TIENKEN ROAD AND KINGS COVE

TRAFFIC STUDY

CITY OF ROCHESTER HILLS

DECEMBER 2002

Prepared by:

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HUBBELL, ROTH & CLARK, INC.

CONSULTING ENGINEERS

December 12, 2002

City of Rochester Hills
1000 Rochester Hills Drive
Rochester Hills, Michigan 48309-3033

Attention: Paul Davis, P.E.

Re: Tienken Road and Kings Cove Traffic Study   HRC Job No. 20020367.02
       Rochester Hills, Michigan

Dear Mr. Davis:

At your request, we conducted a traffic study for the Tienken Road and Kings Cove intersection. The purpose of this traffic study is to determine the future roadway geometry of Tienken Road and whether a traffic signal is warranted at this intersection. Our analysis indicates that with the existing traffic volume, the intersection meets three traffic signal warrants (#2, #9 and #11).

HRC also analyzed the required cross section for Tienken Road. Our analyses indicate that Tienken Road should be widened from two lanes to a five lane roadway through this section. Tienken Road with the proposed geometry operates at desirable level of service for the traffic volume projected for the year 2025. This proposed geometry will require that the Paint Creek Bridge be widened first to accommodate the future road.

Special attention was given to the Paint Creek Trail in this area due to high volume of pedestrians crossing Tienken Road. It is recommended that existing crosswalk for Paint Creek Trail be relocated to the intersection of Tienken and Kings Cove when it is signalized.

If you have any questions or require any additional information, please contact the undersigned.

Very truly yours,

HUBBELL, ROTH & CLARK, INC.

Richard F. Beaubien, P.E., P.T.O.E.
Associate & Transportation Director

Attachment
pc: RCOC; David Allyn
       HRC; G. Knapp, W. Alix, D. Mitchell, File

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DUTTON RD.
OAKLAND TWP.
CITY OF ROCHESTER HILLS
MEAD RD.
WINKLER POND

CITY OF ROCHESTER HILLS

SITE

ROCHESTER

CITY OF ROCHESTER HILLS

WALTON BLVD.
UNIVERSITY RD.
PARKDALE RD.

MILLER LAKE
AVON RD.
RIVER

BUTLER RD.
ADAMS RD.
CROOKS RD.
LIVERNOIS RD.
HAMLIN RD.
HONEYWELL DITCH
SCHOOL RD.
AVON RD.

GRAND TRUNK WESTERN R.R.
59
AUBURN RD.

T3N, R11E

SOUTH BLVD.
CITY OF TROY
SOUTH BLVD.

N

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Section 2 - Field Observations

During site visits, HRC observed field conditions, collected data regarding existing land use and sight distance limitations and took photographs of the roadway. The important field observations of the HRC staff are presented in this chapter.

Tienken Road at Kings Cove is a two lane road at the low point of a sag vertical curve. Vehicles appear to accelerate as they descend and approach the intersection from both sides. There is a right turn lane into Kings Cove from westbound Tienken Road. The outbound lane from Kings Cove is wide enough to allow cars to create a left turn storage lane and a right turn storage lane. See Photo 1 below. Outbound traffic is controlled by a stop sign. The off-set street across Tienken Road is Oakbrook Drive, which provides access to a residential complex.

Photograph 1 - Looking Southbound Kings Cove north of Tienken Road

Immediately west of the Kings Cove intersection is a crosswalk for the popular Paint Creek Trail. See Photo 2. Still further west of the Kings Cove intersection is a driveway north into a parking lot for trail users and Oakwood Ridge street on the south. See Photo 3.

Photograph 2 - Looking eastbound Tienken Road west of Kings Cove

Photograph 3 – Looking eastbound Tienken Road west of Oakbrook Ridge

Photo 4 shows a car attempting to turn left onto Tienken Road from Kings Cove. The vehicle has pulled out substantially beyond the stop bar and into the road because of sight distance restrictions. Sight distance to the east is limited by vegetation and topography. Additional discussion on sight distance can be found in Section 3.

Photograph 4 - Looking westbound Tienken Rd east of Kings Cove

Section 3 - Traffic Data

Current Traffic Volumes

Hubbell, Roth & Clark collected 24-hour traffic counts on September 12, 2002 on the four roads in the site: Tienken Road, Kings Cove Drive, Oakbrook Ridge Drive and Oakbrook Drive. A summary of the counts is provided in Table 1. The AM and PM volumes for the intersection of Tienken and Kings Cove/Oakbrook are shown in Figure 3.

Table 1: 24-Hour Traffic Volumes for 2002

Ending Time Period	Two-Way Tienken Road	Southbound Kings Cove Drive	Northbound Oakbrook Ridge	Northbound Oakbrook Drive
1:00	91	3	4	0
2:00	47	2	4	0
3:00	42	0	3	1
4:00	42	3	0	1
5:00	78	3	0	3
6:00	436	20	5	7
7:00	1129	70	24	7
8:00	1601	97	33	5
9:00	1483	134	19	20
10:00	1294	109	24	16
11:00	1122	110	27	6
12:00	1268	93	19	14
13:00	1361	91	20	3
14:00	1143	79	30	8
15:00	1493	56	19	25
16:00	1694	63	14	12
17:00	1533	64	12	8
18:00	1581	47	15	1
19:00	1625	89	26	12
20:00	1188	59	16	3
21:00	1114	29	16	5
22:00	921	17	15	8
23:00	499	9	8	2
24:00	270	7	14	2
Total	23,055	1,254	367	169

PAINT CREEK TRAIL

KINGS COVE

56/55
47/34

TIENKEN ROAD

23/66
1132/705
2/9

469/920 →
0/12

10/91

OAKBROOK RIDGE

23/17
10/9

OAKBROOK

1/8
4/4

N
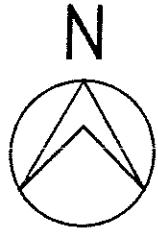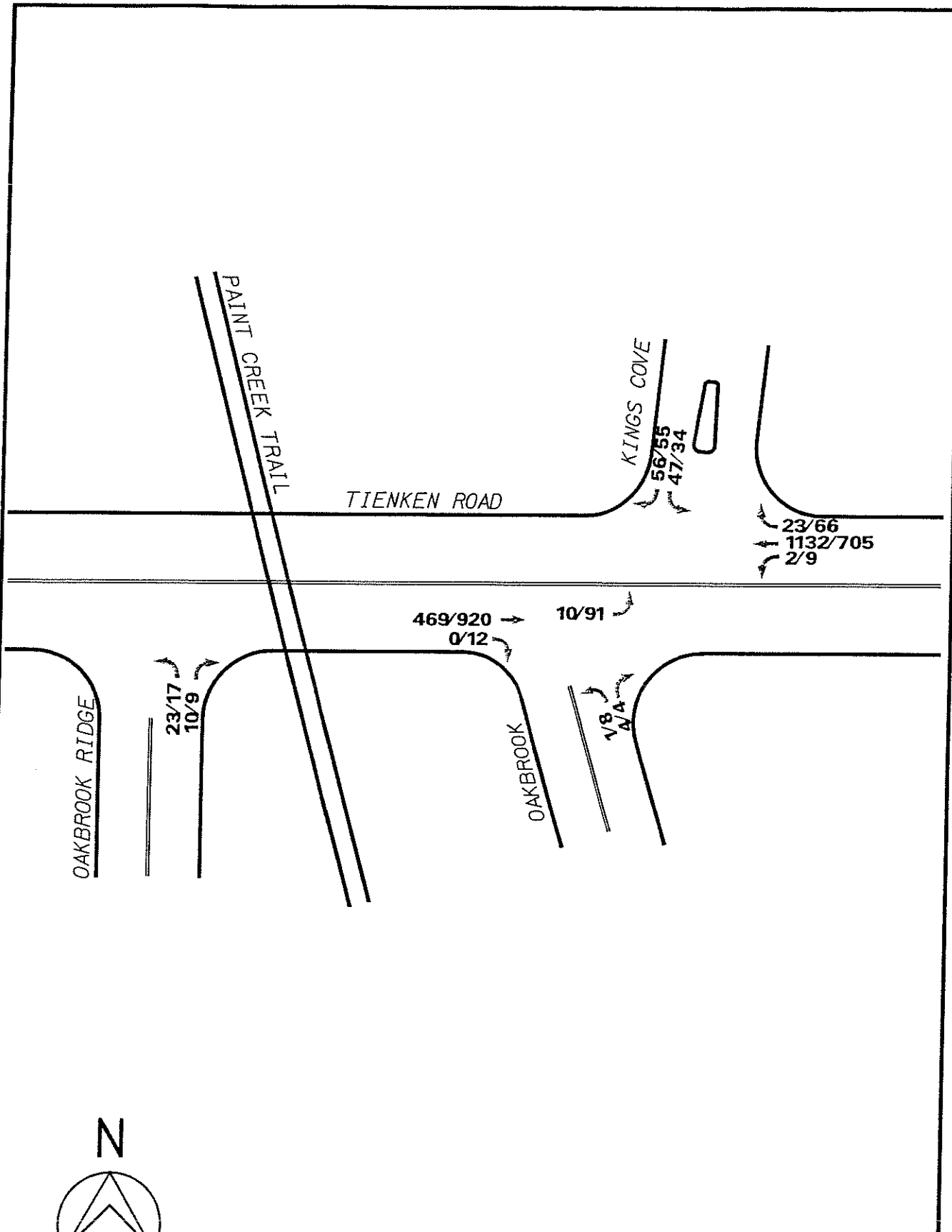
NOT TO SCALE

EXISTING AM/PM PEAK TRAFFIC ASSIGNMENT

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Speed Study

In 1999, HRC collected traffic speed data on Tienken Road between Livernois and Kings Cove and between Kings Cove and Rochester Road to determine if the actual speeds driven on Tienken Road were close to the posted speed limit. The majority of drivers, consciously or unconsciously, consider the factors in the driving environment and travel at a speed that is safe and comfortable regardless of the posted speed limit. The driving environment, which includes other traffic on the road and roadway conditions, is the primary factor, which influences the prevailing speed. The driving environment is reflected by the 85th percentile speed.

The primary basis for establishing a proper, realistic speed limit is the nationally recognized method of using the 85th percentile speed. This is the speed at or below which 85% of the traffic moves. For example, if 85 of each 100 motor vehicles were recorded at 45 mph or under, then 45 mph is the 85th percentile speed.

Table 2 shows that the 85th percentile and the average speeds are higher than the current posted speed limit of 40 mph on Tienken. When the 85th percentile speed of the major street traffic exceeds 40 mph, the traffic signal warrants for the minor street traffic volume are reduced to 70% of the volume otherwise required.

Table 2: Speed Summary

Category	Tienken Road Livernois to Kings Cove	Tienken Road Kings Cove to Rochester
Avg Speed (mph)	40.25	41.3
85th percentile (mph)	44.18	44.62
Percent above posted limit	47.5%	39.6%

Gap Study

In 1999, HRC conducted a gap study on Tienken Road on the same two segments as the speed study. Gap studies refer to the determination of the number of available gaps in traffic passing a point that are of adequate length to permit pedestrians to cross or for vehicles to enter the roadway. In this context a gap is defined as the time that elapses from when the rear of a vehicle passes a point on a roadway until the front of the next arriving vehicle (from either direction) passes the same point. Gaps are expressed in units of seconds.

The 24-hour gap study for a typical weekday found that on Tienken Road between Livernois and Rochester approximately 21 percent of the gaps are less than two seconds; this interval makes it very difficult for pedestrians to cross Tienken or for vehicles to enter the main roadway from minor streets. Table 3 provides the data on percentage of traffic by interval.

Table 3: Gap Summary

Time Interval in Seconds	Tienken Road Livernois to Kings Cove	Tienken Road Kings Cove to Rochester
0 – 1.0 sec	14.6 %	14.0 %
1.0 – 2.0 sec	7.3 %	7.0 %
> 2.0 sec	78.1 %	80.0 %

Based on the width of Tienken Road and a pedestrian walking speed of 4 feet per second, HRC calculated that a minimum of 20 seconds between passing cars was needed to cross Tienken Road. In the 1999 study, two gaps of 20 seconds or more were observed during a one hour observation period. The two gaps accounted for only 1.28% of the gaps in the observation period.

Sight Distance Analysis

Sight distance is an important design factor at the study location because Kings Cove enters Tienken Road at the bottom of a sag. Sight distance is defined as the length of highway visible to the driver. It results from the three-dimensional design of the highway, and is a primary design control for all highway types. At-grade intersections are inherent points of potential vehicle-vehicle conflict. A driver approaching an intersection should have an unobstructed view of sufficient length to permit control of the vehicle to avoid collision. The American Association of State Highway and Transportation Officials (AASHTO) guideline presents four cases for intersection control, each of which results in different intersection sight-distance requirements:

I.   No control, with vehicles adjusting speeds to avoid collision.

II.   Yield control, with vehicles on the minor roadway yielding to the major roadway.

III.   Stop control on the minor roadway.

IV.   Signal control.

The intersection of Tienken Road and Kings Cove falls into Case III, which represents the most critical conditions generally encountered. AASHTO defines Case IIIB as a vehicle entering a cross road from a stopped position by clearing vehicles approaching from the left and then by turning left and entering the traffic stream approaching from the right. AASHTO defines Case IIIC as a vehicle departing from a stopped position, turning right and merging with traffic from the left. HRC used Case III criteria to determine sight distance at the Kings Cove outbound driveway.

The Kings Cove driveway failed to meet the Case III criteria for visibility to the east. With a posted speed of 40 mph on Tienken Road, drivers will need a minimum sight distance of 574 feet to the east and to the west in order to turn safely left or right out of the subdivision. HRC determined that while there was 1550 feet of sight to the west there was only 184 feet of visibility to the east. The sight distance obstructions included elevations, trees and bushes.

Section 4 - Trip Generation

One of the most critical elements of a traffic study is estimating the amount of traffic to be generated by proposed developments in the vicinity of the site. This is usually done by using trip generation rates or equations. Trip generation rates or equations provide an estimate of all trips generated by a site.

Rates are commonly expressed in trips per unit of development. For example, trips per dwelling unit are commonly used for residential developments, while trips per 1,000 square feet of gross floor area are used for offices and retail. Equations provide a direct estimate of trips based upon development units being multiplied in a mathematical relationship.

Trips are defined as a single or one directional movement with either the origin or destination of the trip inside the study site. Thus, a car entering and leaving a site would be recorded as generating two trips. Trip generation estimates are often the most critical factors in assessing impacts and needs of a proposed development.

There are several sources for trip generation rates and equations, which are based on data collected from locations in the United States and Canada. These are compilations of data that have been gathered over many years for various land uses. National data sources are starting points in estimating the amount of traffic that may be generated by a specific building or land use. Whenever possible, the National rates should be adjusted to reflect local or forecasted conditions. These National sources are not intended to be used without question, deviation or sound judgment. They often reflect what are supposed to be the average or typical conditions. Data collected from local sites may be more representatives than National averages of other developments within the area.

The most widely used source of National Trip Generation data is the Trip Generation Manual, 6th Edition, published by the Institute of Transportation Engineers. The information in this report is almost solely derived from suburban and urban sites. Data included in trip generation was obtained from actual driveway counts of vehicular traffic entering and exiting the site. The sixth edition contains more than 2,000 data sets from individual trip generation studies. The report also includes discussions on the application and use of trip generation rates and equations; descriptions of the characteristics of each land

use; maximum/minimum average rates for weekdays, weekends and peak hours of the generator and adjacent street traffic; and additional statistical data regarding data variability.

The table below lists the proposed land use and the estimated number of weekday trips expected to be generated during the AM and PM Peak Hours and on an average daily basis from the proposed 55,350 square foot Papa Joes gourmet market, 3,100 square foot office building, 49 single family houses and 33 single family houses under construction.

Table 4: Weekday Trip Generation for New Development

ITE Land Use Code	Development	AM Peak Hour	PM Peak Hour	Average Daily Traffic
850	Papa Joes Market (55,350 sq.ft.)	180	637	6,172
710	Office Building (3,100 sq.ft.)	5	5	35
210	The Summit (42 Dwelling Units)	32	43	402
210	South Summit (7 Dwelling Units)	6	7	67
210	Hillside Creek (33 Dwelling Units)	25	34	316
Total		248	726	6,992

The two tables below show the split between inbound and outbound trips during the AM and PM Peak Hours for the land uses above. HRC used the percentages provided by the ITE Trip Generation Manual. These numbers will be used in capacity analyses.

Table 5: AM Peak Hour Trip Generation by Direction

ITE Land Use Code	Development	AM Peak Hour	In	Out
850	Papa Joes Market (55,350 sq.ft.)	180	110 (61%)	70 (39%)
710	Office Building (3,100 sq.ft.)	5	4 (88%)	1 (12%)
210	The Summit (42 Dwelling Units)	32	8 (25%)	24 (75%)
210	South Summit (7 Dwelling Units)	6	2 (25%)	4 (75%)
210	Hillside Creek (33 Dwelling Units)	25	6 (25%)	19 (75%)
Total		248	130	118

Section 1 - Introduction

Hubbell, Roth & Clark, Inc. was retained to update a traffic study prepared for the Tienken Road corridor in 2000 and to determine if a traffic signal is warranted at the intersection of Tienken Road and Kings Cove Drive, which serves a large and growing residential subdivision. Another element of the update was to recommend a future pavement width for Tienken Road in this area so that appropriate improvements can be planned for the Paint Creek Bridge on Tienken Road just east of Kings Cove. HRC incorporated new field work with data collected for the 2000 corridor study.

Tienken Road is classified an urban minor arterial in the northern third of the city of Rochester Hills, Michigan. See Figure 1. It consists mainly of a two-lane bituminous roadway with a posted speed limit of 40 mph. Tienken Road currently carries an average daily traffic volume of 23,055 (September 2002 count) between Livernois Road and Rochester Road.

Kings Cove Drive, a residential street, intersects Tienken Road halfway between Livernois Road and Rochester Road. The intersection is currently non-signalized and is just east of the Paint Creek Trail, a popular multi-purpose trail. The speed limit on Kings Cove Drive is 25 mph.

Tienken Road is under the jurisdiction of the Road Commission for Oakland County. The Master Thoroughfare Plan for the city of Rochester Hills, updated in 1996, has established 120 feet as the desired width for right-of-way along Tienken Road. Currently the right-of-way varies from 66 feet to 120 feet. In the vicinity of Kings Cove Drive, the right-of-way is already dedicated at 120 feet.

New residential and commercial developments continue to be proposed for the Tienken Road corridor. Currently, the proposed developments include a 55,350 sq. ft. Papa Joes Gourmet Market, 3,100 sq. ft. office building, and 49 single family homes. These new developments are all to be located on the north side of Tienken Road between Livernois Road and Rochester Road. See Figure 2.
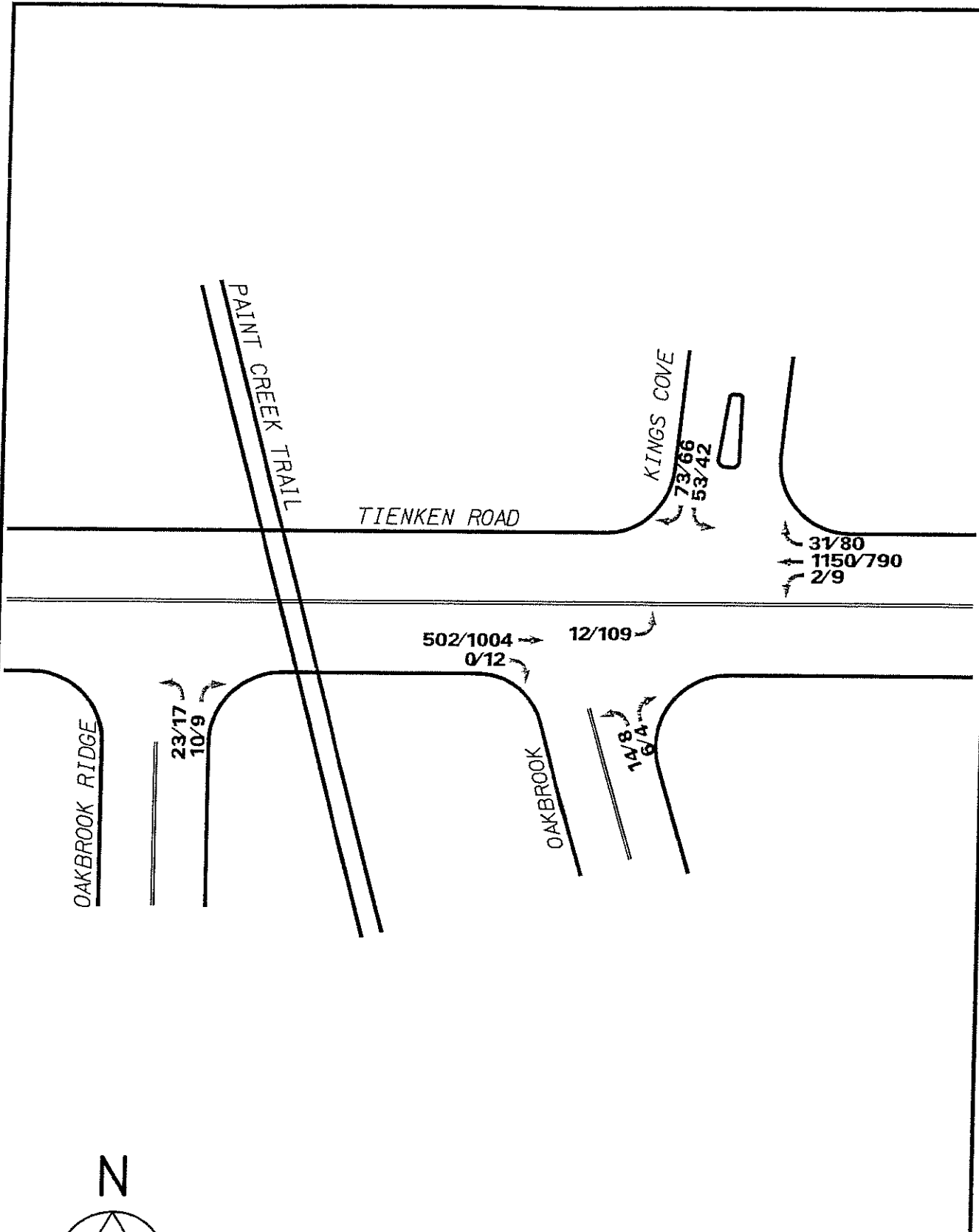
EXISTING + PROPOSED DEVELOPMENT
AM/PM PEAK TRAFFIC ASSIGNMENT

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Labels on drawing:
PAINT CREEK TRAIL
KINGS COVE
TIENKEN ROAD
OAKBROOK RIDGE
OAKBROOK

73/66
53/42
31/80
1150/790
2/9
502/1004
0/12
12/109
23/17
10/9
14/8
6/4

Section 5 - Traffic Signal Warrant Analysis

Traffic control signals should not be installed unless one or more of the signal warrants in the Michigan Manual of Uniform Traffic Control Devices are met. Information should be obtained by means of engineering studies and compared with the requirements set forth in the warrants. If the requirements are not met, traffic signals should not be put in operation. When a traffic control signal is indicated as being warranted, it is presumed that the signal and all related traffic control devices and markings are installed according to the standards set forth in the Michigan Manual of Uniform Traffic Control Devices. It is further presumed that the signal indications are properly phased, that the roadways are properly designed, that adjacent traffic signals are properly coordinated, that there is adequate supervision of the operation and maintenance of the signal and all of its related devices, and that the traffic signal controller will be selected on the basis of engineering study and judgment.

The fact that a single warrant is met does not necessarily indicate that traffic signal control should be installed. Other considerations such as gap studies and turning patterns should be analyzed prior to any commitment to signal control. When for a period of four or more consecutive hours, any traffic volume drops to 50% or less of the stated volume warrant, it is desirable that flashing operation is substituted for conventional operation for the duration of such periods. However, such flashing operations should be restricted to not more than three separate periods during each day.

To determine traffic volumes on Tienken Road and Kings Cove, HRC installed traffic data collector machines on September 11, 2002 to collect 24-hour traffic data on September 12, 2002. This information is needed to perform the calculations prescribed in the Michigan Manual of Traffic Control Devices for Warrant No. 1 *Minimum Vehicular Volume*, Warrant No. 2, *Interruption of Continuous Traffic*, Warrant No. 9, *Four Hour Volumes*, and Warrant 11, *Peak Hour Volume*. The crash data is used in the analysis of Warrant No. 6, *Crash Experience*. The following table lists the hourly traffic volumes at these locations.

Table 7: Current Directional Traffic Volumes

Ending Time	EB Tienken Road	WB Tienken Road	Tienken Road (Total)	SB Kings Cove Drive
1:00	50	41	91	3
2:00	30	17	47	2
3:00	21	21	42	0
4:00	24	18	42	3
5:00	22	56	78	3
6:00	88	348	436	20
7:00	262	867	1129	70
8:00	469	1132	1601	97
9:00	582	901	1483	134
10:00	559	735	1294	109
11:00	528	594	1122	110
12:00	616	652	1268	93
13:00	651	710	1361	91
14:00	580	563	1143	79
15:00	797	696	1493	56
16:00	950	744	1694	63
17:00	838	695	1533	64
18:00	866	715	1581	47
19:00	920	705	1625	89
20:00	637	551	1188	59
21:00	516	598	1114	29
22:00	520	401	921	17
23:00	237	262	499	9
24:00	153	117	270	7
Total	**10,916**	**12,139**	**23,055**	**1,254**

Tienken Road has a posted speed limit of 40 mph. HRC conducted Tienken Road Corridor Study in March 2000. This study indicates that 85th percentile speed in our current study area is 44 mph. Based on the speed characteristics, traffic volume requirements are reduced to 70 percent for warranting installation of traffic signal.

Warrant No. 1, *Minimum Vehicular Volume*, is intended for application where the volume of intersecting traffic is the principal reason for consideration of signal installation. The warrant is satisfied when, for each of any 8 hours of an average day, at least 500 vehicles per hour exist on the major street and at least 200 vehicles per hour exist on the minor street approach to the intersection. An average day is defined as a weekday representing traffic volumes normally and repeatedly found at the location. These major street and minor street volumes are for the same eight hours. During those eight hours, the

direction of the higher volume on the minor street may be on one approach during some hours and on the opposing approach during other hours.

When the 85-percenticle speed of a major street exceeds 40 mph in either an urban or a rural area, the Minimum Vehicular Volume warrant is 70 percent of the requirements above.

Exiting traffic volume on Kings Cove Drive did not meet the required traffic volume for Warrant 1. Therefore, the installation of a traffic signal at the intersection of Tienken Road and King Cove Drive would not be warranted based on the Minimum Vehicular Volume warrant.

Warrant No. 2, *Interruption of Continuous Traffic*, applies to operating conditions where the traffic volume on a major street is so heavy that the traffic on a minor intersecting street suffers excessive delay or hazard in entering or crossing the major street. The warrant is satisfied when, for each of eight hours of an average day, the traffic volume on the major street exceeds 750 vehicles per hour and the higher volume minor street approach volume exceeds 100 vehicles per hours.

When the 85-percenticle speed of a major street exceeds 40 mph in either an urban or a rural area, the Interruption of Continuous Traffic warrant is 70 percent of the requirements above.

This warrant is satisfied for eight (8) hours from 7:00 AM – 2:00 PM and one (1) hour met from 6:00 PM – 7:00 PM. Therefore, the installation of a traffic signal at the intersection of Tienken Road and King Cove Drive would be warranted based on the Interruption of Continuous Traffic warrant.

Warrant No. 6, *Crash Experience*, is satisfied when: 1) adequate trial of less restricted remedies with satisfactory observance and enforcement has failed to reduce the crash frequency; and 2) five or more reported crashes, of type susceptible to correction by traffic signal control, have occurred within a twelve month period, each crash involving a personal injury or property damage to an apparent extent of $100 or more; and 3) there exists a volume of vehicular and pedestrian traffic not less than 80% of the requirements specified either in the minimum vehicular volume warrant, the interruption of continuous traffic warrant, or the minimum pedestrian volume warrant; and 4) the signal installation will not seriously disrupt progressive traffic flow.

HRC analyzed the accident data on Tienken Road on either side of Kings Cove Drive from 1997 to 2001. Thirty-seven (37) crashes were recorded within a radius of 250 feet. See Table 8 below.

Table 8: Summary of Traffic Crash Data

Year	Rear End	Single Vehicle	Head-On	Head-On Left Turn	Sideswipe Opposite	Angle	Total
1997	4	1		1			6
1998	7	3		1			11
1999	3		2		1		6
2000	4		1	1		2	8
2001	5	1					6
Total	23	5	3	3	1	2	37

Of the 37 crashes, 14 involved personal injuries. In over 50 percent, the hazardous action was "failure to stop", which resulted in 23 rear-end type crashes. There were three head-on left turn and five single vehicle type crashes. The crash data do not meet the requirement for this warrant. Therefore, the installation of a traffic signal at this intersection would not be warranted based on requirements of the Accident Experience Warrant.

Warrant No. 9. *Four Hour Volumes*, is satisfied when each of any four hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the high volume minor street approach (one direction only) all fall above the curve in the following for the existing combination of approach lanes.

Warrant 9 – Four-Hour Volumes Warrant
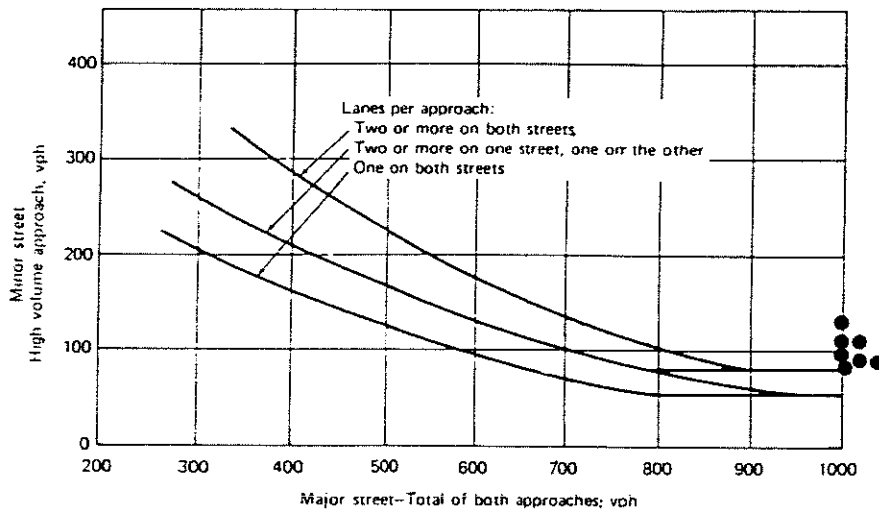
Note: 80 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor street approach with one lane.

Figure 4-4. Four-hour volume warrant—rural locations. Warrant 9

Figure 4-4 is used when the 85-percenticle speed of a major street exceeds 40 mph in either an urban or a rural area, or when the intersection lies within a built-up area of an isolated community having a population less than 10,000.

Based on the traffic volumes for the intersection of Tienken Road and Kings Cove, this warrant would be satisfied for 7 hours from 8:00 AM-2:00 PM and from 6:00 PM-7:00 PM, which meets the four hour requirement. Points are plotted outside the graph area as the major street volume exceeds the graph limits. Therefore, the installation of a traffic signal at this intersection would be warranted based on the requirements of the Four-Hour Volume warrant.

Warrant No. 11, *Peak Hour Volume*, is satisfied when for any one hour of the day, the traffic on the minor street suffers undue delay when proceeding onto the major street. The warrant is satisfied when for any one hour of an average day, the vehicles per hour traveling on the major street (total of both approaches) and the vehicles per hour on the minor street (one direction only) all fall above the curve in the following figure for the existing combination of approach lanes.

Warrant 11 – Peak Hour Volume Warrant
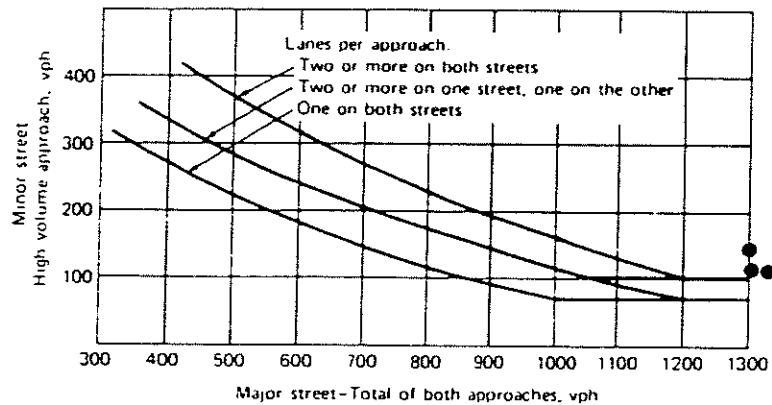
Note: 100 vph applies as the lower threshold volume for a minor street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor street approach with one lane

Figure 4-6.   Peak hour volume warrant—rural or high speed (community less than 10,000 population or above 40 mph on major street). Warrant 11

Figure 4-6 is used when the 85-percenticle speed of a major street exceeds 40 mph in either an urban or a rural area, or when the intersection lies within a built-up area of an isolated community having a population less than 10,000.

The peak hour traffic volume for the intersection of Tienken Road and Kings Cove falls above the curve for 3 hours from 8:00 AM - 11:00 AM. Therefore, the installation of a traffic signal at the intersection of Tienken Road and Kings Cove would be warranted based on the Peak Hour Volume Warrant.

Summary

The following table summarizes the results of the traffic signal warrant study for the intersection.

Table 9: Summary of Traffic Signal Warrant Study

Traffic Signal Warrant	# of Hours Required	# of Hours Met	Warranted
Warrant 1	8	0	No
Warrant 2	8	9	Yes
Warrant 6	-	-	No
Warrant 9	4	7	Yes
Warrant 11	1	3	Yes

As shown above in the table, a signal would be warranted for the intersection of Tienken Road and Kings Cove based on several criteria in the Michigan Manual on Uniform Traffic Control Devices.

Table 6: PM Peak Hour Trip Generation by Direction

ITE Land Use Code	Development	PM Peak Hour	In	Out
850	Papa Joes Market (55,350 sq.ft.)	637	325 (51%)	312 (49%)
710	Office Building (3,100 sq.ft.)	5	1 (17%)	4 (83%)
210	The Summit (42 Dwelling Units)	43	28 (64%)	15 (36%)
210	South Summit (7 Dwelling Units)	7	4 (64%)	3 (36%)
210	Hillside Creek (33 Dwelling Units)	34	9 (64%)	25 (36%)
Total		726	367	359

The following Figure 4 displays the traffic assignment at the intersection of Tienken and Kings Cove/Oakbrook with the addition of the trips from the proposed development.

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Section 6 - Future Traffic Volume

Traffic volumes have been increasing steadily on Tienken Road. HRC compared historical and current traffic volumes to future volumes as forecasted by both the Master Thoroughfare Plan for the city and by the Southeast Michigan Council of Governments (SEMCOG). The segment is Tienken Road between Livernois and Rochester Roads.

Table 10: Comparison of Actual and Forecasted Traffic Volumes

Year	Actual 24 Hour Counts	Forecasted 24 Hour Volumes
1991	16700	
1993	18168	
1997	19745	
1999	18530	
2002	23055	
2015 – Master Plan		22800
2025 - SEMCOG		24600
2025 – HRC		30200

As SEMCOG's 2025 forecasted traffic is very close to existing volumes, HRC used a different methodology to project future traffic volumes. Using SEMCOG's growth rate for Tienken Road - 30% for the years 2000 to 2025 - HRC calculated the future traffic as follows:

Growth rate on pro rated bases for 23 years (2002-2025) is 27.6% or an annual growth rate of 1.2%.

$$\text{Future Traffic Volume} = \text{Existing Traffic Volume } (1+i)^n$$
$$\text{Future Traffic Volume} = 23055 \, (1+.012)^{23}$$
$$\text{Future Traffic Volume} = 23055 * 1.31$$
$$\textbf{Future Traffic Volume} = \textbf{30,200}$$

To determine future volumes at the intersection of Kings Cove and Tienken Road, HRC multiplied the volumes (comprising of current data and additional trips from proposed development) by a factor of 1.31. See Figure 5 for the future traffic assigned to the Tienken and Kings Cove/Oakbrook intersection.

PAINT CREEK TRAIL

KINGS COVE

TIENKEN ROAD

95/86
69/55

40/104
1495/1027
3/12

653/1305
0/16

16/142

OAKBROOK RIDGE

23/17
10/9

OAKBROOK

14/10
6/5

N
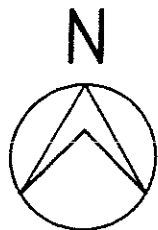
NOT TO SCALE

FUTURE 2025 AM/PM PEAK TRAFFIC ASSIGNMENT

JOB NO. 20020367	HUBBELL, ROTH & CLARK, INC.	SHEET NO.
DATE	CONSULTING ENGINEERS	5
OCTOBER 2002	555 HULET DRIVE P.O. BOX 824 BLOOMFIELD HILLS, MICH. 48303-0824	
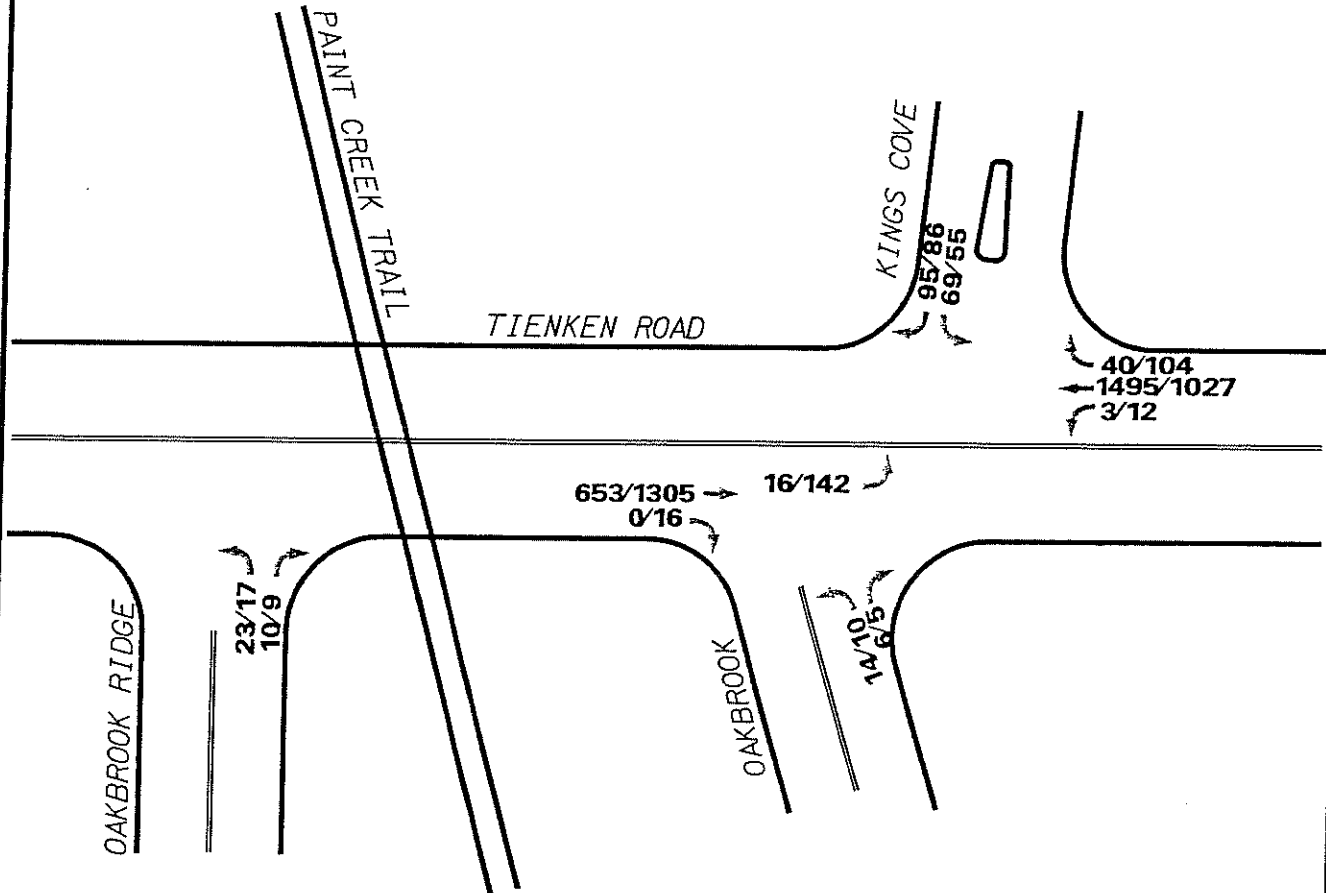
Section 7 - Level of Service Analysis (LOS)

HRC conducted capacity analysis for several scenarios using Highway Capacity Software (HCS 2000). First HRC analyzed the AM and PM peak hours at the unsignalized intersection of Tienken Road and Kings Cove/Oakbrook with existing volumes and then current conditions with a signal. Secondly, HRC analyzed the AM and PM peak hours with the additional traffic from the currently proposed developments. Third, HRC added the projected background traffic volumes through 2025 to the prior volumes and conducted a capacity analysis for the peak hours. HRC also examined the impact on the level of service with different geometries on Tienken Road. Lastly, HRC analyzed the capacity of the Tienken Road segment and compared various scenarios. The complete HCS 2000 generated reports can be found in Appendix B (Existing) and Appendix C (Future).

Analysis Procedure

The procedures for analysis were those outlined in Transportation Research Board Special Report 209, 2000 Highway Capacity Manual. This manual defines level of services for signalized intersections in terms of delay. The level of service calculation provides a measure of performance of the current roadway system and indicates the urgency for roadway improvements.

Delay is a measure of driver discomfort, frustration, fuel consumption, and lost travel time. Specifically, levels of service criteria are stated in terms of the average delay per vehicle for a 15-min. analysis period. The criteria for signalized intersection are given in the table below.

Table 11: Level of Service Criteria for Signalized Intersections

LEVEL OF SERVICE	Stopped Delay per Vehicle (Seconds)
A	≤10
B	>10 to ≤20
C	>20 to ≤35
D	>35 to ≤55
E	>55 to ≤80
F	>80

Delay may be measured in the field, or it may be estimated. Delay is a complex measure, and is dependent on a number of variables, including the quality of progression, the cycle length, the green ratio, and the volume to capacity ratio for the lane group or approach in question.

Following table shows the level of service criteria for unsignalized intersections.

Table 12: Level of Service Criteria for Unsignalized Intersections

LEVEL OF SERVICE	Stopped Delay per Vehicle (Seconds)
A	≤ 10
B	>10 to ≤ 15
C	>15 to ≤ 25
D	>25 to ≤ 35
E	>35 to ≤ 50
F	>50

Level of Service A describes operations with very low control delay up to 10.0 sec per vehicle. This occurs when progression is extremely favorable, and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.

Level of Service B describes operations with control delay in the range of 10.1 to 20.0 sec per vehicle. This generally occurs with good progression and/or short cycle lengths. More vehicles stop than for Level of Service A, causing higher levels of average delay.

Level of Service C describes operations with control delay in the range of 20.1 to 35.0 sec per vehicle. These higher delays may result from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear in this level. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.

Level of Service D describes operations with control delay in the range of 35.1 to 55.0 sec per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, and high volume to capacity ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

Level of Service E describes operations with control delay in the range of 55.1 to 80.0 sec per vehicle. This is considered to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high volume to capacity ratios. Individual cycle failures are frequent occurrences.

Level of Service F describes operations with control delay in excess of 80.1 sec per vehicle. This is considered to be unacceptable to most drivers. This condition often occurs with over saturation, i.e., when arrival flow rates exceed the capacity of the intersection. It may also occur at high volume to capacity ratios below 1.00 with many individual cycle failures. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

Capacity Analysis of Existing Traffic at Tienken & Kings Cove/Oakbrook Intersection

This capacity analysis assumed existing geometry and an unsignalized intersection. There is a single lane on eastbound and northbound approach to accommodate all movements. The southbound approach from Kings Cove has sufficient lane width to allow for a separate left and right turn lane. Westbound Tienken has a shared through and left turn lane and a right turn lane. The Level of Service (LOS) results for the intersection are shown in Table 13 by peak hours.

Table 13: Existing Capacity Analysis for Unsignalized Intersection

Time of Day	Level of Service and Delay in Seconds					
	Eastbound	Westbound		Northbound	Southbound	
	LT/TH/RT	LT/TH	RT	LT/RT	LT	RT
AM Peak	B (11.6)	A (8.4)	A (0)	F (98.8)	F (144.5)	D (27.8)
PM Peak	B (10.1)	B (10.3)	A (0)	F (143.4)	F (349.1)	C (15.5)

Currently, the two minor side streets are experiencing unusually high delays during the peak hours. In the Table 14, the level of service for the side streets improves with the installation of a traffic signal but westbound Tienken Road now experiences significant delay, where before traffic was free-flowing. HRC tried two different cycle lengths with similar results. The following results are for a 120 second cycle. The HCS 2000 generated reports are included in Appendix B.

Table 14: Existing Capacity Analysis for Signalized Intersection

Time of Day	Level of Service and Delay in Seconds					
	Eastbound	Westbound		Northbound	Southbound	
	LT/TH/RT	LT/TH	RT	LT/RT	LT	RT
AM Peak	A (3.4)	D (51.4)	A (7.5)	D (50.8)	D (53.2)	E (57.3)
PM Peak	A (8.2)	B (15.0)	A (7.8)	D (49.8)	D (52.3)	E (57.1)

Capacity Analysis with Proposed Development Traffic at Tienken & Kings Cove/Oakbrook Intersection

HRC assigned the trips generated by the proposed developments to the intersection and ran the capacity analysis. HRC assumed that the intersection was signalized. The Level of Service (LOS) results for the intersection are shown in Table 15 by peak hours. The additional trips have little adverse effect on the level of service during the peak hours except to add additional seconds of delay.

Table 15: Capacity Analysis with Proposed Development for Signalized Intersection

Time of Day	Level of Service and Delay in Seconds					
	Eastbound	Westbound		Northbound	Southbound	
	LT/TH/RT	LT/TH	RT	LT/RT	LT	RT
AM Peak	A (3.6)	E (56.0)	A (7.6)	D (50.8)	D (55.0)	E (61.8)
PM Peak	B (10.7)	B (17.2)	A (7.9)	D (49.8)	D (53.3)	E (59.7)

Capacity Analysis of Future Traffic at Tienken & Kings Cove/Oakbrook Intersection

HRC ran a capacity analysis of future year 2025 traffic conditions during the AM and PM Peak Hours. HRC included all the trips from the proposed developments and the expected growth in background traffic as discussed in Section 6. HRC assumed that the intersection was signalized. The intersection was analyzed in the future using several different roadway geometries: existing two lane road, three lane road and five lane road. The latter two scenarios assume that there is a dedicated left turn lane on Tienken Road, but there was no left turn phase. The Level of Service (LOS) results for the AM peak hour are shown in Table 16 and for the PM peak hour in Table 17.

Table 16: Comparison of Capacity Analysis for Future AM Peak Hour

Roadway Geometry	Level of Service and Delay in Seconds							
	Eastbound		Westbound			Northbound	Southbound	
	LT	TH	LT	TH	RT	LT/RT	LT	RT
2-Lane Road	A (4.4)		F (181.7)		A (7.6)	D (50.8)	E (57.9)	E (70.8)
3-Lane Road	D (47.1)	A (4.3)	F	F (181.7)	A (7.6)	D (50.8)	E (57.9)	E (70.8)
5-Lane Road	D (47.1)	A (2.7)	F	B 15.5	A (7.6)	D (50.8)	E (57.9)	E (70.8)

Table 17: Comparison of Capacity Analysis for Future PM Peak Hour

Roadway Geometry	Level of Service and Delay in Seconds							
	Eastbound		Westbound			Northbound	Southbound	
	LT	TH	LT	TH	RT	LT/RT	LT	RT
2-Lane Road	D (49.8)		C (31.3)		A (8.1)	D (50.2)	E (55.3)	E (66.6)
3-Lane Road	E (66.8)	C (22.3)	F	C (31.3)	A (8.1)	D (50.2)	E (55.3)	E (66.6)
5-Lane Road	E (66.8)	A (4.0)	F	B (11.5)	A (8.1)	D (50.2)	E (55.3)	E (66.6)

In the future, three lanes on Tienken Road would allow left turning traffic on eastbound and westbound Tienken Road to be separated from the through traffic. However, there is still insufficient capacity to accommodate the through traffic on westbound Tienken Road in the AM peak hour, which will experience considerable delay. To achieve an acceptable level of service for the entire intersection during both peak hours, it appears that a five lane road will be necessary.

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Capacity Analysis of Tienken Road Segment

Lastly, HRC analyzed the Level-of-Service on Tienken Road segment during the PM peak hour. Using two different roadway geometries, HRC compared an existing two lane road with existing volumes, to a two lane road with future volumes to a five lane road with future traffic volumes. Table 18 provides the results of the analysis.

Table 18: Capacity Analysis of PM Peak Hour on Tienken Road Segment

ADT Year	Roadway Geometry	Volume/Capacity Ratio	15-Minute Vehicle Miles of Travel	LOS
2002	2-Lane	0.55	442	D
2025	2-Lane	0.86	682	E
2025	5-Lane	N/A	N/A	B

Tienken Road is currently operating at a LOS D during PM peak hour at this location. The Level-of-Service deteriorates to an unacceptable LOS E when the future traffic volume is added to the roadway. Widening Tienken Road to five lanes results in a LOS B. Refer to Appendix D for HCS 2000 generated reports.

Summary of Level of Service Analysis

The results for capacity analysis indicate that signalizing the intersection of Tienken Road and Kings Cove will result in a minimally acceptable LOS D during the AM peak hour. In the future, the signalized intersection will operate at an unacceptable LOS E during the AM peak hour. Additional road capacity and new intersection geometry are needed for the intersection to function with an acceptable delay to the motorists.

Section 8 - Additional Considerations

There are two additional considerations in recommending a traffic signal at the intersection of Tienken Road and Kings Cove/Oakbrook and an important impact.

Paint Creek Trail

The popular Paint Creek Trail crosses Tienken Road about 53 feet west of the edge of road from Kings Cove. The city of Rochester Hills and Paint Creek Trailway commissioners are concerned about the safety of trail users trying to cross the heavily traveled Tienken Road. See Photo 5 below.

As a part of the Tienken Road Corridor Study, HRC conducted two pedestrian surveys at the Paint Creek Trail crossing of Tienken Road. On Thursday, June 3, 1999, from 4:30 – 5:30 pm, HRC counted 22 trail users. On Sunday, June 6, 1999, HRC recorded 125 trail users during 11:30 am – 12:30 pm. The Paint Creek Trailway Commission has also done surveys of trail users and found that users per hour average 81 during April through June[1].

Photograph 5: Paint Creek Trail Crossing over Tienken Road West of Kings Cove

[1] Paint Creek Trailway Commission surveys conducted April – June 1992. Average of six samples.

Based on the width of Tienken Road and a pedestrian walking speed of 4 feet per second, HRC calculated that a minimum of 20 seconds between passing cars was needed to cross Tienken Road. While counting pedestrians on Sunday, June 6, 1999, HRC also counted all gaps that exceeded the 20 second minimum for an hour period. Table 19 has the results of the gap study.

Table 19: Gaps on Tienken Road That Exceed 20 Seconds

Gap Size (sec.)	# of Observances
21	-
22	1
23	-
24	1

The gap study revealed, that even on a Sunday, traffic was so heavy that 98.72% of the time when a pedestrian wanted to cross, he/she did not have an acceptable gap of 20 seconds to cross safely.

Discussions with city staff and trail commissioners led to the conclusion that the trail needs to be diverted to the signalized intersection. To discourage crossing Tienken Road at the old crossing point, it will be necessary block the old crossing with some type of plantings or a barricade. So as to not take unnecessary green time away from Tienken Road, a pedestrian call button should be installed to signal that a pedestrian phase is needed. The relocated crossing would be on the west side of the intersection and seamless connections to the existing paths on either side of Tienken Road will be needed.

Elderly Population

Overall, the city of Rochester's elderly population is just 11 percent of the total population. HRC examined the 2000 Census data for the block groups on the north and south side of Tienken Road between Livernois and Rochester Roads to see what percentage of elderly (age 65+) were in the study area. The census block group to the north has an elderly population of 567 which represents 26 percent of the total population of the block group. The census block group south of Tienken Road has an elderly population of 238, which represents 24 percent of the total population of the block group. Therefore, there is a concentration of elderly residents in the various apartments and condominium developments lining Tienken Road. Consideration should be given to slowing traffic in the area and providing some gaps for turning vehicles.

Paint Creek Bridge

The city of Rochester Hills is concerned about the impact of any recommended road widening on the Paint Creek Bridge. The bridge is approximately 124 feet east of the edge of road into Kings Cove and is designed to accommodate only two travel lanes. There was no room even for a safety path and separate bridge was constructed over the creek to carry non-motorized traffic. Since this bridge is so close to the intersection of Tienken and Kings Cove/Oakbrook any geometric improvement to this intersection will require that the Paint Creek Bridge be widened as well. HRC's analysis has shown that five lanes will be needed in the future to accommodate projected traffic volumes at the intersection. HRC recommends that the Paint Creek Bridge be reconstructed to accommodate five vehicular lanes and a non-motorized walkway on at least the south side.

Section 9 - Recommendations and Conclusions

Traffic on Tienken Road between Livernois and Rochester Roads is projected to reach 30,200 vehicles per day by the year 2025. HRC has shown that the additional trips assigned to the roadway system from new developments in the area and future traffic growth will have an adverse impact on the existing roadway network and the study intersection of Tienken Road and Kings Cove. As a result, we have several recommendations.

Roadway Geometry Improvement

Currently, the level of service on Tienken Road is LOS D. The intersection of Tienken Road and Kings Cove/Oakbrook is not currently signalized; however, a signal is warranted to provide safe access to and from the side streets. Signalization takes critical time away from the through movement on Tienken Road and results in delays for the westbound through movement. A comparison of the level of service for the Tienken Road approaches with and without a signal is in shown in Table 20.

Table 20: Comparison of Level of Service on Tienken Road Approaches

Peak Hour	Unsignalized		Signalized	
	Eastbound LOS	Westbound LOS	Eastbound LOS	Westbound LOS
AM	B	A	A	D
PM	B	B	A	B

In the future, the capacity analysis indicates that both a two-lane and a three-lane road on Tienken Road will result in a LOS F for the overall intersection during the AM peak hour although the PM peak hour is not a problem. A five lane road is the only geometry that results in an acceptable level of service for the overall intersection during both peak hours. See Table 21 for a comparison of level of service for the overall Tienken and Kings Cove/Oakbrook intersection for various scenarios.

**Table 21: Comparison of Level of Service for Overall Intersection
of Tienken at Kings Cove/Oakbrook**

Traffic Condition Road Geometry	Level of Service AM Peak Hour	Level of Service AM Peak Hour
Existing Volumes 2 lanes	D	B
Existing plus Proposed Development 2 lanes	D	B
Future Volumes 2 lanes	F	D
Future Volumes 3 lanes	F	C
Future Volumes 5 lanes	B	B

To accommodate future traffic volumes and to provide an acceptable level of service, HRC recommends widening Tienken Road from two to five lanes through this section. Further, HRC has concluded that to install a signal today without making the necessary geometric improvements to Tienken Road will worsen congestion and delay on Tienken Road. In order to widen the road, it will be first necessary to widen the bridge over the Paint Creek from two to five lanes. The Paint Creek Bridge is located so close to the intersection (approximately 124 feet) and the road widening project will begin several hundred feet east of the bridge.

Traffic Signal Installation

HRC recommends the installation of a traffic signal at the intersection of Tienken Road and Kings Cove/Oakbrook after Tienken Road is widened to five lanes. Warrants were met to install a traffic signal at this intersection based on Warrant 2, Warrant 9 and Warrant 11.

HRC has concluded that there area other factors which bear on the need for a traffic signal at this location. A speed study done in 1999 for Tienken Road indicated that the 85th percentile speed is over 44 mph as compared to the posted speed of 40 mph. The combination of higher speeds and heavy volume on Tienken Road results in very few gaps of sufficient length for either vehicles from the side streets to enter the main road or pedestrians at the Paint Creek Trail to cross the main road safely. The non-motorized traffic consists of walkers, skaters and bicyclists of all ages and abilities. Regardless of the day of week, the majority of trail users must wait to cross Tienken Road and often cross without an acceptable gap of 20 seconds to cross safely. Lastly, sight distance is an important factor. Kings Cove enters Tienken Road at the low point of a sag vertical curve. The Kings Cove driveway does not meet

AASHTO Case III criteria for visibility to the east. HRC calculated that the actual sight distance at the driveway is just one-third of the minimum sight distance required by AASHTO. A signal at this location would address these safety concerns.

Relocation of Paint Creek Trail Crosswalk

When a signal is installed, HRC recommends that the crosswalk over Tienken Road for the Paint Creek Trail be relocated to the signalized intersection. Noting the high volume of pedestrian traffic identified in HRC's Tienken Road Corridor Study from March 2000, pedestrian traffic is a major consideration when designing the intersection and signal. A push button type pedestrian signal will provide a safer passage for non-motorized traffic. In addition, when there is no pedestrian traffic, the traffic signal controller will skip the pedestrian phase and provide maximum time to Tienken Road. Seamless connections between the Paint Creek Trail and the safety paths on either side of Tienken Road will need to be made. See Figure 6. HRC recommends that the old trail path to the Tienken crossing point be blocked to discourage jaywalking.

Appendix A
24 Hour Traffic Volumes

Sta: EB_TIENKEN__   Id: 000000000000   CId: 01   Fmt: 300 - Imperial   Int: 60 Min.
Start: Wed - Sep 11, 2002 at 20:00   End: Fri - Sep 13, 2002 at 10:0
City/Town: ROCHESTER HILLS   County: OAKLAND
Location: EB TIENKEN ROAD WEST OF KING COVE   File: D0911003.PRN
Ln1-East

Wed - Sep 11, 2002

Lane	1	Total
21:00	587	587
22:00	441	441
23:00	192	192
24:00	125	125
Daily Totals	1345	1345
Percentages	100.00	

Thu - Sep 12, 2002

	1	Total
01:00	50	50
02:00	30	30
03:00	21	21
04:00	24	24
05:00	22	22
06:00	88	88
07:00	262	262
08:00	469	469
09:00	582	582
10:00	559	559
11:00	528	528
12:00	616	616
13:00	651	651
14:00	580	580
15:00	797	797
16:00	950	950
17:00	838	838
18:00	866	866
19:00	920	920
20:00	637	637
21:00	516	516
22:00	520	520
23:00	237	237
24:00	153	153
24 Hour Totals	10916	10916
Daily Totals	10916	10916
Percentages	100.00	

Sta: WB_TIENKEN__   Id: 000000000000   CId: 01   Fmt: 300 - Imperial   Int: 60 Min.
Start: Thu - Sep 12, 2002 at 00:00   End: Thu - Sep 12, 2002 at 24:
City/Town: ROCHESTER HILLS   County: OAKLAND
Location: WB TIENKEN RD EAST OF KING COVE
Ln1-West   File: D0912002.PR

Thu - Sep 12, 2002

Lane	1	Tota
01:00	41	4.
02:00	17	1:
03:00	21	2:
04:00	18	1ε
05:00	56	5ε
06:00	348	34ε
07:00	867	86:
08:00	1132	1132
09:00	901	901
10:00	735	735
11:00	594	594
12:00	652	652
13:00	710	710
14:00	563	563
15:00	696	696
16:00	744	744
17:00	695	695
18:00	715	715
19:00	705	705
20:00	551	551
21:00	598	598
22:00	401	401
23:00	262	262
24:00	117	117
24 Hour Totals	12139	12139

| Daily Totals | 12139 | 12139 |
| Percentages | 100.00 | |

Sta: SB_KING_COVE   Id: 000000000000   CId: 01   Fmt: 300 - Imperial   Int: 60 Min.
Start: Thu - Sep 12, 2002 at 00:00   End: Thu - Sep 12, 2002 at 24:
City/Town: ROCHESTER HILLS   County: OAKLAND
Location: SB KING COVE (LEFT LANE) N OF TIENKEN RD   File: D0912001.PR
Ln1-South

Thu - Sep 12, 2002

Lane	1	Total
01:00	2	2
02:00	0	0
03:00	0	0
04:00	3	3
05:00	2	2
06:00	15	15
07:00	49	49
08:00	56	56
09:00	77	77
10:00	58	58
11:00	57	57
12:00	55	55
13:00	56	56
14:00	54	54
15:00	33	33
16:00	39	39
17:00	38	38
18:00	27	27
19:00	55	55
20:00	36	36
21:00	23	23
22:00	12	12
23:00	8	8
24:00	5	5
==============	======	======
24 Hour Totals	760	760

============== | ====== | ======

| Daily Totals | 760 | 760 |
| Percentages | 100.00 | |

Sta: SB_KING_COVE   Id: 000000000000   Cld: 01   Fmt: 300 - Imperial   Int: 60 Min.

Start: Wed - Sep 11, 2002 at 20:00   End: Fri - Sep 13, 2002 at 10:00

City/Town: ROCHESTER HILLS   County: OAKLAND

Location: SB KING COVE (RIGHT LANE) N OF TIENKEN   File: D0911006.PRN

Ln1-South

Wed - Sep 11, 2002

Lane	1	Total
21:00	12	12
22:00	6	6
23:00	4	4
24:00	2	2
Daily Totals	24	24
Percentages	100.00	

Thu - Sep 12, 2002

	1	Total
01:00	1	1
02:00	2	2
03:00	0	0
04:00	0	0
05:00	1	1
06:00	5	5
07:00	21	21
08:00	41	41
09:00	57	57
10:00	51	51
11:00	53	53
12:00	38	38
13:00	35	35
14:00	25	25
15:00	23	23
16:00	24	24
17:00	26	26
18:00	20	20
19:00	34	34
20:00	23	23
21:00	6	6
22:00	5	5
23:00	1	1
24:00	2	2
24 Hour Totals	494	494
Daily Totals	494	494
Percentages	100.00	

Appendix B
Existing Capacity Analysis

TWO-WAY STOP CONTROL SUMMARY

General Information		Site Information	
Analyst	T Khan	Intersection	Tienken Rd/Kings Cove
Agency/Co.	Hubbell, Roth & Clark, Inc.	Jurisdiction	Rochester Hills
Date Performed	10/9/02	Analysis Year	2002
Analysis Time Period	Existing AM Peak		

Project Description	Kings Cove Traffic Study		
East/West Street: Tienken Road		North/South Street: Kings Cove	
Intersection Orientation: East-West		Study Period (hrs): 0.25	

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume	10	469	0	2	1132	23
Peak-Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Hourly Flow Rate, HFR	10	509	0	2	1230	24
Percent Heavy Vehicles	2	--	--	2	--	--
Median Type			Undivided			
RT Channelized			0			0
Lanes	0	1	0	0	1	1
Configuration	LTR			LT		R
Upstream Signal		0			0	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume	14	0	6	41	0	56
Peak-Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Hourly Flow Rate, HFR	15	0	6	44	0	60
Percent Heavy Vehicles	2	0	2	2	0	2
Percent Grade (%)		0			0	
Flared Approach		N			N	
Storage		0			0	
RT Channelized			0			0
Lanes	0	1	0	0	1	1
Configuration		LTR		LT		R

Delay, Queue Length, and Level of Service

Approach	EB	WB		Northbound		Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	LTR	LT		LTR		LT		R
v (vph)	10	2		21		44		60
C (m) (vph)	555	1056		58		63		217
v/c	0.02	0.00		0.36		0.70		0.28
95% queue length	0.06	0.01		1.32		3.04		1.09
Control Delay	11.6	8.4		98.8		144.5		27.8
LOS	B	A		F		F		D
Approach Delay	--	--		98.8			77.2	
Approach LOS	--	--		F			F	

TWO-WAY STOP CONTROL SUMMARY

General Information

Analyst	T Khan		
Agency/Co.	Hubbell, Roth & Clark, Inc.		
Date Performed	10/9/02		
Analysis Time Period	Existing PM Peak		

Site Information

Intersection	Tienken Rd/Kings Cove
Jurisdiction	Rochester Hills
Analysis Year	2002

Project Description   Kings Cove Traffic Study

East/West Street: Tienken Road

North/South Street: Kings Cove Drive

Intersection Orientation: East-West

Study Period (hrs):   0.25

Vehicle Volumes and Adjustments

Major Street	Eastbound			Westbound		
Movement	1	2	3	4	5	6
	L	T	R	L	T	R
Volume	91	920	12	9	705	66
Peak-Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Hourly Flow Rate, HFR	98	999	13	9	766	71
Percent Heavy Vehicles	2	--	--	2	--	--
Median Type	Undivided					
RT Channelized			0			0
Lanes	0	1	0	0	1	1
Configuration	LTR			LT		R
Upstream Signal		0			0	

Minor Street	Northbound			Southbound		
Movement	7	8	9	10	11	12
	L	T	R	L	T	R
Volume	8	0	4	34	0	55
Peak-Hour Factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92
Hourly Flow Rate, HFR	8	0	4	36	0	59
Percent Heavy Vehicles	2	0	2	2	0	2
Percent Grade (%)		0			0	
Flared Approach		N			N	
Storage		0			0	
RT Channelized			0			0
Lanes	0	1	0	0	1	1
Configuration		LTR		LT		R

Delay, Queue Length, and Level of Service

Approach	EB	WB	Northbound			Southbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	LTR	LT		LTR		LT		R
v (vph)	98	9		12		36		59
C (m) (vph)	797	685		37		34		403
v/c	0.12	0.01		0.32		1.06		0.15
95% queue length	0.42	0.04		1.07		3.80		0.51
Control Delay	10.1	10.3		143.4		349.1		15.5
LOS	B	B		F		F		C
Approach Delay	--	--		143.4			141.9	
Approach LOS	--	--		F			F	

SHORT REPORT

General Information		Site Information	
Analyst	Tanveer Khan	Intersection	Tienken Road/King's Cove Drive
Agency or Co.	Hubbell, Roth & Clark, Inc.	Area Type	All other areas
Date Performed	10/21/02	Jurisdiction	City of Rochester Hills
Time Period	Existing AM Peak	Analysis Year	2002

Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Num. of Lanes	0	1	0	0	1	1	0	0	0	1	0	1
Lane group		LT			LT	R		LR			L		R
Volume (vph)	10	469		0	1132	23	14		6	41		56
% Heavy veh	0	0		0	0	0	0		0	0		0
PHF	0.90	0.90		0.90	0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time		2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green		2.0			2.0	2.0		2.0		2.0		2.0
Arrival type		3			3	3		3		3		3
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0			0		0	0		0	0		0
Lane Width		12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr		0			0	0		0		0		0
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Adj. flow rate	532			1258	25		23			46		62
Lane group cap.	1550			1235	1050		176			181		162
v/c ratio	0.34			1.02	0.02		0.13			0.25		0.38
Green ratio	0.82			0.65	0.65		0.10			0.10		0.10
Unif. delay d1	2.8			21.0	7.5		49.2			49.9		50.5
Delay factor k	0.50			0.50	0.50		0.50			0.50		0.50
Increm. delay d2	0.6			30.4	0.0		1.5			3.4		6.7
PF factor	1.000			1.000	1.000		1.000			1.000		1.000
Control delay	3.4			51.4	7.5		50.8			53.2		57.3
Lane group LOS	A			D	A		D			D		E
Apprch. delay	3.4			50.5			50.8			55.5		
Approach LOS	A			D			D			E		
Intersec. delay	37.9			Intersection LOS						D		

SHORT REPORT

General Information		Site Information	
Analyst	Tanveer Khan	Intersection	Tienken Road/Kings Cove
Agency or Co.	Hubbell, Roth & Clark, Inc.	Area Type	All other areas
Date Performed	10/30/02	Jurisdiction	City of Rochester Hills
Time Period	Existing PM Peak	Analysis Year	2002

Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Num. of Lanes	0	1	0	0	1	1	0	0	0	1	0	1
Lane group		LTR			LT	R		LR			L		R
Volume (vph)	91	920	12	0	705	66	8		4	34		55
% Heavy veh	0	0	0	0	0	0	0		0	0		0
PHF	0.90	0.90	0.90	0.90	0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time		2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green		2.0			2.0	2.0		2.0		2.0		2.0
Arrival type		3			3	3		3		3		3
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width		12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr		0			0	0		0		0		0
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB		SB	
Adj. flow rate	1136		783	73	13		38	61
Lane group cap.	1543		1235	1050	176		181	162
v/c ratio	0.74		0.63	0.07	0.07		0.21	0.38
Green ratio	0.82		0.65	0.65	0.10		0.10	0.10
Unif. delay d1	5.1		12.5	7.7	49.0		49.6	50.5
Delay factor k	0.50		0.50	0.50	0.50		0.50	0.50
Increm. delay d2	3.2		2.5	0.1	0.8		2.6	6.6
PF factor	1.000		1.000	1.000	1.000		1.000	1.000
Control delay	8.2		15.0	7.8	49.8		52.3	57.1
Lane group LOS	A		B	A	D		D	E
Apprch. delay	8.2		14.4		49.8		55.2	
Approach LOS	A		B		D		E	
Intersec. delay	13.2		Intersection LOS				B	

SHORT REPORT

General Information		Site Information	
Analyst	Tanveer Khan	Intersection	Tienken Road/King's Cove Drive
Agency or Co.	Hubbell, Roth & Clark, Inc.	Area Type	All other areas
Date Performed	10/31/02	Jurisdiction	City of Rochester Hills
Time Period	Existing+Propsed AM Peak	Analysis Year	2002

Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Num. of Lanes	0	1	0	0	1	1	0	0	0	1	0	1
Lane group		LTR			T	R		LR			L		R
Volume (vph)	12	502	0		1150	31	14		6	53		73
% Heavy veh	0	0	0		0	0	0		0	0		0
PHF	0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time		2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green		2.0			2.0	2.0		2.0		2.0		2.0
Arrival type		3			3	3		3		3		3
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width		12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr		0			0	0		0		0		0
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB			SB		
Adj. flow rate	571			1278	34		23		59			81
Lane group cap.	1550			1235	1050		176		181			162
v/c ratio	0.37			1.03	0.03		0.13		0.33			0.50
Green ratio	0.82			0.65	0.65		0.10		0.10			0.10
Unif. delay d1	2.9			21.0	7.5		49.2		50.2			51.2
Delay factor k	0.50			0.50	0.50		0.50		0.50			0.50
Increm. delay d2	0.7			35.0	0.1		1.5		4.7			10.6
PF factor	1.000			1.000	1.000		1.000		1.000			1.000
Control delay	3.6			56.0	7.6		50.8		55.0-			61.8
Lane group LOS	A			E	A		D		D			E
Apprch. delay	3.6			54.8			50.8			58.9		
Approach LOS	A			D			D			E		
Intersec. delay	40.7			Intersection LOS						D		

SHORT REPORT

General Information		Site Information	
Analyst	Tanveer Khan	Intersection	Tienken Road/Kings Cove
Agency or Co.	Hubbell, Roth & Clark, Inc.	Area Type	All other areas
Date Performed	10/31/02	Jurisdiction	City of Rochester Hills
Time Period	Existing+Proposed PM Peak	Analysis Year	2002

Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Num. of Lanes	0	1	0	0	1	1	0	0	0	1	0	1
Lane group		LTR			T	R		LR			L		R
Volume (vph)	109	1004	12		790	80	8		4	42		66
% Heavy veh	0	0	0		0	0	0		0	0		0
PHF	0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time		2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green		2.0			2.0	2.0		2.0		2.0		2.0
Arrival type		3			3	3		3		3		3
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width		12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr		0			0	0		0		0		0
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB		SB	
Adj. flow rate	1250		878	88	13		47	73
Lane group cap.	1542		1235	1050	176		181	162
v/c ratio	0.81		0.71	0.08	0.07		0.26	0.45
Green ratio	0.82		0.65	0.65	0.10		0.10	0.10
Unif. delay d1	6.0		13.7	7.8	49.0		49.9	50.9
Delay factor k	0.50		0.50	0.50	0.50		0.50	0.50
Increm. delay d2	4.7		3.5	0.2	0.8		3.5	8.8
PF factor	1.000		1.000	1.000	1.000		1.000	1.000
Control delay	10.7		17.2	7.9	49.8		53.3	59.7
Lane group LOS	B		B	A	D		D	E
Apprch. delay	10.7		16.3		49.8		57.2	
Approach LOS	B		B		D		E	
Intersec. delay	15.6		Intersection LOS				B	

Appendix C
Future Capacity Analysis

SHORT REPORT

General Information

Analyst	Tanveer Khan
Agency or Co.	Hubbell, Roth & Clark, Inc.
Date Performed	10/31/02
Time Period	AM Peak

Site Information

Intersection	Tienken Road/King's Cove Drive
Area Type	All other areas
Jurisdiction	City of Rochester Hills
Analysis Year	2025

Volume and Timing Input

		EB			WB			NB			SB		
		LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Num. of Lanes		0	1	0	0	1	1	0	0	0	1	0	1
Lane group			LTR			T	R		LR		L		R
Volume (vph)		16	653	0		1495	40	14		6	69		95
% Heavy veh		0	0	0		0	0	0		0	0		0
PHF		0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)		P	P			P	P	P		P	P		P
Startup lost time			2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green			2.0			2.0	2.0		2.0		2.0		2.0
Arrival type			3			3	3		3		3		3
Unit Extension			3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume		0		0	0		0	0		0	0		0
Lane Width			12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking		N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr													
Bus stops/hr			0			0	0		0		0		0
Unit Extension			3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB			NB		SB		
Adj. flow rate	744		1661	44		23		77		106
Lane group cap.	1550		1235	1050		176		181		162
v/c ratio	0.48		1.34	0.04		0.13		0.43		0.65
Green ratio	0.82		0.65	0.65		0.10		0.10		0.10
Unif. delay d1	3.3		21.0	7.6		49.2		50.8		52.0
Delay factor k	0.50		0.50	0.50		0.50		0.50		0.50
Increm. delay d2	1.1		160.7	0.1		1.5		7.2		18.8
PF factor	1.000		1.000	1.000		1.000		1.000		1.000
Control delay	4.4		181.7	7.6		50.8		57.9		70.8
Lane group LOS	A		F	A		D		E		E
Apprch. delay	4.4		177.2			50.8		65.4		
Approach LOS	A		F			D		E		
Intersec. delay	120.0		Intersection LOS					F		

SHORT REPORT

General Information

Analyst	Tanveer Khan
Agency or Co.	Hubbell, Roth & Clark, Inc.
Date Performed	10/31/02
Time Period	PM Peak

Site Information

Intersection	Tienken Road/King's Cove Drive
Area Type	All other areas
Jurisdiction	City of Rochester Hills
Analysis Year	2025

Volume and Timing Input

	EB LT	EB TH	EB RT	WB LT	WB TH	WB RT	NB LT	NB TH	NB RT	SB LT	SB TH	SB RT
Num. of Lanes	0	1	0	0	1	1	0	0	0	1	0	1
Lane group		LTR			T	R		LR		L		R
Volume (vph)	142	1305	16		1027	104	10		5	55		86
% Heavy veh	0	0	0		0	0	0		0	0		0
PHF	0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time		2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green		2.0			2.0	2.0		2.0		2.0		2.0
Arrival type		3			3	3		3		3		3
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width		12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr		0			0	0		0		0		0
Unit Extension		3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25

Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB		NB		SB		
Adj. flow rate	1626			1141	115	17		61		96
Lane group cap.	1542			1235	1050	175		181		162
v/c ratio	1.05			0.92	0.11	0.10		0.34		0.59
Green ratio	0.82			0.65	0.65	0.10		0.10		0.10
Unif. delay d1	11.0			18.4	7.9	49.1		50.3		51.7
Delay factor k	0.50			0.50	0.50	0.50		0.50		0.50
Increm. delay d2	38.8			12.9	0.2	1.1		5.0		14.9
PF factor	1.000			1.000	1.000	1.000		1.000		1.000
Control delay	49.8			31.3	8.1	50.2		55.3		66.6
Lane group LOS	D			C	A	D		E		E
Apprch. delay	49.8			29.1		50.2		62.2		
Approach LOS	D			C		D		E		
Intersec. delay	41.9			Intersection LOS				D		

SHORT REPORT

General Information		Site Information	
Analyst	Tanveer Khan	Intersection	Tienken Road/King's Cove Drive
Agency or Co.	Hubbell, Roth & Clark, Inc.	Area Type	All other areas
Date Performed	10/31/02	Jurisdiction	City of Rochester Hills
Time Period	AM Peak	Analysis Year	2025

Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Num. of Lanes	1	1	0	0	1	1	0	0	0	1	0	1
Lane group	L	TR			T	R		LR		L		R
Volume (vph)	16	653	0		1495	40	14		6	69		95
% Heavy veh	0	0	0		0	0	0		0	0		0
PHF	0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Arrival type	3	3			3	3		3		3		3
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width	12.0	12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr	0	0			0	0		0		0		0
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB			WB			NB		SB		
Adj. flow rate	18	726		1661	44		23		77		106
Lane group cap.	226	1552		1235	1050		176		181		162
v/c ratio	0.08	0.47		1.34	0.04		0.13		0.43		0.65
Green ratio	0.13	0.82		0.65	0.65		0.10		0.10		0.10
Unif. delay d1	46.4	3.3		21.0	7.6		49.2		50.8		52.0
Delay factor k	0.50	0.50		0.50	0.50		0.50		0.50		0.50
Increm. delay d2	0.7	1.0		160.7	0.1		1.5		7.2		18.8
PF factor	1.000	1.000		1.000	1.000		1.000		1.000		1.000
Control delay	47.1	4.3		181.7	7.6		50.8		57.9		70.8
Lane group LOS	D	A		F	A		D		E		E
Apprch. delay	5.3			177.2			50.8		65.4		
Approach LOS	A			F			D		E		
Intersec. delay	120.2			Intersection LOS					F		

SHORT REPORT

General Information		Site Information	
Analyst	Tanveer Khan	Intersection	Tienken Road/Kings Cove
Agency or Co.	Hubbell, Roth & Clark, Inc.	Area Type	All other areas
Date Performed	10/31/02	Jurisdiction	City of Rochester Hills
Time Period	PM Peak	Analysis Year	2025

Volume and Timing Input

	EB			WB			NB			SB		
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT
Num. of Lanes	1	1	0	0	1	1	0	0	0	1	0	1
Lane group	L	TR			T	R		LR		L		R
Volume (vph)	142	1305	16		1027	104	10		5	55		86
% Heavy veh	0	0	0		0	0	0		0	0		0
PHF	0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Arrival type	3	3			3	3		3		3		3
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width	12.0	12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr	0	0			0	0		0		0		0
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB		SB	
Adj. flow rate	158	1468	1141	115	17		61	96
Lane group cap.	226	1549	1235	1050	175		181	162
v/c ratio	0.70	0.95	0.92	0.11	0.10		0.34	0.59
Green ratio	0.13	0.82	0.65	0.65	0.10		0.10	0.10
Unif. delay d1	50.3	8.9	18.4	7.9	49.1		50.3	51.7
Delay factor k	0.50	0.50	0.50	0.50	0.50		0.50	0.50
Increm. delay d2	16.5	13.4	12.9	0.2	1.1		5.0	14.9
PF factor	1.000	1.000	1.000	1.000	1.000		1.000	1.000
Control delay	66.8	22.3	31.3	8.1	50.2		55.3	66.6
Lane group LOS	E	C	C	A	D		E	E
Apprch. delay	26.7		29.1		50.2		62.2	
Approach LOS	C		C		D		E	
Intersec. delay	29.6		Intersection LOS				C	

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SHORT REPORT

General Information

Analyst	Tanveer Khan
Agency or Co.	Hubbell, Roth & Clark, Inc.
Date Performed	10/31/02
Time Period	AM Peak

Site Information

Intersection	Tienken Road/Kings Cove
Area Type	All other areas
Jurisdiction	City of Rochester Hills
Analysis Year	2025

Volume and Timing Input

	EB LT	EB TH	EB RT	WB LT	WB TH	WB RT	NB LT	NB TH	NB RT	SB LT	SB TH	SB RT
Num. of Lanes	1	2	0	0	2	1	0	0	0	1	0	1
Lane group	L	TR			T	R		LR		L		R
Volume (vph)	16	653	0		1495	40	14		6	69		95
% Heavy veh	0	0	0		0	0	0		0	0		0
PHF	0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Arrival type	3	3			3	3		3		3		3
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width	12.0	12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr	0	0			0	0		0		0		0
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB	EB			WB	WB		NB		SB		SB
Adj. flow rate	18	726			1661	44		23		77		106
Lane group cap.	226	2948			2346	1050		176		181		162
v/c ratio	0.08	0.25			0.71	0.04		0.13		0.43		0.65
Green ratio	0.13	0.82			0.65	0.65		0.10		0.10		0.10
Unif. delay d1	46.4	2.5			13.6	7.6		49.2		50.8		52.0
Delay factor k	0.50	0.50			0.50	0.50		0.50		0.50		0.50
Increm. delay d2	0.7	0.2			1.8	0.1		1.5		7.2		18.8
PF factor	1.000	1.000			1.000	1.000		1.000		1.000		1.000
Control delay	47.1	2.7			15.5	7.6		50.8		57.9		70.8
Lane group LOS	D	A			B	A		D		E		E
Apprch. delay	3.8				15.2			50.8		65.4		
Approach LOS	A				B			D		E		
Intersec. delay	15.8				Intersection LOS					B		

SHORT REPORT

General Information

Analyst	Tanveer Khan
Agency or Co.	Hubbell, Roth & Clark, Inc.
Date Performed	10/31/02
Time Period	PM Peak

Site Information

Intersection	Tienken Road/Kings Cove
Area Type	All other areas
Jurisdiction	City of Rochester Hills
Analysis Year	2025

Volume and Timing Input

	EB LT	EB TH	EB RT	WB LT	WB TH	WB RT	NB LT	NB TH	NB RT	SB LT	SB TH	SB RT
Num. of Lanes	1	2	0	0	2	1	0	0	0	1	0	1
Lane group	L	TR			T	R		LR		L		R
Volume (vph)	142	1305	16		1027	104	10		5	55		86
% Heavy veh	0	0	0		0	0	0		0	0		0
PHF	0.90	0.90	0.90		0.90	0.91	0.90		0.90	0.90		0.90
Actuated (P/A)	P	P			P	P	P		P	P		P
Startup lost time	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Ext. eff. green	2.0	2.0			2.0	2.0		2.0		2.0		2.0
Arrival type	3	3			3	3		3		3		3
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0
Ped/Bike/RTOR Volume	0		0	0		0	0		0	0		0
Lane Width	12.0	12.0			12.0	12.0		12.0		12.0		12.0
Parking/Grade/Parking	N	0	N	N	0	N	N	0	N	N	0	N
Parking/hr												
Bus stops/hr	0	0			0	0		0		0		0
Unit Extension	3.0	3.0			3.0	3.0		3.0		3.0		3.0

Phasing	EB Only	Thru & RT	03	04	NS Perm	06	07	08
Timing	G = 15.0	G = 78.0	G =	G =	G = 12.0	G =	G =	G =
	Y = 5	Y = 5	Y =	Y =	Y = 5	Y =	Y =	Y =

Duration of Analysis (hrs) = 0.25   Cycle Length C = 120.0

Lane Group Capacity, Control Delay, and LOS Determination

	EB		WB		NB	SB	
Adj. flow rate	158	1468	1141	115	17	61	96
Lane group cap.	226	2942	2346	1050	175	181	162
v/c ratio	0.70	0.50	0.49	0.11	0.10	0.34	0.59
Green ratio	0.13	0.82	0.65	0.65	0.10	0.10	0.10
Unif. delay d1	50.3	3.4	10.7	7.9	49.1	50.3	51.7
Delay factor k	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Increm. delay d2	16.5	0.6	0.7	0.2	1.1	5.0	14.9
PF factor	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Control delay	66.8	4.0	11.5	8.1	50.2	55.3	66.6
Lane group LOS	E	A	B	A	D	E	E
Apprch. delay	10.1		11.2		50.2	62.2	
Approach LOS	B		B		D	E	
Intersec. delay	13.4		Intersection LOS			B	

Version 4.1b

Appendix D
Tienken Road Capacity
Analysis

Hubbell, Roth & Clark, Inc.
555 Hulet Drive
Bloomfield Hills, MI 48302

Phone: (248) 338-9241   Fax: (248) 338-2592
E-Mail: tkhan@hrc-engr.com

_____Two-Way Two-Lane Highway Segment Analysis_____

Analyst	Tanveer Khan
Agency/Co.	Hubbell, Roth & Clark, Inc.
Date Performed	10/21/02
Analysis Time Period	PM Peak Hour
Highway	Tienken Road
From/To	East of Livernois Road
Jurisdiction	Rochester Hills
Analysis Year	2002
Description	Existing Year 2002 Traffic Analysis

_____Input Data_____

Highway class	Class 2				
Shoulder width	2.0	ft	Peak-hour factor, PHF	0.92	
Lane width	12.0	ft	% Trucks and buses	5	%
Segment length	1.0	mi	% Recreational vehicles	1	%
Terrain type	Level		% No-passing zones	0	%
Grade: Length		mi	Access points/mi	10	/mi
Up/down		%			

Two-way hourly volume, V   1625   veh/h
Directional split   57 /   43   %

_____Average Travel Speed_____

Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor,	0.995	
Two-way flow rate,(note-1) vp	1775	pc/h
Highest directional split proportion (note-2)	1012	pc/h

Free-Flow Speed from Field Measurement:

Field measured speed, SFM	–	mi/h
Observed volume, Vf	–	veh/h

Estimated Free-Flow Speed:

Base free-flow speed, BFFS	50.0	mi/h
Adj. for lane and shoulder width, fLS	2.6	mi/h
Adj. for access points, fA	2.5	mi/h
Free-flow speed, FFS	44.9	mi/h
Adjustment for no-passing zones, fnp	0.0	mi/h
Average travel speed, ATS	31.1	mi/h

Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.0	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor, fHV	1.000	
Two-way flow rate,(note-1) vp	1766	pc/h
Highest directional split proportion (note-2)	1007	
Base percent time-spent-following, BPTSF	78.8	%
Adj.for directional distribution and no-passing zones, fd/np	0.0	
Percent time-spent-following, PTSF	78.8	%

_____Level of Service and Other Performance Measures_____

Level of service, LOS	D	
Volume to capacity ratio, v/c	0.55	
Peak 15-min vehicle-miles of travel, VMT15	442	veh-m:
Peak-hour vehicle-miles of travel, VMT60	1625	veh-m:
Peak 15-min total travel time, TT15	14.2	veh-h

Notes:
1. If vp >= 3200 pc/h, terminate analysis-the LOS is F.
2. If highest directional split vp >= 1700 pc/h, terminate
   analysis-the LOS is F.

Hubbell, Roth & Clark, Inc.
555 Hulet Drive
Bloomfield Hills, MI 48302

Phone: (248) 338-9241   Fax: (248) 338-2592
E-Mail: tkhan@hrc-engr.com

_____Two-Way Two-Lane Highway Segment Analysis_____

Analyst	Tanveer Khan
Agency/Co.	Hubbell, Roth & Clark, Inc.
Date Performed	10/31/02
Analysis Time Period	PM Peak Hour
Highway	Tienken Road
From/To	East of Livernois Road
Jurisdiction	Rochester Hills
Analysis Year	2025
Description	Future Year 2025 Traffic Analysis

_____Input Data_____

Highway class   Class 2

Shoulder width	4.0	ft	Peak-hour factor, PHF	0.92	
Lane width	12.0	ft	% Trucks and buses	5	%
Segment length	1.0	mi	% Recreational vehicles	1	%
Terrain type	Level		% No-passing zones	0	%
Grade: Length		mi	Access points/mi	10	/mi
Up/down		%			

Two-way hourly volume, V   2508   veh/h
Directional split   56 / 44   %

_____Average Travel Speed_____

Grade adjustment factor, fG	1.00	
PCE for trucks, ET	1.1	
PCE for RVs, ER	1.0	
Heavy-vehicle adjustment factor,	0.995	
Two-way flow rate,(note-1) vp	2740	pc/h
Highest directional split proportion (note-2)	1534	pc/h

Free-Flow Speed from Field Measurement:

Field measured speed, SFM	–	mi/h
Observed volume, Vf	–	veh/h

Estimated Free-Flow Speed:

Base free-flow speed, BFFS	50.0	mi/h
Adj. for lane and shoulder width, fLS	1.3	mi/h
Adj. for access points, fA	2.5	mi/h
Free-flow speed, FFS	46.2	mi/h
Adjustment for no-passing zones, fnp	0.0	mi/h
Average travel speed, ATS	24.9	mi/h

Phone: Fax:
E-mail:

_____OPERATIONAL ANALYSIS_____

Analyst: Tanveer Khan
Agency/Co: Hubbell, Roth & Clark, Inc.
Date: 10/31/02
Analsis Period: PM Peak
Highway: Tienken Road
From/To: Livernois To Rochester
Jurisdiction: City of Rochester Hills
Analysis Year: 2025
Project ID: 5-Lane Tienken Road

_____FREE-FLOW SPEED_____

Direction	1		2	
Lane width	12.0	ft	12.0	ft
Lateral clearance:				
Right edge	6.0	ft	6.0	ft
Left edge	6.0	ft	6.0	ft
Total lateral clearance	12.0	ft	12.0	ft
Access points per mile	0		0	
Median type				
Free-flow speed:	Measured		Measured	
FFS or BFFS	45.0	mph	45.0	mph
Lane width adjustment, FLW	0.0	mph	0.0	mph
Lateral clearance adjustment, FLC	0.0	mph	0.0	mph
Median type adjustment, FM	0.0	mph	0.0	mph
Access points adjustment, FA	0.0	mph	0.0	mph
Free-flow speed	45.0	mph	45.0	mph

_____VOLUME_____

Direction	1		2	
Volume, V	1365	vph	1143	vph
Peak-hour factor, PHF	0.90		0.90	
Peak 15-minute volume, v15	379		318	
Trucks and buses	0	%	0	%
Recreational vehicles	0	%	0	%
Terrain type	Level		Level	
Grade	0.00	%	0.00	%
Segment length	0.00	mi	0.00	mi
Number of lanes	2		2	
Driver population adjustment, fP	1.00		1.00	
Trucks and buses PCE, ET	1.5		1.5	
Recreational vehicles PCE, ER	1.2		1.2	
Heavy vehicle adjustment, fHV	1.000		1.000	
Flow rate, vp	758	pcphpl	635	pcphpl

Direction	1		2	
Flow rate, vp	758	pcphpl	635	pcphpl
Free-flow speed, FFS	45.0	mph	45.0	mph
Avg. passenger-car travel speed, S	45.0	mph	45.0	mph
Level of service, LOS	B		B	
Density, D	16.8	pc/mi/ln	14.1	pc/mi/ln

Overall results are not computed when free-flow speed is less than 45 mph

Grade adjustment factor, fG   1.00
PCE for trucks, ET   1.0
PCE for RVs, ER   1.0
Heavy-vehicle adjustment factor, fHV   1.000
Two-way flow rate,(note-1) vp   2726   pc/h
Highest directional split proportion (note-2)   1527
Base percent time-spent-following, BPTSF   90.9   %
Adj.for directional distribution and no-passing zones, fd/np -0.1
Percent time-spent-following, PTSF   90.8   %

_____Level of Service and Other Performance Measures_____

Level of service, LOS   E
Volume to capacity ratio, v/c   0.86
Peak 15-min vehicle-miles of travel, VMT15   682   veh-mi
Peak-hour vehicle-miles of travel, VMT60   2508   veh-mi
Peak 15-min total travel time, TT15   27.3   veh-h

Notes:
1. If vp >= 3200 pc/h, terminate analysis-the LOS is F.
2. If highest directional split vp >= 1700 pc/h, terminate
   analysis-the LOS is F.