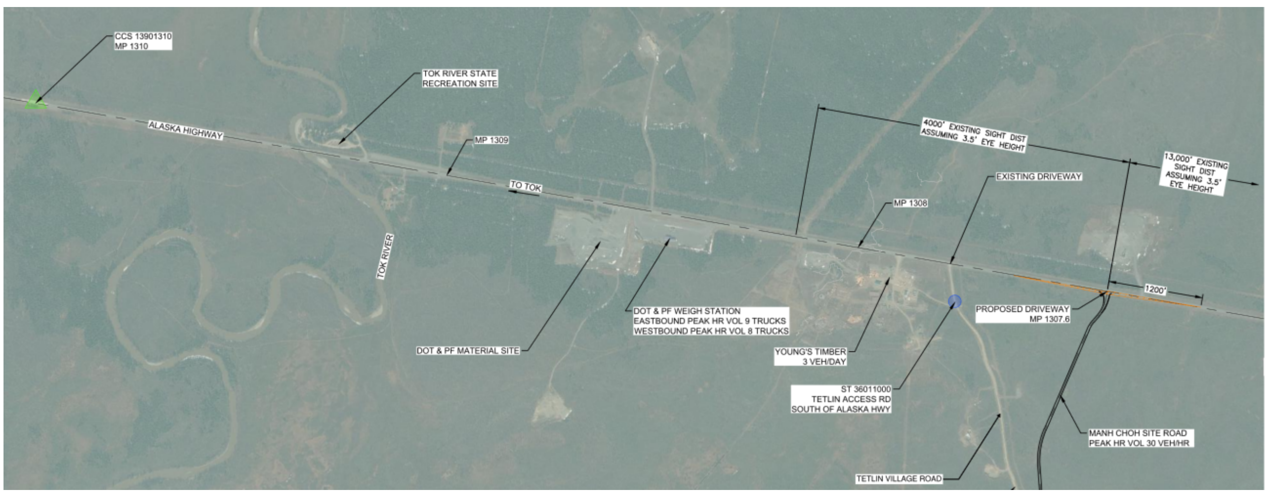
Manh Choh Twin Road

Developer: Peak Gold, LLC

Traffic Impact Analysis Report

November 2022



Prepared For:
Alaska Department of
Transportation & Public
Facilities

Prepared By:
RESPEC
2700 Gambell Street,
Suite 500
Anchorage, AK 99503
907-743-3200
AECC163270

STATE OF ALASKA
49 TH
Heather D. Estabrook
Heather D. Estabrook
CE-11130
REGISTERED PROFESSIONAL ENGINEER

2022.11.03 17:26:08-08'00'

Manh Choh Twin Road
Traffic Impact Analysis Requirement Checklist

Peak Gold, LLC plans to operate a mine near Tok, Alaska. The project will require a new access with an approach at Mile 1307.6 of the Alaska Highway. There will be 130 ore trucks using the highway spread over 24 hours (approximately 6 per hour). Exhibit A is a map that shows the vicinity of the new access to the Alaska Highway. The map shows proximity to adjacent facilities, traffic generated, and existing vs minimum sight distances. The traffic of the area was analyzed and shows that the expected traffic will have little impact on safety and operations of the Alaska Highway. To evaluate the traffic, the month with the highest traffic since 2019 was used to get a peak daily volume that is nearly 4 times the winter volumes (i.e. when road conditions are suboptimal, the volume will be at its lowest). Exhibit B shows the turning traffic at the new approach.

Pre-analysis meeting

The developer and the registered engineer that will sign and seal the TIA must meet with the DOT&PF&PF Regional Traffic & Safety engineer and Right-of-Way agent before beginning the TIA. At the meeting, the following will be determined:

- The design year (This is typically the buildout year or 10 years beyond the buildout year, depending on the development size and location)
    - 5 years – 2028
    - Peak in 2023 during construction.
    - 2024 begin normal operations – decommissioned in 2028
- The study area
    - Tok River to Manh Choh Twin Road turn-off
- Key intersections and key road segments to consider/evaluate in the TIA
    - DOT&PF Weigh Station
    - Young’s Timber
    - Tetlin Village Road
    - Manh Choh Twin Road
- The projected area-wide traffic growth rate
    - 1%
- Level of Service (LOS) standards
    - LOS C (lowest acceptable)
- Other planned developments to consider
    - None

- Planned road improvements to consider
    - None
- Any other items of note regarding the TIA
    - TIA is limited to the study area, and a broader look at the corridor is being analyzed by DOT&PF in another project.

Traffic Impact Analysis. Include the following:

Development Information

- ☐ Development description
  Description of mine/traffic
    - Ore will be hauled by B-Trains running at regular intervals over 24 hours
    - The mine will operate with double shifts and personnel will be bussed to and from the site.
- ☐ Land use intensity including square footage, types of land use, employees, etc.
    - Land use will be a gold mine operation.
- ☐ Proposed zoning changes or zoning variances
    - N/A
- ☐ Construction year, opening year, projected year for full buildout
    - Construct 2023-2024
    - Open 2024 -2028 for operations 6 trucks per hour plus operations – bussed workers, light vehicles, and deliveries.
- ☐ Map of the development, including traffic circulation and parking area
    - Overall site map with study area along the road provided in Exhibit A.
- ☐ Sight distance evaluation from access points
    - Approximately 13,000’ to the East assuming a 3.5’ height of eye.
    - Approximately 4,000’ to the West assuming a 3.5’ height of eye. This distance is between Young’s Timber and DOT&PF & PF’s weigh station. With the B-Trains having a height of eye significantly higher than 3.5’ the ore haulers expect to have a line of sight to the weigh station, and similarly, any trucks at the weigh station will have a line of sight to any trucks coming from the mine.
    - The calculated minimum sight distance is 1,200’ and is well exceeded by existing conditions.
- ☐ Alternatives to the proposed location
    - Sharing Tetlin Village Road (not desired by Tetlin Village, and ruled out)
    - Previous design next to Tetlin Village Road (approximately 450’ between approaches)

Project Area Background

- ☐ Surrounding land zoning
  - N/A
- ☐ Surrounding land uses and site land use
  - Tetlin Village land
  - State land for DOT&PF material site, weigh station, and Tok River rest area
- ☐ Adjacent development
  - Young's Timber, DOT&PF, Tok River
- ☐ Traffic improvements already funded, programmed, or planned
  - N/A
- ☐ Other planned developments
  - N/A

Data Requirements

- ☐ Map of the study area street network
  - Map of Tok River to Manh Choh Twin Road, plus the intersection sight triangle
- ☐ Peak hour intersection turning movement counts for all key intersections
  - From DOT&PF
    - Estimate of weigh station usage
      - 2022 and 2021 peak data were received from the scale operator and peak hour volumes are:
        - Eastbound – 9 Trucks in 2022
        - Westbound – 8 Trucks in 2022
  - Estimates from Young's Timber
    - 3 vehicles per hour
- ☐ Daily volume counts for all streets and roadways in the study area
  - Alaska Highway data
    - AADT obtained from CCS 13901310 at Mile 1310 of Alaska Highway showed a maximum of 619 in 2019
  - Estimates from Tetlin Village
    - AADT obtained from ST 36011000 on Tetlin Village Road showed a maximum of 69 in 2019
- ☐ Number of lanes on the streets in the study area
  - Two
- ☐ Intersection geometry information for all key intersections
  - Included in driveway permit
- ☐ Traffic signal phasing and timing information for all key intersections
  - N/A

- ☐ 5-year crash history within the study area
  - From DOT&PF
    - Study area is between DOT&PF & PF Weigh Station and MP 1307.5
    - 3 crashes from 2016 – 2020
      - 2 live animal strikes
      - 1 rollover/overturn
- ☐ Sidewalks and other pedestrian facilities
  - Shoulders of Alaska Highway
- ☐ Bike lanes and other bicycle facilities
  - Shoulders of Alaska Highway
- ☐ Transit operation and facilities including pullouts, frequency of service and utilization
  - N/A

Traffic Forecasting

- ☐ Projected traffic to be generated by the development (Use the ITE Trip Generation Manual, latest version)

  Peak Gold forecast on personnel and support vehicles plus ore haul

  - Peak Gold traffic projection for peak hours are (Veh/HR):
    - Ore Haul – 6
    - Crew Change – 10
    - Light Vehicles – 6
    - Deliveries – 2
    - Other – 6
  - Peak hours are expected to occur at shift changes. Shift change hours are anticipated to be:
    - 6:00 AM – 7:00 AM
    - 6:00 PM – 7:00 PM
- ☐ Projected trip distribution, turning movements, and rationale for determining same
  - N/A – single intersection leading to mine outside of study area
- ☐ Projected total traffic for the design year (base traffic + site traffic) at all key intersections and route segments within the study area
  - Figure showing anticipated traffic from Manh Choh Twin Road, Tetlin Village Road, Young's Timber, and DOT&PF weigh station.
- ☐ Trip generation from other planned developments
  - N/A

Traffic Analysis

- ☐ Baseline LOS calculations for all key intersections and key road segments (For LOS computations, use the TRB Special Report 209, Highway Capacity Manual, latest version)
    - 3 mile segment of the Alaska Highway was analyzed from MP 1307 – MP 1310
        - ATS = 57 MPH – Exhibit 15-3 HCM shows LOS A
        - PTSF = 26% - Exhibit 15-3 HCM shows LOS A
    - Weigh station LOS not calculated because proposed calculations from the Manh Choh Twin Road intersection showed LOS A therefore it is expected that the weigh station's LOS is A as well because there is less traffic. Data obtained from the scale house showed a maximum of 9 trucks in an hour which equates to a 6-minute gap between trucks.

No-Build Alternative – Without Development – using existing

- ☐ Projected LOS calculations for all key intersections and key road segments for the opening date or the design year, as required
    - Exhibit B shows proposed traffic movements.
- ☐ Vehicle queue lengths (95th percentile) and available storage
    - n/a – no existing queuing
- ☐ Pedestrian considerations, including applicable school walking routes
    - Shoulders of Alaska Highway
- ☐ Bicycle considerations
    - Shoulders of Alaska Highway
- ☐ Transit considerations
    - N/A – no public transit
- ☐ Safety considerations for all key intersections and key road segments
    - No existing safety concerns

Build Alternative – With Development – using new

- ☐ Projected LOS calculations for all key intersections and key road segments for the opening date or the design year, as required
    - Simple figure with analysis of road segments and intersections.
    - 3 mile segment of the Alaska Highway was analyzed from MP 1307 – MP 1310
        - ATS = 55.7 MPH – Exhibit 15-3 HCM shows LOS A
        - PTSF = 28% - Exhibit 15-3 HCM shows LOS A

- Intersection LOS
    - Mainline left turn onto Manh Choh Site Road has control delay of 7.5 sec. Exhibit 20-2 of HCM shows LOS A.
    - Manh Choh Site Road has control delay of 9 sec. Exhibit 20-2 of HCM shows LOS A.

☐ Turn lane warrants for all movements

- New driveway left and right turn lane warrants
    - The proposed peak hourly driveway volume is 30, with a peak hourly right-hand turn movement of 13 vehicles.
    - HCPM pg. 1190-8 states that a minimum of 100 Veh/HR is required to warrant a speed change lane; or use the following:
        - Figure 4-23 of NCHRP 279 intersection channelization Design Guide shows that the peak hourly right turn volume does not require a right turn lane. The total peak hour approach volume (79) versus the right turn in peak hour (13) is well below the threshold for a full-width turn lane on the graph.
        - Exhibit 9-75 in AASHTO *A Policy on the Geometric Design of Highways and Streets 2001* (Table 9-23 of the 2011 Edition) shows the volumes do not warrant a turn lane. For example, when opposed by 100 vehicles, the minimum suggested left turn volume requiring a left turn lane is 25 at 60 mph. (we are expecting 2 or less vehicles making a left-hand turn from the Alaska Highway.)
- Weigh scale turn lane warrants
    - Weigh station has existing speed change lanes

☐ Vehicle queue lengths (95th percentile) and available storage

- Mainline left turn onto Manh Choh Site Road has queue length of 0.004 Veh.
    - No queuing expected at peak volume
- Manh Choh Twin Road has queue length of 0.007 Veh.
    - Approach provides ample queuing space.

☐ Pedestrian considerations, including applicable school walking routes

- Shoulders of Alaska Highway

☐ Bicycle considerations

- Shoulders of Alaska Highway

☐ Transit considerations

- N/A – no transit
- Mine employees will be bussed to and from the mine at shift change, eliminating passenger vehicles for staff.

☐ Safety considerations for all key intersections and key road segments

- The analysis does not indicate any need for safety considerations. The team discussed signage for "Truck Crossing", and it was decided that signing will not be required. It can be added in the future if warranted.

Summary

☐ Summary of impacts

- There will not be enough traffic generated by the mine to have a negative effect on the Alaska Highway. According to the HCM the capacity of a two-lane highway is 3,200 passenger cars per hour. The base peak volume is approximately 49 Veh/HR and the proposed volume is 79 Veh/HR. The proposed volume makes the Alaska Highway at 2.5% of the capacity.
- Given the anticipated volume of 6 ore trucks per hour that could potentially add between 2 and 3 trucks per hour at the weigh station. That would make the time between trucks at peak volume 5 minutes. 5 minutes is significantly more time than required for trucks to decelerate and enter the weigh station or leave the weigh station and accelerate prior to the next truck.
- Traffic analysis assumed a 50/50 directional split for traffic on Alaska Highway. The base peak volume is 49 Veh/HR giving approximately 25 vehicles in each direction allowing for over 2 minutes between vehicles.

Mitigation

☐ Mitigation measure alternatives to address capacity, delay, pedestrian, bicycle, transit and safety issues caused by or exacerbated by the development

- See comments on weigh scale coordination with MS/CVC to reduce number of trucks weighed at the DOT&PF weigh station.
- See comments on employee bussing at shift change, eliminating the need for staff passenger vehicles.

☐ Proposed mitigation measures

- About a year ago Peak Gold discussed a concept with Daniel Smith Director of the Division of Measurement Standards and Commercial Vehicle Compliance (MS/CVC) to allow the ore haul trucks to bypass the DOT&PF scales except for ad-hoc inspections.

  The general idea is that Peak Gold would set up and certify the scale at Manh Choh to DOT&PF standards and Peak Gold would provide scale tickets to DOT&PF to audit. This transparency and ad-hoc inspections of ore haul vehicles at the scales would allow the ore haul contractor (BGT) permission to bypass the majority of the state scales. This trust would need to be earned and maintained by consistently sending safe and legal loads that passed ad-hoc inspections. This was to be a mutual benefit to BGT, Peak Gold, and DOT&PF by saving everyone time and resources.

☐ Proposed improvements to development parking and circulation routes

- N/A

☐ Mitigation measure affects (include projected LOS calculations and / or crash reduction factors as applicable)

- None anticipated

☐ Conclusion

- The project plans to provide employee bussing to keep traffic to a minimum and proposes to work with DOT&PF's MS/CVC to reduce weigh scale redundancy.

Typical Reporting Requirements:

- Submit electronic data/files compatible with Microsoft Office products, latest release of Autodesk AutoCAD, Trafficware Synchro Studio 7, and MacTrans HCS+

LEGEND

25 — EXPECTED MOVEMENT COUNTS (VEH/HR)

DRAWING NO.	TITLE	NO.	DESCRIPTION	DATE	BY	CH.	SUPV	PE	PROC	MECH	PL&P	C/S	INST	ELEC	PEM
		A	INTERNAL REVIEW	10/31/2022	KMG	HDE	KLH								

REFERENCE DWGS — REVISIONS

11/1/2022 11:14 AM

RESPEC
Fairbanks, AK
1028 Aurora Drive
Fairbanks, AK 99709
Phone: 907.452.1414
Fax: 907.456.2707
AECC163270

ENGINEER'S SEAL

ISSUED FOR INTERNAL REVIEW

	DRAWN	CHECKED	APPROVED	DESIGN	PROJ. ENG.	P.E. MGR.	CLIENT
BY	K. GARCIA	H. ESTABROOK	K. HANNEMAN	K. GARCIA			
DATE	10/31/22	10/31/22	10/31/22	10/31/22			

SCALE:
UNITS: US UNITS
CAD DRAWING FILE NO.: Exhibit.dwg
PROJ. NO.: PG0086

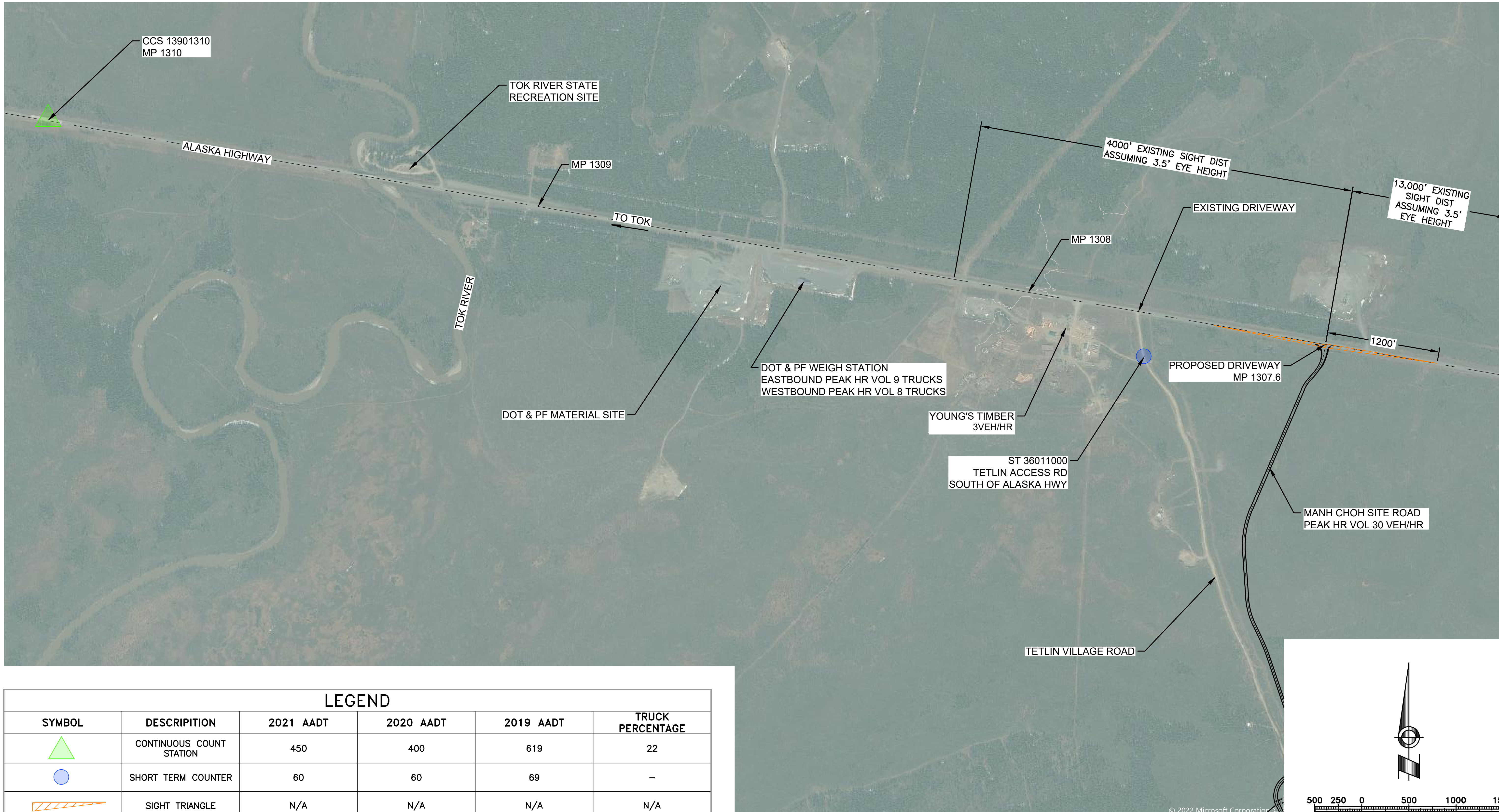
CLIENT/PROJECT
KINROSS — Manh Choh, A JV with Contango ORE

MANH CHOH, PROJECT

MINE DEVELOPMENT PROJECT
MANH CHOH TWIN ROAD
ALTERNATIVE

TITLE
TRAFFIC IMPACT ANALYSIS
EXHIBIT B

DRAWING NUMBER: PG00XX-XXXXX-0X-DWG-XXXX
REV.: A



LEGEND

SYMBOL	DESCRIPTION	2021 AADT	2020 AADT	2019 AADT	TRUCK PERCENTAGE
(green triangle)	CONTINUOUS COUNT STATION	450	400	619	22
(blue circle)	SHORT TERM COUNTER	60	60	69	–
(orange hatched triangle)	SIGHT TRIANGLE	N/A	N/A	N/A	N/A

NO.	DESCRIPTION	DATE	BY	CH.	SUPV	PE	PROC	MECH	PL&P	C/S	INST	ELEC	PEM
A	INTERNAL REVIEW	10/31/2022	KMG	HDE	KLH								

REVISIONS

DRAWING NO.	TITLE

REFERENCE DWGS

RESPEC
Fairbanks, AK
1028 Aurora Drive
Fairbanks, AK 99709
Phone: 907.452.1414
Fax: 907.456.2707
AECC163270

ENGINEER'S SEAL

ISSUED FOR INTERNAL REVIEW

	DRAWN	CHECKED	APPROVED	DESIGN	PROJ. ENG.	P.E. MGR.	CLIENT
BY	K. GARCIA	H. ESTABROOK	K. HANNEMAN	K. GARCIA			
DATE	10/31/22	10/31/22	10/31/22	10/31/22			

SCALE
UNITS: US UNITS
CAD DRAWING FILE NO.: Exhibit.dwg
PROJ. NO.: PG0086

CLIENT/PROJECT
KINROSS
Manh Choh — A JV with Contango ORE

MANH CHOH, PROJECT
MINE DEVELOPMENT PROJECT
MANH CHOH TWIN ROAD
ALTERNATIVE

TITLE
TRAFFIC IMPACT ANALYSIS EXHIBIT A

DRAWING NUMBER: PG00XX-XXXXX-0X-DWG-XXXX
REV.: A

10/31/2022 10:12 AM

Appendix A
Calculations

Alaska Highway Design Speed	70 MPH		
Time Gap	11.5 sec	Combination Truck	
ISD=1.47*Vmaj*tg			
			Use
ISD	1183.35 FT	<==Leg b	1,200 FT

A	Dist from edge of pavement to stop point	15	FT	
B	Shoulder width	6	FT	
C	Lane width	12	FT	
	leg a2=A+B+1.5*C			
	a2	39	FT	For left turn
	Leg a1=A+B+0.5*C	27	FT	For right turn

Table 9-5. Time Gap for Case B1, Left Turn from Stop

Design Vehicle	Time Gap (t_g)(s) at Design Speed of Major Road
Passenger car	7.5
Single-unit truck	9.5
Combination truck	11.5

Note: Time gaps are for a stopped vehicle to turn left onto a two-lane highway with no median and with grades of 3 percent or less. The table values should be adjusted as follows:

For multilane highways—For left turns onto two-way highways with more than two lanes, add 0.5 s for passenger cars or 0.7 s for trucks for each additional lane, from the left, in excess of one, to be crossed by the turning vehicle.

For minor road approach grades—If the approach grade is an upgrade that exceeds 3 percent, add 0.2 s for each percent grade for left turns.

The intersection sight distance along the major road (distance *b* in Figure 9-15B) is determined by:

Metric	U.S. Customary
$ISD = 0.278\ V_{major}\ t_g$	$ISD = 1.47\ V_{major}\ t_g$ (9-1)
where:	where:
ISD = intersection sight distance (length of the leg of sight triangle along the major road) (m)	ISD = intersection sight distance (length of the leg of sight triangle along the major road) (ft)
V_{major} = design speed of major road (km/h)	V_{major} = design speed of major road (mph)
t_g = time gap for minor road vehicle to enter the major road (s)	t_g = time gap for minor road vehicle to enter the major road (s)

this is much more conservative than the HPCM values, as it is calculated for a combination truck.

Sight Distance for Case F, Left turns from the Major Road	Time Gap	Sight Dist	Use
Passenger Car	5.5	565.95	570
SU Truck	6.5	668.85	670
Comb Truck	7.5	771.75	780

Design Speed	70	MPH

Table 9-13. Time Gap for Case F, Left Turns from the Major Road

Design Vehicle	Time Gap (t_g)(s) at Design Speed of Major Road
Passenger car	5.5
Single-unit truck	6.5
Combination truck	7.5

Note: *Adjustment for multilane highways*—For left-turning vehicles that cross more than one opposing lane, add 0.5 s for passenger cars and 0.7 s for trucks for each additional lane to be crossed.

Station Type	Station ID	Location	Mile Point	2021		2020		2019	
				AADT	Truck %	AADT	Truck %	AADT	Truck %
CCS	13601300	Taylor Hwy & AK Hwy	1300	210	27%	210	27%	369	23%
ST	33002301	AK Hwy West of Taylor	1301	280		250		319	
ST	36011000	Tetlin Village Road	1307.8	60		60		69	
CCS	13901310	AK Hwy West of Weigh Sta	1310	450	22%	400	22%	619	
WIM	tok	AK Hwy WIM	1310	470	14%	420	14%		

2028
AADT
282
283
63
490
445

Growth Rate	1.00%

Ore Trucks	144	ADT
Other Traffic	576	ADT
Truck %	0.20	

130 per day from their calculations...but 6x24=144
30-6 trucks = 24...24x24 = 576
ok, 18% if we use 130

PEAK GOLD NUMBERS

Ore Haul	6	based on 110% of planned haul rate; 24 hr operations	
Crew Chang	4	ops crew change by crew bus from Tok camp	(later bumped up by 6)
Light Vehicle	6	security, supervision, misc	
Deliveries	2	e.g. fuel, parts, explosives	
Other (contir	12	contingency for others	(later bumped down by 6)
Total	30		

	Veh/HR	Truck %
Base Traffic	49	26%
Site Traffic	30	20%
Total Traffic	79	24%

Montly Average Daily Total - CCS 13901310

	2019	2020	2021	2022
Jan	249.36		233.08	199.67
Feb	265.75	289.44	239.33	228.38
Mar	351.58	304.23	343.69	
Apr	495.16	293.92	409.41	
May	770.72	458.24	542.89	609.52
Jun	1098.21	513.09	643.9	932.38
Jul	1177.52	561.57	622.8	948.84
Aug	1158.73	632.64	692.39	1018.07
Sep	883.42	691.82	745.75	952.84
Oct	412.21	369.94	361.33	485.31
Nov	296.63	258.06	270	
Dec	269.85	266.81	229.96	
Highest Average Daily Volume	1177.52	Jul-19		

Annual Stats

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
AADT	565	596	577	611	643	592	593	619	400	450

	Base	Total
Assuming Class I Hwy		
Demand Volume	49.1	79.1
Directional Split	0.5	0.5
PHF	0.88	
No Passing Zone %	50%	
Rolling Terrain		
Truck %	24%	
Lane Width (FT)	12	
Shoulder Width (FT)	6	
Access Points/MI	3.33	
Base FFS (BFFS)	60	estimating the trucks 5 mph less than posted
Segment Length (MI)	3	
LOS ATS	A	A
LOS PTSF	A	A
ATS	57.0	55.7
PTSF	26	28
LOS	A	A

Exhibit 15-3
Motorized Vehicle LOS for Two-Lane Highways

LOS	Class I Highways ATS (mi/h)	Class I Highways PTSF (%)	Class II Highways PTSF (%)	Class III Highways PFFS (%)
A	>55	≤35	≤40	>91.7
B	>50–55	>35–50	>40–55	>83.3–91.7
C	>45–50	>50–65	>55–70	>75.0–83.3
D	>40–45	>65–80	>70–85	>66.7–75.0
E	≤40	>80	>85	≤66.7
F	Demand exceeds capacity			

Note: For Class I highways, LOS is determined by the worse of ATS-based LOS and PTSF-based LOS.

FFS=BFFS-fLS-fA

fLS	0	
fA	0.8	
FFS=	59.2	MPH

Highway Capacity Manual: A Guide for Multimodal Mobility Analysis

Exhibit 15-7
Adjustment Factor for Lane and Shoulder Width (f_{LS})

Lane Width (ft)	Shoulder Width (ft) ≥0, <2	≥2, <4	≥4, <6	≥6
≥9, <10	6.4	4.8	3.5	2.2
≥10, <11	5.3	3.7	2.4	1.1
≥11, <12	4.7	3.0	1.7	0.4
≥12	4.2	2.6	1.3	0.0

Exhibit 15-8
Adjustment Factor for Access Point Density (f_A)

Access Points per Mile (Both Sides)	Reduction in FFS (mi/h)
0	0.0
10	2.5
20	5.0
30	7.5
40	10.0

Note: Interpolation to the nearest 0.1 is recommended.

Vi,ATS=Vi/(PHF*fg,ATS*fHV,ATS)

fg,ATS	0.67	0.67
Demand Volume	27.9	44.9
Vi,ATS=	68	107

Exhibit 15-9
ATS Grade Adjustment Factor ($f_{g,ATS}$) for Level Terrain, Rolling Terrain, and Specific Downgrades

One-Direction Demand Flow Rate, v_{vph} (veh/h)	Adjustment Factor: Level Terrain and Specific Downgrades	Rolling Terrain
≤100	1.00	0.67
200	1.00	0.75
300	1.00	0.83
400	1.00	0.90
500	1.00	0.95
600	1.00	0.97
700	1.00	0.98
800	1.00	0.99
≥900	1.00	1.00

Note: Interpolation to the nearest 0.01 is recommended.

fHV,ATS=1/(1+PT*(ET-1)+PR*(ER-1))			
PT	26%	24%	
PR	0	0	<==assuming 0
ET	2.7	2.7	
FHV,ATS=	0.70	0.71	

Exhibit 15-11
ATS Passenger Car Equivalents for Trucks (E_T) and RVs (E_R) for Level Terrain, Rolling Terrain, and Specific Downgrades

Vehicle Type	Directional Demand Flow Rate, v_{vph} (veh/h)	Level Terrain and Specific Downgrades	Rolling Terrain
Trucks, E_T	≤100	1.9	2.7
	200	1.5	2.3
	300	1.4	2.1
	400	1.3	2.0
	500	1.2	1.8
	600	1.1	1.7
	700	1.1	1.6
	800	1.1	1.4
	≥900	1.0	1.3
RVs, E_R	All flows	1.0	1.1

Note: Interpolation to the nearest 0.1 is recommended.

ATS=FFS-0.00776*(Vd,ATS+V0,ATS)-fnp,ATS

ATS=	57.0	55.7
fnp,ATS	1.2	1.8

FFS 55			
V0 (PC/H)	% No Pass		
	40	50	60
100	1.2	1.7	2.2
68		1.2	
100	1.2	1.7	2.2

FFS 60			
V0 (PC/H)	% No Pass		
	40	50	60
100	1.2	1.7	2.2
68		1.2	
100	1.2	1.7	2.2

FFS 55			
V0 (PC/H)	% No Pass		
	40	50	60
100	1.2	1.7	2.2
107		1.8	
100	1.2	1.7	2.2

FFS 60			
V0 (PC/H)	% No Pass		
	40	50	60
100	1.2	1.7	2.2
107		1.8	
100	1.2	1.7	2.2

Exhibit 15-15
ATS Adjustment Factor for No-Passing Zones ($f_{np,ATS}$)

Opposing Demand Flow Rate, v_o (pc/h)	Percent No-Passing Zones ≤20	40	60	80	100
FFS ≥ 65 mi/h					
≤100	1.1	2.2	2.8	3.0	3.1
200	2.2	3.3	3.9	4.0	4.2
400	1.6	2.3	2.7	2.8	2.9
600	1.4	1.5	1.7	1.9	2.0
800	0.7	1.0	1.2	1.4	1.5
1,000	0.6	0.8	1.1	1.1	1.2
1,200	0.6	0.8	0.9	1.0	1.1
1,400	0.6	0.7	0.9	0.9	0.9
≥1,600	0.6	0.7	0.7	0.7	0.8
FFS = 60 mi/h					
≤100	0.7	1.7	2.5	2.8	2.9
200	1.9	2.9	3.7	4.0	4.2
400	1.4	2.0	2.5	2.7	3.9
600	1.1	1.3	1.6	1.9	2.0
800	0.6	0.9	1.1	1.3	1.4
1,000	0.6	0.7	0.9	1.1	1.2
1,200	0.5	0.7	0.9	0.9	1.1
1,400	0.5	0.6	0.8	0.8	0.9
≥1,600	0.5	0.6	0.7	0.7	0.7
FFS = 55 mi/h					
≤100	0.5	1.2	2.2	2.6	2.7
200	1.5	2.4	3.5	3.9	4.1
400	1.3	1.9	2.4	2.7	2.8
600	0.9	1.1	1.6	1.8	1.9
800	0.5	0.7	1.1	1.2	1.4
1,000	0.5	0.6	0.8	0.9	1.1
1,200	0.5	0.6	0.7	0.9	1.0
1,400	0.5	0.6	0.7	0.7	0.9
≥1,600	0.5	0.6	0.6	0.6	0.7

Vi,PTSF=Vi/(PHF*fg,PTSF*fHV,PTSF)

fg,PTSF	0.73	0.73
Demand Volume	27.9	44.9
Vi,PTSF=	23	37

Exhibit 15-16
PTSF Grade Adjustment Factor ($f_{g,PTSF}$) for Level Terrain, Rolling Terrain, and Specific Downgrades

Directional Demand Flow Rate, v_{vph} (veh/h)	Level Terrain and Specific Downgrades	Rolling Terrain
≤100	1.00	0.73
200	1.00	0.80
300	1.00	0.85
400	1.00	0.90
500	1.00	0.96
600	1.00	0.97
700	1.00	0.99
800	1.00	1.00
≥900	1.00	1.00

Note: Interpolation to the nearest 0.01 is recommended.

fHV,PTSF=1/(1+PT*(ET-1)+PR*(ER-1))

PT	26%	24%	
PR	0	0	<==assuming 0
ET	0.1	0.1	
FHV,PTSF=	1.90	1.90	

Exhibit 15-18
PTSF Passenger Car Equivalents for Trucks (E_T) and RVs (E_R) for Level Terrain, Rolling Terrain, and Specific Downgrades

Vehicle Type	Directional Demand Flow Rate, v_{vph} (veh/h)	Level and Specific Downgrade	Rolling
	≤100	1.1	1.9
	200	1.1	1.8
	300	1.1	1.7
	400	1.1	1.6
Trucks, E_T	500	1.0	1.4
	600	1.0	1.2
	700	1.0	1.0
	800	1.0	1.0
	≥900	1.0	1.0
RVs, E_R	All	1.0	1.0

Note: Interpolation in this exhibit is not recommended.

PTSF=BPTSF+fnp,PTSF*(Vd,PTSF/(Vd,PTSF+V0,PTSF)

PTSF=	26	28

BPTSF=100(1-exp(aVd^b))

a	-0.0014	-0.001
b	0.973	0.973
BPTSF=	3	5

Exhibit 15-20
PTSF Coefficients for Use in Equation 15-10 for Estimating BPTSF

Opposing Demand Flow Rate, v_o (pc/h)	Coefficient *a*	Coefficient *b*
≤200	-0.0014	0.973
400	-0.0022	0.923
600	-0.0033	0.870
800	-0.0045	0.833
1,000	-0.0049	0.829
1,200	-0.0054	0.825
1,400	-0.0058	0.821
≥1,600	-0.0062	0.817

Note: Straight-line interpolation of *a* to the nearest 0.0001 and *b* to the nearest 0.001 is recommended.

fnp,PTSF	46.4	46.4
total 2-way flow rate	46	74

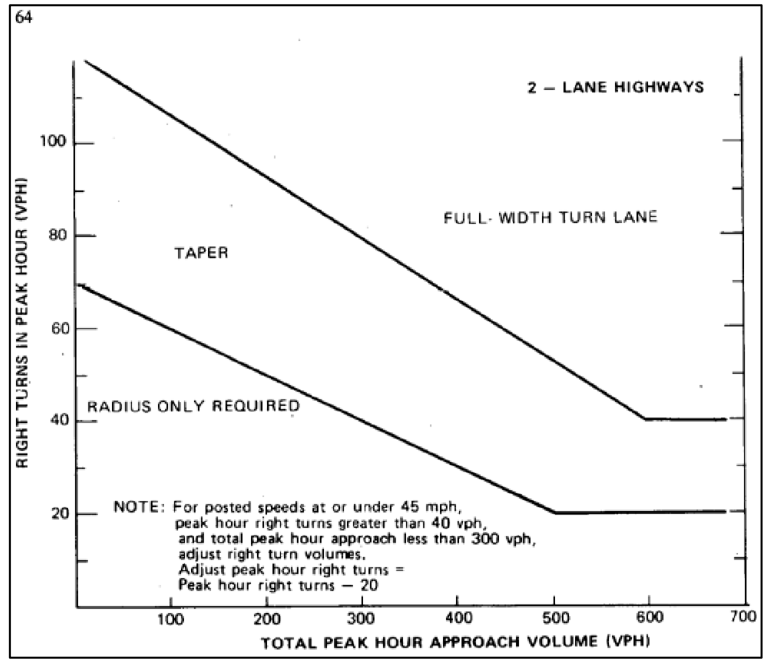
	%NPZ		
	40	50	60
200	43.4	46.4	49.4
46		46.4	
200	43.4	46.4	49.4

	%NPZ		
	40	50	60
200	43.4	46.4	49.4
74		46.4	
200	43.4	46.4	49.4

Exhibit 15-21
No-Passing-Zone Adjustment Factor ($f_{np,PTSF}$) for Determination of PTSF

Total Two-Way Flow Rate, $v = v_d + v_o$ (pc/h)	Percent No-Passing Zones 0	20	40	60	80	100
Directional Split = 50/50						
≤200	9.0	29.2	43.4	49.4	51.0	52.6
400	16.2	41.0	54.2	61.6	63.8	65.8
600	15.8	38.2	47.8	53.2	55.2	56.8
800	15.8	33.8	40.4	44.0	44.8	46.6
1,400	12.8	20.0	23.8	26.2	27.4	28.6
2,000	10.0	13.6	15.8	17.4	18.2	18.8
2,600	5.5	7.7	8.7	9.5	10.1	10.3
3,200	3.3	4.7	5.1	5.5	5.7	6.1
Directional Split = 60/40						

	Basis	Proposed
Mainline Demand Vol (Veh/HR)	49	79
HPCM - More than 100 Veh/HR		
Design Hourly Volume (Right Turns)	0	13
Speed Change Lane Required?	No	No



Right-turn lanes can be incorporated within standard cross sections that include parking lanes. Removal of parking upstream of the intersection creates the opportunity to develop an exclusive right-turn lane.

At suburban and high-speed rural intersections, design concerns should focus on right-turn lanes as a solution to potential rear-end conflicts. High volumes of right turns generated by shopping centers, developments, and office buildings may warrant construction of right-turn lanes of multilane highways. For 2-lane highways, volume warrants for right turns are generally much lower. This is because right and through vehicles are restricted to a single lane. Figure 4-23 and Table 4-7 can be consulted to provide guidance for including right-turn lanes.

Additional factors not explicitly covered in the volume warrants, but clearly appropriate in considering right-turn lanes, include:

1. Geometrics (both horizontal and vertical) that significantly affect the ease or speed of the right-turn maneuver.
2. Marked routes that make a turn (*Note:* these may require right-turn lanes regardless of volume considerations; driver expectations are important in this case).
3. Minimum stopping sight distance to the intersection (versus desirable stopping sight or decision sight distance).

Reconstruction / Rehabilitation

Table 4-7. Summary of state design practice in providing right-turn lanes on rural highways.

	Conditions Warranting Right Turn Lane off Major (Through) Highway		
State	**Through Volume**	**Right-Turn Volume**	**Highway Conditions**
Alaska	N/A	DHV = 25 vph	
Idaho	DHV = 200 vph	DHV = 5 vph	2-lane
Michigan	N/A	ADT = 600 vpd	2-lane
Minnesota	ADT = 1,500 vpd	All	Des. speed > 45 mph
Utah	DHV = 300 vph	crossroad ADT = 100 vpd	2-lane
Virginia	DHV = 500 All	DHV = 40 vph DHV = 120 vph	2-lane, Des. speed > 45 mph
	DHV = 1200 vph All	DHV = 40 vph DHV = 90 vph	4-lane
West Virginia	DHV = 500 vph	DHV = 250 vph	Divided highways
Wisconsin	ADT = 2500 vpd	crossroad ADT = 1000 vpd	2-lane

DHV—design hourly volume
ADT—average daily traffic

Left turn lane required?	
Opposing volume	38
No left turn lane required	

Table 9-23. Guide for Left-Turn Lanes on Two-Lane Highways (10)

Metric					U.S. Customary				
	Advancing Volume (veh/h)					Advancing Volume (veh/h)			
Opposing Volume (veh/h)	5% Left Turns	10% Left Turns	20% Left Turns	30% Left Turns	Opposing Volume (veh/h)	5% Left Turns	10% Left Turns	20% Left Turns	30% Left Turns
60-km/h Operating Speed					40-mph Operating Speed				
800	330	240	180	160	800	330	240	180	160
600	410	305	225	200	600	410	305	225	200
400	510	380	275	245	400	510	380	275	245
200	640	470	350	305	200	640	470	350	305
100	720	515	390	340	100	720	515	390	340
80-km/h Operating Speed					50-mph Operating Speed				
800	280	210	165	135	800	280	210	165	135
600	350	260	195	170	600	350	260	195	170
400	430	320	240	210	400	430	320	240	210
200	550	400	300	270	200	550	400	300	270
100	615	445	335	295	100	615	445	335	295
100-km/h Operating Speed					60-mph Operating Speed				
800	230	170	125	115	800	230	170	125	115
600	290	210	160	140	600	290	210	160	140
400	365	270	200	175	400	365	270	200	175
200	450	330	250	215	200	450	330	250	215
100	505	370	275	240	100	505	370	275	240

- From the outer edge of traveled way to the edge of the shoulder or 8 feet, whichever is greater, the driveway profile grade should be the same as the traveled way superelevation rate.
- From the outer edge of the shoulder, a vertical curve should connect the profile to a positive or negative grade, which will bring the driveway profile to the adjacent property grade

d. **Driveway with Curb Cuts**

- From the bottom face of curb or flow line, the driveway profile grade should slope uniformly upward at a grade not to exceed an algebraic difference of 8 percent with the adjacent lane or shoulder cross-slope.
- If a sidewalk or portion thereof remains to be crossed, the driveway profile may match the surface of the sidewalk.
- The profile should then follow a vertical curve or have an angle point, if necessary, to connect with a positive or negative grade, which will bring the driveway profile to the adjacent property grade.

e. **Vertical Curves:** Vertical curve should be symmetrical and as flat as feasible. Crest vertical curves should not exceed a 3¼-inch hump in a 12-foot chord, and sag vertical curves should not exceed a 2-inch depression in a 12-foot chord. Vertical curves must not have humps or depressions exceeding 3.6 inches in a 12-foot chord.

f. **Landings:** All driveways are to have landing zones. Landing length depends on anticipated traffic. Passenger cars require 12 feet minimum while semi-tractor trailers require 30 feet based on wheel bases.

g. **Pedestrian Areas:** Where curbed returns intersect a pedestrian way, provide appropriate handicapped access ramps.

11. **Speed Change Lane and Left-Turn Lanes:** On high-speed (50 mph or over) or high-volume arterial roadways, speed change lanes may be required for the acceleration or deceleration of vehicles entering or leaving the public roadway from or to a higher-volume traffic generation (greater than or equal to 100 vehicles per hour) or attracting development. Use Figure 4-3 of NCHRP 279 Intersection Channelization Design Guide as a guideline for the right-turn treatments. On a one-way street, the above criteria also apply to the left through lane. For guidelines on the need for left-turn lanes on a main street or road at a driveway, refer to Exhibit 9-75 in AASHTO *A Policy on the Geometric Design of Highways and Streets 2001.*

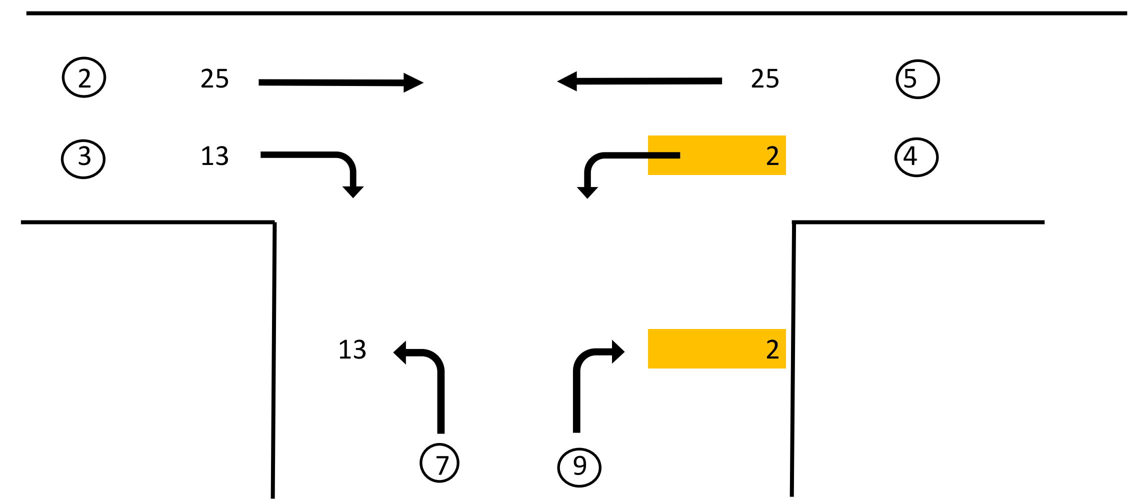
Traffic Info	
Traffic AK Hwy (Veh/HR)	49
Traffic New Road (Veh/HR)	30

	Base	Proposed
Directional Split	0.5	
East Bound	25	25
West Bound	25	25
Northbound	6	15
Southbound	6	15

Peak 15 Min

Hour Volumes	
V1	0
V2	25
V3	13
V4	2
V5	25
V6	0
V7	13
V9	2
V13	0
V14	0
V15	0

Mainline Left Turn LOS	A	
Northbound LOS	A	
Mainline Left Turn 95th Queue	0.004	Veh
Northbound 95th Queue	0.007	Veh



Manual Input Cells

VC,4=V2+V3+V15

VC,4= 38 Veh/HR

Vc,9=V2+0.5V3+V14+V15

Vc,9= 31 Veh/HR

Vc,7=(2*V1+2*V1U+V2+0.5*V3+V15)+(2*V4+2*V4U+V5+0.5*V6+V13)

Vc,7= 64 Veh/HR

tc,4=tc,base+tc,HV*PHV+tC,G*G-tc,LT

tc,4base	4.1	
tc,HV	1	
PHV	24%	
tC,G	-	
tc,LT	0	
tc,4=	4.3	sec

tc,9base	6.2	
t,LT	0	
tc,9=	6.4	sec

tc,7base	7.1	
t,LT	0.7	
tc,7=	6.6	sec

$t_{c,x}$ = critical headway for movement x (s),

$t_{c,\text{base}}$ = base critical headway from Exhibit 20-12 (s),

$t_{c,HV}$ = adjustment factor for heavy vehicles (1.0 for major streets with one lane in each direction; 2.0 for major streets with two or three lanes in each direction) (s),

P_{HV} = proportion of heavy vehicles for movement (expressed as a decimal; e.g., $P_{HV} = 0.02$ for 2% heavy vehicles),

$t_{c,G}$ = adjustment factor for grade for given movement (0.1 for Movements 9 and 12; 0.2 for Movements 7, 8, 10, and 11) (s),

G = percentage grade (expressed as an integer; e.g., $G = -2$ for a 2% downhill grade), and

$t_{3,LT}$ = adjustment factor for intersection geometry (0.7 for minor-street left-turn movement at three-leg intersections; 0.0 otherwise) (s).

Vehicle Movement	Base Critical Headway, $t_{c,\text{base}}$ (s) Two Lanes	Four Lanes	Six Lanes
Left turn from major street	4.1	4.1	5.3
U-turn from major street	NA	6.4 (wide)[a] 6.9 (narrow)[a]	5.6
Right turn from minor street	6.2	6.9	7.1
Through traffic on minor street	1 stage: 6.5 2 stage, Stage I: 5.5 2 stage, Stage II: 5.5	1 stage: 6.5 2 stage, Stage I: 5.5 2 stage, Stage II: 5.5	1 stage: 6.5[b] 2 stage, Stage I: 5.5[b] 2 stage, Stage II: 5.5[b]
Left turn from minor street	1 stage: 7.1 2 stage, Stage I: 6.1 2 stage, Stage II: 6.1	1 stage: 7.5 2 stage, Stage I: 6.5 2 stage, Stage II: 6.5	1 stage: 6.4 2 stage, Stage I: 7.3 2 stage, Stage II: 6.7

Notes: NA = not available.
[a] Narrow U-turns have a median nose width <21 ft; wide U-turns have a median nose width ≥21 ft.
[b] Use caution; values estimated.

tf,4=tf,base+tf,HV*PHV

tv,HV	0.9	
PHV	24%	
tf,4=	2.4	sec
tf,9=	3.5	sec
tf,7=	3.7	sec

$$t_{f,x} = t_{f,\text{base}} + t_{f,HV} P_{HV}$$

Equation 20-31

where

$t_{f,x}$ = follow-up headway for movement x (s),

$t_{f,\text{base}}$ = base follow-up headway from Exhibit 20-13 (s),

$t_{f,HV}$ = adjustment factor for heavy vehicles (0.9 for major streets with one lane in each direction; 1.0 for major streets with two or three lanes in each direction), and

P_{HV} = proportion of heavy vehicles for movement (expressed as a decimal; e.g., $P_{HV} = 0.02$ for 2% heavy vehicles).

Exhibit 20-13
Base Follow-Up Headways for TWSC Intersections

Vehicle Movement	Base Follow-Up Headway, $t_{f,\text{base}}$ (s) Two Lanes	Four Lanes	Six Lanes
Left turn from major street	2.2	2.2	3.1
U-turn from major street	NA	2.5 (wide)[a] 3.1 (narrow)[a]	2.3
Right turn from minor street	3.3	3.3	3.9
Through traffic on minor street	4.0	4.0	4.0
Left turn from minor street	3.5	3.5	3.8

Notes: NA = not available.
[a] Narrow U-turns have a median nose width <21 ft; wide U-turns have a median nose width ≥21 ft.

Cp,4=	1,445	Veh/HR
Cp,9=	985	Veh/HR
cp,7=	891	Veh/HR

Cm,4=Cp,4
Cm,9=Cp,9

The potential capacity $c_{p,x}$ of a movement is computed according to the gap acceptance model provided in Equation 20-32 (7).

$$c_{p,x} = v_{c,x} \frac{e^{-v_{c,x}t_{c,x}/3,600}}{1 - e^{-v_{c,x}t_{f,x}/3,600}}$$

Equation 20-32

where

$c_{p,x}$ = potential capacity of movement x (veh/h),

$v_{c,x}$ = conflicting flow rate for movement x (veh/h),

Chapter 20/Two-Way STOP-Controlled Intersections
Version 6.0.1

Motorized Vehicle Core Metho
Page

ghway Capacity Manual: A Guide for Multimodal Mobility Analysis

$t_{c,x}$ = critical headway for minor movement x (s), and

$t_{f,x}$ = follow-up headway for minor movement x (s).

P0,4=1-(V4/Cm,4)		
P0,4=	1.00	
Cm,7=	890	Veh/HR
CSH,NB=(V7+V9)/(V7/Cm,7)+(V9/Cm,9)	902	Veh/HR

d4=3600/Cm,4+900*T((V4/Cm,4)-1+ sqrt((V4/Cm,4)-1)^2+ ((3600/Cm,4)*(V4/Cm,4))/450*T)+5	7.5	sec	LOS	A
T	0.25			
3600/Cm,4	2.49			
V4/Cm,4	0.00138			

Equation 20-64

$$d = \frac{3,600}{c_{m,x}} + 900T\left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3,600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{450T}}\right] + 5$$

where

d = control delay (s/veh),

v_x = flow rate for movement x (veh/h),

$c_{m,x}$ = capacity of movement x (veh/h), and

T = analysis time period (0.25 h for a 15-min period) (h).

A constant value of 5 s/veh is used to reflect delay during deceleration to and acceleration from a stop.

The constant 5 s/veh is included in Equation 20-64 to account for the deceleration of vehicles from free-flow speed to the speed of vehicles in the queue and the acceleration of vehicles from the stop line to free-flow speed.

dSH,NB=3600/CSH,NB+900*T((V4/CSH,NB)-1+ sqrt((V4/CSH,NB)-1)^2+ ((3600/CSH,NB)*(V4/CSH,NB))/450*T)+5	9.0	sec	LOS	A
T	0.25			
3600/CSH,NB	3.99			
V4/CSH,NB	0.00222			

Exhibit 20-2
LOS Criteria: Motorized Vehicle Mode

Control Delay (s/veh)	LOS by Volume-to-Capacity Ratio $v/c \le 1.0$	$v/c > 1.0$
0–10	A	F
>10–15	B	F
>15–25	C	F
>25–35	D	F
>35–50	E	F
>50	F	F

Note: The LOS criteria apply to each lane on a given approach and to each approach on the minor street. LOS is not calculated for major-street approaches or for the intersection as a whole.

Q95,4	0.004
T	0.25
3600/Cm,4	2.49
V4/Cm,4	0.00138
900T	225
(V4/Cm,4)-1	(0.998616)
(3600/Cm,4)*(V4/Cm,4)	0.003449181
150T	37.5
Cm,4/3600	0.40

Q95,NB	0.007
V4/CSH,NB	0.0022
V4/CSH,NB-1	-0.99778
3600/CSH,NB	3.99
CSH,NB/3600	0.25

Equation 20-68

$$Q_{95} \approx 900T\left[\frac{v_x}{c_{m,x}} - 1 + \sqrt{\left(\frac{v_x}{c_{m,x}} - 1\right)^2 + \frac{\left(\frac{3{,}600}{c_{m,x}}\right)\left(\frac{v_x}{c_{m,x}}\right)}{150T}}\right]\left(\frac{c_{m,x}}{3{,}600}\right)$$

where

Q_{95} = 95th percentile queue (veh),
v_x = flow rate for movement x (veh/h),
$c_{m,x}$ = capacity of movement x (veh/h), and
T = analysis time period (0.25 h for a 15-min period) (h).