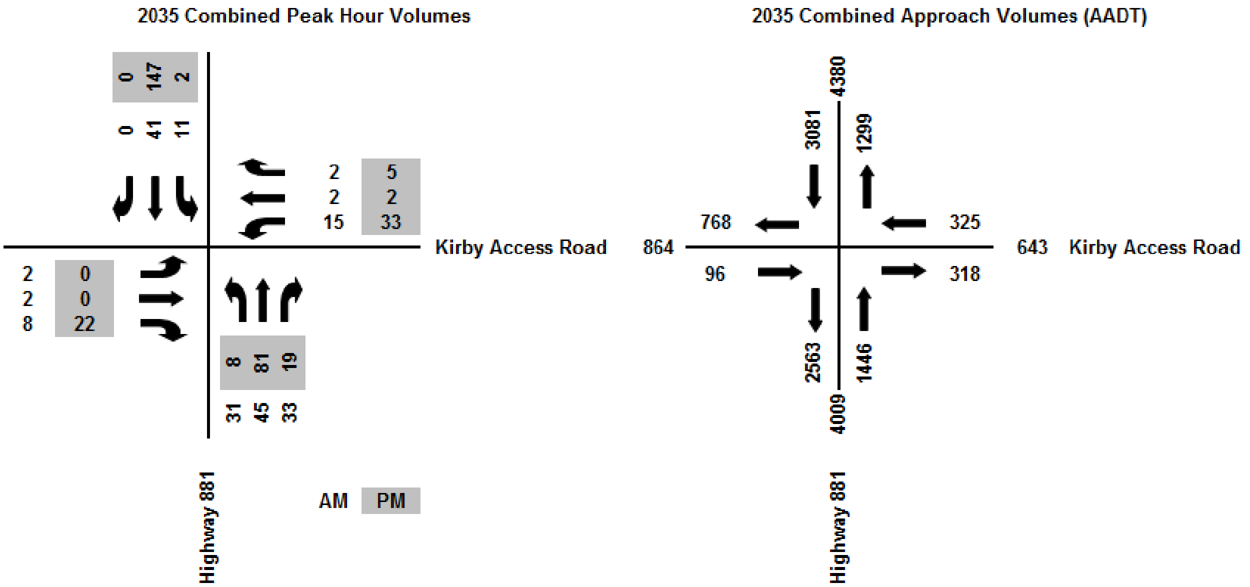

Figure 2.7: 2035 Operations Phase Combined Volumes – AM & PM Peak Hour and AADT by Approach

3. Capacity Analysis Methodology

3.1 Intersection Analysis Methodology

Intersection capacity analyses were performed using Synchro 7 software. This software predominantly uses methodology outlined in the *Highway Capacity Manual 2000 (HCM 2000)* edition for signalized and unsignalized intersections.

The level of service (LOS) grading scale for intersection analysis is based on average control delay per vehicle. LOS ranges from 'A' to 'F' where LOS 'A' reflects ideal free flow conditions with little or no delay, and LOS 'F' indicated general failure of the movement. Grading criteria are different for signalized versus unsignalized intersections. The reason for this difference is that drivers expect signalized intersections to carry higher volumes and therefore tolerate longer control delays. The LOS grading for unsignalized intersection analysis is based on the time elapsing as a vehicle stops at the end of a queue until it departs from the stop line. **Table 4.1** shows LOS criteria for signalized and unsignalized intersections.

Table 3.1. LOS Criteria for Signalized and Unsignalized Intersections

Level of Service	Average Total Delay (seconds) [Signalized Intersections]	Average Total Delay (seconds) [Unsignalized Intersections]
A	10.0 or less	10.0 or less
B	10.1 to 20.0	10.1 to 15.0
C	20.1 to 35.0	15.1 to 25.0
D	35.1 to 55.0	25.1 to 35.0
E	55.1 to 80.0	35.1 to 50.0
F	Greater than 80.0	Greater than 50.0

Volume to capacity (v/c) ratios are important measures of effectiveness of at-grade intersections that Synchro 7 calculates. The v/c ratio is an indication of the relative utilization of available capacity for a movement. Alberta Transportation's acceptable standard for LOS is typically 'D' and a v/c ratio of 0.90. Intersection improvements were therefore determined by striving to ensure that traffic v/c ratios remain below the recommended threshold of 0.90 and levels of service are 'D' or better. Further elaboration is provided if these standards are not adhered to in any instance.

3.2 Synchro Guidelines

The traffic volumes described in **Section 3.0** were analyzed using Synchro 7. **Table 4.2** provides an overview of the default parameters used in Synchro 7 if specific values were not known.

Table 3.2. Analysis Parameters Reflecting Assumed Traffic Operations

Factors	Parameters
Ideal Saturation Flow [vphpl]	
• Left Turn	1,850
• Through	1,850
• Right Turn	1,850
Lane Width [m]	
• Left Turn	3.5
• Through / Through Shared	3.7
• Right Turn	3.5
• All Shared	4.8
Total Lost Time [s]	3.0

Factors	Parameters
Detectors [m]	
• Leading – Left Turns	8.0
• Leading – Through	4.0
• Trailing	2.0
Lane Utilization	Program Defaults
Peak Hour Factors	
• AM Peak	0.77
• PM Peak	0.78
Heavy Vehicle %	Actual
Conflicting Peds [peds]	0
Conflicting Bikes [bikes]	0
Signal Timing & Clearance Intervals [s]	
• Minimum Initial – Main Street	20.0
• Minimum Initial – Side Street	10.0
• Amber Through	3.5
• All Red Through	1.5
Recall Mode	
• Major Street	Max
• Minor Street	Max
Controller Type	Pretimed
Lead/Lag	Lead Only Unless a Benefit to Coordination
Dual Entry	Yes for Even Phases, No for Odd Phases
Inhibit Maximum	No

3.2.1 Peak Hour Factor

Varying values for the peak hour factors can be applied based on the context and characteristics of the region. The peak hour factor represents the relationship between the peak 15-minute flow rate and the peak hour. A higher peak hour factor implies that there is a fairly regular flow of traffic for the entire hour, with little fluctuation between each 15-minute period. A lower peak hour factor reflects a distinct spike, where the peak 15-minute period is significantly higher than the rest of the hour.

This study applied a peak hour factor of 0.77 and 0.78 at the study intersection for the AM and PM peak periods, respectively. These values represent the peak hour factors based on the count conducted.

4. Capacity Analysis Results

A traffic model representing each of the scenarios listed below was created using Synchro 7 software. Capacity analyses were then conducted for the AM and PM peak hours to determine the volume/capacity ratios and levels of service at the intersection for the following horizons:

- Existing Conditions – 2011
- Peak Construction – 2015: Background Traffic Conditions
- Peak Construction – 2015: Combined Traffic Conditions
- Operations Horizon – 2035: Background Traffic Conditions
- Operations Horizon – 2035: Combined Traffic Conditions

Synchro capacity analysis reports are included in **Appendix C**. A summary of results by horizon follows below.

4.1 Existing Conditions – 2011

The intersection operates well under 2011 existing conditions, with levels of service of A during both the AM and PM peak hours and a maximum v/c ratio of 0.02, occurring during the PM peak hour. No upgrades are recommended to improve operations at the intersection for this scenario.

4.2 Peak Construction – 2015

4.2.1 Background Traffic Conditions

The intersection continues to operate well under 2015 background traffic conditions, with levels of service of B or better and a maximum v/c ratio of 0.13 in the AM peak hour, and levels of service of B or better and a maximum v/c ratio of 0.19 in the PM peak hour. No upgrades are recommended to improve operations at the intersection for this scenario.

4.2.2 Combined Traffic Conditions

Under combined traffic conditions, the intersection continues to operate at adequate tolerances, with the westbound movement experiencing levels of service of C, and all other movements operating at level of service B or better in the AM peak hour, with a maximum v/c ratio of 0.33. In the PM peak hour, the westbound movement operates at level of service D, with a v/c ratio of 0.56. All other movements operate with levels of service of B or better.

While a LOS D is generally considered to be below acceptable tolerances for Alberta Transportation, AECOM does not anticipate there to be any issues associated with the occurrence of a LOS D on the westbound movement at this intersection. It occurs only during the PM peak hour of the peak construction horizon, and traffic volumes generated by the site will decrease after the 2015 horizon. The queue length for the westbound approach is only 25 m, and traffic flow on Highway 881 is not affected by the delay on this movement. As such, no recommendations for improvement to the intersection are suggested at this point.

4.3 Operations Horizon – 2035

4.3.1 Background Traffic Conditions

The intersection operates well under 2035 background traffic conditions, with levels of service of B or better and a maximum v/c ratio of 0.04, occurring during the PM peak hour. No upgrades are recommended to improve operations at the intersection for this scenario.

4.3.2 Combined Traffic Conditions

The intersection operates well under 2035 combined traffic conditions with site operations traffic. The intersection experiences levels of service of B or better and a maximum v/c ratio of 0.10, occurring during the PM peak hour. No upgrades are recommended to improve operations at the intersection for this scenario.

5. Alberta Transportation Warrant Analysis

Analysis to determine the required intersection treatments during the construction and operations phases was completed based on the procedures outlined in Section D.7 of the Alberta Transportation Highway Geometric Design Guide (HGDG). The analyses focused on the traffic volumes warrant and functional characteristics of the intersection. All figures references below for right and left turn warrant analyses have been obtained from the Alberta Transportation HGDG.

5.1 Peak Construction – 2015

Figure 5.1 shows the combined conditions AADT values for Highway 881 and the access road plotted on the Traffic Volume Warrant Chart for At-Grade Intersection Treatment on Two Lane Rural Highways.

Based on the results shown in **Figure 5.1**, either a Type II, III, IV or V intersection is required. Further analysis for exclusive left turn and right turn lanes is required.

5.1.1 Left Turn Warrants

Left turn warrant analyses are required for both the north and south approaches at the intersection, as per Section D.7.5 of the Highway Geometric Design Guide. Procedures for the left turn warrant analysis are outlined in Section D.7.6 of the HGDG. For both the north and south approaches, analysis of both the morning and afternoon peak hour turning volumes was completed. The results of this analysis are presented below:

North Approach

The analysis for the morning peak hour at the north approach is as follows:

V_l = Number of southbound left turning vehicles per hour = 7 vph
V_a = Total number of southbound vehicles = 33 vph
L= Portion of left turns in approach volume = $V_{l/}$ V_a = 7/33 = 21%
V_0 =Opposing volumes = 257 vph

From Figure D-7.6-7b: Type II

Using this data and Figure D-7.6-7b, it is determined that an exclusive left turn lane is not warranted.

The analysis for the afternoon peak hour at the north approach is as follows:

V_l = Number of southbound left turning vehicles per hour = 1 vph
V_a = Total number of southbound vehicles = 94 vph
L= Portion of left turns in approach volume = $V_{l/}$ V_a = 1/94 = 1%
V_0 =Opposing volumes = 186 vph

From Figure D-7.6-7a: Type II

Using this data and Figure D-7.6-7a, it is determined that an exclusive left turn lane is not warranted.

South Approach

The analysis for the morning peak hour at the south approach is as follows:

V_l = Number of northbound left turning vehicles per hour = 114 vph
V_a = Total number of northbound vehicles = 257 vph
L= Portion of left turns in approach volume = $V_{l/}$ V_a = 114/257 = 44%

V_0 =Opposing volumes = 33 vph

From Figure D-7.6-7d: Type II

Using this data and Figure D-7.6-7d, it is determined that an exclusive left turn lane is not warranted.

The analysis for the afternoon peak hour at the south approach is as follows:

V_l = Number of northbound left turning vehicles per hour = 64 vph
V_a = Total number of northbound vehicles = 186 vph
L= Portion of left turns in approach volume = $V_{l/}$ V_a = 64/186 = 34%
V_0 =Opposing volumes = 94 vph

From Figure D-7.6-7d: Type II

Using this data and Figure D-7.6-7d, it is determined that an exclusive left turn lane is not warranted.

5.1.2 Right Turn Warrants

Procedures for the right turn lane warrant analysis are outlined in Section D.7.6 of the Highway Geometric Design Guide. To warrant a right turn lane, all three of the following conditions must be met:

1. Main road AADT > 1800
2. Intersection road AADT > 900
3. Right turn daily traffic volume > 360

North Approach

For the north approach during the 2015 construction phase, the warrant conditions are as follows:

1. Main road AADT = 2764 > 1800 CONDITION MET
2. Intersection road AADT = 929 > 900 CONDITION MET
3. Right turn daily traffic volume = 421 > 360 CONDITION MET

As all three conditions are met, an exclusive right turn lane is warranted.

South Approach

For the south approach during the 2015 construction phase, the warrant conditions are as follows:

1. Main road AADT = 3299 > 1800 CONDITION MET
2. Intersection road AADT = 790 < 900 CONDITION NOT MET
3. Right turn daily traffic volume = 304 < 360 CONDITION NOT MET

As not all three conditions are met, an exclusive right turn lane is not warranted.

5.1.3 Result

Based on the expected AADT volumes and left and right turn warrant analyses, a Type IVd intersection treatment will be required for this location during the 2015 construction phase. This intersection treatment includes an exclusive southbound right turn lane.

5.2 Operations Horizon – 2035

Figure 5.1 shows the combined conditions AADT values for Highway 881 and the access road plotted on the Traffic Volume Warrant Chart for At-Grade Intersection Treatment on Two Lane Rural Highways.

Based on the results shown in **Figure 5.1**, either a Type II, III, IV or V intersection treatment is required. Further analysis for exclusive left turn and right turn lanes is required.

5.2.1 Left Turn Warrants

Left turn warrant analyses are required for both the north and south approaches at the intersection, as per Section D.7.5 of the Highway Geometric Design Guide. Procedures for the left turn warrant analysis are outlined in Section D.7.6 of the HGDG. For both the north and south approaches, analysis of both the morning and afternoon peak hour turning volumes was completed. The results of this analysis are presented below:

North Approach

The analysis for the morning peak hour at the north approach is as follows:

V_l = Number of southbound left turning vehicles per hour = 11 vph
V_a = Total number of southbound vehicles = 52 vph
L= Portion of left turns in approach volume = $V_{l/}$ V_a = 11/52 = 21%
V_0 =Opposing volumes = 109 vph

From Figure D-7.6-7b: Type II

Using this data and Figure D-7.6-7b, it is determined that an exclusive left turn lane is not warranted.

The analysis for the afternoon peak hour at the north approach is as follows:

V_l = Number of southbound left turning vehicles per hour = 2 vph
V_a = Total number of southbound vehicles = 149 vph
L= Portion of left turns in approach volume = $V_{l/}$ V_a = 2/149 = 1%
V_0 =Opposing volumes = 108 vph

From Figure D-7.6-7a: Type II

Using this data and Figure D-7.6-7a, it is determined that an exclusive left turn lane is not warranted.

South Approach

The analysis for the morning peak hour at the south approach is as follows:

V_l = Number of northbound left turning vehicles per hour = 31 vph
V_a = Total number of northbound vehicles = 109 vph
L= Portion of left turns in approach volume = $V_{l/}$ V_a = 31/109 = 28%
V_0 =Opposing volumes = 52 vph

From Figure D-7.6-7c: Type II

Using this data and Figure D-7.6-7c, it is determined that an exclusive left turn lane is not warranted.

The analysis for the afternoon peak hour at the south approach is as follows:

V_l = Number of northbound left turning vehicles per hour = 8 vph
V_a = Total number of northbound vehicles = 108 vph

L= Portion of left turns in approach volume = $V_{l/} V_a$ = 8/108 = 7%
V_0 =Opposing volumes = 149 vph

From Figure D-7.6-7a: Type II

Using this data and Figure D-7.6-7a, it is determined that an exclusive left turn lane is not warranted.

5.2.2 Right Turn Warrants

Procedures for the right turn lane warrant analysis are outlined in Section D.7.6 of the Highway Geometric Design Guide. To warrant a right turn lane, all three of the following conditions must be met:

1. Main road AADT > 1800
2. Intersection road AADT > 900
3. Right turn daily traffic volume > 360

North Approach

For the north approach during the 2035 operations phase, the warrant conditions are as follows:

1. Main road AADT = 4380 > 1800 CONDITION MET
2. Intersection road AADT = 864 < 900 CONDITION NOT MET
3. Right turn daily traffic volume = 668 > 360 CONDITION MET

As not all three conditions are met, an exclusive right turn lane is not warranted.

South Approach

For the south approach during the 2035 operations phase, the warrant conditions are as follows:

1. Main road AADT = 4009 > 1800 CONDITION MET
2. Intersection road AADT = 643 < 900 CONDITION NOT MET
3. Right turn daily traffic volume = 178 < 360 CONDITION NOT MET

As not all three conditions are met, an exclusive right turn lane is not warranted.

5.2.3 Result

Based on the expected AADT volumes and left and right turn warrant analyses, a Type II intersection treatment will be sufficient for this location during the 2035 operations phase.

5.3 Intersection Warrant Summary

Analysis of the 2015 peak construction horizon results in the requirement for an exclusive southbound right turn lane, as per the Type IVd intersection treatment. However, this exclusive lane is not required by the 2035 horizon, when the site is in its operations phase, and a Type II intersection treatment is adequate to accommodate expected turning traffic volumes.

Additionally, the Synchro analysis of the 2015 horizon does not result in the need for an exclusive southbound right turn at this intersection. Based on the fact that the exclusive right turn lane is not required in the longer term horizon, and the Synchro analysis does not support the recommendation to improve the intersection, AECOM feels that the current Type II intersection treatment will be adequate to accommodate traffic volumes for both the 2015 and 2035 horizons.

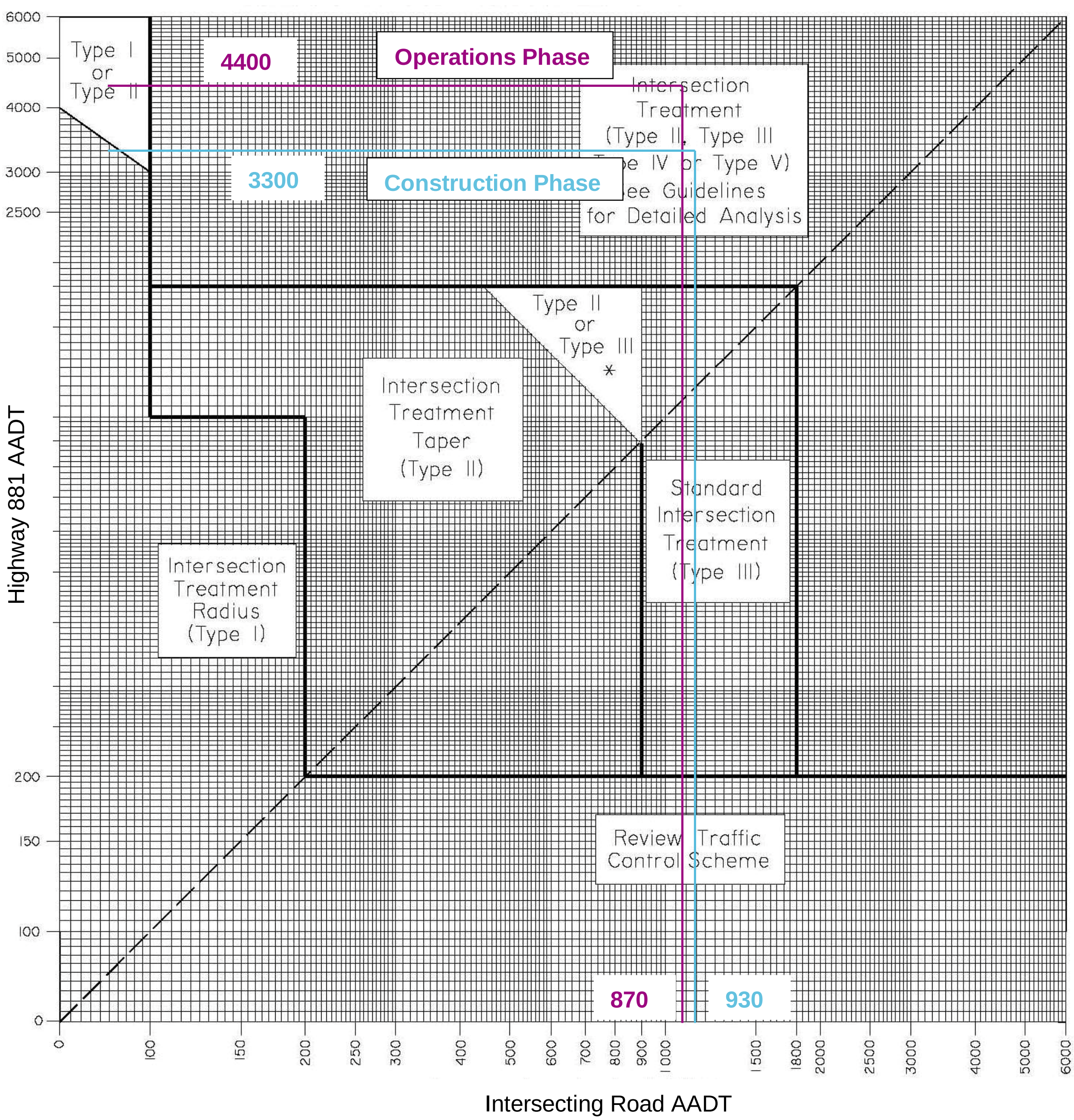

Figure 5.1: Traffic Volume Warrant Chart for At-Grade Intersection Treatment on Two Lane Rural Highways – 2015 Construction Phase and 2035 Operations Phase AADT Values

Source: Alberta Infrastructure Highway Geometric Design Guide Pg. D-110

6. Conclusions and Recommendations

The existing intersection operates considerably better than the minimum acceptable LOS under background traffic conditions at the 2011, 2015 and 2035 horizons. The addition of site generated traffic in 2015 and 2035 does not significantly impact operations and the intersection continues to operate at LOS C or better and v/c ratios of 0.56 or lower. No improvements are considered necessary to improve operations.

Under 2015 combined traffic conditions, the westbound approach does experience LOS D in the PM peak. While a LOS D is generally considered to be below acceptable tolerances for Alberta Transportation, AECOM does not anticipate there to be any issues associated with the occurrence of a LOS D on the westbound movement at this intersection. It occurs only during the PM peak hour of the peak construction horizon, and traffic volumes generated by the site will decrease after the 2015 horizon. The queue length for the westbound approach is only 25 m, and traffic flow on Highway 881 is not affected by the delay on this movement. As such, no recommendations for improvement are suggested.

The Alberta Transportation intersection warrant analyses were conducted using the combined traffic conditions for both the 2015 and 2035 horizons. Under 2015 conditions, an exclusive southbound right turn lane is warranted. However, this intersection improvement is not warranted at the 2035 horizon, and they Synchro analysis did not support the need for an exclusive southbound right turn lane. As such, AECOM feels that the current Type II intersection treatment will be adequate to accommodate expected traffic volumes for both the 2015 and 2035 horizons.

Overall, it is not anticipated that there will be significant transportation effects from the Canadian Natural Kirby Expansion project.

Appendix A

AECOM 12-Hr Traffic Volume Count

INTERSECTION TRAFFIC FLOW ANALYSIS REPORT

ME2 TRANSPORTATION DATA CORP.

Location Hwy 881 TWP 743a, Conklin   Date 11-Aug-11   Observers CB,DM

time	FROM THE NORTH on Hwy 881						FROM THE SOUTH on Hwy 881						FROM THE EAST on TWP 743a						FROM THE WEST on TWP 743a								
ending	LT	ST	RT	CV	PED	BIKE	LT	ST	RT	CV	PED	BIKE	LT	ST	RT	CV	PED	BIKE	LT	ST	RT	CV	PED	BIKE			
6:15	0	4	0	1	0	0	1	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10		
6:30	1	4	0	0	0	0	1	3	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11		
6:45	1	6	0	2	0	0	0	7	1	6	0	0	0	0	1	0	0	0	0	1	0	0	0	0	17		
7:00	10	4	0	3	0	0	0	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	17	55	
7:15	3	4	0	0	0	0	1	5	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	59	**PHF**
7:30	2	3	0	3	0	0	2	11	1	7	0	0	4	0	0	1	0	0	0	0	0	0	0	0	23	71	**0.771739**
7:45	1	8	0	0	0	0	1	4	0	2	0	0	0	1	0	1	0	0	1	1	0	2	0	0	17	71	
8:00	0	8	0	3	0	0	1	5	4	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	19	73	
8:15	0	6	0	0	0	0	0	13	0	7	0	0	1	1	0	1	0	0	0	1	0	0	0	0	22	81	
8:30	1	13	0	7	0	0	0	8	2	3	0	0	0	0	1	1	0	0	0	0	0	0	0	0	25	83	
8:45	0	6	0	2	0	0	1	15	1	8	0	0	4	0	0	1	0	0	0	0	0	0	0	0	27	93	
9:00	0	13	0	5	0	0	0	9	0	5	0	0	0	1	1	1	0	0	0	0	0	0	0	0	24	98	
9:15	1	6	0	2	0	0	1	11	0	7	0	0	1	1	0	2	0	0	1	1	0	1	0	0	23	99	
9:30	2	10	0	4	0	0	0	11	3	7	0	0	0	0	1	1	0	0	0	0	0	0	0	0	27	101	
9:45	0	13	0	3	0	0	1	10	0	1	0	0	3	0	1	0	0	0	0	0	0	0	0	0	28	102	
10:00	1	7	1	3	0	0	0	20	1	11	0	0	0	0	1	1	0	0	0	0	1	0	0	0	32	110	
10:15	0	10	0	4	0	0	0	18	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	117	
10:30	0	11	0	5	0	0	0	16	1	6	0	0	1	0	1	1	0	0	0	0	0	0	0	0	30	120	
10:45	2	21	0	6	0	0	0	10	1	4	0	0	3	0	3	1	0	0	0	0	0	0	0	0	40	132	
11:00	1	21	0	11	0	0	0	14	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	138	
11:15	1	27	0	11	0	0	0	14	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	150	
11:30	1	14	0	5	0	0	0	10	1	3	0	0	3	0	0	2	0	0	0	0	0	0	0	0	29	149	
11:45	0	17	0	6	0	0	1	13	3	4	0	0	2	1	2	2	0	0	0	0	0	0	0	0	39	148	
12:00	0	23	0	11	0	0	0	10	1	7	0	0	0	0	0	0	0	0	0	0	1	0	0	0	35	145	
12:15	2	32	0	6	0	0	0	6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	145	
12:30	0	36	0	10	0	0	0	13	1	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	51	167	
12:45	2	24	0	3	0	0	0	4	0	2	0	0	4	1	1	2	0	0	1	0	0	1	0	0	37	165	
1:00	1	32	1	3	0	0	0	7	2	4	0	0	3	0	0	0	0	0	0	0	0	0	0	0	46	176	
1:15	0	34	0	14	0	0	1	8	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	46	180	
1:30	2	28	0	7	0	0	0	16	2	7	0	0	2	0	1	0	0	0	1	0	0	0	0	0	52	181	
1:45	2	35	1	8	0	0	0	9	2	7	0	0	4	0	1	3	0	0	0	0	0	0	0	0	54	198	
2:00	0	19	0	2	0	0	0	8	1	2	0	0	1	1	1	1	0	0	0	1	0	1	0	0	32	184	
2:15	0	30	0	8	0	0	0	14	2	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	47	185	
2:30	3	23	0	8	0	0	0	6	1	4	0	0	2	0	0	1	0	0	0	0	0	0	0	0	35	168	
2:45	2	28	0	6	0	0	0	9	3	2	0	0	2	1	1	1	0	0	0	0	0	0	0	0	46	160	
3:00	1	27	0	7	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	1	3	2	0	0	34	162	
3:15	0	45	0	7	0	0	0	8	0	3	0	0	2	1	3	3	0	0	0	0	0	0	0	0	59	174	
3:30	0	27	0	6	0	0	0	10	0	3	0	0	6	0	1	5	0	0	0	1	0	1	0	0	45	184	
3:45	0	17	0	6	0	0	0	3	1	4	0	0	2	1	2	4	0	0	0	1	1	1	0	0	28	166	
4:00	0	22	0	9	0	0	0	6	0	0	0	0	1	0	0	1	0	0	0	0	2	0	0	0	31	163	
4:15	0	19	0	7	0	0	0	5	0	2	0	0	5	0	0	0	0	0	0	0	0	0	0	0	29	133	
4:30	1	19	0	3	0	0	0	13	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	36	124	
4:45	0	18	0	7	0	0	0	11	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	31	127	
5:00	0	20	0	6	0	0	0	13	1	1	0	0	1	0	1	2	0	0	0	0	0	0	0	0	36	132	
5:15	1	17	0	3	0	0	0	9	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	28	131	**PHF**
5:30	0	25	0	12	0	0	0	6	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	129	**0.782609**
5:45	0	20	0	5	0	0	0	17	2	2	0	0	4	1	2	1	0	0	0	0	0	0	0	0	46	144	
6:00	0	14	0	3	0	0	0	10	1	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	26	134	
12 hr total	45	870	3	253	0	0	12	455	54	190	0	0	66	12	31	43	0	0	6	8	8	9	0	0	1570		
		918		28%				521		36%				109		39%				22		41%					
peak hour	5	129	2				1	40	6				10	0	3				2	0	0						
		136						47						13						2							
2 direct L	SB	918	65%				NB	521	#DIV/0!				WB	109	#DIV/0!				EB	22	45%						
total	NB	492	35%				SB	944	64%				EB	107	#DIV/0!				WB	27	55%						
		1410						1465						216						49							

AM peak 7 - 8 am	6	23	0	6	0	0	5	25	6	18	0	0	4	1	1	2	0	0	1	1	0	2	0	0
PM peak 4:45-5:45	1	82	0	26	0	0	0	45	6	8	0	0	6	1	3	4	0	0	0	0	0	0	0	0

Appendix B

Relevant Correspondence

Leonhardt, Heather

From:	Peter Kilburn <Peter.Kilburn@gov.ab.ca>
Sent:	Monday, August 22, 2011 2:23 PM
To:	Stevenson, Heather
Cc:	Orlando Rodriguez; Tom Wilkinson; Mike Bradley (TRANS); Cathy Maniego
Subject:	RE: Hwy 881 Growth Rates

Heather,

We do not have a long history of traffic on Highway 881 but
based on Highway 63 data from 1987 onward
the average non compounding annual growth has been **3.13 %** of 2010 levels.

This should be used for background traffic on a Traffic Impact Assessment.
You the consultant have to figure out what additional traffic is being generated by oil field activity in the area.

You should note that the Automated Traffic Recorder at the Highway 63 end of Highway 881 has recovered a bit in 2010 from a four year decline in traffic.

My speculation is that there is less interaction between Fort McMurray and oil field work in the Anzac area.

Peter Kilburn, P.Eng.,M.Sc.E.
Planning Specialist
Strategic and Network Planning Section
Planning Branch
Alberta Transportation
peter.kilburn@gov.ab.ca
(780) 415-1359

From: Stevenson, Heather [mailto:Heather.Leonhardt@aecom.com]
Sent: Monday, August 22, 2011 1:37 PM
To: Peter Kilburn
Cc: ! IRINI.AKHNOUKH
Subject: Hwy 881 Growth Rates

Hi Peter,

I'm working on a couple of TIAs for in-situ oil sands projects along Highway 881. Both sites will access the highway at Twp Rd 743a. I have spoken with Moges Gebreleoul regarding the scope for the project, and he suggested I touch base with you to confirm appropriate growth rates for background volumes along the highway. Historical AADTs result in a fairly high growth rate, but I'm aware that this is not typically considered representative of future growth. Please let me know if there's a particular growth rate you use for this corridor and would like us to apply.

Thanks,

Heather Leonhardt, P.Eng.
Civil Engineer, Transportation

D 403.270.9130
heather.stevenson@aecom.com

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Appendix C

Synchro Reports

HCM Unsignalized Intersection Capacity Analysis
1: Kirby Site Access & Hwy 881

10/7/2011

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	1	0	4	1	1	5	25	6	6	23	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Hourly flow rate (vph)	1	1	0	5	1	1	6	32	8	8	30	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	97	99	30	95	95	36	30			40		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	97	99	30	95	95	36	30			40		
tC, single (s)	7.5	6.9	6.6	7.5	6.9	6.6	4.5			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	3.7	3.9	4.4	3.7	2.5			2.5		
p0 queue free %	100	100	100	99	100	100	100			99		
cM capacity (veh/h)	792	716	943	799	723	940	1389			1417		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	3	8	47	38
Volume Left	1	5	6	8
Volume Right	0	1	8	0
cSH	752	805	1389	1417
Volume to Capacity	0.00	0.01	0.00	0.01
Queue Length 95th (m)	0.1	0.2	0.1	0.1
Control Delay (s)	9.8	9.5	1.1	1.6
Lane LOS	A	A	A	A
Approach Delay (s)	9.8	9.5	1.1	1.6
Approach LOS	A	A		

Intersection Summary			
Average Delay	2.2		
Intersection Capacity Utilization	13.3%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	0	6	1	3	0	45	6	1	82	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	0	0	0	8	1	4	0	58	8	1	105	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	174	173	105	169	169	62	105			65		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	174	173	105	169	169	62	105			65		
tC, single (s)	7.5	6.9	6.6	7.5	6.9	6.6	4.5			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	3.7	3.9	4.4	3.7	2.5			2.5		
p0 queue free %	100	100	100	99	100	100	100			100		
cM capacity (veh/h)	705	655	853	718	661	909	1299			1386		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	0	13	65	106
Volume Left	0	8	0	1
Volume Right	0	4	8	0
cSH	1700	759	1299	1386
Volume to Capacity	0.00	0.02	0.00	0.00
Queue Length 95th (m)	0.0	0.4	0.0	0.0
Control Delay (s)	0.0	9.8	0.0	0.1
Lane LOS	A	A		A
Approach Delay (s)	0.0	9.8	0.0	0.1
Approach LOS	A	A		

Intersection Summary			
Average Delay	0.7		
Intersection Capacity Utilization	15.1%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	1	1	64	5	1	1	114	28	7	7	26	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Hourly flow rate (vph)	1	1	83	6	1	1	148	36	9	9	34	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	391	394	34	473	389	41	34			45		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	391	394	34	473	389	41	34			45		
tC, single (s)	7.5	6.9	7.1	7.5	6.9	6.6	5.0			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	3.9	4.4	3.7	3.0			2.5		
p0 queue free %	100	100	90	98	100	100	87			99		
cM capacity (veh/h)	451	422	834	359	427	934	1168			1411		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	86	9	194	43
Volume Left	1	6	148	9
Volume Right	83	1	9	0
cSH	811	404	1168	1411
Volume to Capacity	0.11	0.02	0.13	0.01
Queue Length 95th (m)	2.8	0.6	3.5	0.2
Control Delay (s)	10.0	14.1	6.8	1.6
Lane LOS	A	B	A	A
Approach Delay (s)	10.0	14.1	6.8	1.6
Approach LOS	A	B		

Intersection Summary			
Average Delay	7.1		
Intersection Capacity Utilization	25.6%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	108	7	1	3	64	51	7	1	93	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	0	0	138	9	1	4	82	65	9	1	119	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	360	360	119	494	356	70	119			74		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	360	360	119	494	356	70	119			74		
tC, single (s)	7.5	6.9	7.1	7.5	6.9	6.6	5.0			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	3.9	4.4	3.7	3.0			2.5		
p0 queue free %	100	100	81	97	100	100	92			100		
cM capacity (veh/h)	494	470	741	329	475	899	1061			1375		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	138	14	156	121
Volume Left	0	9	82	1
Volume Right	138	4	9	0
cSH	741	412	1061	1375
Volume to Capacity	0.19	0.03	0.08	0.00
Queue Length 95th (m)	5.5	0.8	2.0	0.0
Control Delay (s)	11.0	14.1	4.9	0.1
Lane LOS	B	B	A	A
Approach Delay (s)	11.0	14.1	4.9	0.1
Approach LOS	B	B		

Intersection Summary			
Average Delay	5.8		
Intersection Capacity Utilization	26.7%	ICU Level of Service	A
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
1: Kirby Site Access & Hwy 881

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		✥			✥			✥			✥	
Volume (veh/h)	1	1	64	69	1	1	114	28	115	7	26	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Hourly flow rate (vph)	1	1	83	90	1	1	148	36	149	9	34	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	461	534	34	543	459	111	34			186		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	461	534	34	543	459	111	34			186		
tC, single (s)	7.5	6.9	7.1	8.0	6.9	6.6	5.0			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	4.3	4.4	3.7	3.0			2.5		
p0 queue free %	100	100	90	68	100	100	87			99		
cM capacity (veh/h)	403	348	834	277	388	851	1168			1247		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	86	92	334	43
Volume Left	1	90	148	9
Volume Right	83	1	149	0
cSH	804	280	1168	1247
Volume to Capacity	0.11	0.33	0.13	0.01
Queue Length 95th (m)	2.9	11.1	3.5	0.2
Control Delay (s)	10.0	24.0	4.5	1.7
Lane LOS	B	C	A	A
Approach Delay (s)	10.0	24.0	4.5	1.7
Approach LOS	B	C		

Intersection Summary			
Average Delay	8.4		
Intersection Capacity Utilization	38.8%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	108	115	1	3	64	51	71	1	93	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	0	0	138	147	1	4	82	65	91	1	119	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	401	442	119	535	397	111	119			156		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	401	442	119	535	397	111	119			156		
tC, single (s)	7.5	6.9	7.1	8.0	6.9	6.6	5.0			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	4.3	4.4	3.7	3.0			2.5		
p0 queue free %	100	100	81	44	100	100	92			100		
cM capacity (veh/h)	463	420	741	266	449	851	1061			1280		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	138	153	238	121
Volume Left	0	147	82	1
Volume Right	138	4	91	0
cSH	741	271	1061	1280
Volume to Capacity	0.19	0.56	0.08	0.00
Queue Length 95th (m)	5.5	25.4	2.0	0.0
Control Delay (s)	11.0	34.1	3.5	0.1
Lane LOS	B	D	A	A
Approach Delay (s)	11.0	34.1	3.5	0.1
Approach LOS	B	D		

Intersection Summary			
Average Delay	11.6		
Intersection Capacity Utilization	37.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	2	2	8	7	2	2	31	45	11	11	41	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Hourly flow rate (vph)	3	3	10	9	3	3	40	58	14	14	53	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	232	235	53	240	228	66	53			73		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	232	235	53	240	228	66	53			73		
tC, single (s)	7.5	6.9	7.1	7.5	6.9	6.6	4.8			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	3.9	4.4	3.7	2.9			2.5		
p0 queue free %	100	100	99	99	100	100	97			99		
cM capacity (veh/h)	623	577	817	612	585	904	1190			1377		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	16	14	113	68
Volume Left	3	9	40	14
Volume Right	10	3	14	0
cSH	728	645	1190	1377
Volume to Capacity	0.02	0.02	0.03	0.01
Queue Length 95th (m)	0.5	0.5	0.8	0.3
Control Delay (s)	10.1	10.7	3.1	1.7
Lane LOS	B	B	A	A
Approach Delay (s)	10.1	10.7	3.1	1.7
Approach LOS	B	B		

Intersection Summary			
Average Delay	3.7		
Intersection Capacity Utilization	18.0%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	22	11	2	5	8	81	11	2	147	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	0	0	28	14	3	6	10	104	14	3	188	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	333	332	188	353	325	111	188			118		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	333	332	188	353	325	111	188			118		
tC, single (s)	7.5	6.9	7.1	7.5	6.9	6.6	5.0			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	3.9	4.4	3.7	3.0			2.5		
p0 queue free %	100	100	96	97	100	99	99			100		
cM capacity (veh/h)	542	523	675	511	531	851	1002			1324		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	28	23	128	191
Volume Left	0	14	10	3
Volume Right	28	6	14	0
cSH	675	577	1002	1324
Volume to Capacity	0.04	0.04	0.01	0.00
Queue Length 95th (m)	1.0	1.0	0.2	0.0
Control Delay (s)	10.6	11.5	0.8	0.1
Lane LOS	B	B	A	A
Approach Delay (s)	10.6	11.5	0.8	0.1
Approach LOS	B	B		

Intersection Summary			
Average Delay	1.9		
Intersection Capacity Utilization	24.2%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	2	2	8	15	2	2	31	45	33	11	41	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Hourly flow rate (vph)	3	3	10	19	3	3	40	58	43	14	53	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	246	264	53	254	242	80	53			101		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	246	264	53	254	242	80	53			101		
tC, single (s)	7.5	6.9	7.1	7.8	6.9	6.6	4.8			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	4.1	4.4	3.7	2.9			2.5		
p0 queue free %	100	100	99	97	100	100	97			99		
cM capacity (veh/h)	609	555	817	558	574	887	1190			1343		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	16	25	142	68
Volume Left	3	19	40	14
Volume Right	10	3	43	0
cSH	719	583	1190	1343
Volume to Capacity	0.02	0.04	0.03	0.01
Queue Length 95th (m)	0.5	1.1	0.8	0.3
Control Delay (s)	10.1	11.5	2.5	1.7
Lane LOS	B	B	A	A
Approach Delay (s)	10.1	11.5	2.5	1.7
Approach LOS	B	B		

Intersection Summary			
Average Delay	3.7		
Intersection Capacity Utilization	19.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	0	0	22	33	2	5	8	81	19	2	147	0
Sign Control		Stop			Stop			Free			Free	
Grade		0%			0%			0%			0%	
Peak Hour Factor	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
Hourly flow rate (vph)	0	0	28	42	3	6	10	104	24	3	188	0
Pedestrians												
Lane Width (m)												
Walking Speed (m/s)												
Percent Blockage												
Right turn flare (veh)												
Median type								None			None	
Median storage veh)												
Upstream signal (m)												
pX, platoon unblocked												
vC, conflicting volume	338	342	188	358	330	116	188			128		
vC1, stage 1 conf vol												
vC2, stage 2 conf vol												
vCu, unblocked vol	338	342	188	358	330	116	188			128		
tC, single (s)	7.5	6.9	7.1	7.8	6.9	6.6	5.0			4.4		
tC, 2 stage (s)												
tF (s)	3.9	4.4	4.1	4.2	4.4	3.7	3.0			2.5		
p0 queue free %	100	100	96	91	100	99	99			100		
cM capacity (veh/h)	537	516	670	459	527	845	1002			1312		

Direction, Lane #	EB 1	WB 1	NB 1	SB 1
Volume Total	28	51	138	191
Volume Left	0	42	10	3
Volume Right	28	6	24	0
cSH	670	490	1002	1312
Volume to Capacity	0.04	0.10	0.01	0.00
Queue Length 95th (m)	1.1	2.8	0.2	0.0
Control Delay (s)	10.6	13.2	0.7	0.1
Lane LOS	B	B	A	A
Approach Delay (s)	10.6	13.2	0.7	0.1
Approach LOS	B	B		

Intersection Summary			
Average Delay	2.7		
Intersection Capacity Utilization	25.9%	ICU Level of Service	A
Analysis Period (min)	15		