Some of the following slides have been modified after the March 21, 2023 presentation. These changes are noted on the revised slides. Inserted a new sheet 74, changed page numbers of the existing slides 74-91 to 74-92.

Alaska Department of Transportation & Public Facilities

Alaska-Richardson-Steese Hwys Corridor Action Plan

Engineering Elements Discussion

Transportation Advisory Committee Meeting

March 21, 2023

Engineering Analysis Discussion

- Phase 1: current, short-term (5 years), and medium-term (10 years) conditions- Evaluate corridor uses, safety, operations without and with Manh Choh *B-Train* mine ore haul vehicles.
- 60 loaded B-Trains northbound trips and 60 unloaded B-Train southbound trips, daily.

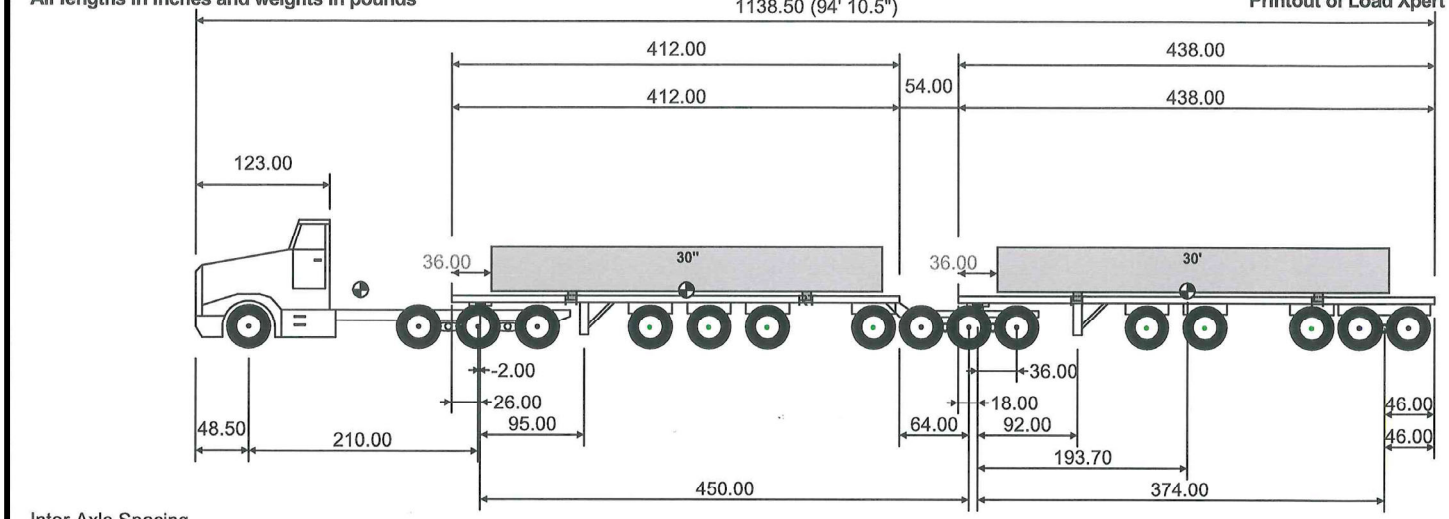
Engineering Analysis Discussion

This TAC meeting will these cover these analyses modules:

- Corridor system attributes
- Crash History (All corridor, rural and urban segments and intersections)
- B-Train Stopping Sight Distance
- B-Train operational impact on traffic speeds and potential safety impacts (rural segments)
- B-Train impacts to the pavement structure (rural segments)

B-Train Configuration

All lengths in inches and weights in pounds — Printout of Load Xpert software



Inter Axle Spacing (Total =1066)

156 | 54 | 54 | 104 | 54 | 54 | 98 | 44 | 44 | 44 | 120 | 54 | 98 | 44 | 44

238-5151 | 745-54-98-44-PR | 536-54-98-44

Axle Loads:	#1 (lb)	#2 (lb)	#3 (lb)	#4 (lb)	#5 (lb)	#6 (lb)	#7 (lb)	#8 (lb)	#9 (lb)	#10 (lb)	#11 (lb)	Total (lb)
Tare:	10271	23700	0	0	0	0	19429	0	0	0	9000	62400
Accessories:	0	0	0	0	0	0	0	0	0	0	0	0
Payload:	-130	13784	9000	9000	9000	9000	15330	9000	9000	9000	10516	102500
Total:	10141	37484	9000	9000	9000	9000	34759	9000	9000	9000	19516	164900
Desired/(GVW)*:	13000	42500	9000	9000	9000	9000	41000	9000	9000	9000	24000	-
GAWR/(GVWR*):	-	-	-	-	-	-	-	-	-	-	-	-

Unit:	1 (Tractor)	2 (Trailer)	3 (Trailer)	Vehicle
Tare weight (lb):	20400	23500	18500	62400
Accessories(lb):	0	0	0	0
Payload (lb):	0	52000	50500	102500
Total (lb):	20400	75500	69000	164900
Overall C.G. height (in):	N/A	N/A	N/A	

18" Kin Pin 24" Back Axle.

Title: Company: Date:

≈ 165,000 lbs, gross vehicle weight (GVW)

- Tractor: Kenworth T880, 565 HP➔≈290 lbs/HP.
- 16 axles of which 7 retract. Single and dual tires.
- All disc brakes.
- Width of tractor and trailers are 102 inches, not oversized.

Corridor System Attributes Module

National or Alaska Highway System

- **National Highway System (NHS): "**The NHS includes the Interstate System; Congressional High Priority Routes; National Defense Roads (i.e. the Strategic Highway Network); and principal arterial routes or other routes that connect intermodal facilities."

- **Alaska Highway System (AHS)**: "The Alaska Highway System includes existing or planned surface facilities that are of statewide significance though not included in the National Highway System."

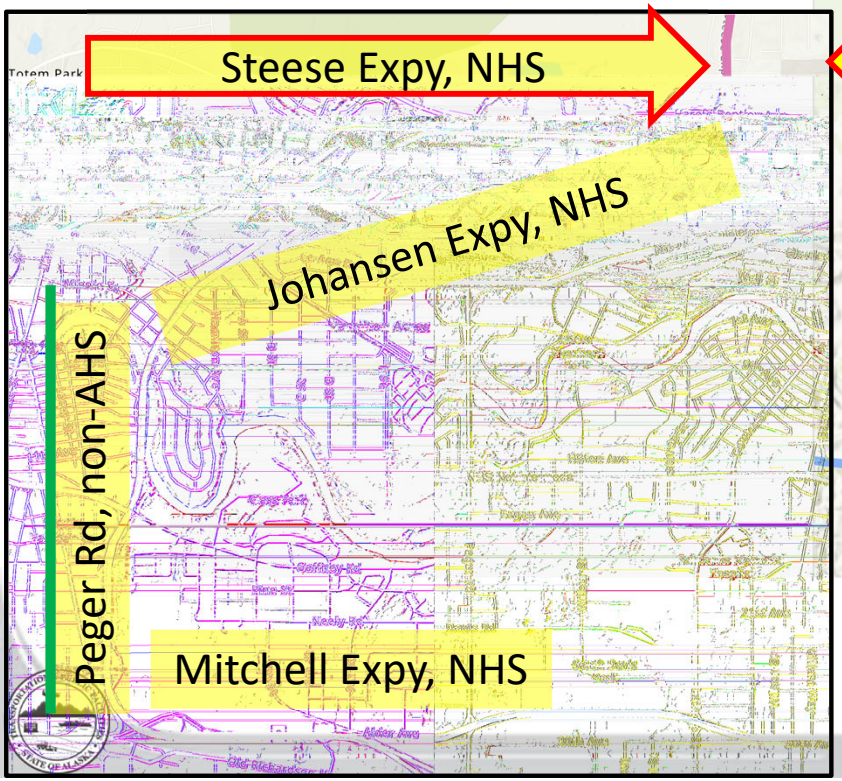
NHS and AHS

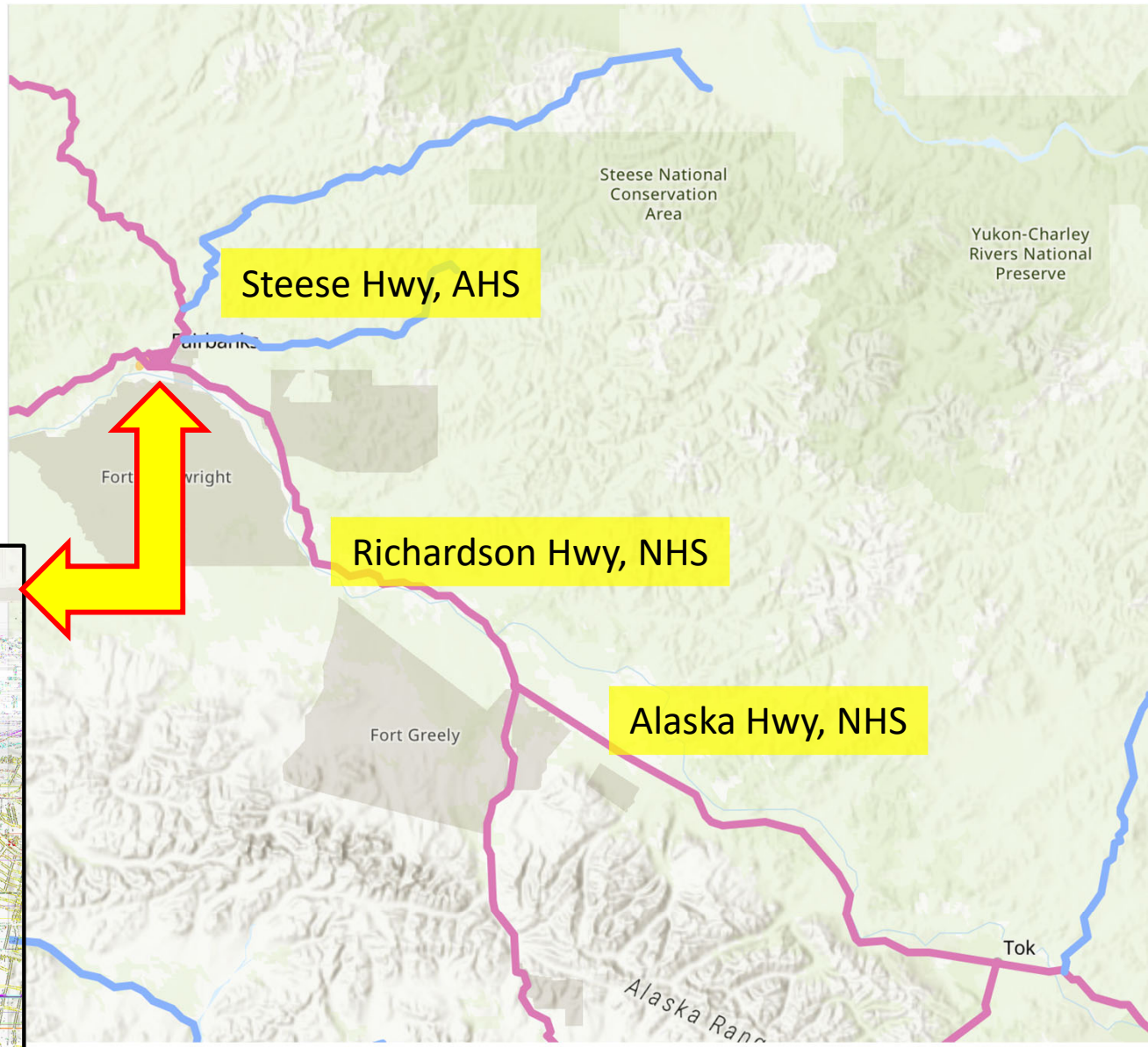
Route Designations

Alaska Highway System (AHS)

National Highway System (NHS)

- NHS NOT INTERMODAL
- NHS IM AIRPORT TERMINAL
- NHS IM PORT TERMINAL
- NHS IM FERRY TERMINAL





System Functional Classification- Local and Collector Class

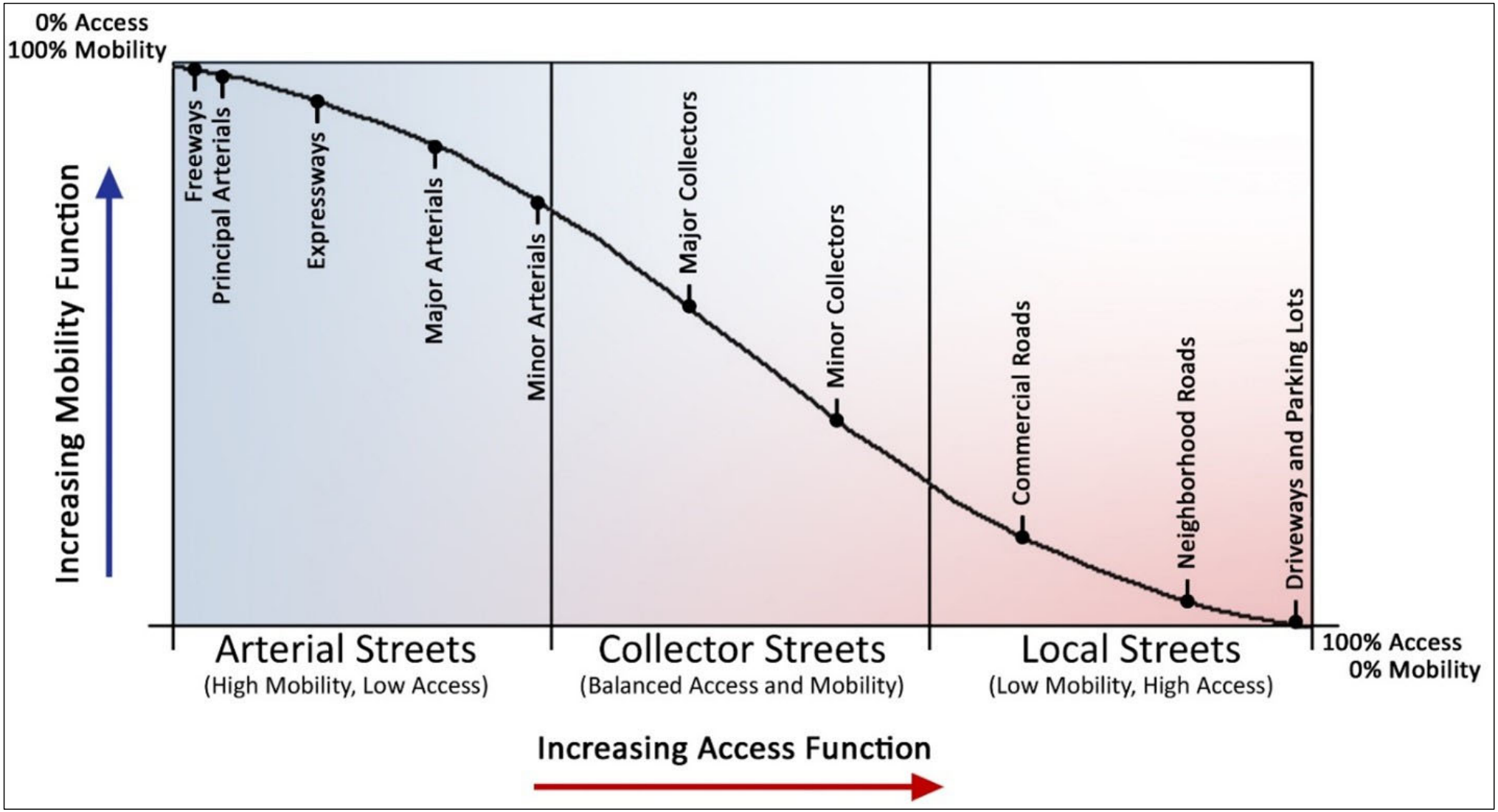
- **Local Road/Street:** "A street or road primarily for access to homes, businesses, or other abutting property.

- **Collector Road/Street:** "Collector streets serve a dual function: collecting traffic for movement between arterial streets and local roads, and providing access to abutting properties. Collector streets link neighborhoods or areas of homogenous land use with the arterial street systems. These streets not only serve traffic movements between arterials and local streets, but also serve through traffic within local areas."

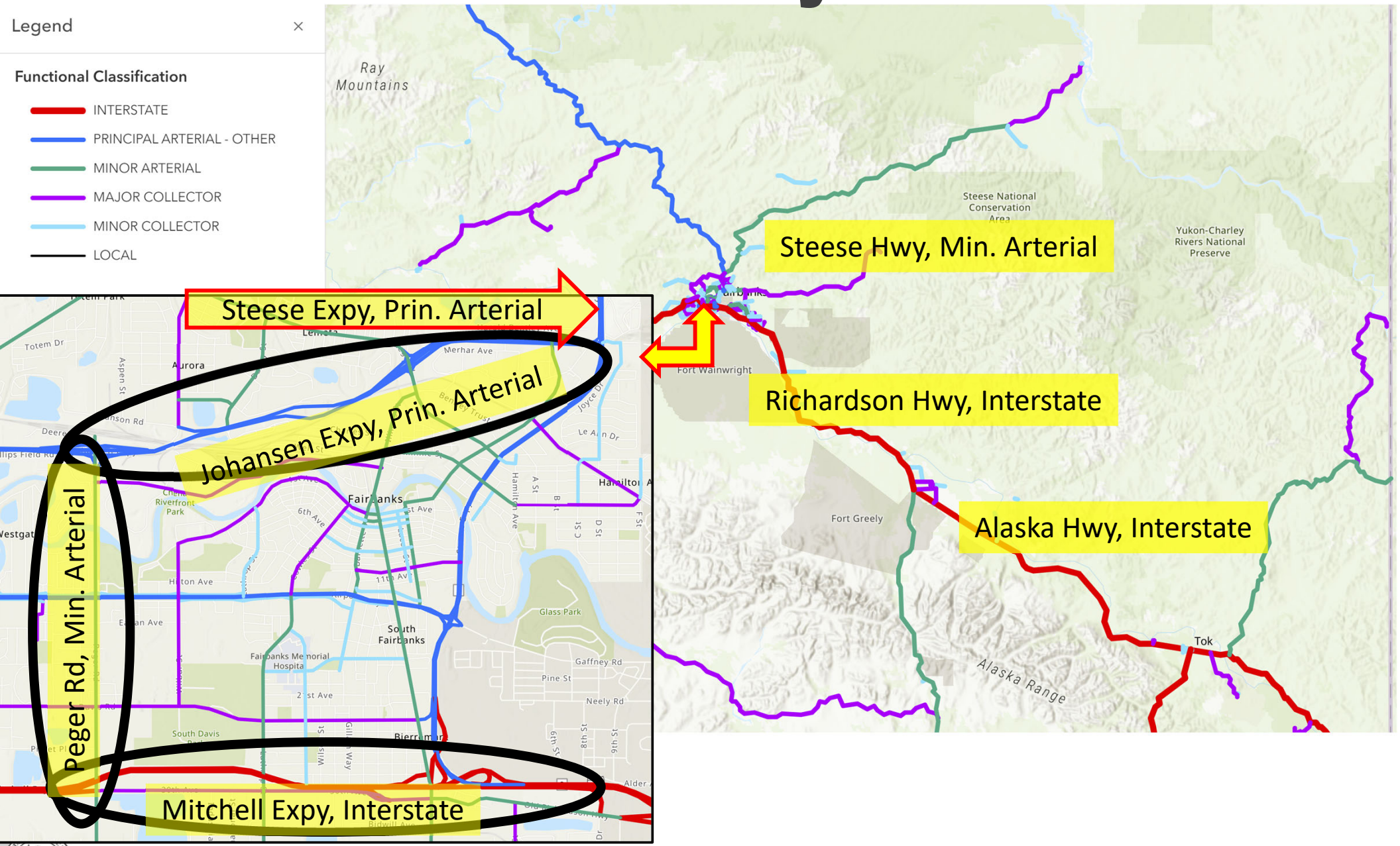
System Functional Classification- Arterial Class

- **Arterial Street/Road/Highway:** "That portion of the road system which provides a high-volume, higher speed network for travel between major points in both rural and urban areas."
- Arterial sub-categories include:
  - Major or minor.
  - Expressway: "A high-speed divided arterial highway for through traffic with access partially or fully controlled and grade-separations at major intersections."
  - Interstate: "Interstate is the highest level of principal arterial, primarily rural. Interstates connect large population centers." *Note that Alaska interstate highways do not resemble interstate freeways in the lower 48.*

Functional Class- Mobility vs. Access



Functional Classification ARS Corridor Roadways



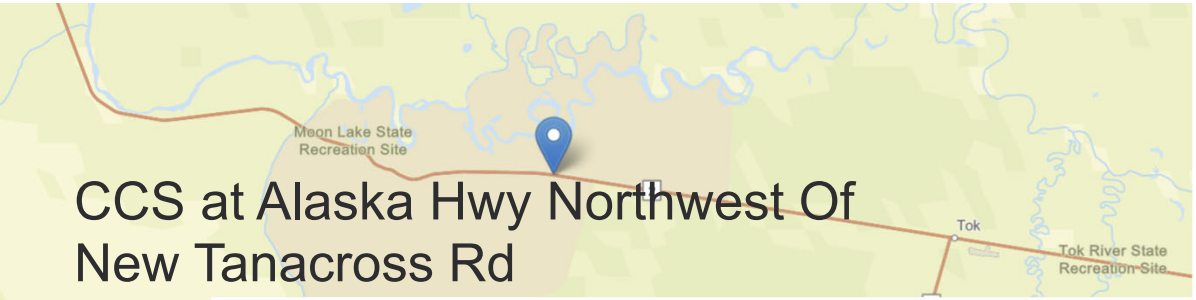
Traffic Volumes- Average Annual Daily Traffic (AADT)

- Used for design standards, safety performance models.
- AADT= All of the vehicles occupying road segment in one year, divided by 365.
- Collected by Continuous Count Station (CCS) collecting traffic data all year round
- Short-Term Stations (STS) collect a week or so of data and apply day and month factors from near CCS for intermediate roadway segment estimates.

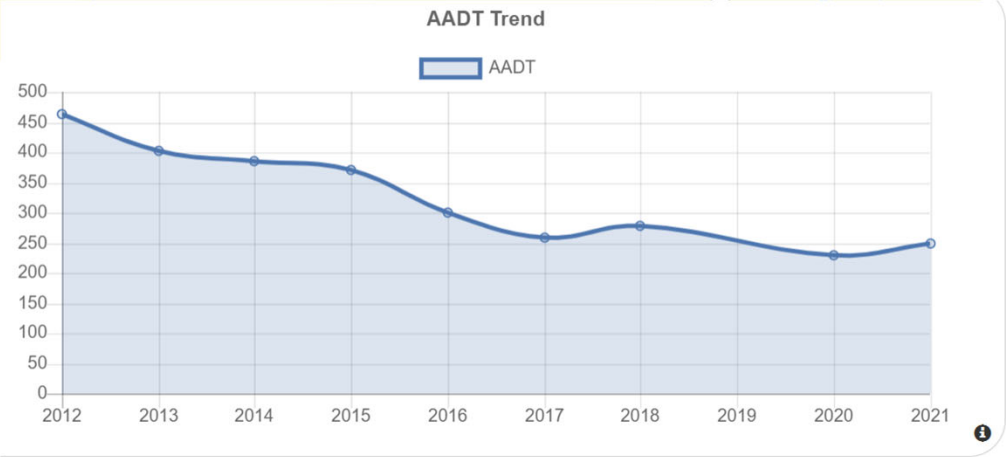
Traffic Volumes-Design Hourly Volumes (DHV)

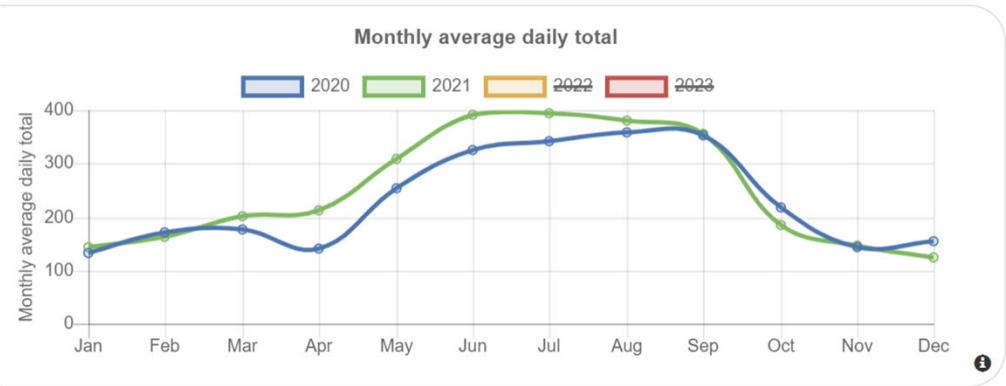
- Also used for some design standards, and capacity studies
- Common DHV is for 30th highest hour occurring 20 years in the future.
- CCS and STS provide DHV data.

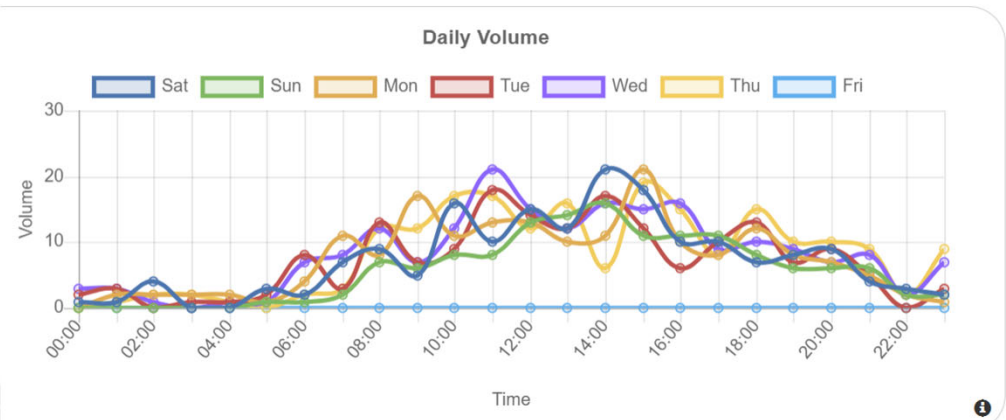
Continuous Count Station



CCS at Alaska Hwy Northwest Of New Tanacross Rd





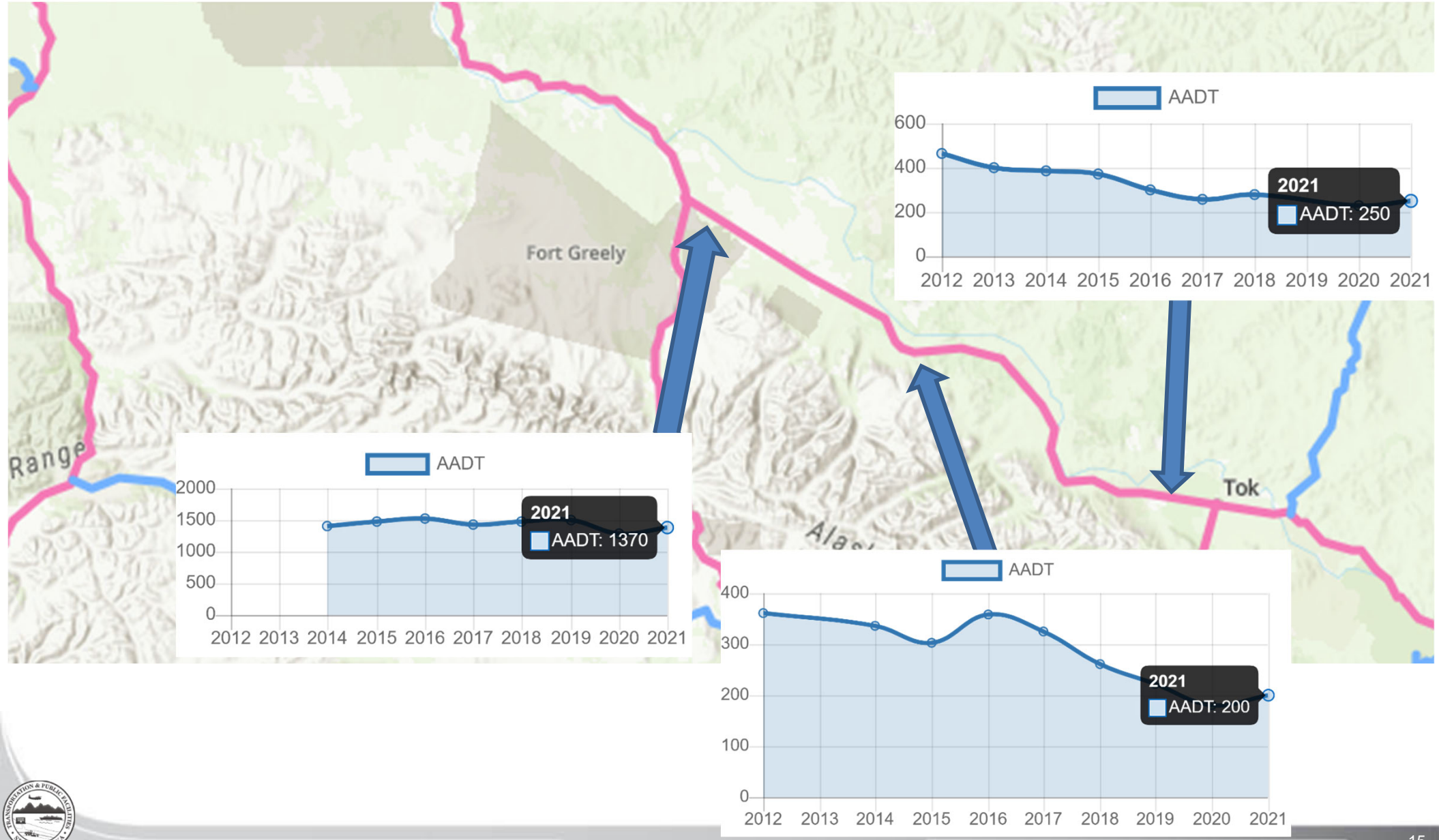


Vehicle Classification

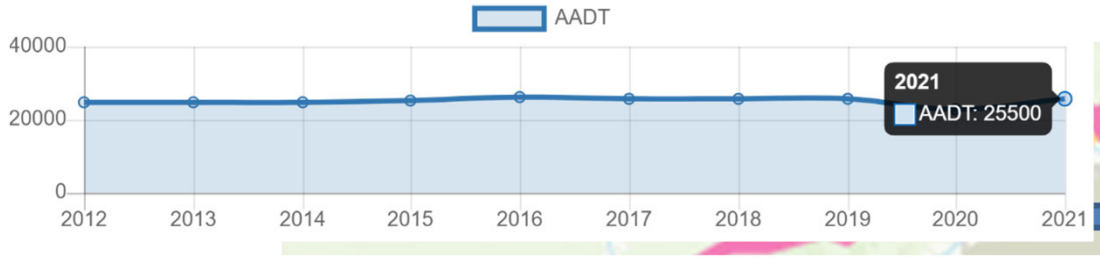
1. Motorcycles 2 axles, 2 or 3 wheels.	0%
2. Passenger cars 2 axles. Can have 1- or 2-axle trailers.	37.15%
3. Pickups, panels, vans 2-axle, 4-tire single units. Can have 1- or 2-axle trailers.	42.36%
4. Buses 2- or 3-axle, full length.	0.28%
5. Single-unit trucks 2-axle, 6-tire, (dual rear tires), single-unit trucks.	7.54%
6. Single-unit trucks 3-axle, single-unit trucks.	0.47%
7. Single-unit trucks 4 or more axle, single-unit trucks.	0%
8. Single-trailer trucks 3- or 4-axle, single-trailer trucks.	0.47%
9. Single-trailer trucks 5-axle, single-trailer trucks.	9.59%
10. Single-trailer trucks 6 or more axle, single-trailer trucks.	1.77%
11. Multi-trailer trucks 5 or less axle, multi-trailer trucks.	0%
12. Multi-trailer trucks 6-axle, multi-trailer trucks.	0%
13. Multi-trailer trucks 7 or more axle, multi-trailer trucks.	0.19%

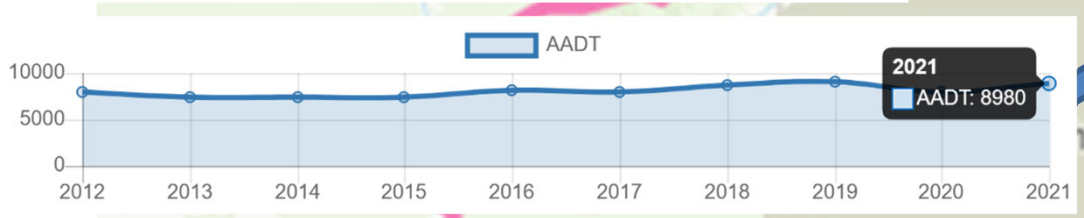
This slide has been modified after the March 21, 2023 presentation. Added CCS location.

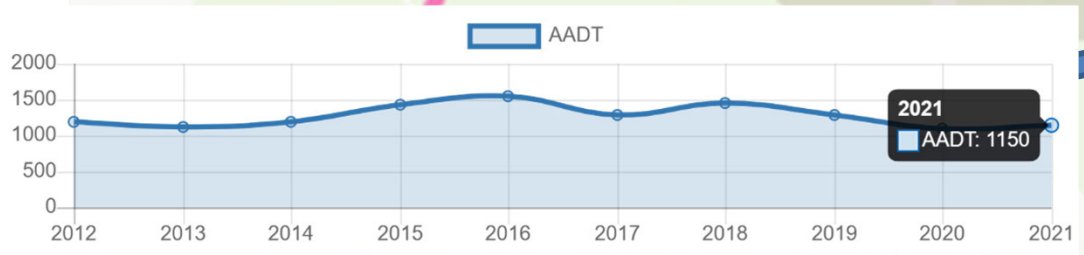
Alaska Hwy AADT

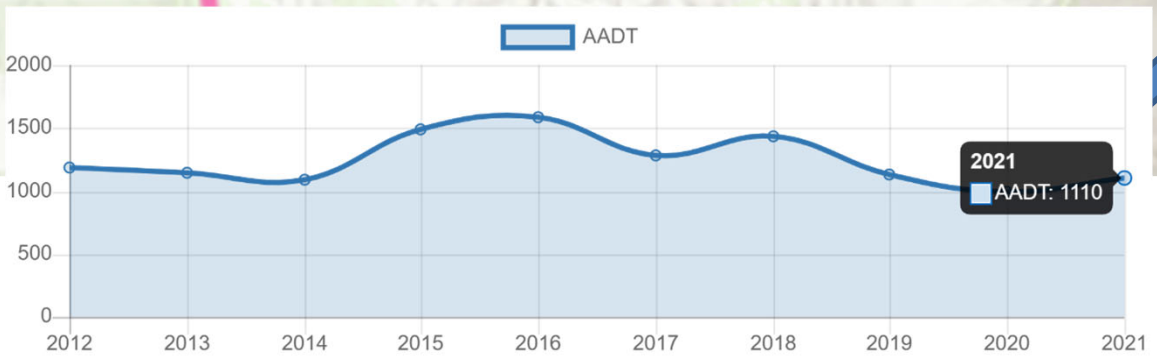


Richardson Hwy AADT

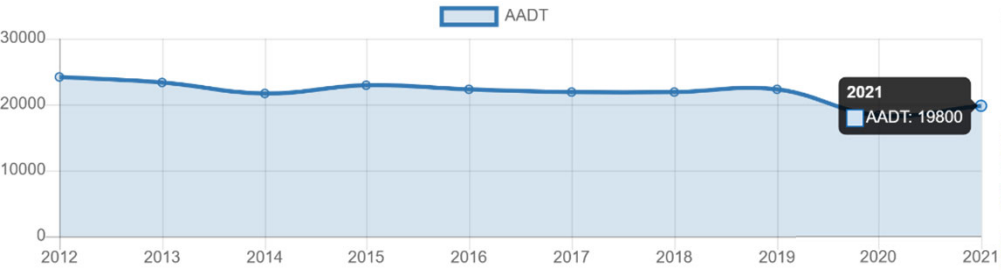


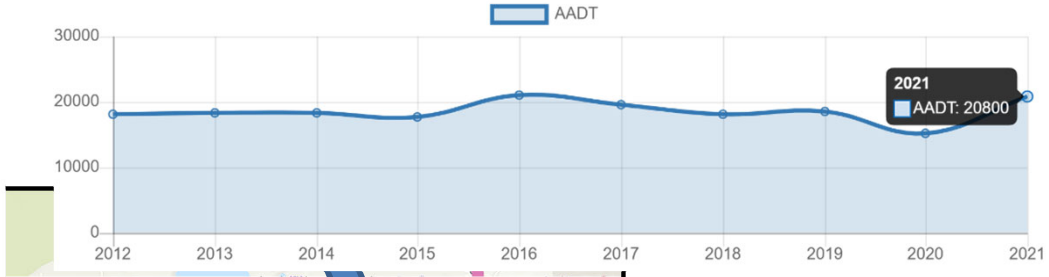


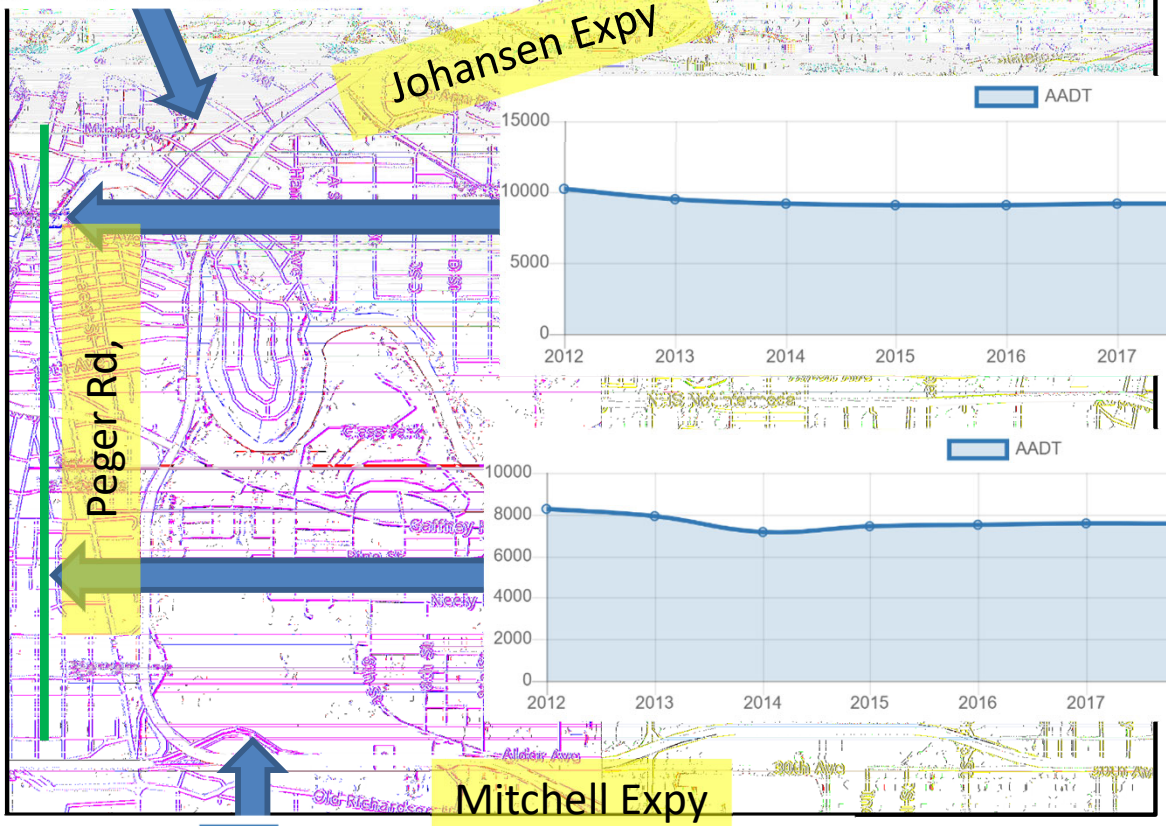


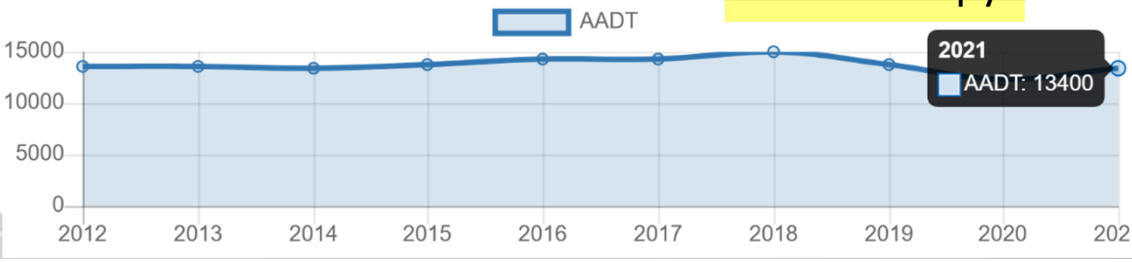


Fairbanks AADT

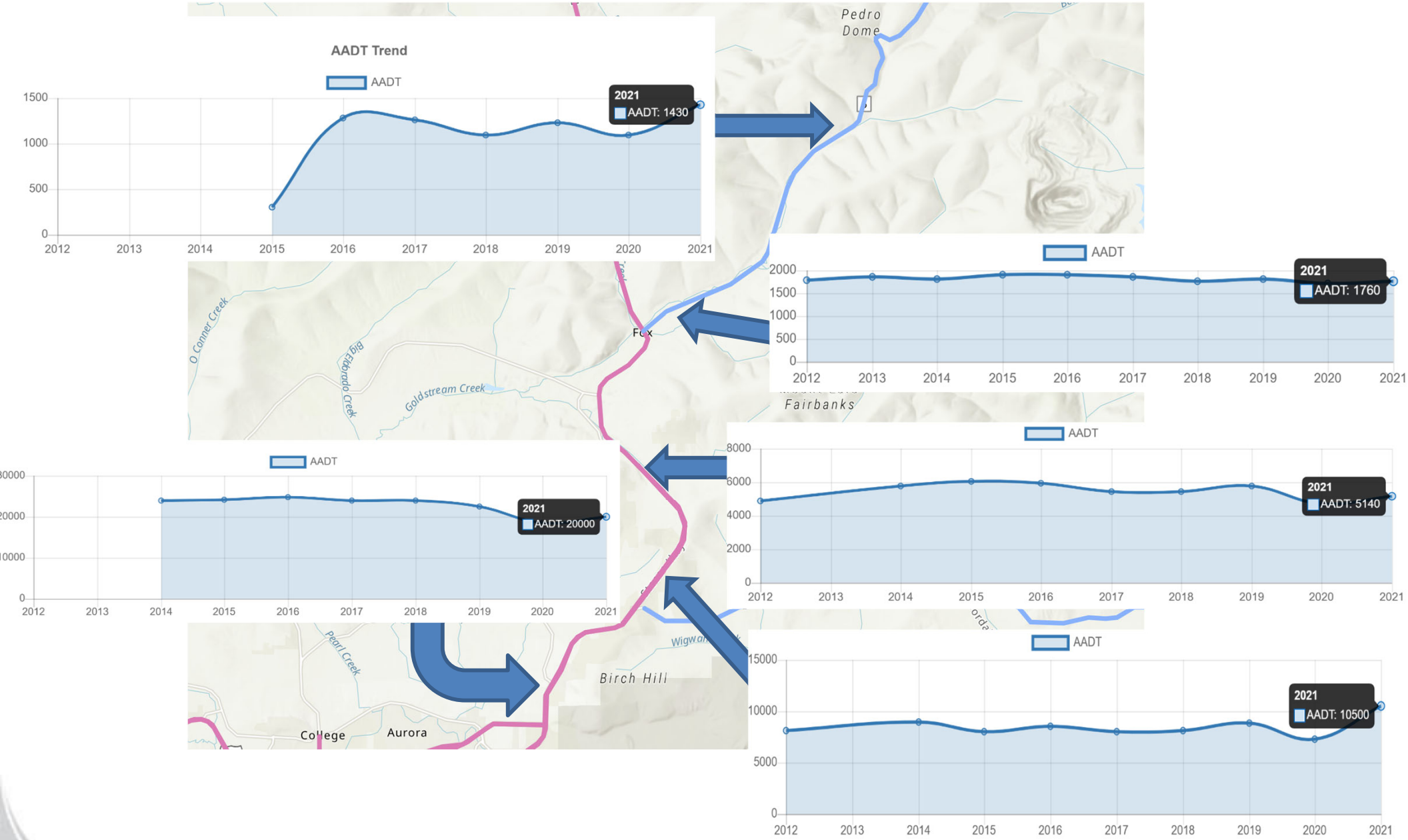








Steese Expy & Hwy AADT



Corridor System Attributes Module Summary

- B-Train industrial use is consistent with corridor NHS and AHS system designations.
- Functional classification of proposed haul corridor segments are consistent with B-Train industrial use. The B-Trains use higher mobility functional class roads, and avoid collector and local segments.
- The mine generates 120 B-Train vehicles per day. (Support traffic is not known at this point).
  - AADT impacts highest on the Alaska Highway (>50% increase)
- Short-term background traffic growth is expected to be 1% to 1.5% per year. (Provided by DOT&PF)

Crash History Module

Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash Analysis Methodology

*Includes partial 2022 Crash Data

2185 recorded crashes on the proposed ARS corridor (2013-2021).*

To evaluate the safety performance of this corridor and create a predictive model for future crashes, we begin by conducting an in-depth analysis of existing crash history, factors and circumstances within the study area including:

- *Type of crashes (single vs. multiple vehicle, roadway departure, animal related, fixed object, barrier, etc.)*
- *Road surface condition (dry, wet, snow/ice, dirt, etc.)*
- *Ambient Light (daylight, dawn/dusk, dark with and without streetlight, etc.)*
- *Type of vehicles involved (passenger car, suv, pickup, motorcycle, pedestrian or bicycle, van, bus, tractor trailers, tow trucks, tankers, panel trucks, etc.)*
- *Crash Rates (based on number of crashes, segment length, and traffic volumes)*
- *Locations displaying clusters of crashes (intersections, geometric features, bridges, urban vs. rural areas, etc.)*
- *Highway segment and intersection entering traffic volumes*

Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash Analysis Methodology

*Includes partial 2022 Crash Data

Annualized Signalized Intersection Crash Rates in ARS Corridor

ARS Corridor - Annualized Signalized Intersection Crash Rates

Intersection Name		2013 -2021 Crashes			Total Crashes (2013-2021)	Average Number of Crashes per Year	Average Annual Daily Entering Volume	Annual Crash Rate*	2018 Alaska DOT/PF Average Crash Rate**	Above DOT/PF Average Crash Rate?
Main Street	Cross Street	Fatal	Serious	Minor and/or PDO						
Parks/Mitchell Expwy	Lathrop St	0	1	42	43	4.8	20593	0.636	1.57	no
Parks/Mitchell Expwy	Peger Road	0	0	17	17	1.9	17200	0.301	1.57	no
Peger Road	Davis Rd	0	0	37	37	4.1	16590	0.679	1.57	no
Peger Road	Airport Way	0	1	152	153	17.0	30372	1.534	1.57	no
Peger Road	Phillips Field Rd	0	1	65	66	7.3	18222	1.103	1.57	no
Johansen Expwy	Danby St	0	0	67	67	7.4	24770	0.823	1.57	no
Johansen Expwy	Hunter St	0	0	17	17	1.9	29263	0.177	1.57	no
Johansen Expwy	Old Steese Hwy	0	0	17	17	1.9	27417	0.189	1.57	no
Johansen Expwy	Steese Hwy	0	1	42	43	4.8	22531	0.581	1.57	no
Steese Expwy	Farmers Loop Rd	0	1	75	76	8.4	20713	1.117	1.57	no

* Annual Crash Rate Formula for Intersections: (Average Number of Crashes per Year) x (1,000,000)/(365 Days x Average Annual Daily Entering Volume)

** Value calculated by Alaska DOT/PF for the Annual Highway Safety Improvement Program (HSIP) depicting average crash rates for similar intersection types.

Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash Analysis Methodology

*Includes partial 2022 Crash Data

Annualized Highway Segment Crash Rates in ARS Corridor

Segment Information			Segment Length (miles)	2013-2021 Crashes			Total Crashes	Average Number of Crashes per Year	Average Segment Volume	Annual Segment Crash Rate*	2018 Alaska DOT/PF Average Crash Rate**	Above DOT/PF Average Crash Rate?
Highway	Segment Begin	Segment End		Fatal	Serious	Minor and/or PDO						
Alaska Highway	Tanana River	Richardson Highway (Delta)	118.101	5	10	177	192	21.3	400	1.24	2.30	No
Richardson Highway	Nistler Road (Delta)	Parks/Mitchell Jct	93.20	9	28	871	908	100.9	4440	0.67	2.3/1.3	No
Parks/Mitchell Expressway	Richardson Highway	Peger Road	2.605	0	1	36	37	4.1	15140	0.29	1.30	No
Peger Road	Parks/Mitchell Expressway	Johansen Expressway On-Ramp	2.112	0	0	60	60	6.7	11720	0.74	1.90	No
Johansen Expressway	Peger Road	Steese Highway	2.769	2	0	73	75	8.3	19160	0.43	1.30	No
Steese Expressway/Highway	Johansen Expressway	Pedro Dome Road	17.953	4	6	175	185	20.6	5510	0.57	2/1.3/2.3	No

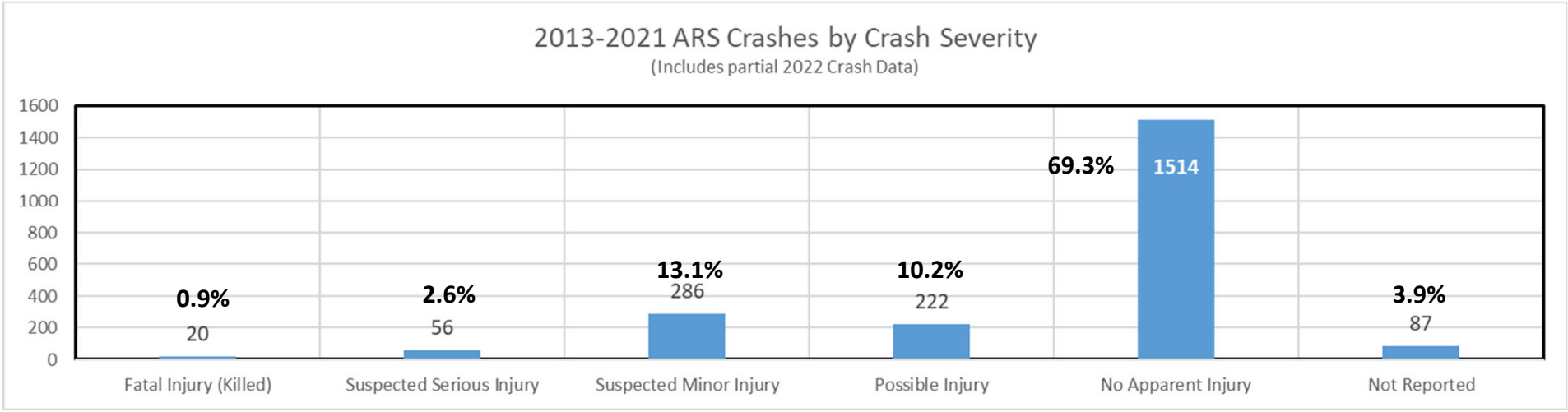
* Annual Crash Rate Formula for highway segments: (Average Number of Crashes per Year) x (1,000,000)/(365 Days x Average Annual Segment Volume x Segment Length)

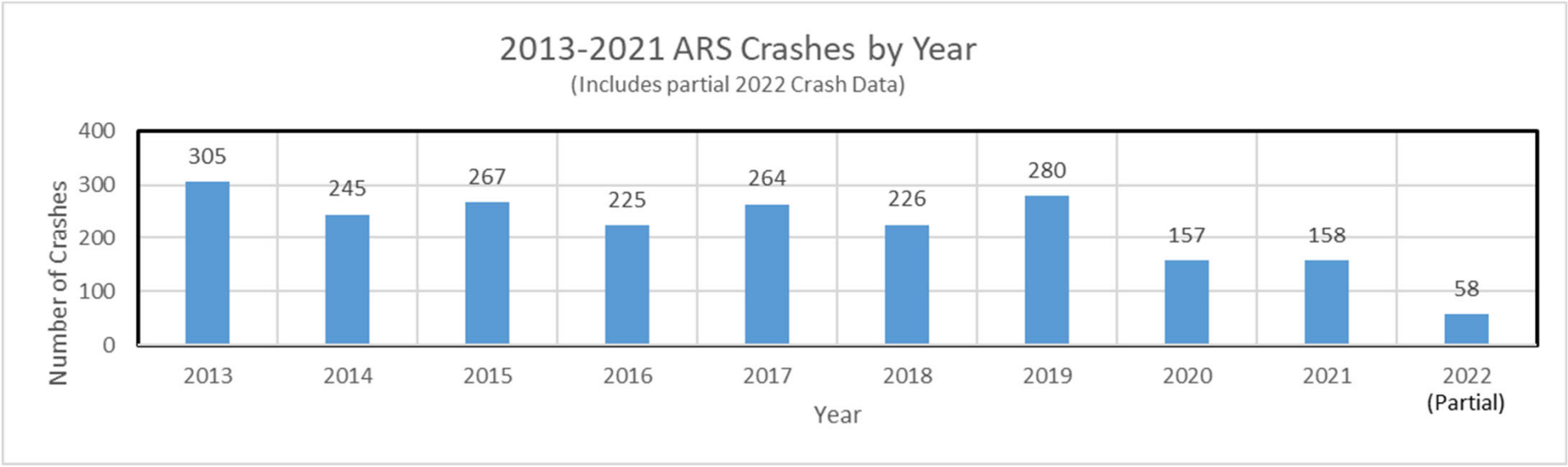
** Value calculated by Alaska DOT/PF for the Annual Highway Safety Improvement Program (HSIP) depicting average crash rates for similar segment types.

Alaska/Richardson/Steese Corridor Safety Performance
2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

Crashes by Crash Severity and Year





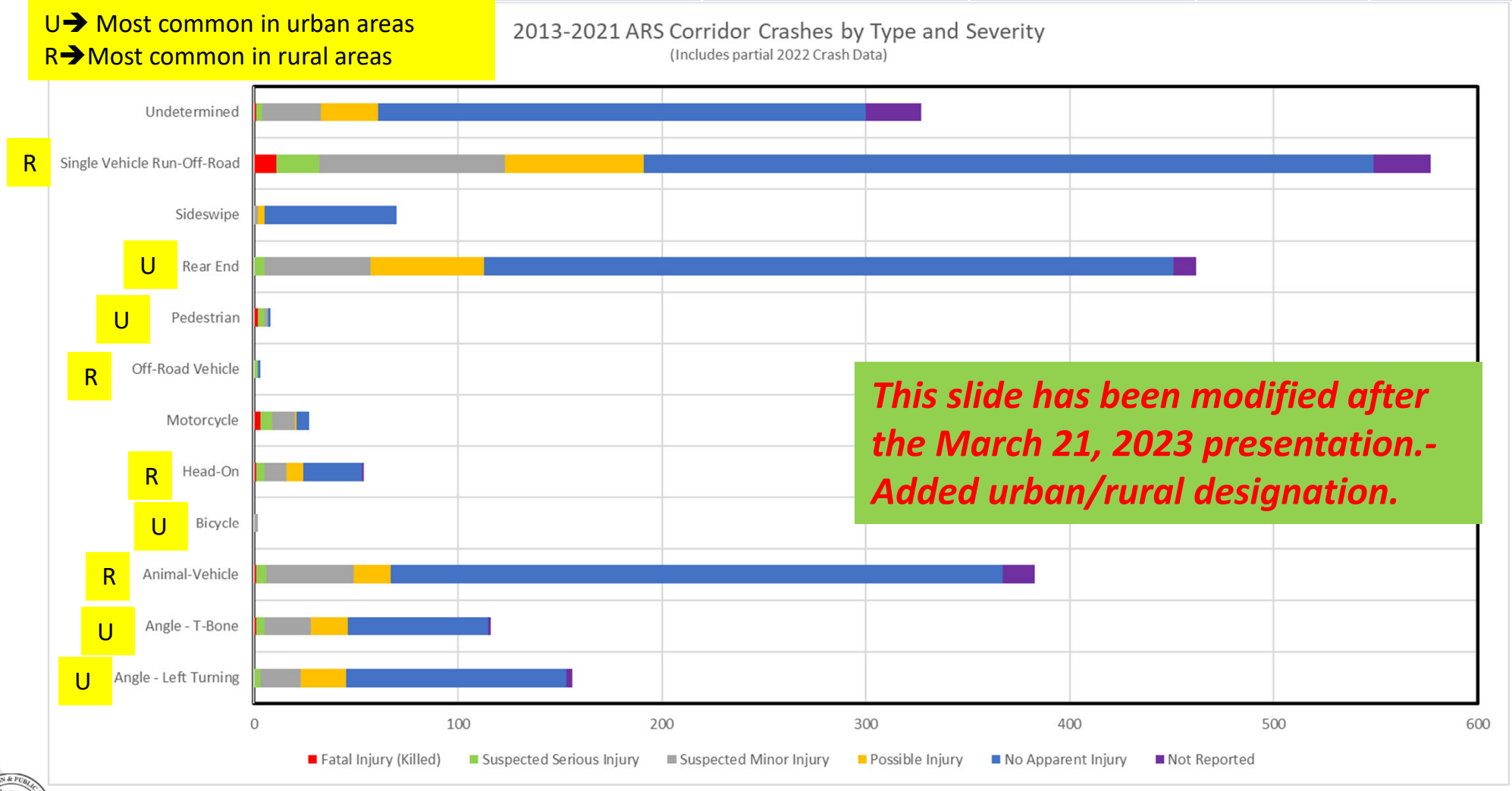
Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

Major Crash Types and % of TOTAL Crashes

Single Vehicle ROR	Rear End	Animal/ Vehicle	Angle/ Left Turning	Angle/ T-Bone	Sideswipe	Head On
26.4%	21.1%	17.5%	7.1%	5.3%	3.2%	2.5%

U➔ Most common in urban areas
R➔Most common in rural areas



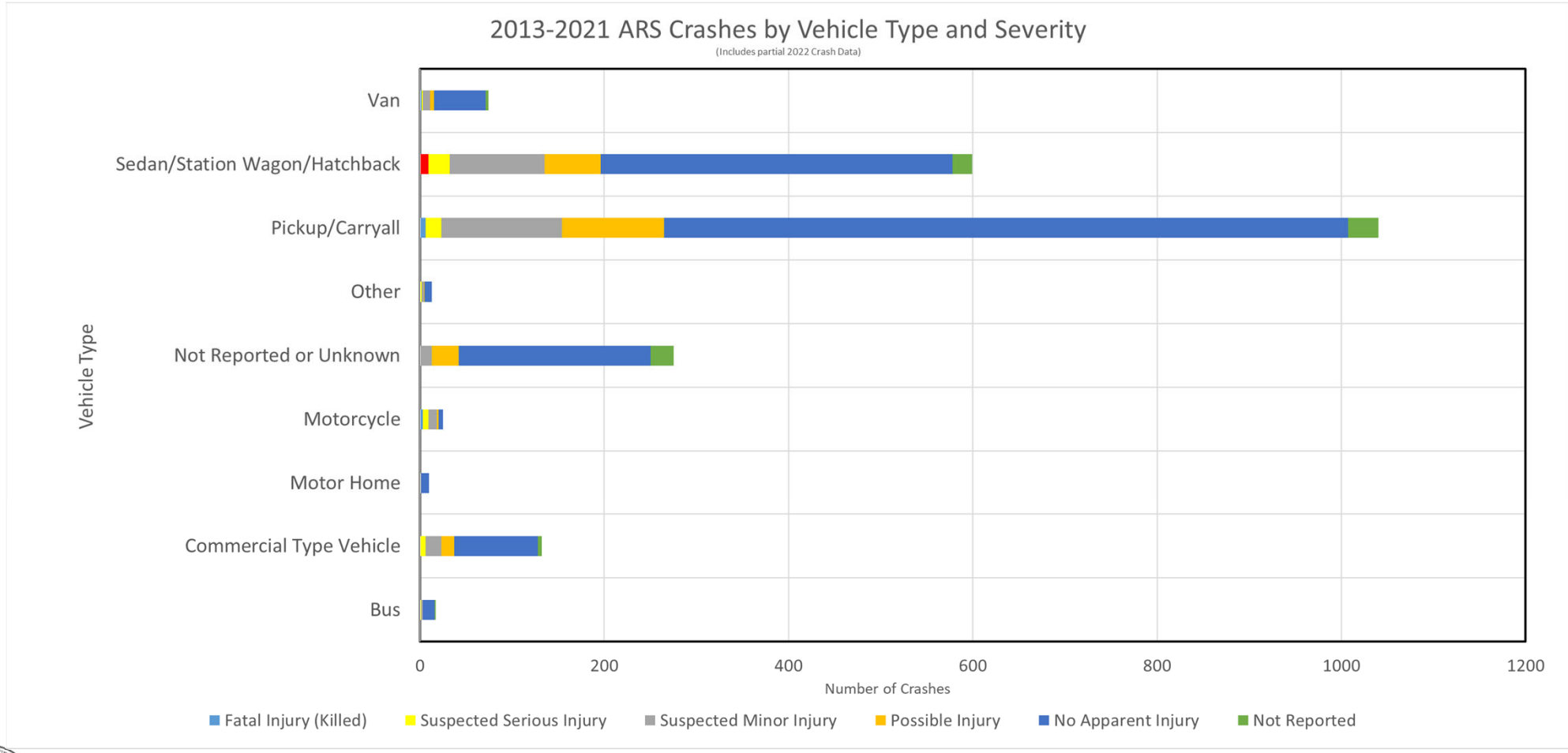
This slide has been modified after the March 21, 2023 presentation.- Added urban/rural designation.

Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

Major Vehicle Types and % of TOTAL Crashes

	Pickup/Carryall	Sedan/Hatchback	Commercial Vehicle	Van	Motorcycle	Bus	Motorhome
All Crashes	47.6%	27.4%	6.0%	3.4%	1.1%	0.8%	0.5%
Fatal & Serious Injury	30.3%	42.1%	7.9%	4.0%	11.8%	1.3%	0%

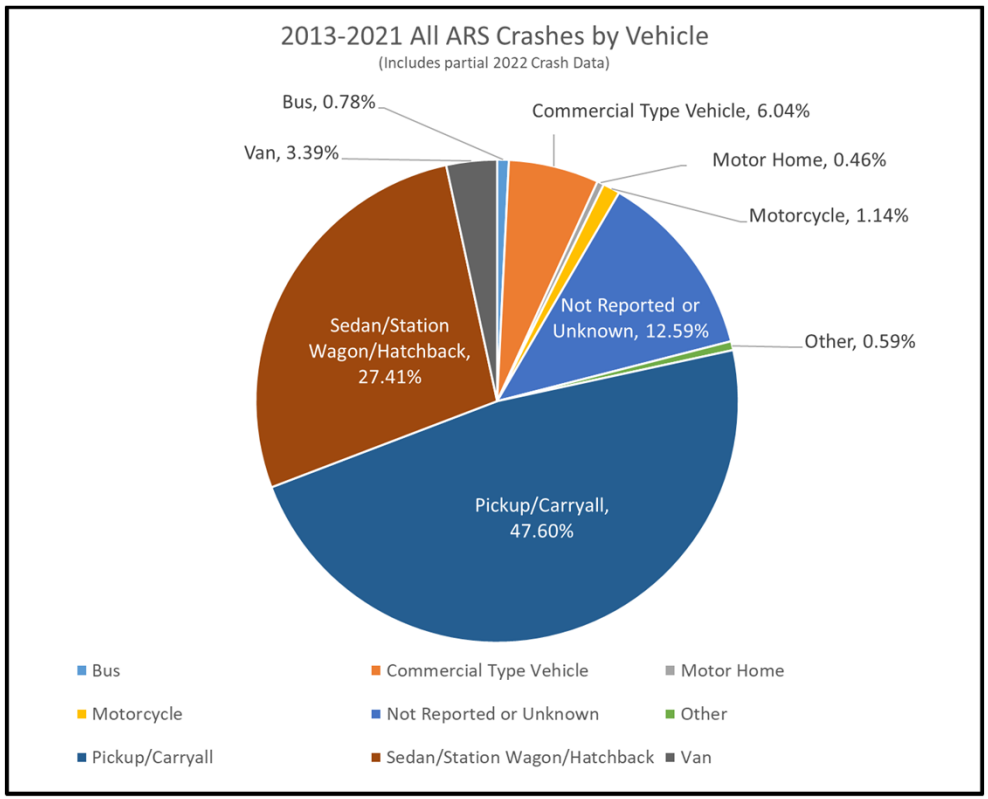


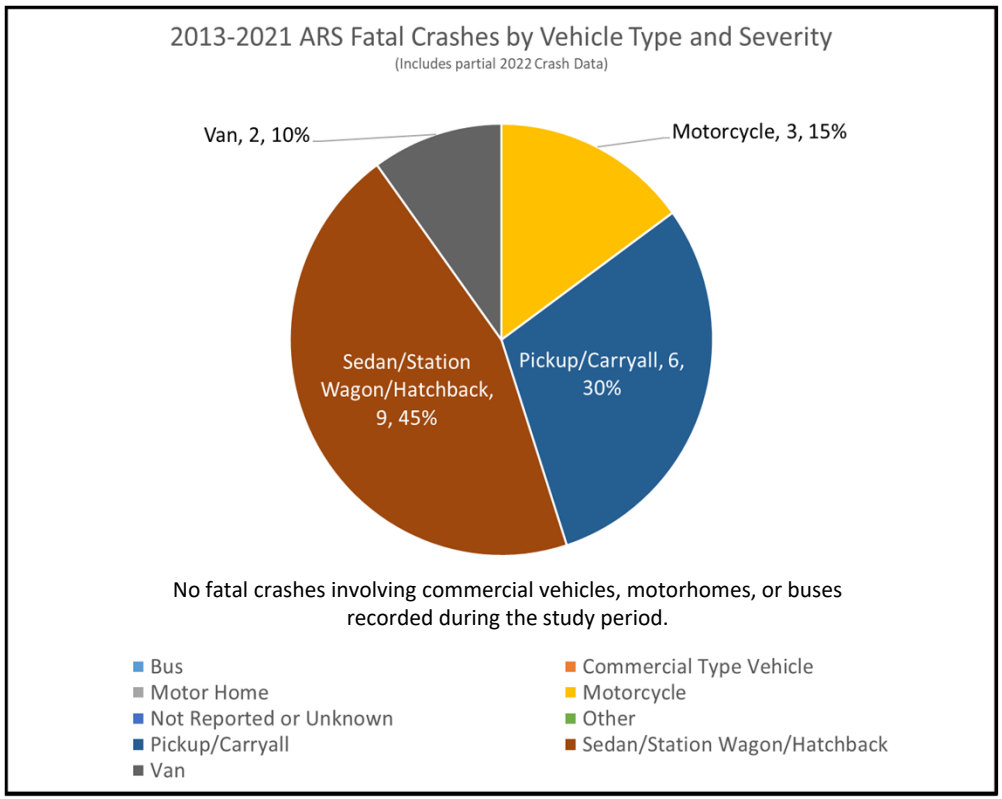
Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

Crash Percentages by Vehicle Type, All Crashes and Fatal Crashes

	Pickup/Carryall	Sedan/Hatchback	Commercial Vehicle	Van	Motorcycle	Bus	Motorhome
All Crashes	47.6%	27.4%	6.0%	3.4%	1.1%	0.8%	0.5%
Fatal Crashes	30%	45%	0%	10%	15%	0%	0%

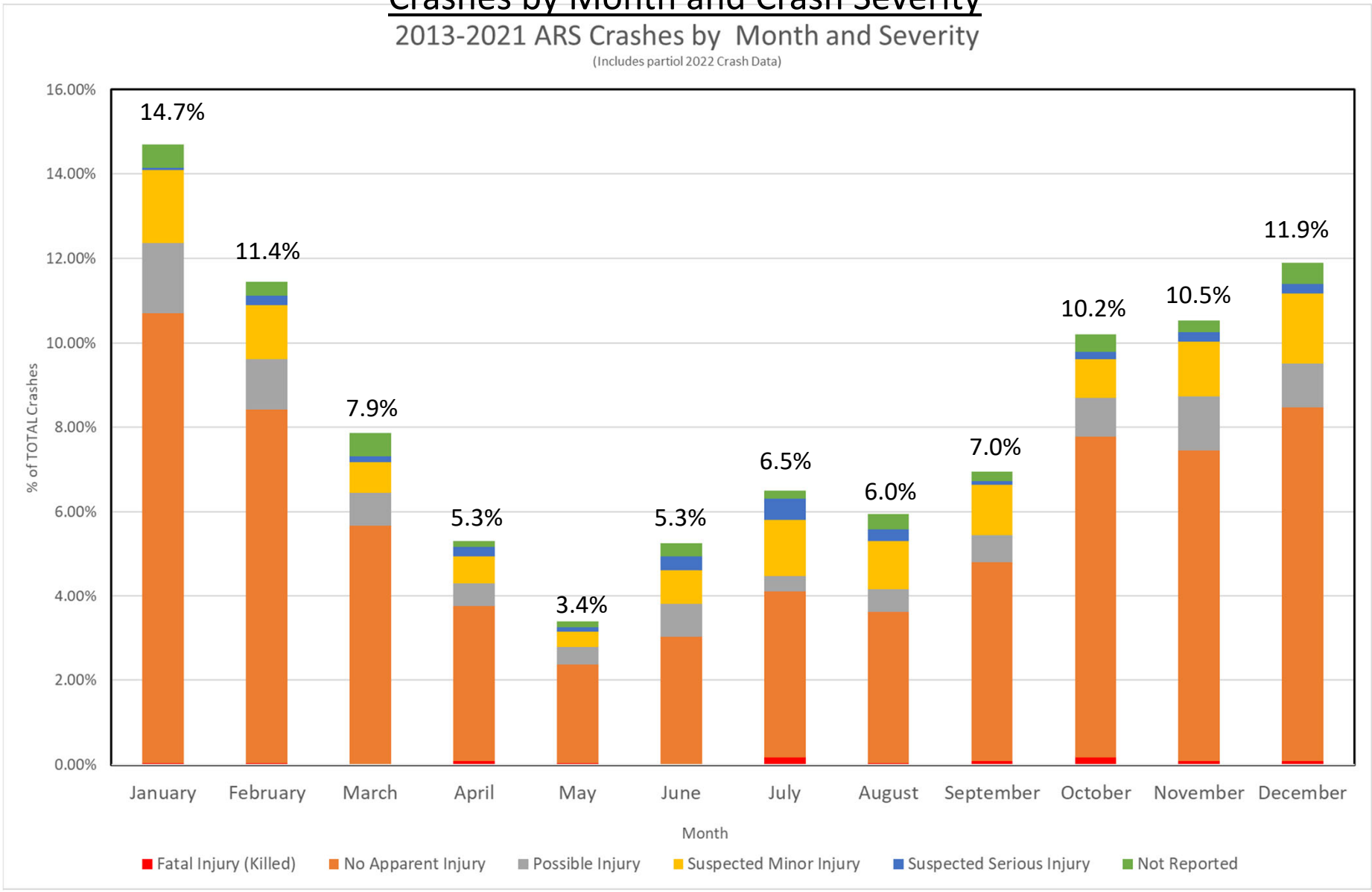




Alaska/Richardson/Steese Corridor Safety Performance
2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

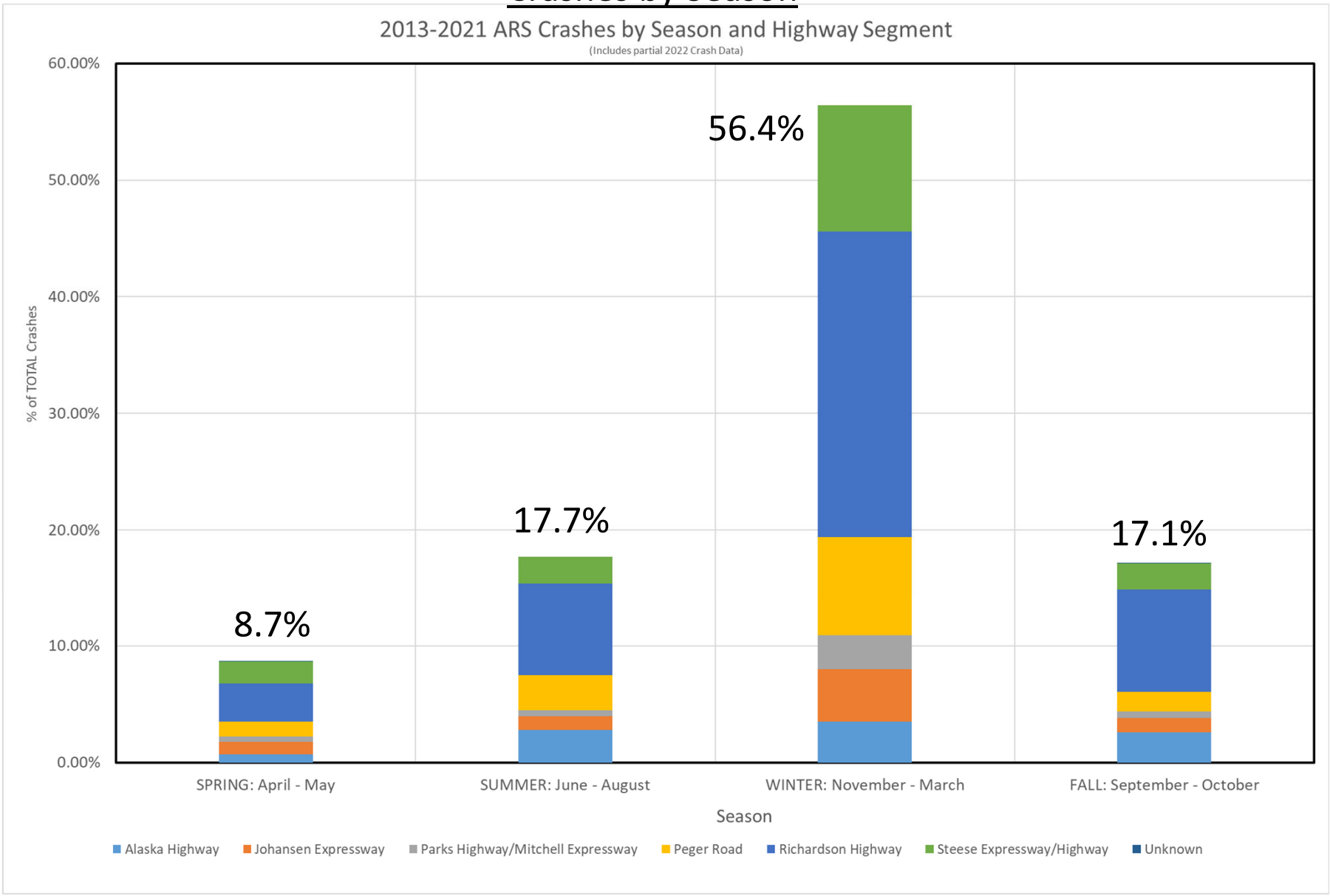
Crashes by Month and Crash Severity



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

Crashes by Season

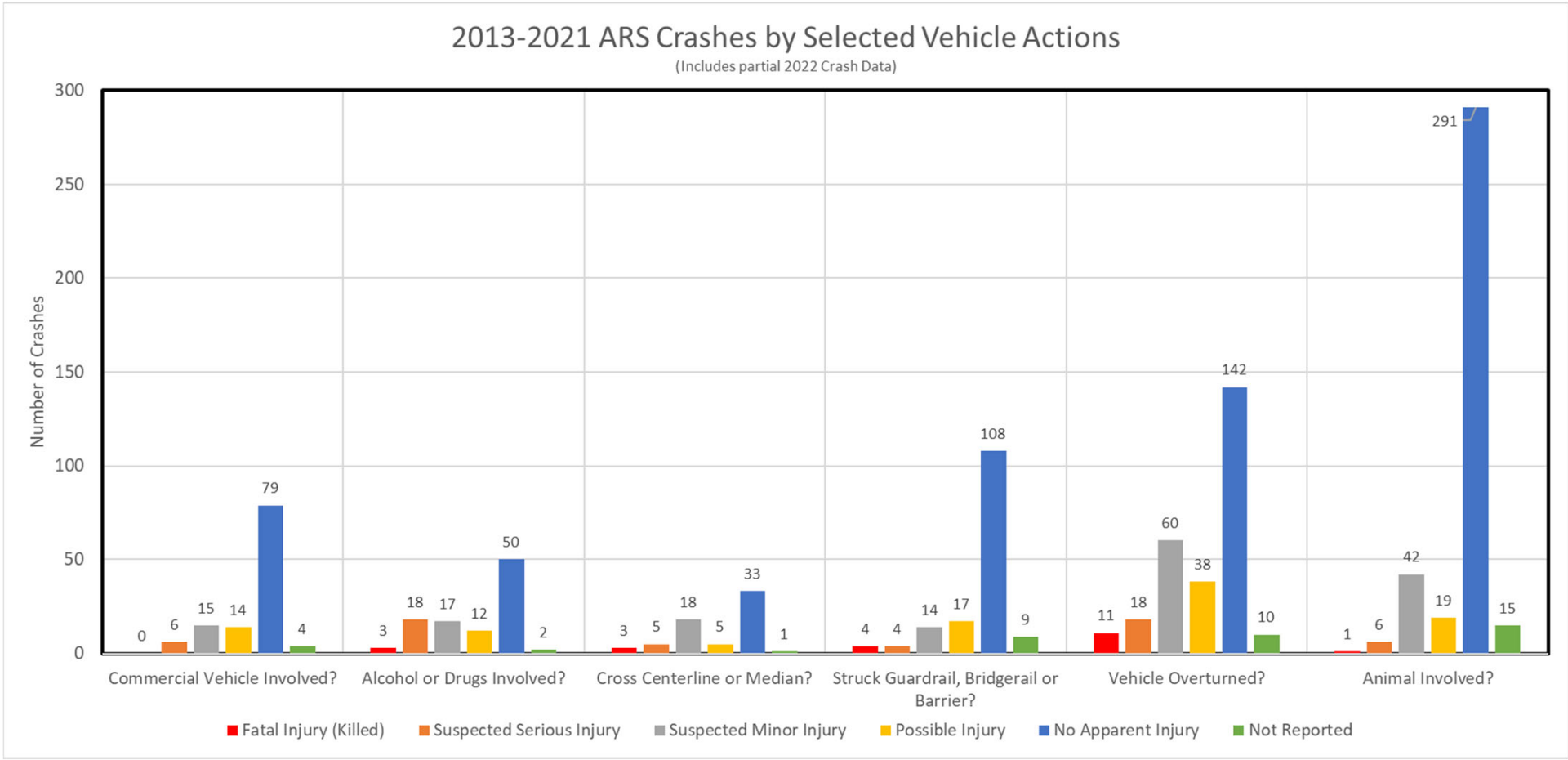


Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

Selected Driver/Vehicle Actions and % of TOTAL Crashes

Driver/Vehicle Action	Commercial Vehicle	Alcohol / Drugs	Cross Centerline/ Median	Struck Guardrail/Barrier	Vehicle Overturn	Animal Involved
% of All Crashes	6.4%	4.7%	3.0%	7.1%	12.8%	17.1%
% of Fatal/Serious Injury	7.9%	27.6%	10.5%	10.5%	38.2%	9.2%

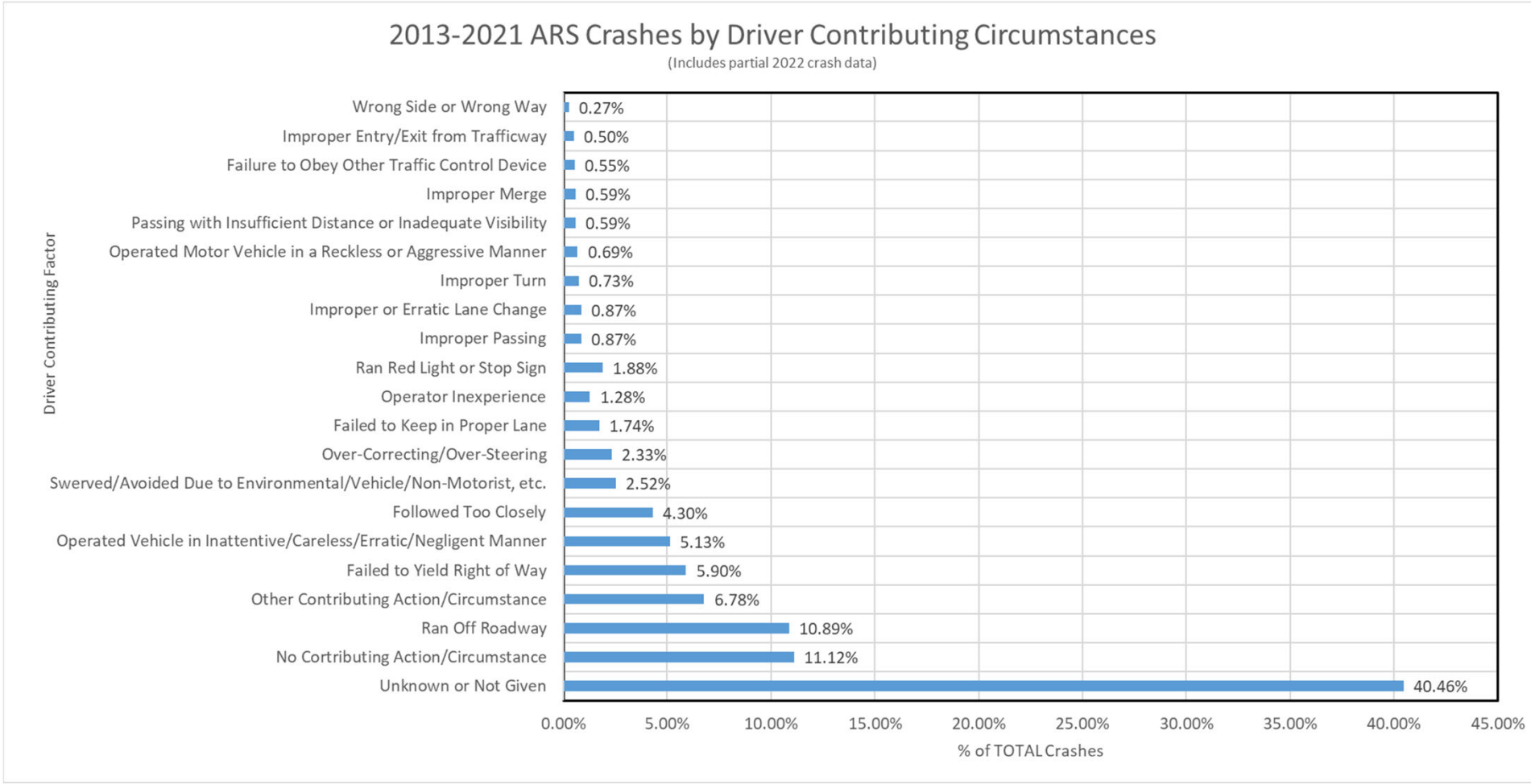


Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Entire Corridor Crash History

*Includes partial 2022 Crash Data

Crashes by Driver Contributing Circumstances

Ran off Road	Other	Failure to Yield	Inattentive/ Careless	Follow Too Closely	Swerved/Over Correct
10.9%	6.8%	5.9%	5.1%	4.3%	4.8%

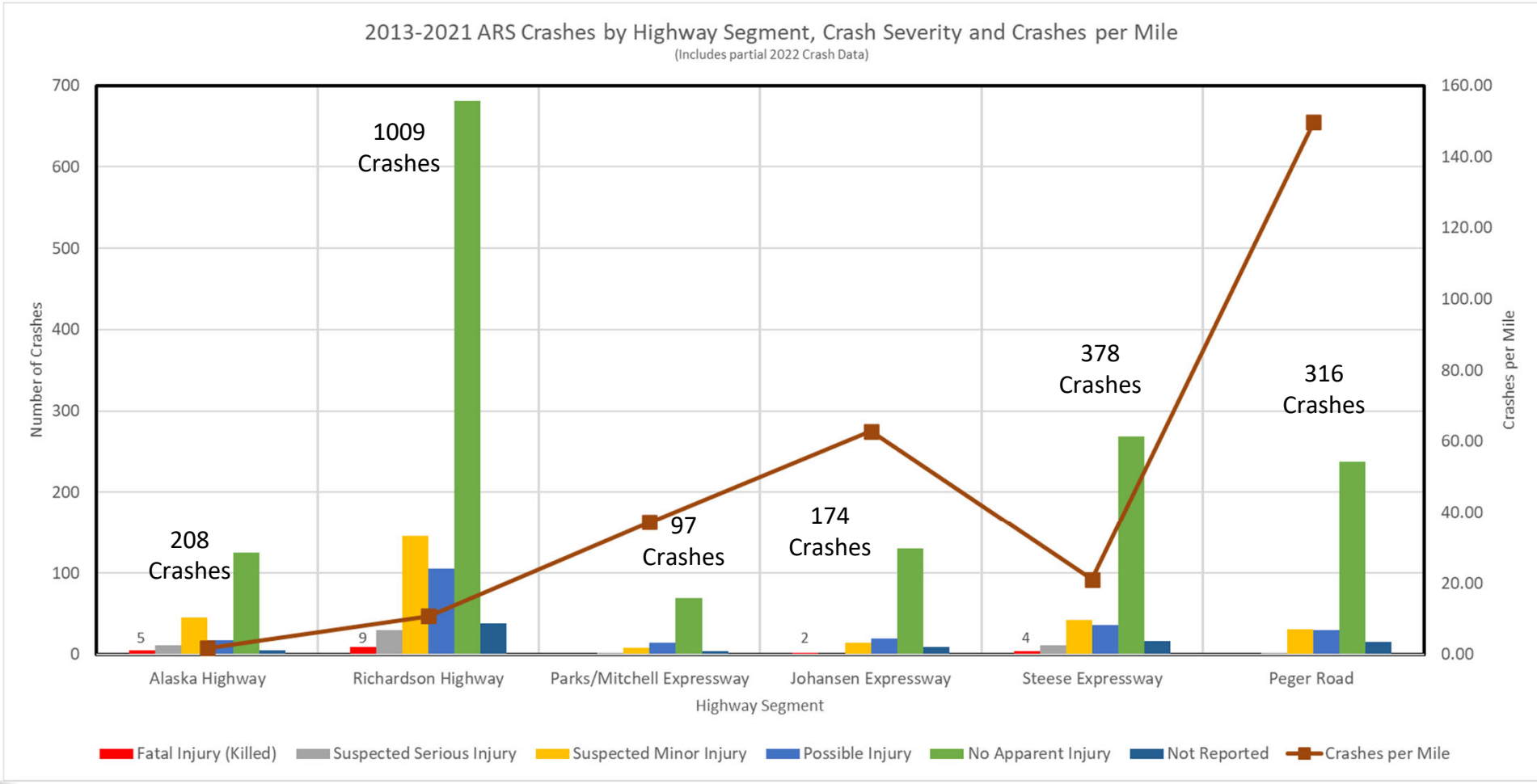


Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash History by Highway Segment

*Includes partial 2022 Crash Data

Crashes by Highway Segment, Crash Severity and Crashes per Mile

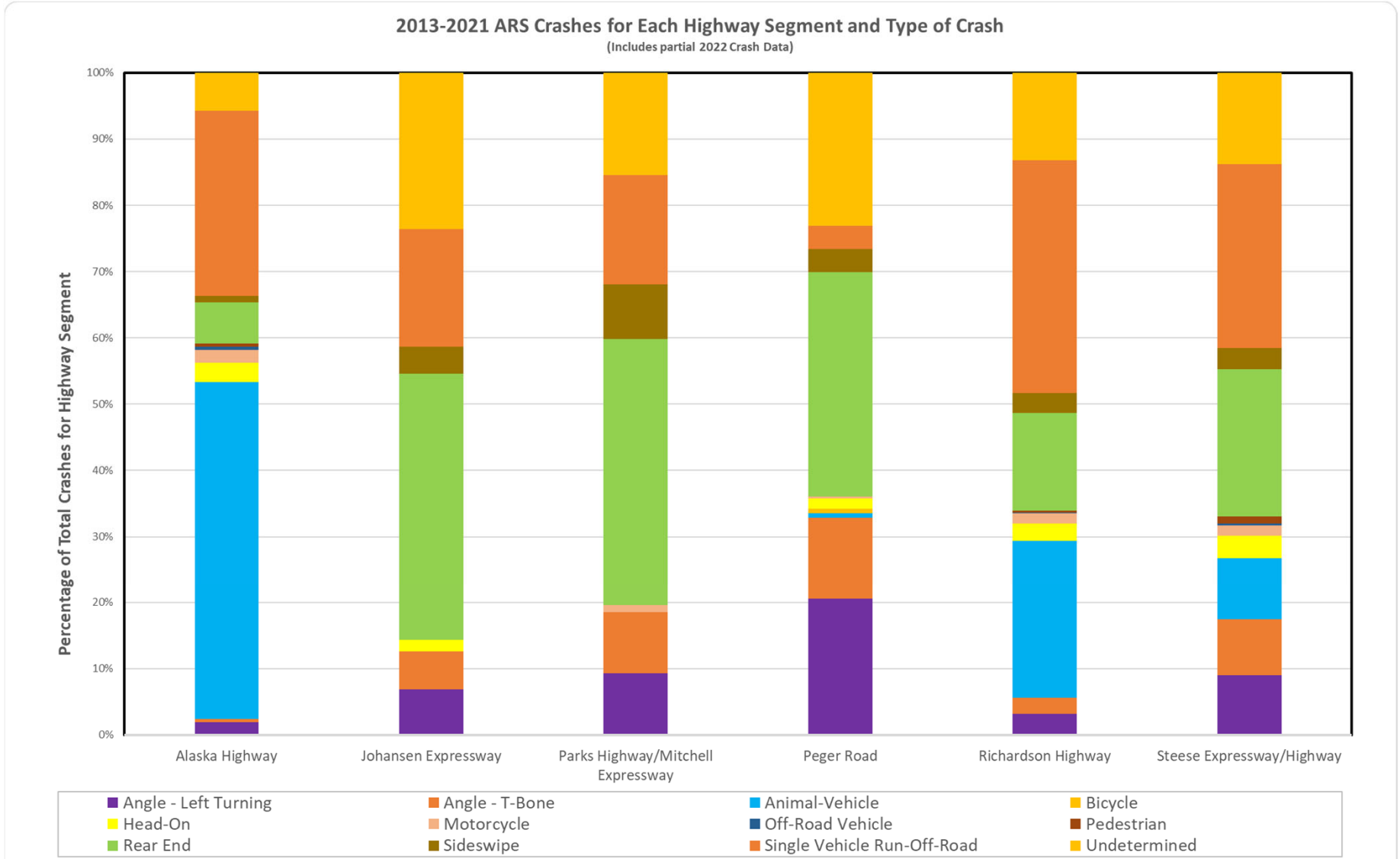
	Alaska Hwy	Richardson Hwy	Parks/ Mitchell Expwy	Johansen Expwy	Steese Expwy/ Hwy	Peger Rd
Segment Length (mi)	118.10	93.20	2.61	2.77	17.95	2.11
Average AADT	400	14790	15140	11720	19160	5510
Crashes per Mile	1.76	10.83	37.24	62.84	21.05	149.62



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash History by Highway Segment

*Includes partial 2022 Crash Data

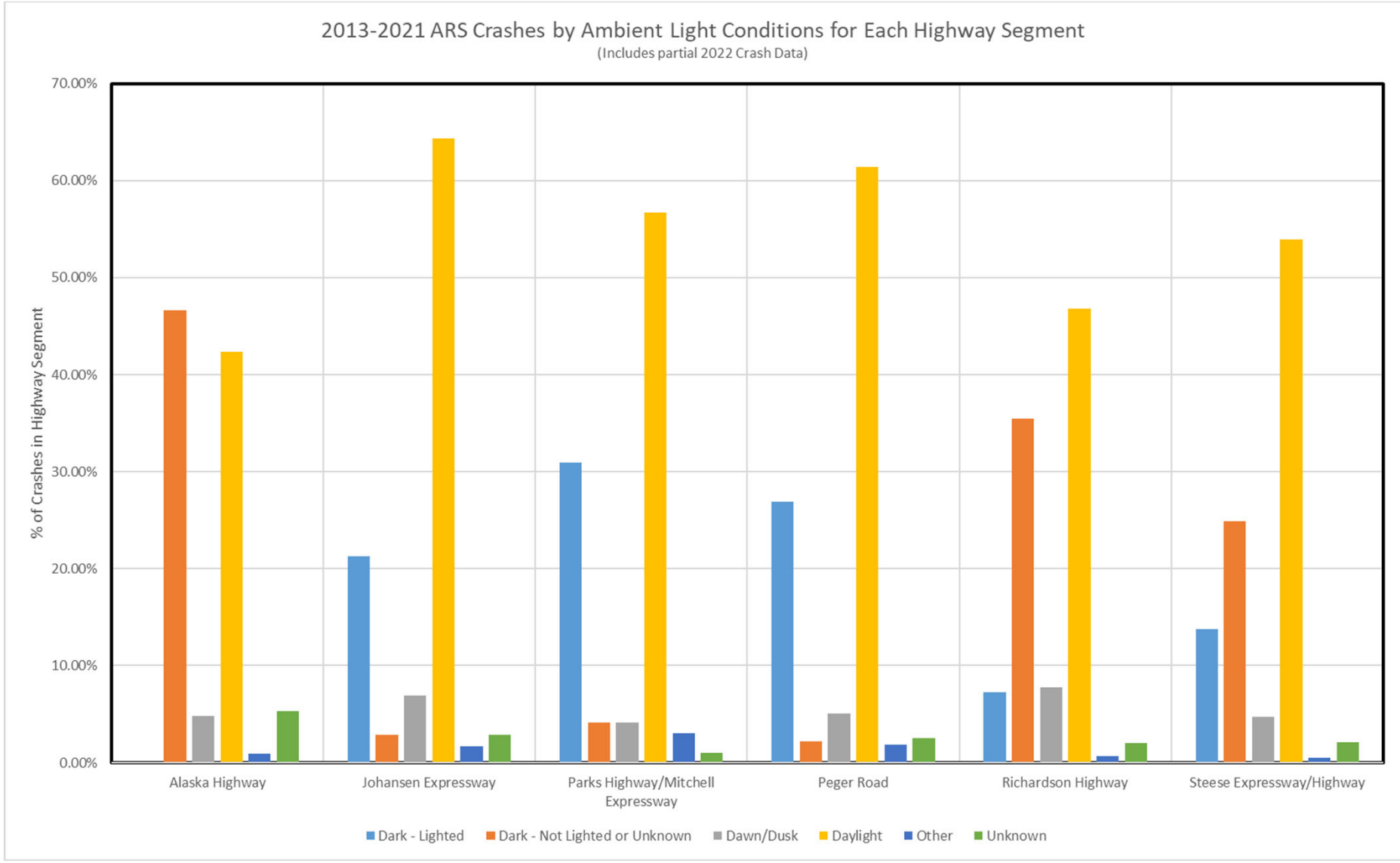
Crashes for Each Highway Segment and Type of Crash



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash History by Highway Segment

*Includes partial 2022 Crash Data

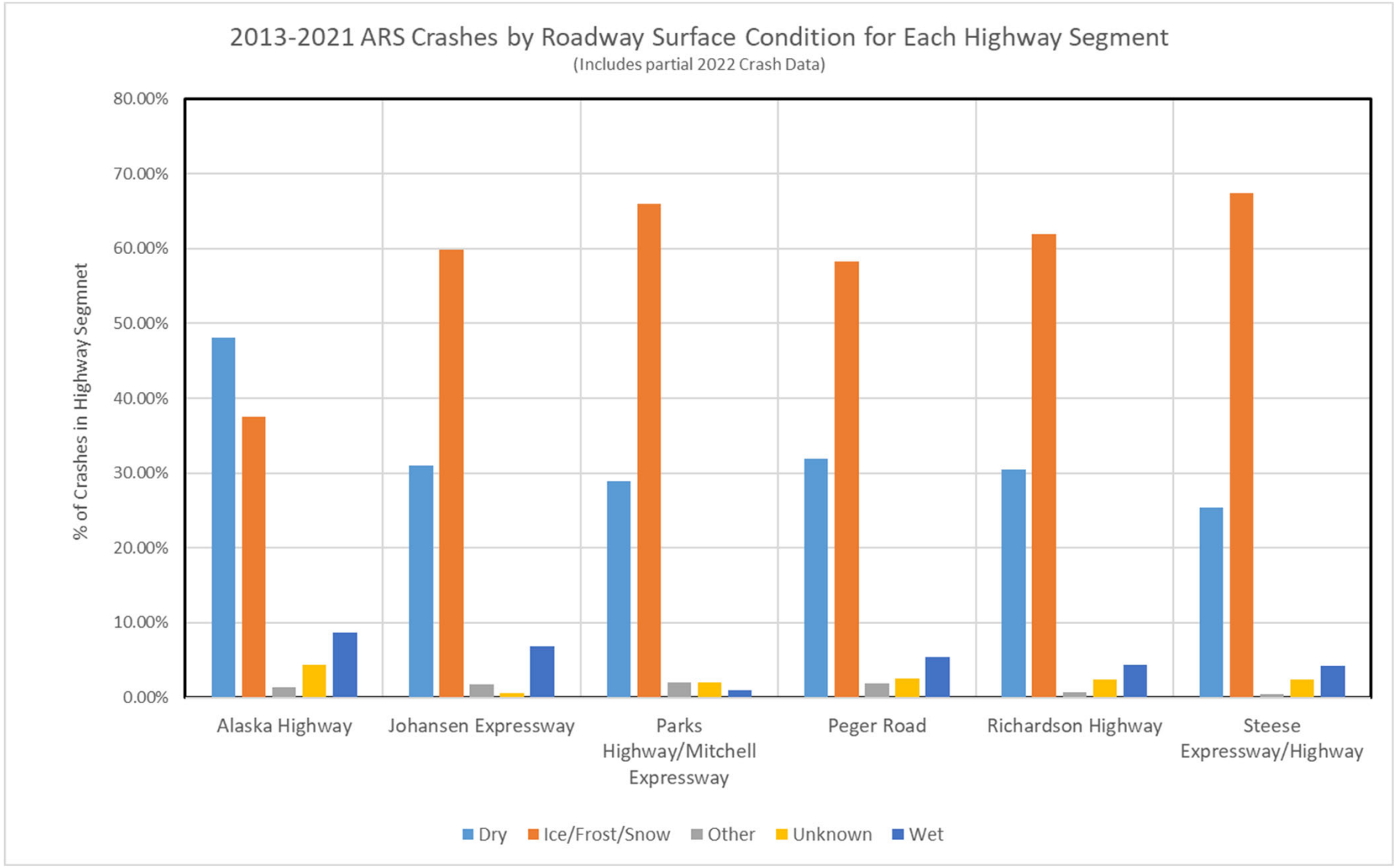
Crashes by Ambient Light Conditions for Each Highway Segment



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash History by Highway Segment

*Includes partial 2022 Crash Data

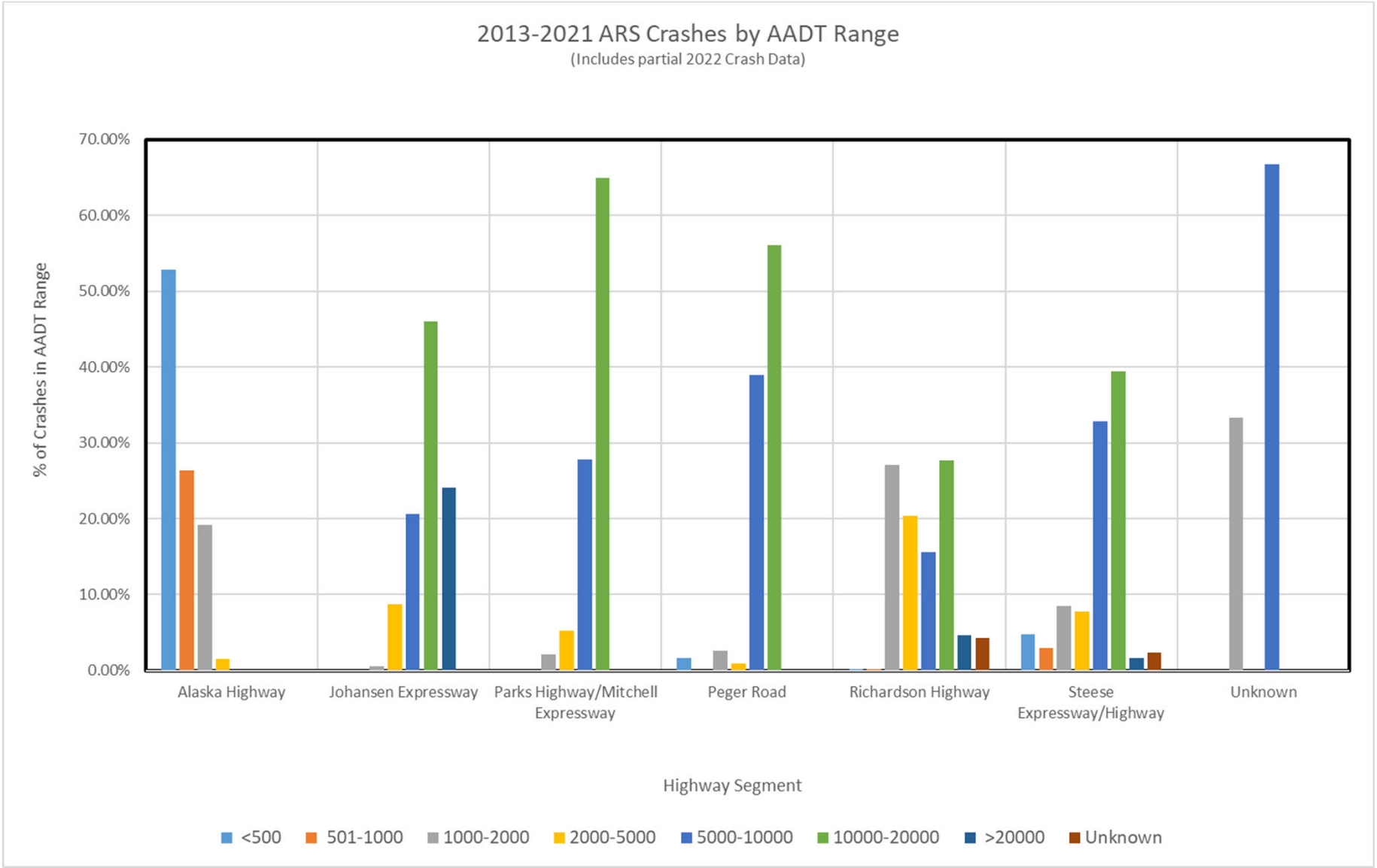
Crashes by Roadway Surface Conditions for Each Highway Segment



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Crash History by Highway Segment

*Includes partial 2022 Crash Data

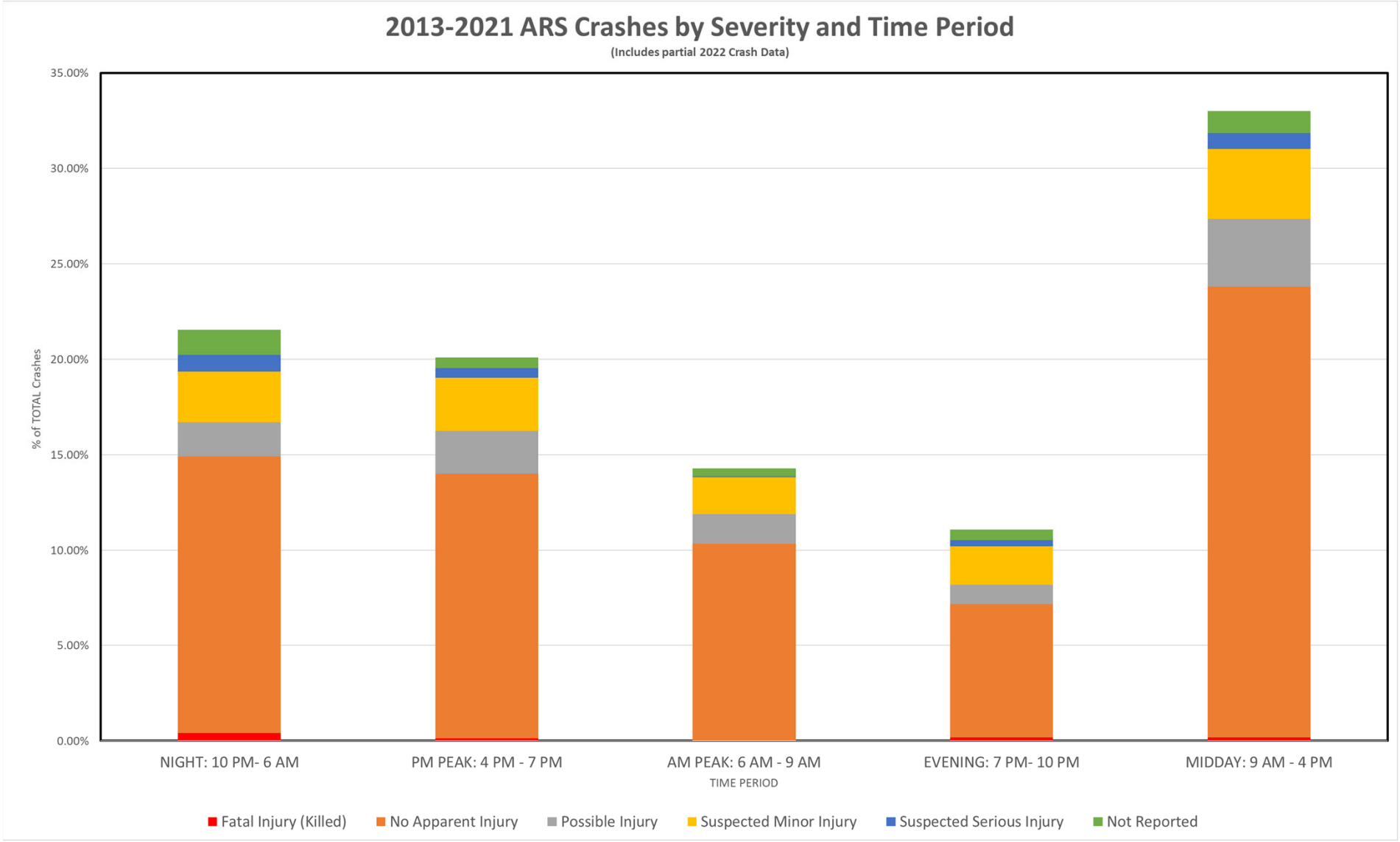
Crashes by AADT Range



Alaska/Richardson/Steese Corridor Safety Performance
2013-2021* Crash History by Highway Segment

*Includes partial 2022 Crash Data

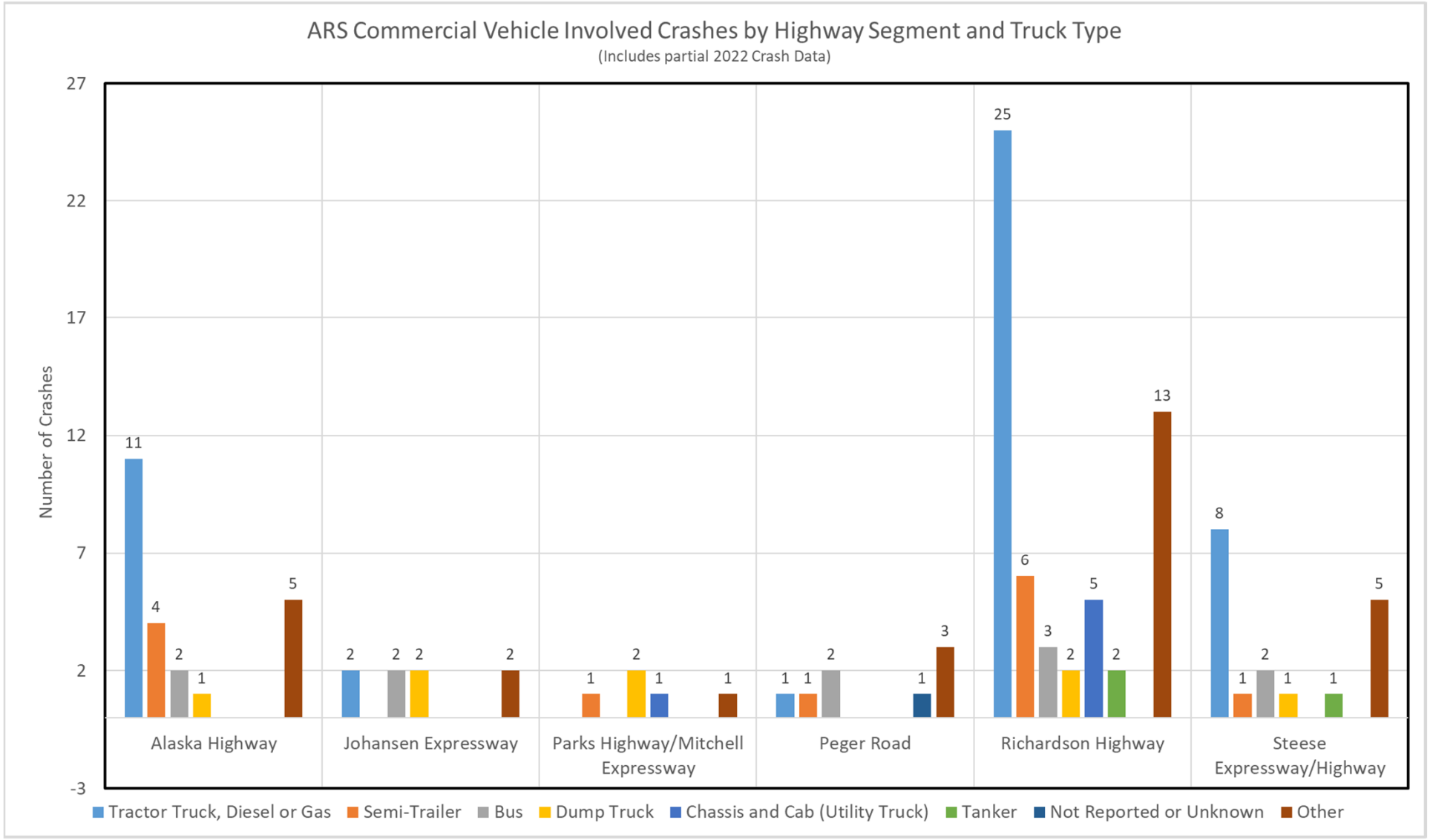
Crashes by Time Period



Alaska/Richardson/Steese Corridor Safety Performance
2013-2021* Commercial Vehicle Crashes

*Includes partial 2022 Crash Data

Commercial Vehicle** Crashes by Truck Type for Each Highway Segment



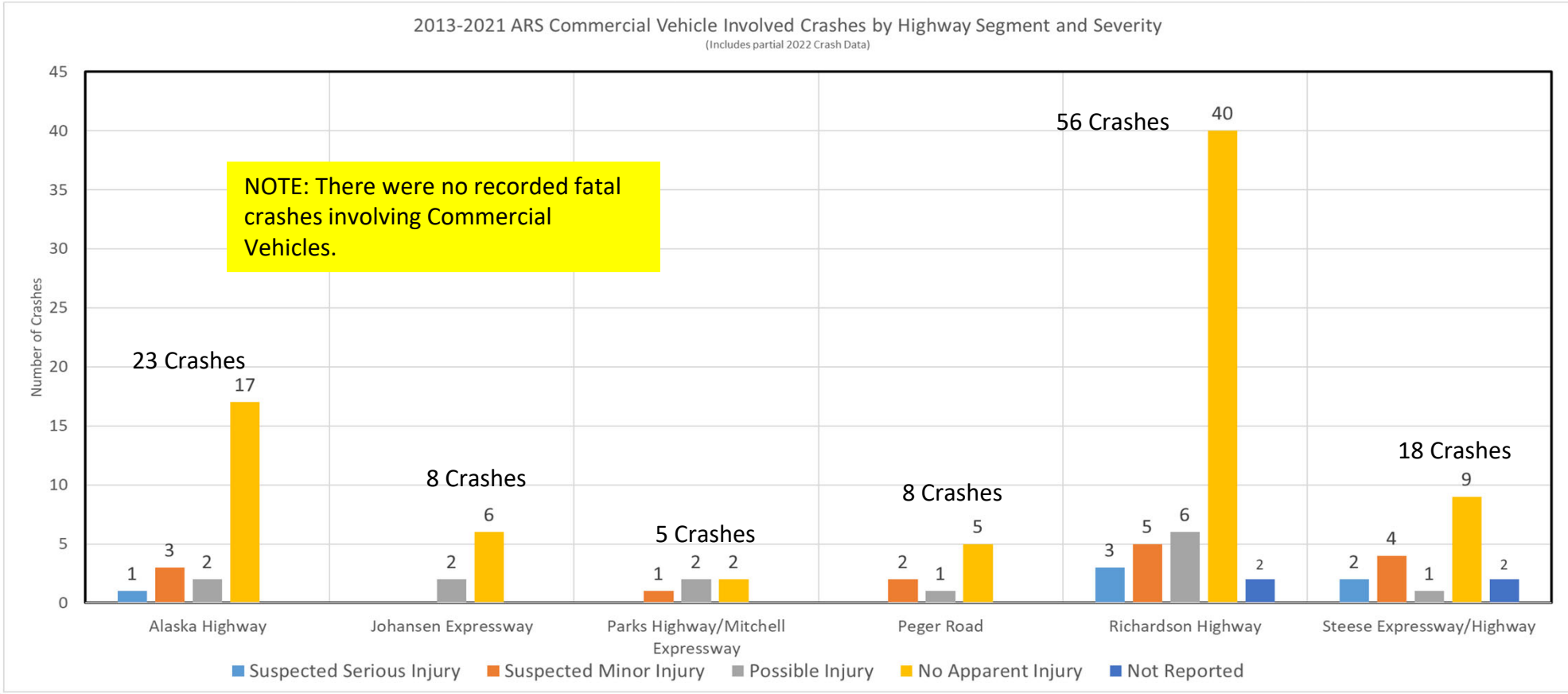
**Commercial Vehicles include Tractor Trailer, Semi Trailer, Tanker, Bus, Dump Truck, Garbage Truck, Flatbed, Grader, Tow Truck, Etc.

Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Commercial Vehicle Crashes

*Includes partial 2022 Crash Data

Commercial Vehicle Crashes by Severity for Each Highway Segment

	Richardson Hwy	Alaska Hwy	Steese Expwy/ Hwy	Johansen Expwy	Peger Road	Parks/ Michell Expwy
All Crashes	46.2%	9.5%	17.3%	8.0%	14.4%	4.4%
All Commercial Vehicle	47.5%	19.5%	15.3%	6.8%	6.8%	4.2%
Tractor-Semi Trailer Only	28.0%	12.7%	8.5%	1.7%	1.7%	0.9%

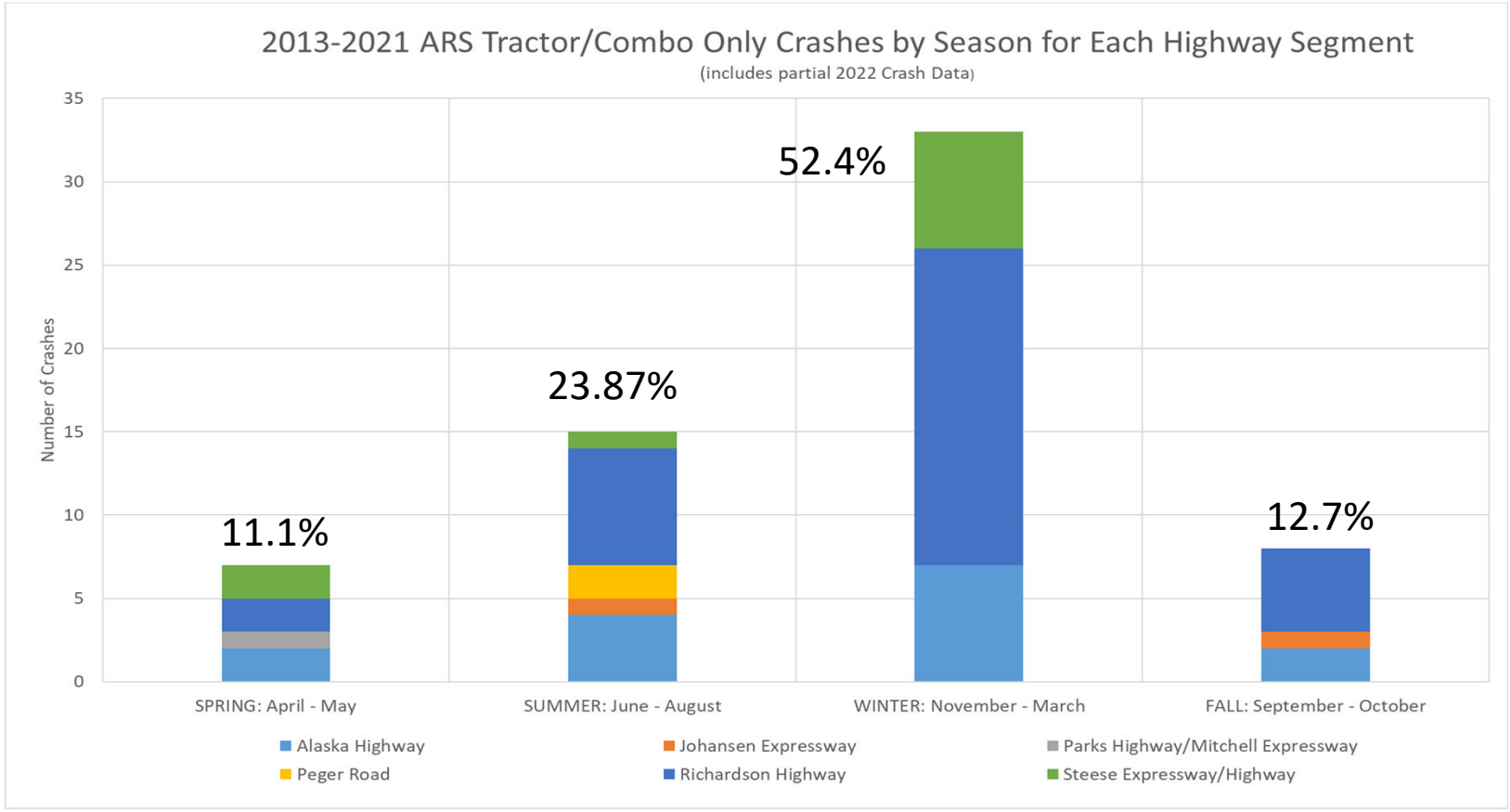


Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Tractor/Trailer Combo Only Crashes

*Includes partial 2022 Crash Data

Commercial Vehicle Crashes by Season for Each Highway Segment

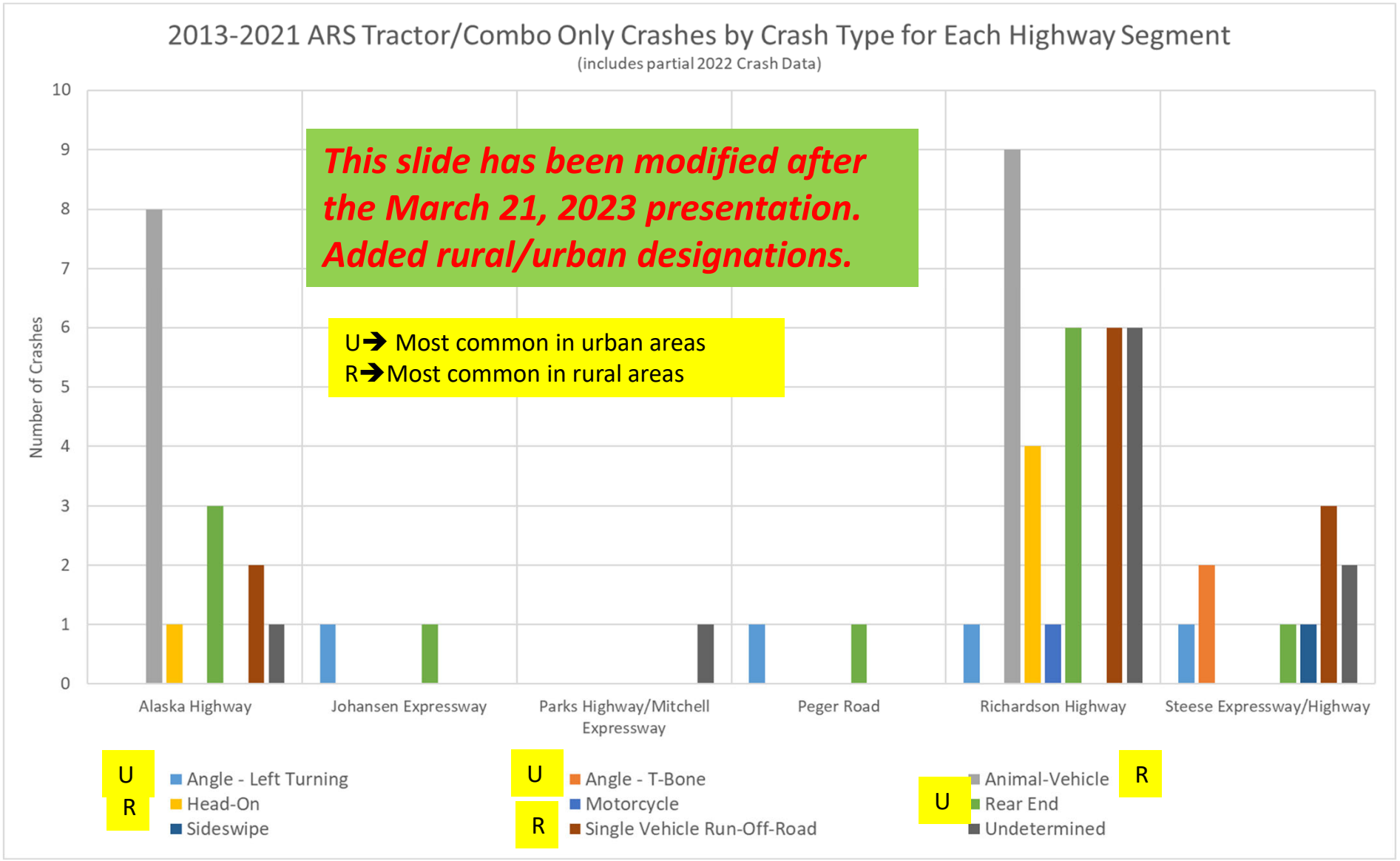
	Spring	Summer	Fall	Winter
All Crashes	8.7%	17.7%	17.1%	56.4%
Commercial Vehicles	7.6%	18.6%	16.1%	57.6%
Tractor-Semi Trailer Only	11.1%	23.8%	12.7%	52.4%



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Tractor/Trailer Combo Only Crashes

*Includes partial 2022 Crash Data

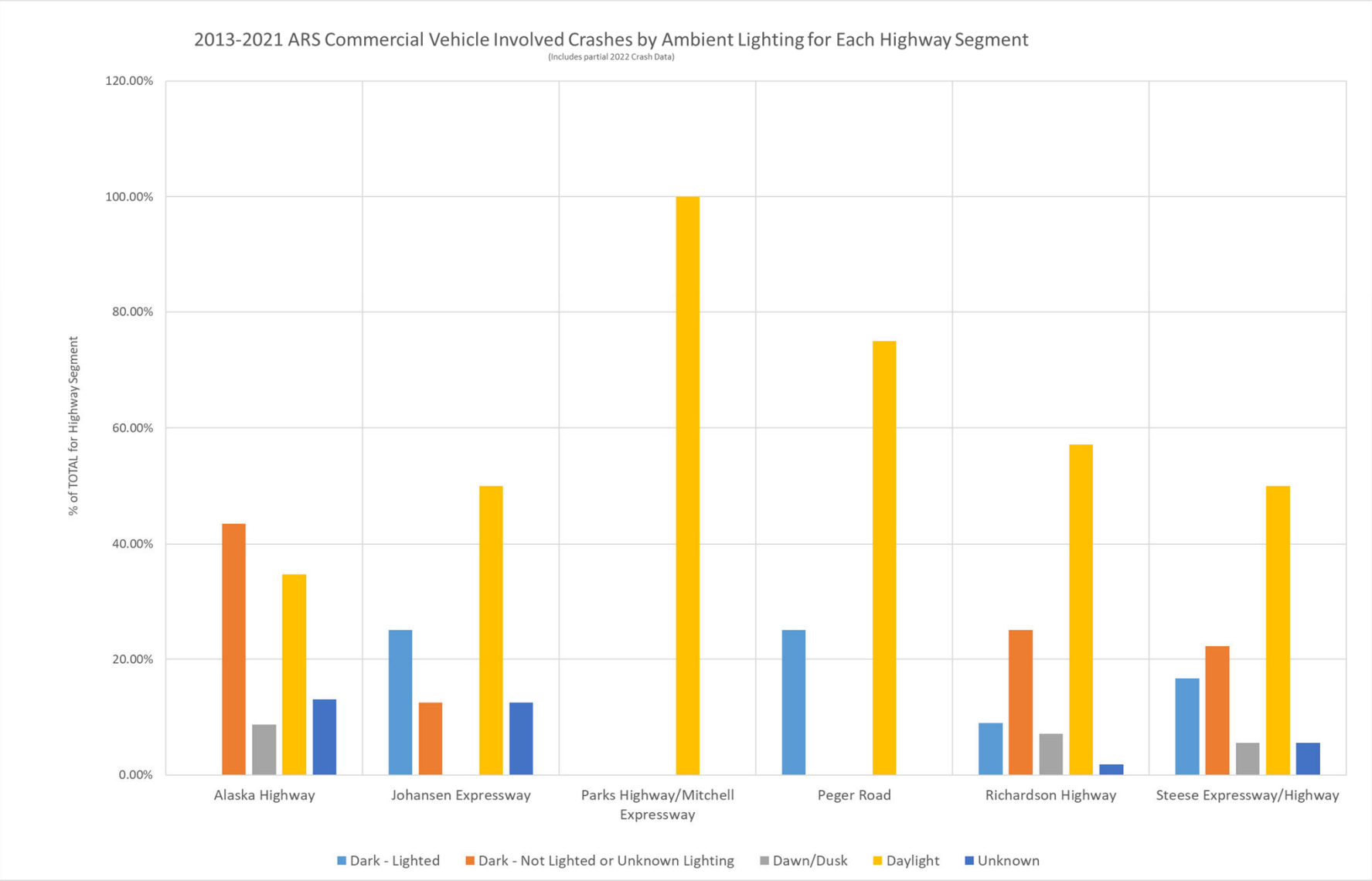
Tractor/Trailer Combo Only Crashes by Type for Each Highway Segment



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Tractor/Trailer Combo Only Crashes

*Includes partial 2022 Crash Data

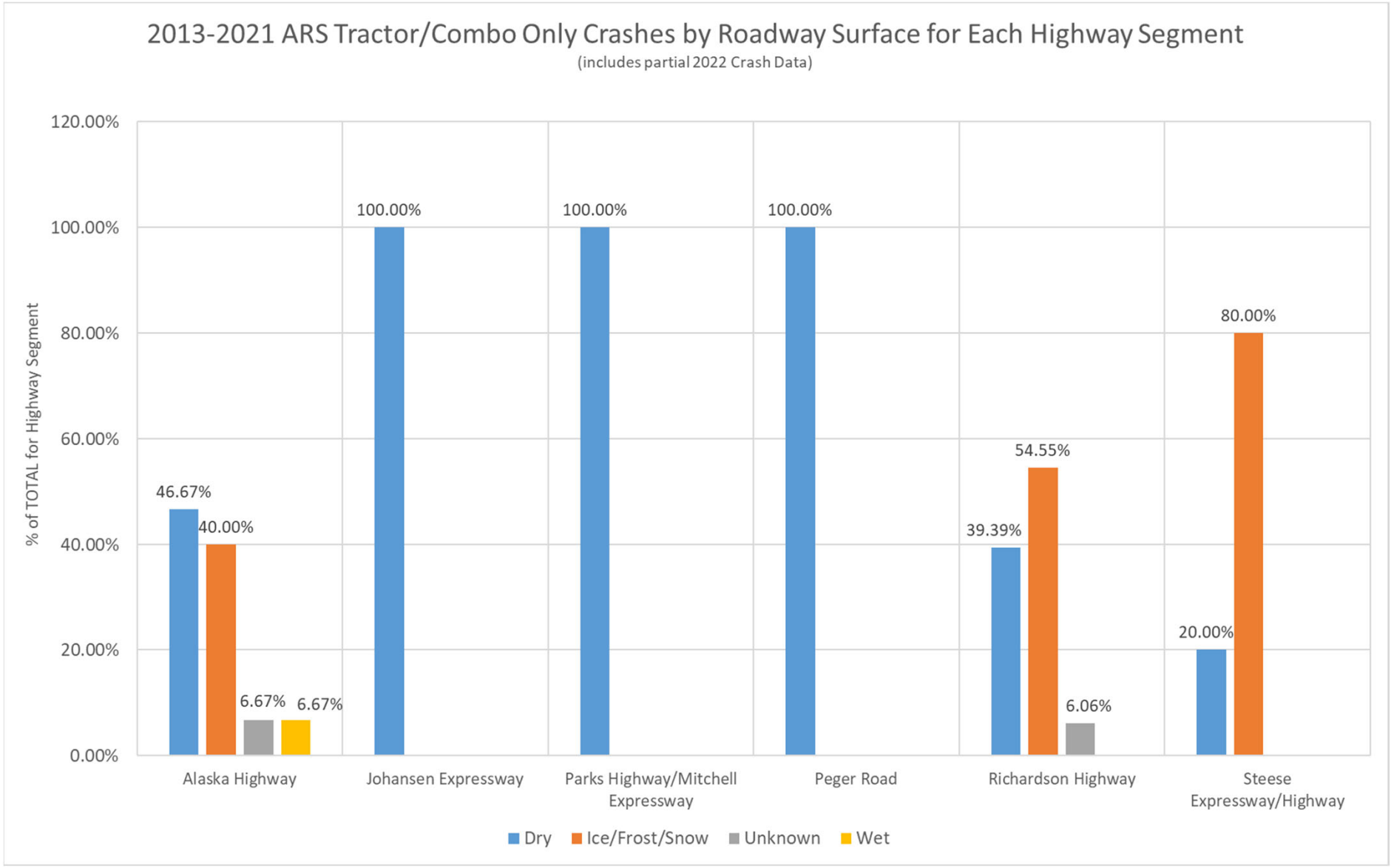
Tractor/Trailer Combo Only Crashes by Ambient Light for Each Highway Segment



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Tractor/Trailer Combo Only Crashes

*Includes partial 2022 Crash Data

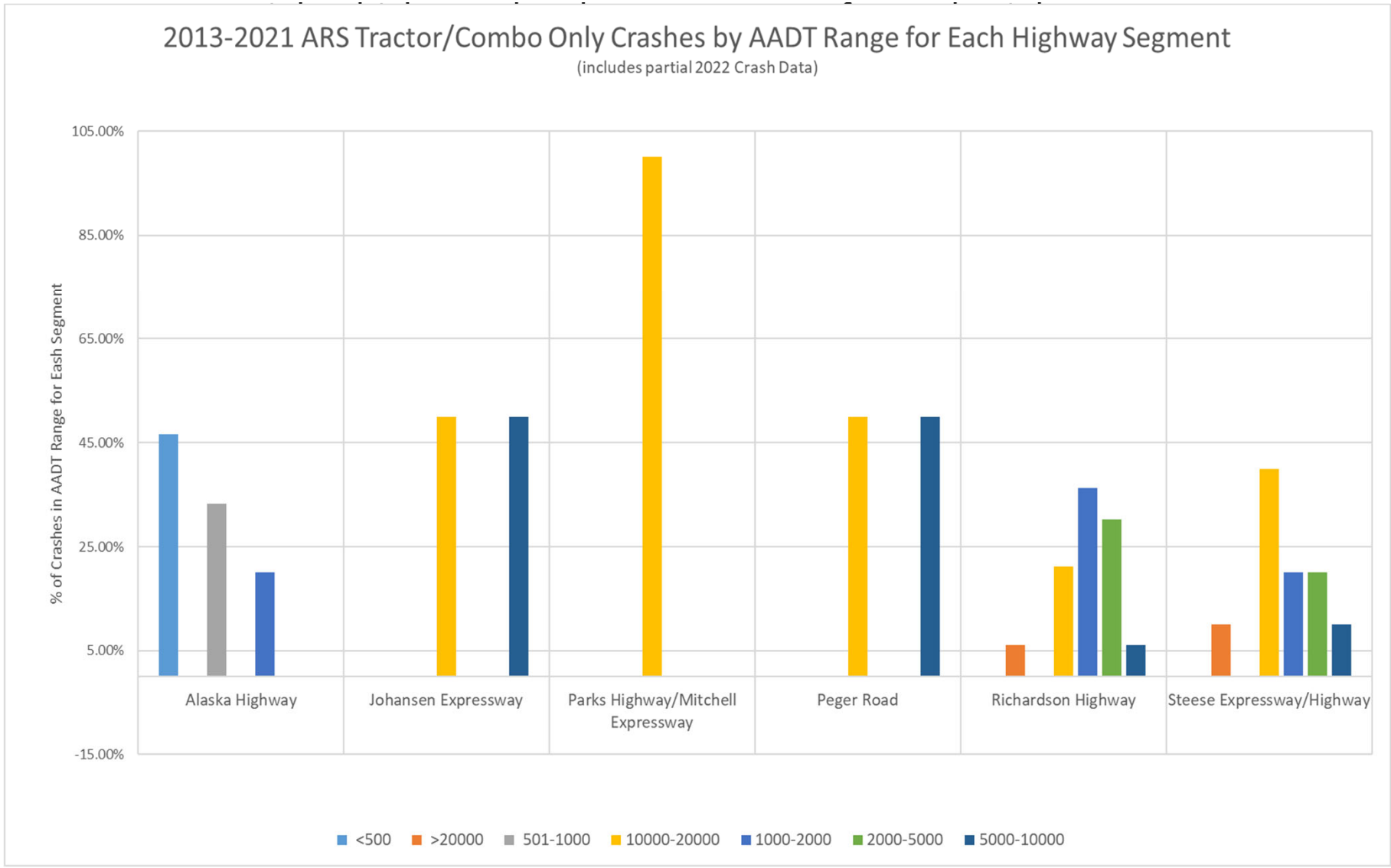
Tractor/Trailer Combo Only Crashes by Roadway Surface for Each Highway Segment



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Tractor/Trailer Combo Only Crashes

*Includes partial 2022 Crash Data

Tractor/Trailer Combo Only Crashes by AADT Range for Each Highway Segment



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Bus Related Crashes

*Includes partial 2022 Crash Data

Summary of Crashes Involving Buses

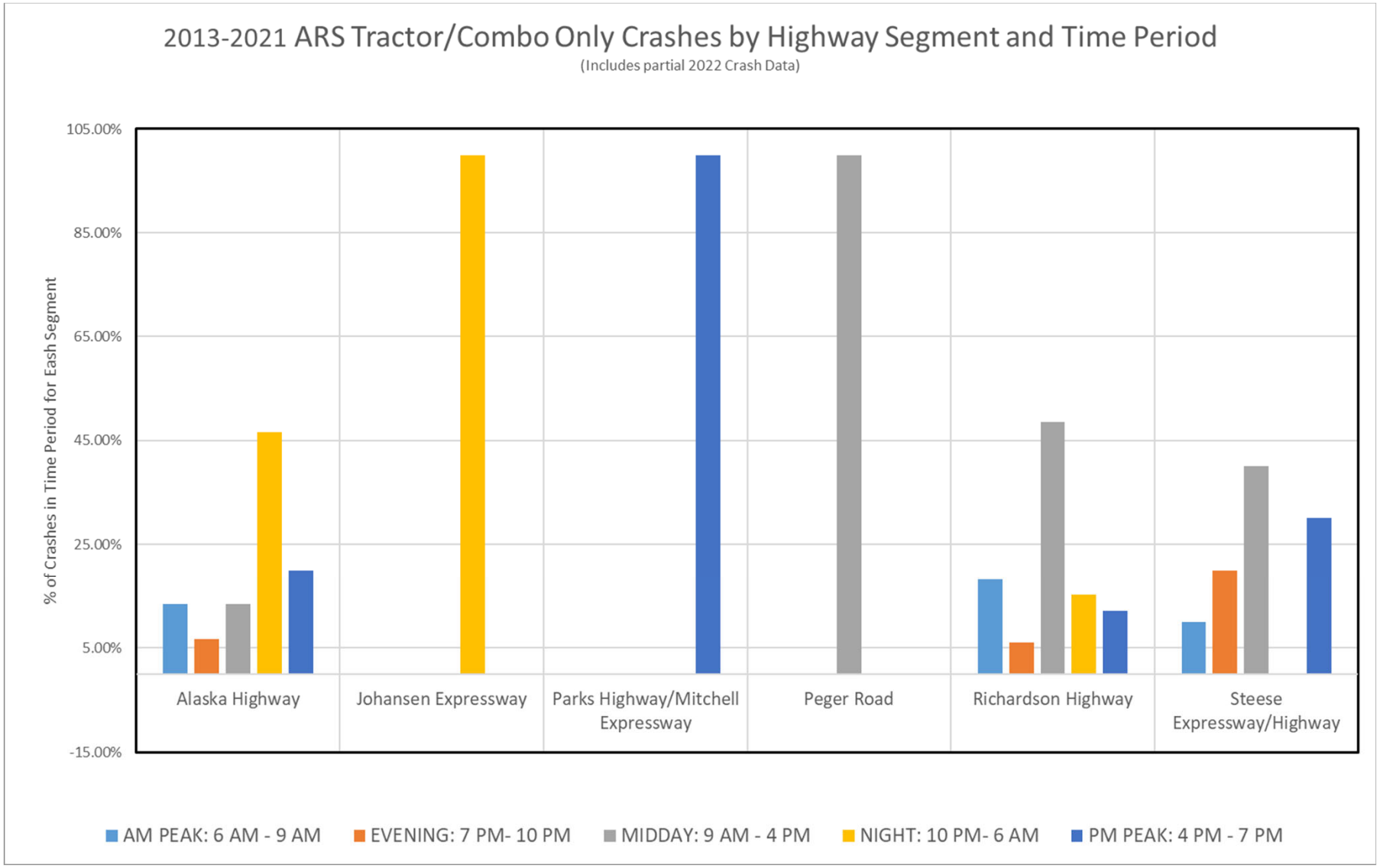
Crashes involving Buses	Bus-Not School	Bus-School	Bus-Unknown	Grand Total	Crash Types
Alaska Highway (No apparent Injury		1	1	2	2 Animal/Vehicle
Johansen Expressway (Possible Injury)		2		2	2 Angle
Peger Road (No apparent Injury, Suspected Minor Injury)		1	1	2	1 Angle, 1 Rear End
Richardson Highway (No apparent injury)	1	2		3	1 Animal, 1 Sideswipe, 1 Single Vehicle ROR
Steese Expressway/Highway (No apparent Injury)		2		2	2 Animal/Vehicle
Grand Total	1	8	2	11	

- No Fatal or Serious Injury crashes were noted in the crash data involving Buses.
- No bus crashes that involves other large commercial vehicles.

Alaska/Richardson/Steese Corridor Safety Performance 2013-2021*Tractor/Trailer Combo Only Crashes

*Includes partial 2022 Crash Data

Tractor/Trailer Combo Only Crashes by Time Period for Each Highway Segment



Alaska/Richardson/Steese Corridor Safety Performance 2013-2021* Observations & Takeaways

*Includes partial 2022 Crash Data

- Much of this data will be used for the predictive model.

  Effect of the ore hauling trucks on crash rates/severity)
- Nearly all segments below statewide average crash rate for the types of highway segments involved. (Except Johansen Expressway: Peger Road to Danby Street)
- 60% rural, 40% urban crashes** (Richardson @ Eielson to Steese at Farmers Loop)
- None of the signalized intersections had a rate above the statewide average for similar type signalized intersections.

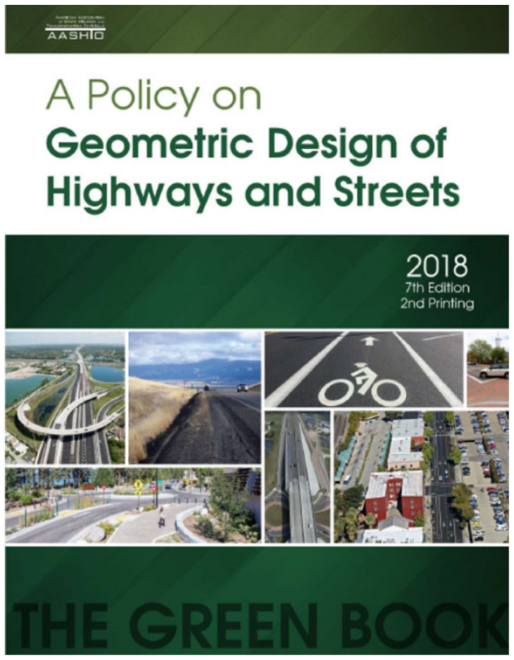
  6 minor side street intersections on the Richardson Hwy. and 3 intersections on the Stees Expressway/Hwy. has intersection rates above the average rate.
- Fatal & serious injury crashes comprise 3.5%. (69% of crashes with no injuries)
- No fatal crashes involving commercial vehicles.***
- Passenger cars and pickups nearly 75% of all crashes.
- 60% occurred in Snow/Ice/Frost roadway surface conditions.
- Nearly 48% were single vehicle crashes.
- 64.4% Intersection related. 35.6% not at intersection.

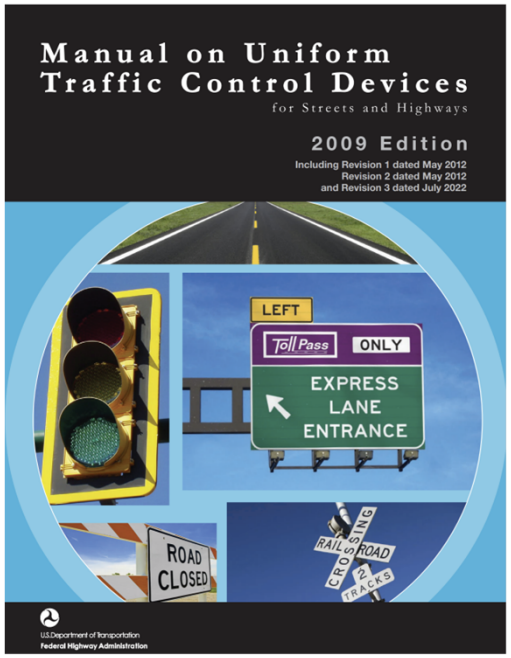
**Urban defined from Richardson Hwy. @ Eielson to Steese Expwy. at Farmers Loop.

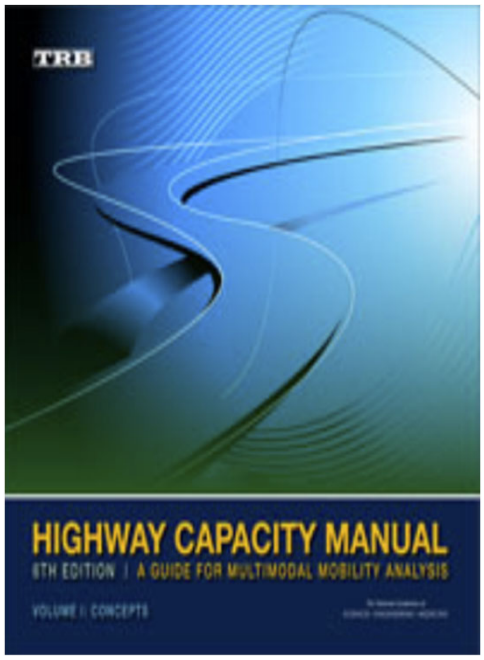
***Tractor Trailer, Semi Trailer, Tanker, Bus, Dump Truck, Garbage Truck, Flatbed, Grader, Tow Truck, Etc.

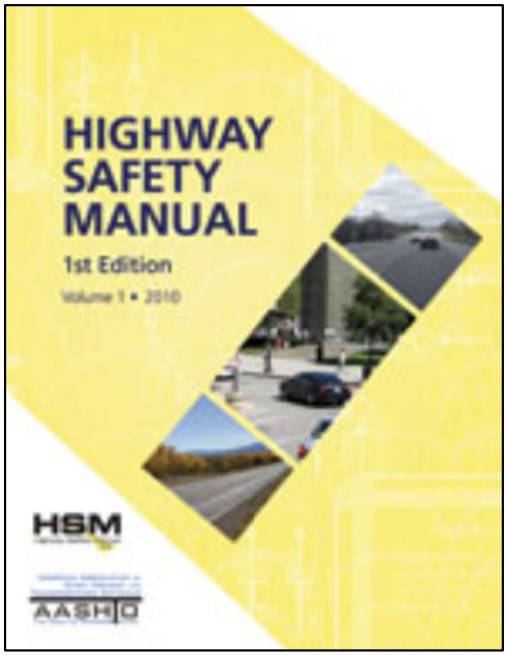
B-Train Stopping Sight Distance Module

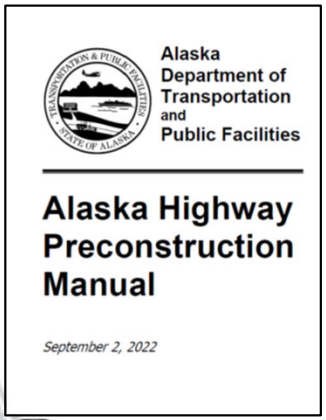
Design Criteria Standards and Guidelines (Partial List)

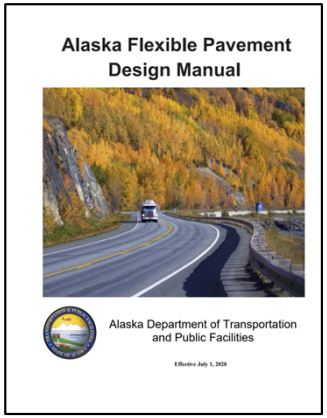


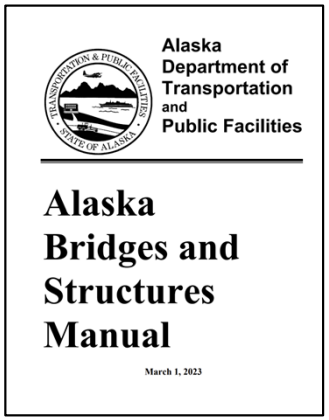


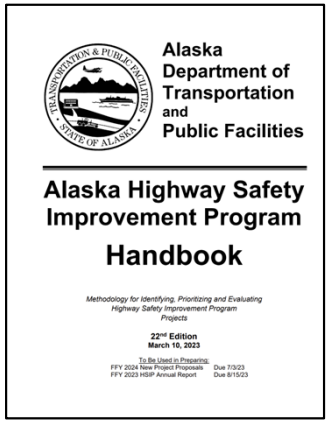


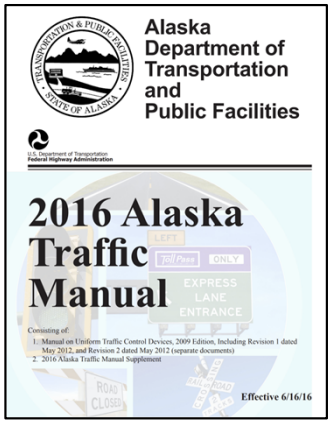


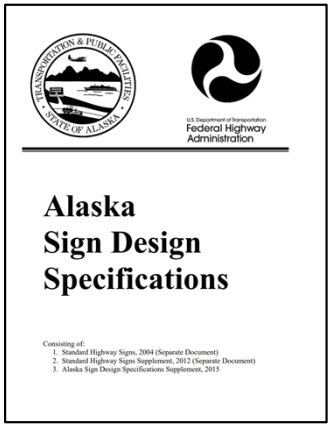












10 Controlling Design Criteria

Design Speed (V)	Minimum design speed met based on the functional classification
Lane Width	Minimum lane width achieved based on functional classification and chosen design speed
Shoulder Width	Minimum shoulder width achieved based on functional classification and chosen design speed
Horizontal Curve Radius (R)	Minimum horizontal curve radius achieved based on chosen design speed and maximum superelevation rate
Superelevation Rate (e)	Was the correct superelevation rate chosen for each curve? Identify curves with insufficient superelevation.
Stopping Sight Distance (S)	Is stopping sight distance available along the horizontal alignment and for crest vertical curves? Use k values to assist calculation.
Maximum Grade	Are all grades below the maximum grade?
Cross Slope	Selected cross slope falls within the appropriate standard range
Vertical Clearance	Minimum value achieved
Design Loading Structural Capacity	Is structural capacity achieved

https://highways.dot.gov/federal-lands/pddm/dpg/about-controlling-criteria

Selecting Design Criteria Values

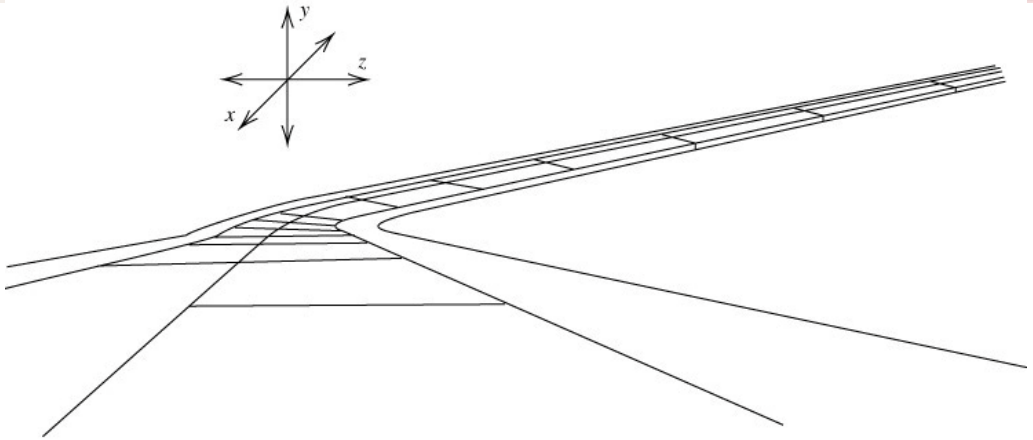
- Numerous factors, some different or unique for each criteria depending upon:
  - Functional class, AADT
  - Terrain- level, rolling, mountainous,
  - Rural vs Urban
  - New construction vs. rehabilitation or pavement preservation.
- Meeting the minimum criteria implies it is nominally safe.
- In addition to meeting minimum criteria, we want consistency in the application of design criteria, so we don’t violate driver expectancy!

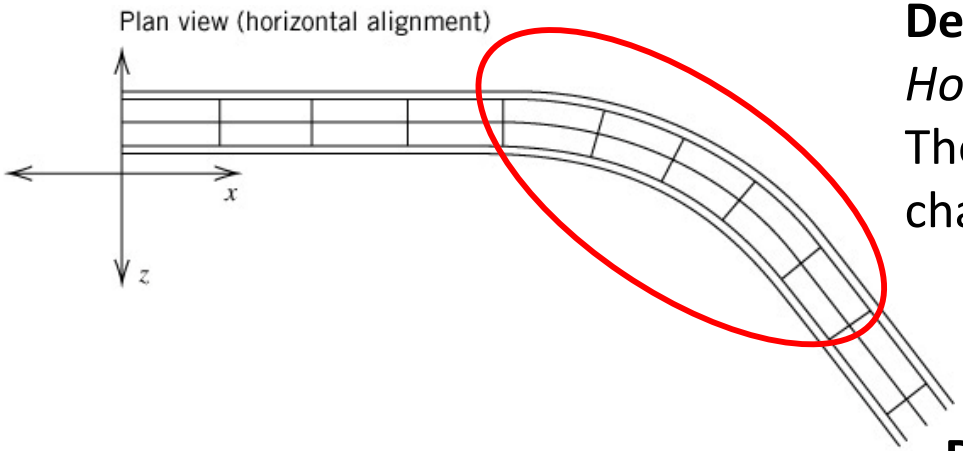
Design Speed

- **Design Speed (V):** *"A selected speed used to determine the various geometric design features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of highway."* **Defines the <u>minimum</u> operating speed for isolated, independent geometric elements on a highway.**
- Original Design Speeds varies along corridor, 50 to 65 mph. Posted speeds vary, up to 65 mph.
- Alaska Interstate Design Speed varies: 70 mph for level terrain, 60 mph for rolling terrain, 50 mph for mountains.

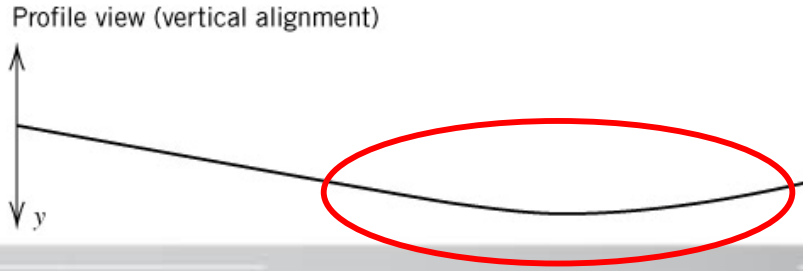
Highway Design Geometric Elements

Highways have
3 dimensions
to coordinate



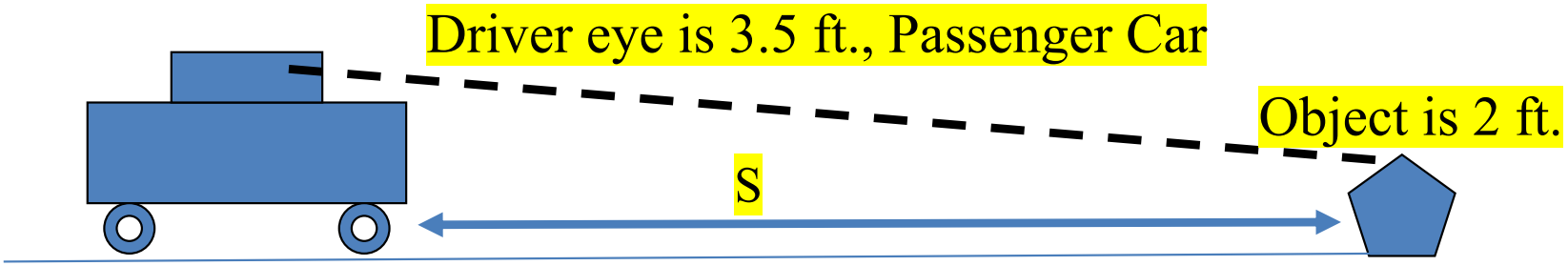


Design Speed determines *Horizontal Curve* design (R and e). These are circular curve arcs to change roadway direction.



Design Speed determines *Stopping Sight Distance, S,* used to design parabolic vertical curves for transitions between roadway grades.

Design Stopping Sight Distance (S)



V in mi/h | $1.47xVx\ t$ | $1.075\ x\ V^2/a$

t=2.5 seconds, perception/reaction time
a=11.2 ft/sec^2, braking deceleration

Design Speed (mi/h)	*Brake Reaction Distance (ft)*	*Braking Distance on Level (ft)*	*Calculated (ft)*	*Design*
15	55.1	21.6	76.7	80
20	73.5	38.4	111.9	115
25	91.9	60.0	151.9	155
30	110.3	86.4	196.7	200
35	128.6	117.6	246.2	250
40	147.0	153.6	300.6	305
45	165.4	194.4	359.8	360
50	183.8	240.0	423.8	425
55	202.1	290.3	492.4	495
60	220.5	345.5	566.0	570
65	238.9	405.5	644.4	645
70	257.3	470.3	727.6	730
75	275.6	539.9	815.5	820
80	294.0	614.3	908.3	910

What impedes S?

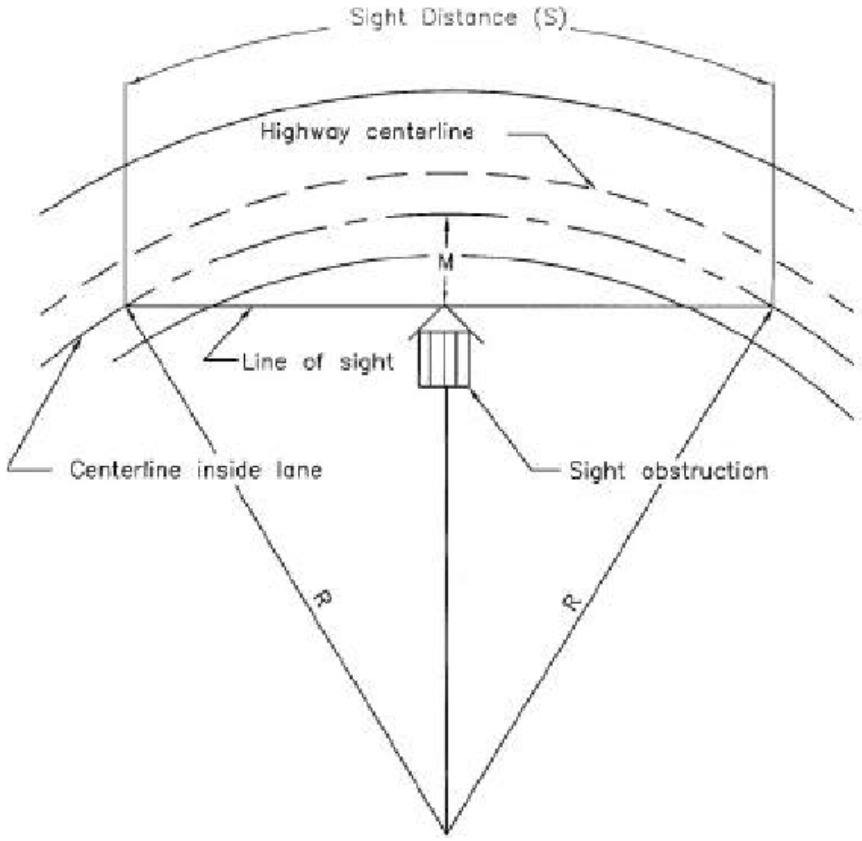
- We should be able to travel highway speed, V, and have sufficient stopping sight distance for V.
  - If so, we meet the design standards for S given V. That constitutes a nominally safe highway.

- Horizonal and vertical alignment changes are points where sight lines can be impeded and therefore require accommodation in design to achieve S.

This slide has been modified after the March 21, 2023 presentation. Grammar correction.

S impeded on Horizontal Alignments

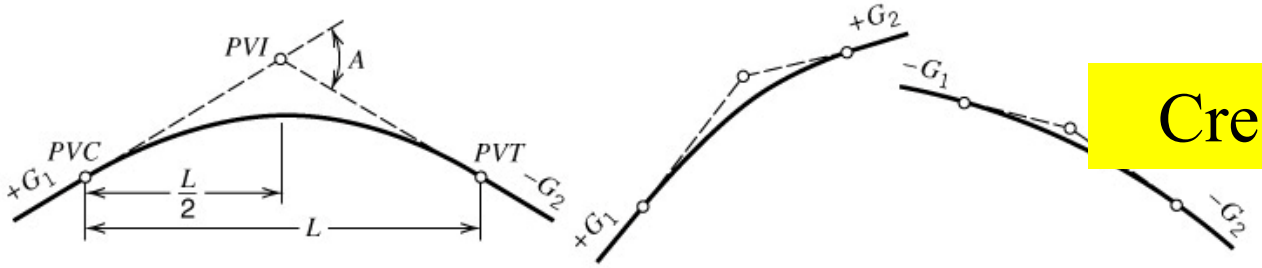
- Primary Design Consideration for Horizontal Curves is that the combination of curve radius, R, and superelevation, e, permits a vehicle to maintain control at a design speed, V.
- Within a horizontal curve, especially those designed at a minimum R, S may be restricted by sight obstruction that is too close to the roadway (M).
- Not a significant issue in Alaska, since right-of-way is cleared.



S on Vertical Alignments

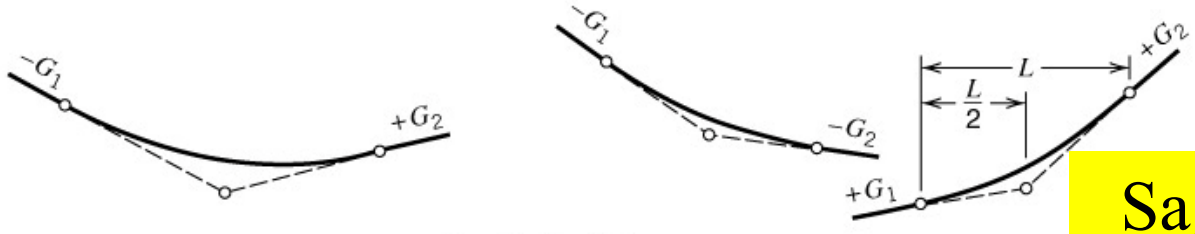
- Sight lines are potentially obstructed by vertical curves (parabolic) needed to transition changes in roadway grades.
  - Vertical curve needs to be long enough for vehicles to see in time to stop (S).
  - No one value for length, because it depends on grade change and V and S, as well as curve type.

This slide has been modified after the March 21, 2023 presentation. Hidden text now visible.



Crest Vertical Curves

Crest $G_2<G_1$



Sag Vertical Curves

Sag $G_2>G_1$

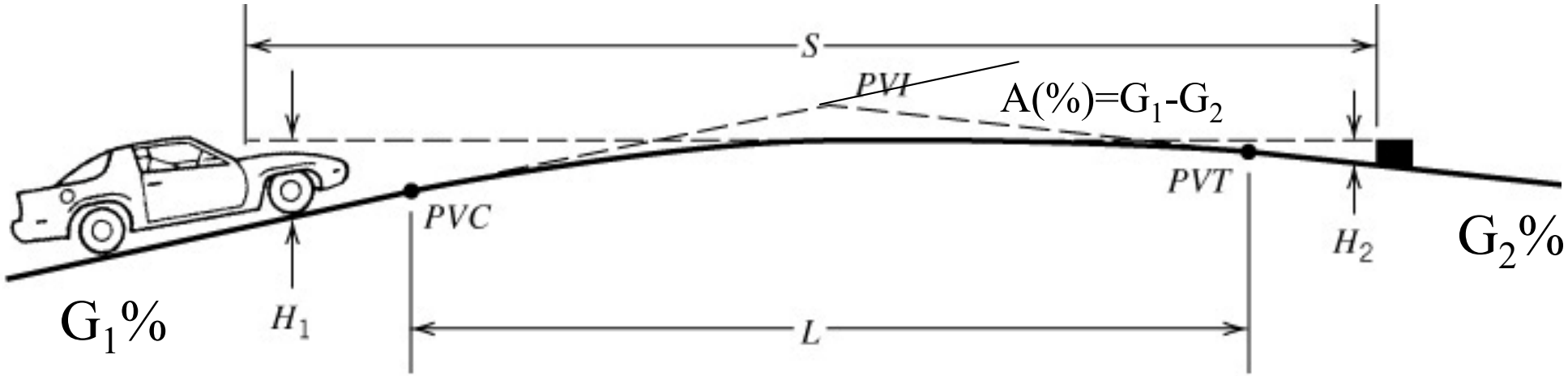
Crest Vertical Curves

- No single value criteria for V
- Combination of the change in grades (A) and required S determines length (L). Design basis is the passenger car.

S= related to V

H_1= Eye ht. 3.5 ft.

H_2 = Object ht., or 2 ft.



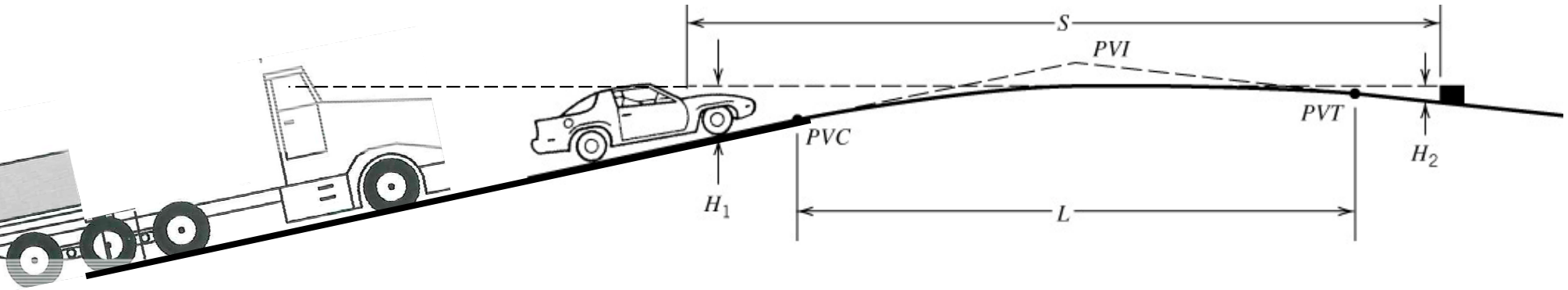
Truck Stopping Sight Distance

Truck deceleration rate is less that automobiles (truck maximum deceleration rate still >11.2 fps^2), resulting in increased braking distance.

H_1= Eye ht. 7.6 ft or more (published in AASHTO)

H_2 = Object ht., or 2 ft.

So, it is assumed that truck additional eye height compensates for increased truck braking distance, and L of vertical curve designed for passenger cars for stopping sight distance is adequate for trucks.



B-Train Braking Performance

DEPARTMENT OF TRANSPORTATION National Highway Traffic Safety Administration 49 CFR Part 571 Docket No. NHTSA–2009-0083 RIN: 2127-AJ37 Federal Motor Vehicle Safety Standards; Air Brake Systems

https://www.nhtsa.gov/sites/nhtsa.gov/files/fmvss/121_Stopping_Distance_FR_0.pdf

TABLE II. Stopping Distance Calculations for Three-Axle Tractors with a GVWR Greater Than 70,000 Pounds, and Tractors with Four or More Axles and a GVWR Greater Than 85,000 Pounds, in the Loaded-to-GVWR Condition. (Brake System Reaction Time of 0.45 Seconds)

Initial Vehicle Speed		Steady-State Deceleration		Stopping Distance
(mph)	(ft/sec)	(ft/sec²)	(g's)	(ft)
20	29.3	15.00	0.47	35
25	36.7	14.65	0.45	54
30	44.0	14.15	0.44	78
35	51.3	13.90	0.43	106
40	58.7	13.75	0.43	138
45	66.0	13.60	0.42	175
50	73.3	13.45	0.42	216
55	80.7	13.40	0.42	261
60	88.0	13.35	0.41	310

65 mph performance is extrapolated as deceleration = 13.33 ft./sec^2. Stopping distance is 341 feet (rounded).

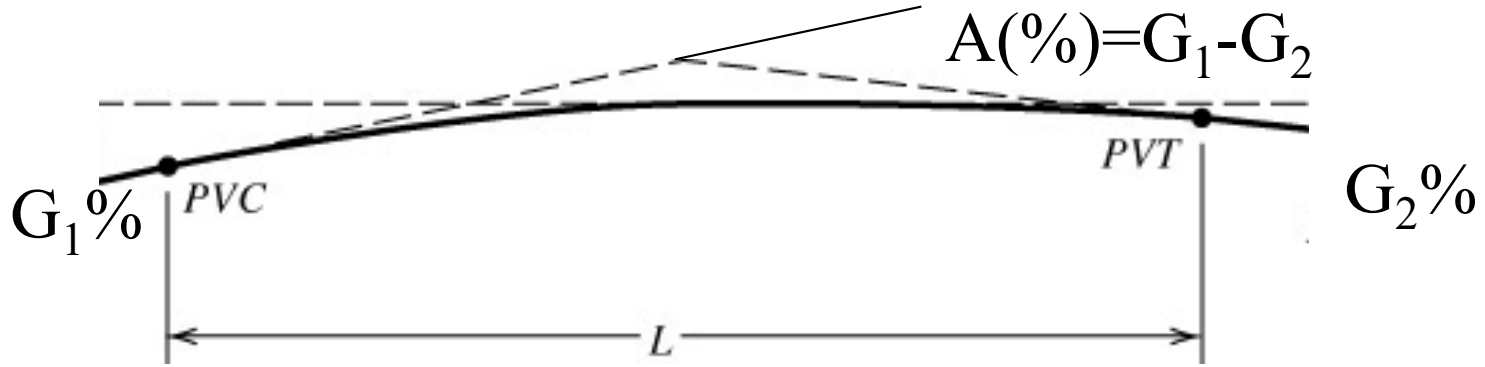
Computing S for Passenger Car and B-Train

$$S = (1.47 \times V \times t) + (1.075 \times V^2/a)$$ ➔ **Computed Stopping Sight Distance**

Vehicle S Case	Perception / Reaction Time, t, seconds	Deceleration, a, feet per second^2	Driver Eye Ht., feet	S for V=65 mph, feet	S for V=60 mph, feet	S for V=55 mph, feet
1- Design Standard for S, Design Basis	2.5	11.2	3.5	644.4	566.0	492.5
2- Passenger Car, Hard Braking	1.5	29.3	3.5	298.3	264.4	232.3
3- Passenger Car, Moderate- Aggressive Braking	2.5	19.9	3.5	467.1	415.0	365.5
4- B-Train, Hard Braking	1.5	13.3	7.6	484.1	422.6	365.2
5- B-Train, Moderate-Aggressive Braking	2.5	9.1	7.6	738.0	645.8	559.5

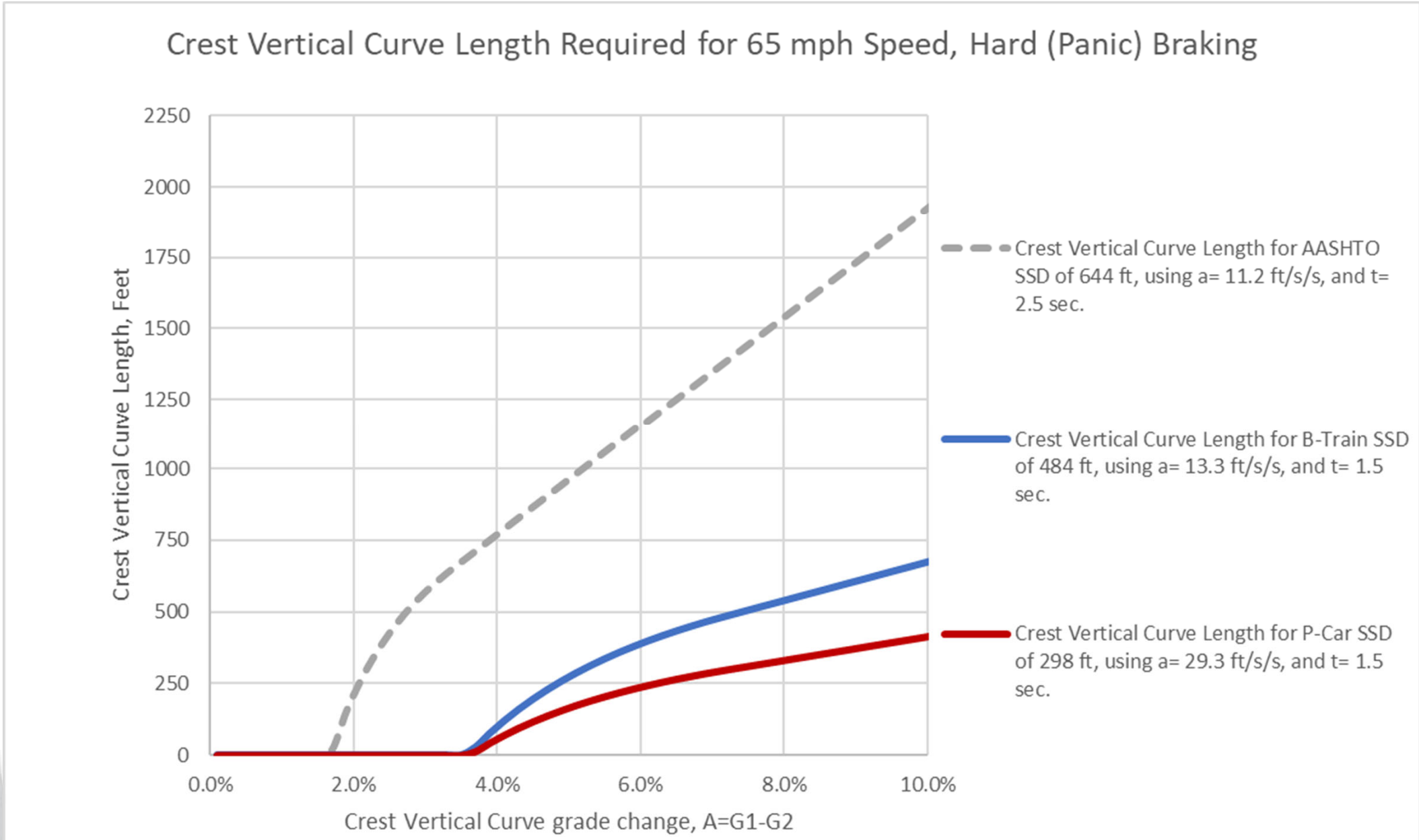
1. Both t and a from AASHTO A Policy on Geometric Design of Highways and Streets (2018)
2. The value of perception / reaction time is based on engineering judgement upon literature review. Value of hard braking deceleration is the average of braking values presented in Consumer Reports, found here: https://www.consumerreports.org/car-safety/best-and-worst-braking-distances-a2960086475/ .
3. Deceleration values based on literature review and engineering judgement, about 68% of hard braking values.
4. Hard braking deceleration rate is based on FMVSS 121.
5. Moderate-Aggressive deceleration rate 68% of hard braking value, consistent with passenger car percentage.

Evaluation Crest Vertical Curves

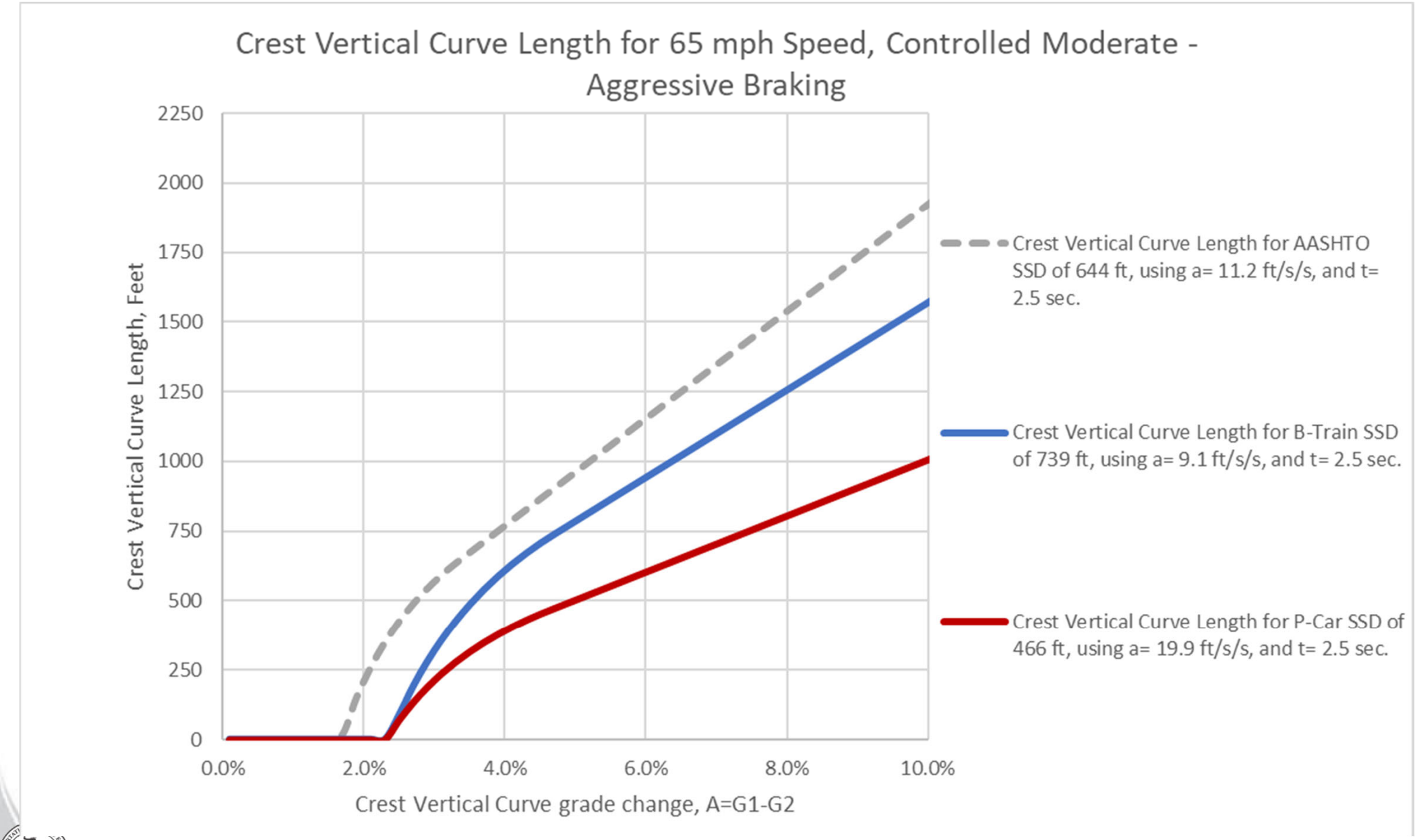


Since grade change, A, varies, we will evaluate vertical curve lengths, L, needed for B-Train stopping cases. If L for B-Trains is less than the Design Standard Case, then stopping sight distance is satisfied.

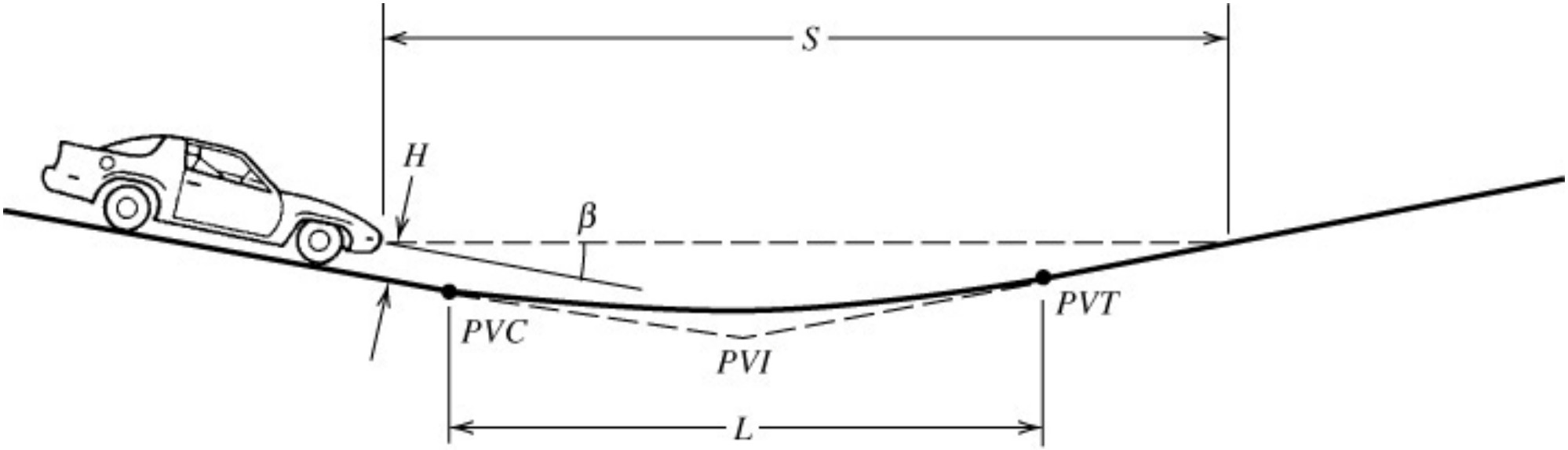
65 mph Crest Vertical Curves, Hard Braking



65 mph Crest Vertical Curves, Moderate-Aggressive Braking



Sag Vertical Curves



Sag VC not sight restricted in daylight.

Constraint is that the headlight SD= SSD.

H for Sag Vertical Curve L design is 2 feet

β is 1 degree

Trucks and B-Trains have advantage because the headlight height >>2 feet.

B-Train Stopping Sight Distance Module Summary

- Stopping sight distance or S, a critical design criteria, allows vehicles to safely travel at design speeds and perceive, react, and brake to a full stop in advance of hazards or obstructions.
- S uses perception reaction time (t=2.5 seconds) and a deceleration rate (a=11.2 feet per second^2) which are conservative providing a factor of safety. Majority of drivers have t values less than 2.5 seconds, and almost all vehicles have higher deceleration rates. S for passenger cars form the basis of design for horizonal and vertical curves.

B-Train Stopping Sight Distance Module Summary

- Trucks (> 4 tractor axles, >85,000 lb GVW), including B-Trains, have lower deceleration rates than autos, but must be able to stop within 310 feet at 60 mph (FMVSS 121).
- B-Train eye height offsets the decreased braking ability, thus B-Train S is satisfied when roadway is designed with AASHTO criteria.

B-Train Operational Impact on Traffic Speeds

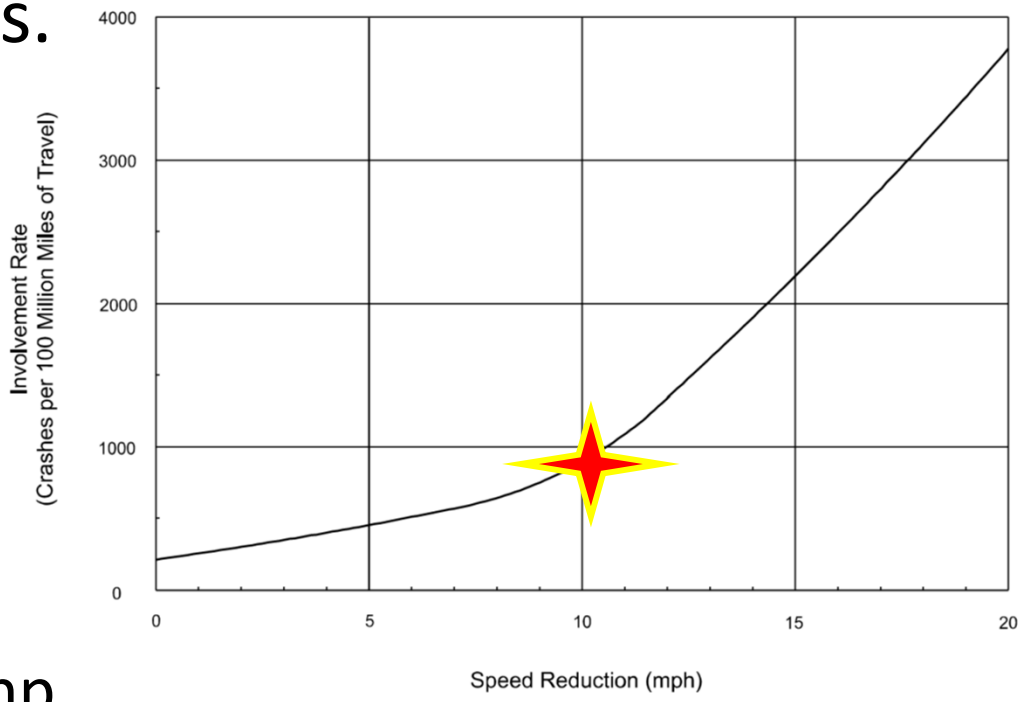
Analysis for the rural segments of the A R S corridor. The Alaska, Richardson, and Steese Highways rural segments operate under the *Uninterrupted Flow Regime*, meaning that flow is regulated by vehicle-vehicle interactions and interactions between the roadway and vehicle.

Interrupted Flow Regime, typically the dominate urban flow type, is flow regulated by external means, for example, traffic signals and roundabouts.

Speed Reduction and Crash Rates

Deviation from traffic flow prevailing speed of more than **10 mph increases crashes-** Creates a condition of inconsistency, violates driver expectancy**.** Heavy vehicles are affected by adverse grades.

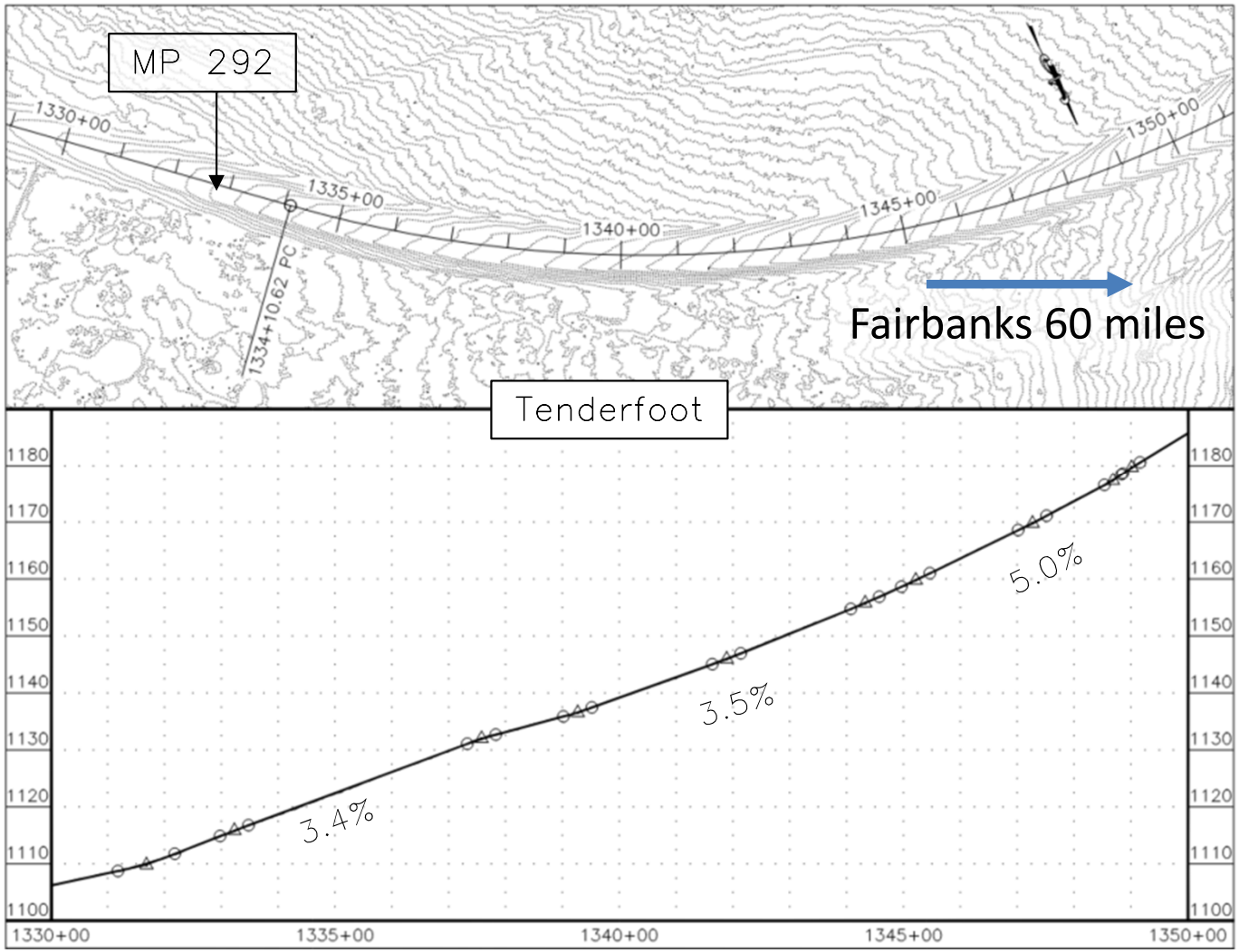
- B-Train Combination
  - GVW: 165,000 lb
  - Weight/Power: ≈290 lb/hp
- Commercial Tractor Trailer
  - GVW: 80,000 lb
    - Weight/Power: ≈ 140 lb/hp



Source: AASHTO A Policy on Geometric Design of Highways and Streets (2018)

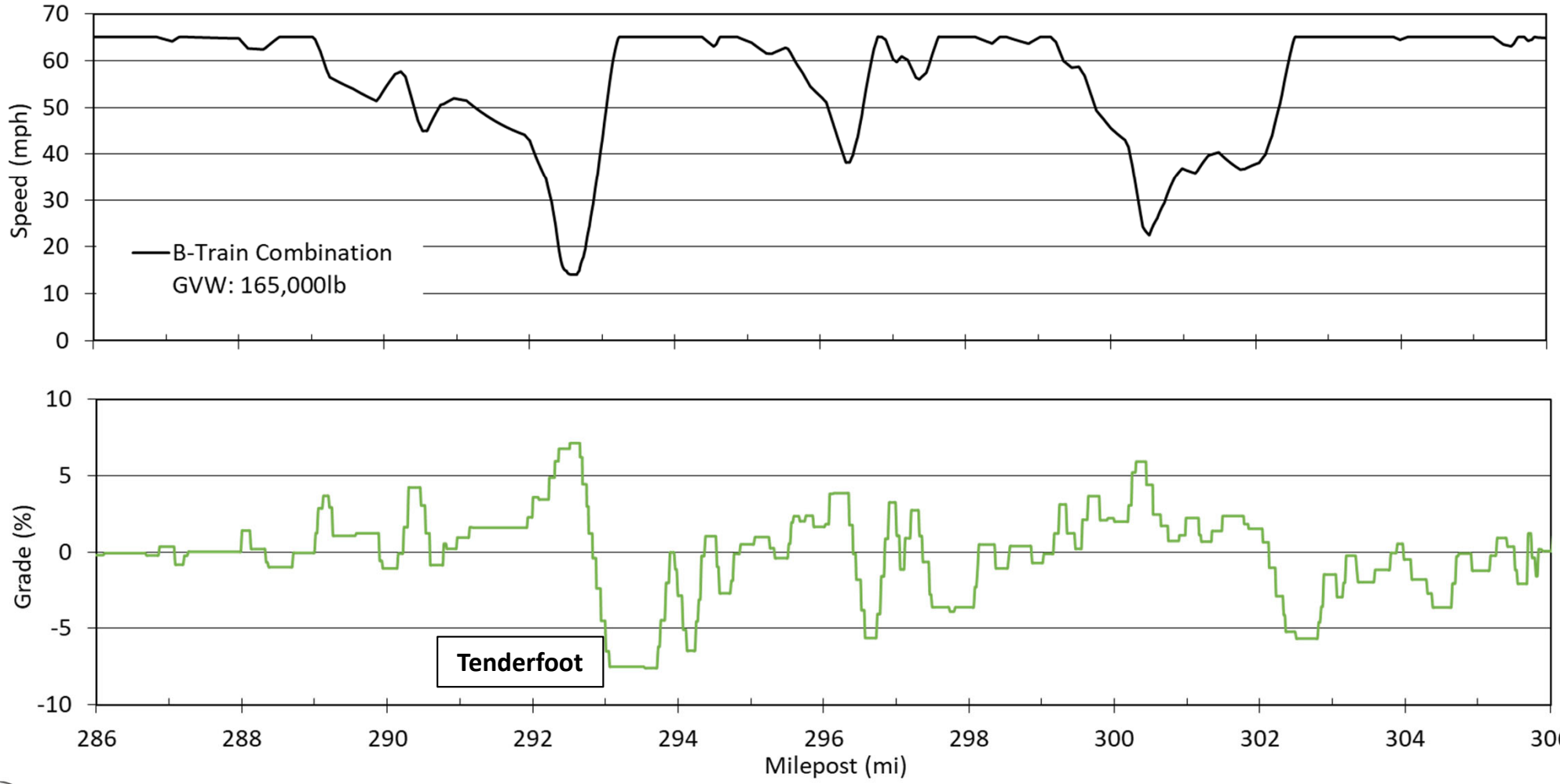
Speed Profile Analysis

- Obtain elevation information from existing sources
  - As-Builts
  - Lidar scans
- Northbound Direction, only. Southbound B-Trains are not loaded.



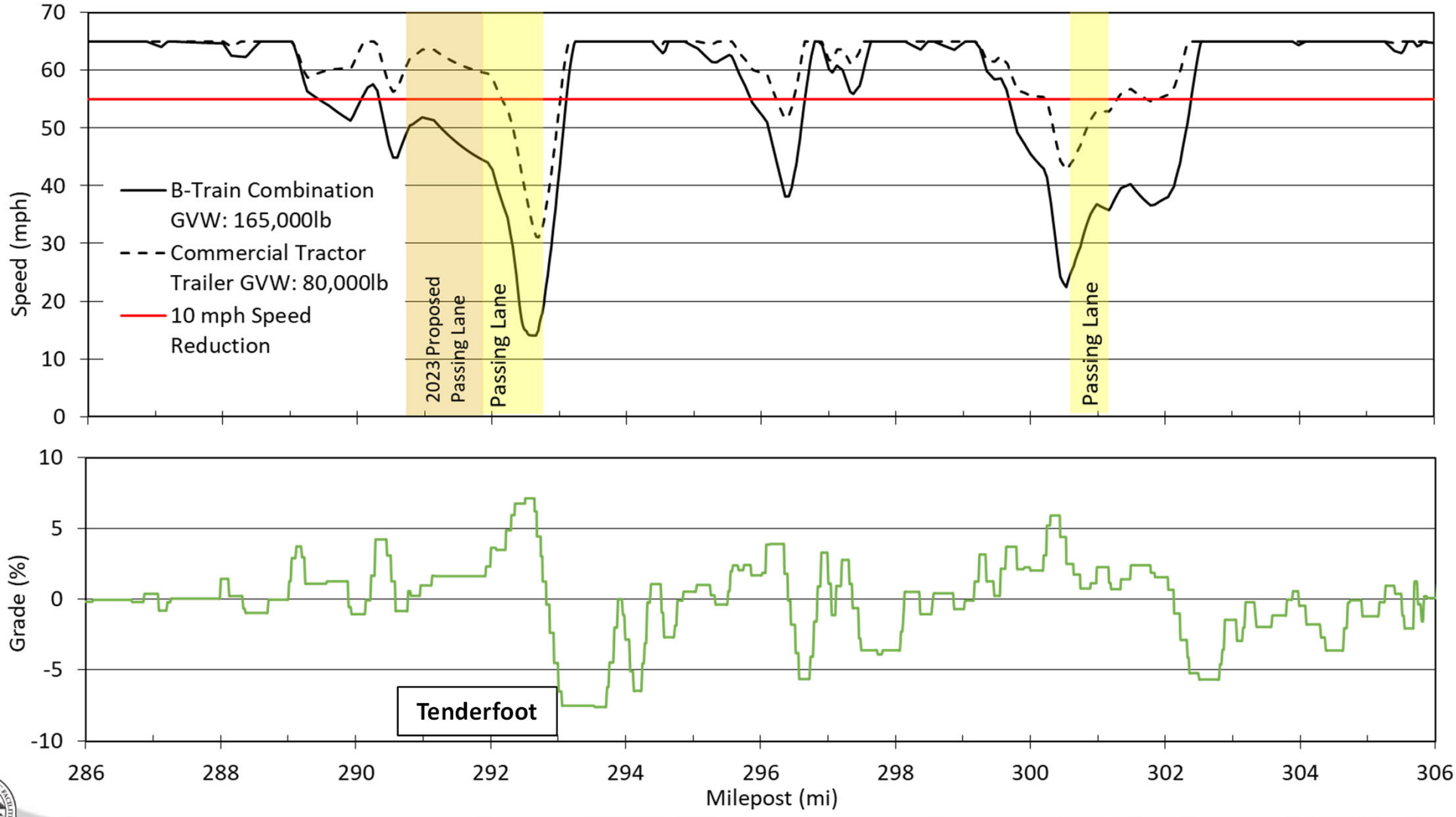
Speed Profile Analysis

- Use grade profile and truck performance information to create speed profile along route



Speed Profile Analysis

- Combined B-Train Combination and Commercial Tractor Trailer speed profiles and existing/proposed passing lane locations



B-Train Speed Reduction

This slide has been modified after the March 21, 2023 presentation. Table information modified.

Alaska Highway Segment

Manh Choh to Delta Junction: 114 miles

Vehicle	Overall Route (No consideration of Multi-lane segments)			As currently constructed and excluding passing lanes, climbing lanes, and multi-lane segments (where slower vehicles can be passed)			Excluding existing and 2023/2024 constructed passing lanes, climbing lanes, and multi-lane segments (where slower vehicles can be passed)		
	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed
B-Train Combination	8%	41 mph	5%	8%	41 mph	5%	8%	41 mph	5%
Commercial Tractor Trailer	1%	51 mph	5%	1%	51 mph	5%	1%	51 mph	5%

Richardson Highway Segment

Delta Junction to Mitchell Expressway: 95 miles

Vehicle	Overall Route (No consideration of Multi-lane segments)			As currently constructed and excluding passing lanes, climbing lanes, and multi-lane segments (where slower vehicles can be passed)			Excluding existing and 2023/2024 constructed passing lanes, climbing lanes, and multi-lane segments (where slower vehicles can be passed)		
	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed
B-Train Combination	11%	14 mph	7%	9%	17 mph	6%	7%	17 mph	6%
Commercial Tractor Trailer	4%	31 mph	7%	2%	32 mph	6%	2%	32 mph	6%

Steese Highway Segment

Johansen Expressway to Fort Knox: 18 miles

Vehicle	Overall Route (No consideration of Multi-lane segments)			As currently constructed and excluding passing lanes, climbing lanes, and multi-lane segments (where slower vehicles can be passed)			Excluding existing and 2023/2024 constructed passing lanes, climbing lanes, and multi-lane segments (where slower vehicles can be passed)		
	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed	Route Below 10 mph of Posted Speed Limit	Minimum Speed	Grade at Minimum Speed
B-Train Combination	59%	13 mph	8%	32%	13 mph	8%	32%	13 mph	8%
Commercial Tractor Trailer	27%	25 mph	8%	17%	25 mph	8%	17%	25 mph	8%

B-Train Speed Reduction Summary

This new slide has been added/inserted after the March 21, 2023 presentation. Subsequent previous slide page numbers, 74-91, increased by one, become 75-92.

- Maintaining a speed within 10 mph of traffic flow is important to maintain a lower crash rate.
  - The addition of passing and climbing lanes gives impeded traffic the opportunity pass slow moving vehicles.
- Reduced speeds on rural highway segments are as follows in 2024-2030.
  - Alaska Highway: B-Trains are expected to be 10+ mph slower than other traffic for 8% of the 114-mile route on two-lane segments without existing and planned passing, climbing, or multilane sections.
  - Richardson Highway: B-Trains are expected to be 10+ mph slower than other traffic for 7% of the 95-mile route on two-lane segments without existing and planned passing, climbing, or multilane sections.
  - Steese Highway: B-Trains are expected to be 10+ mph slower than other traffic for 32% of the 18-mile route on two-lane segments without existing and planned passing, climbing, or multilane sections.

Pavement Impacts Module

Pavement Health

2022 Alaska Transportation Asset Management (TAMP)

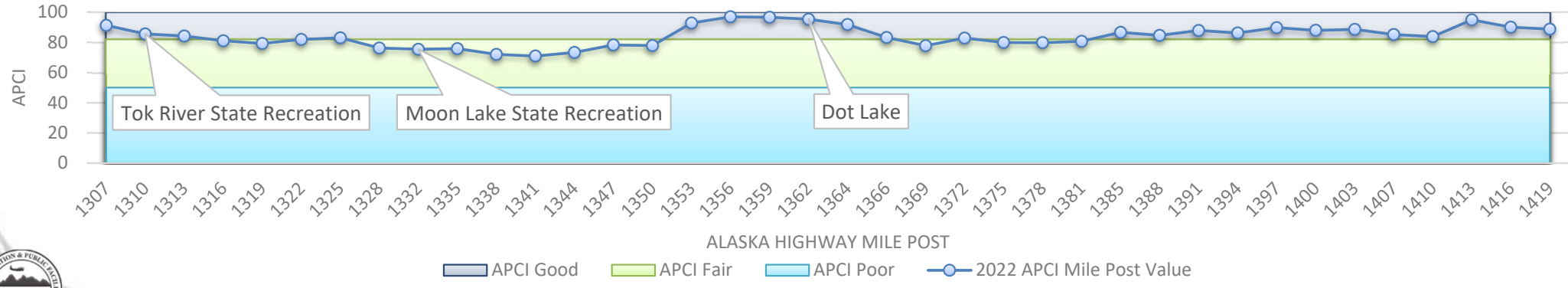
Pavement "Health"

Alaska Pavement Condition Index (APCI)

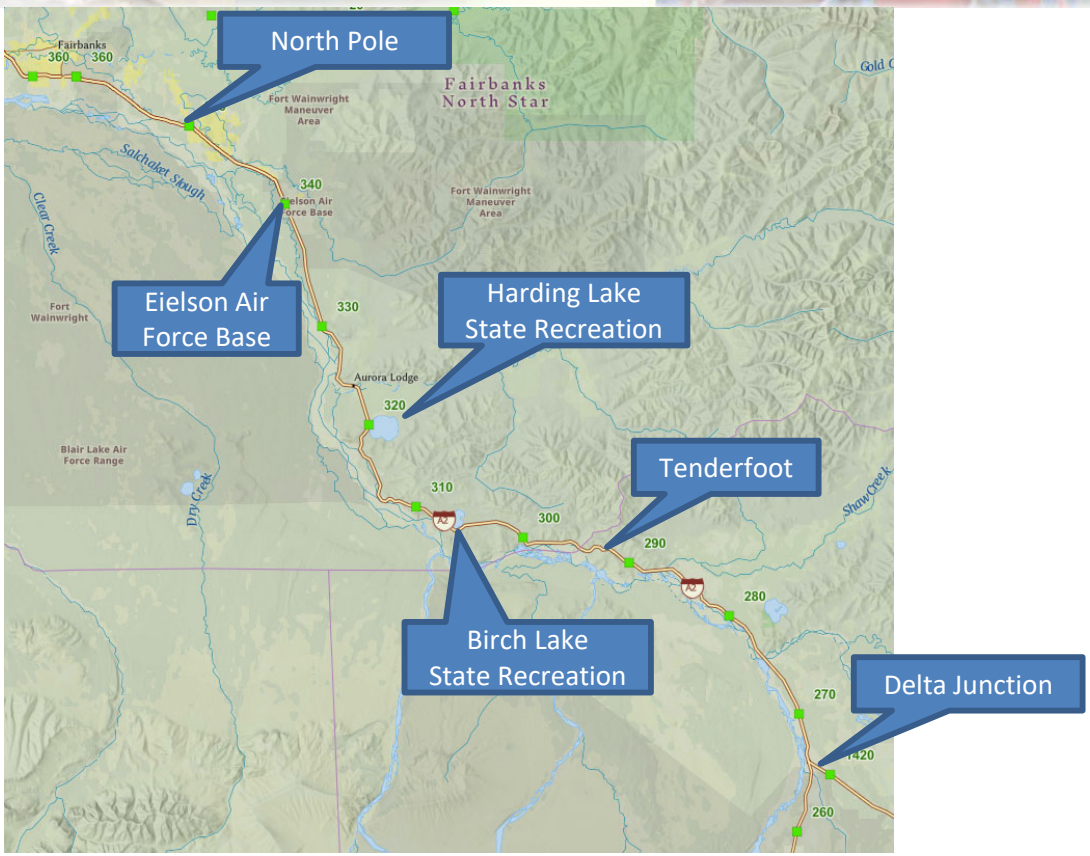
- 0-100 Rating
  - 100 Perfect Condition
  - 50 Poor Condition
- Automatic Road Analyzer (ARAN)
  - Measured Distresses (combined for APCI rating)
    - Rutting (>0.4 inch depth is poor)
    - International Roughness Index (>170 vertical inch/mile is poor)
    - Fatigue Cracking (> 20% is poor)

Alaska Highway APCI

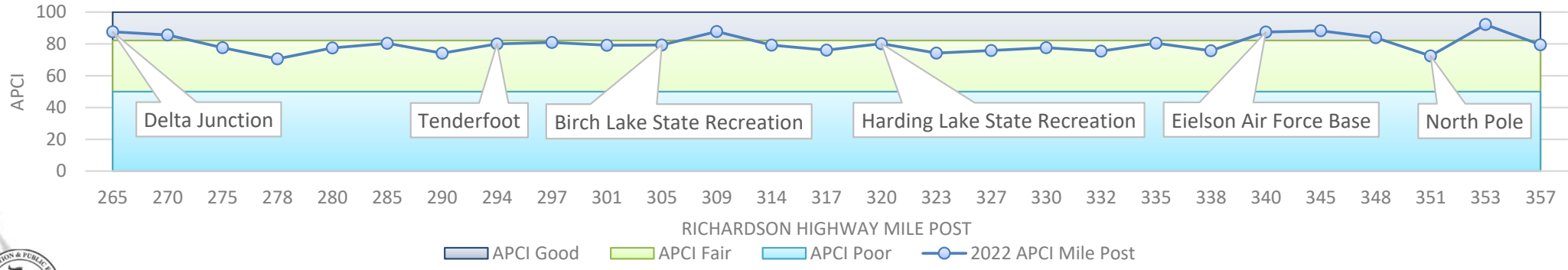
Alaska Highway: MP 1307-1419



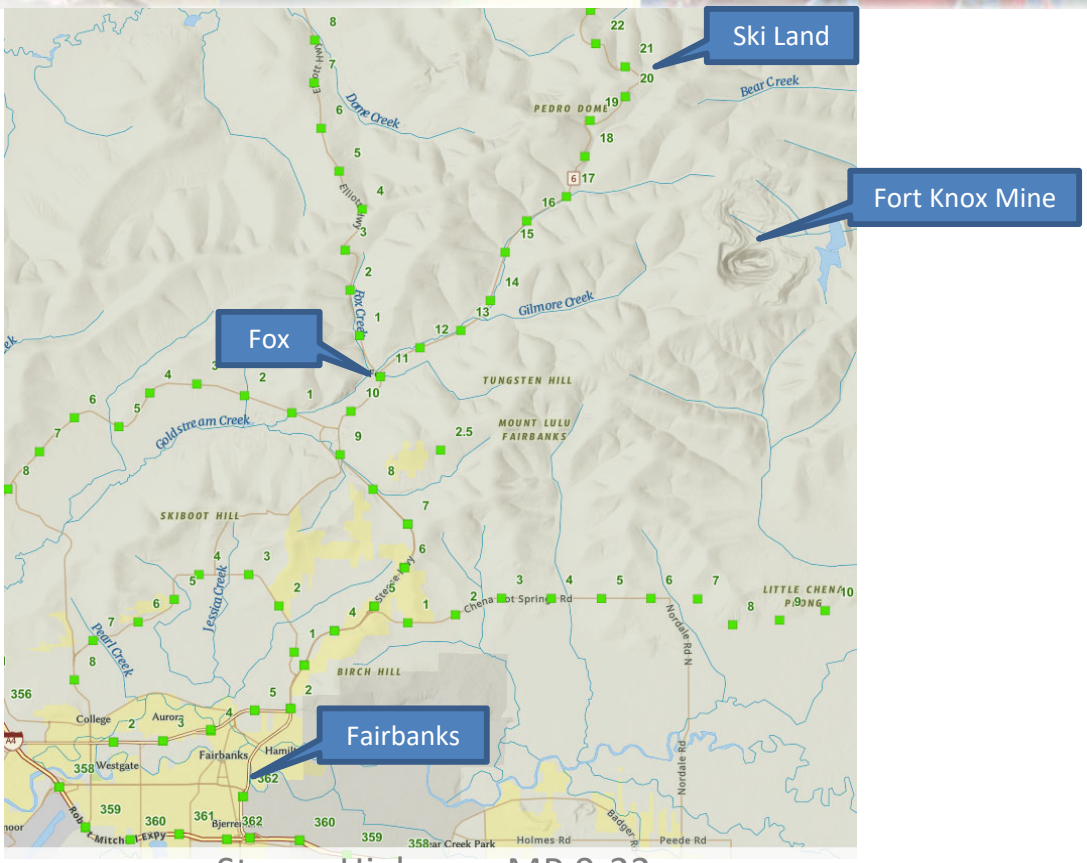
Richardson Highway APCI



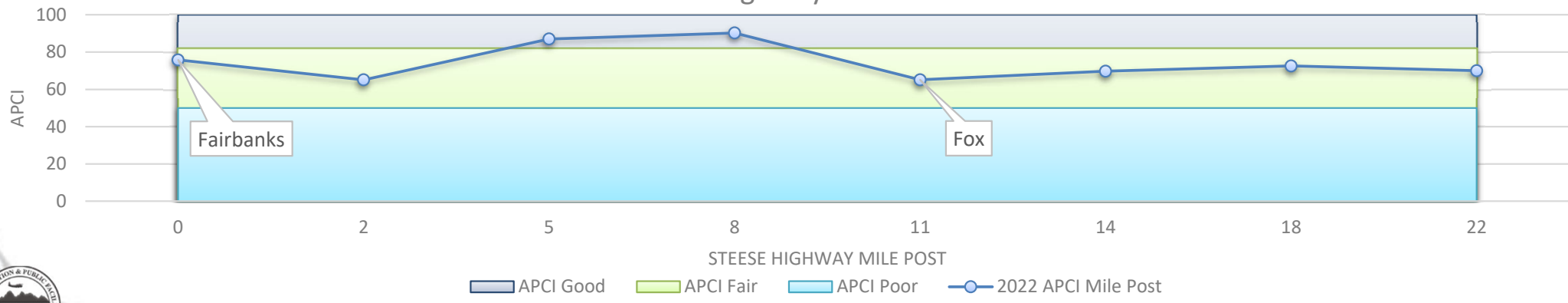
Richardson Highway: MP 265-357



Steese Highway APCI



Steese Highway: MP 0-22



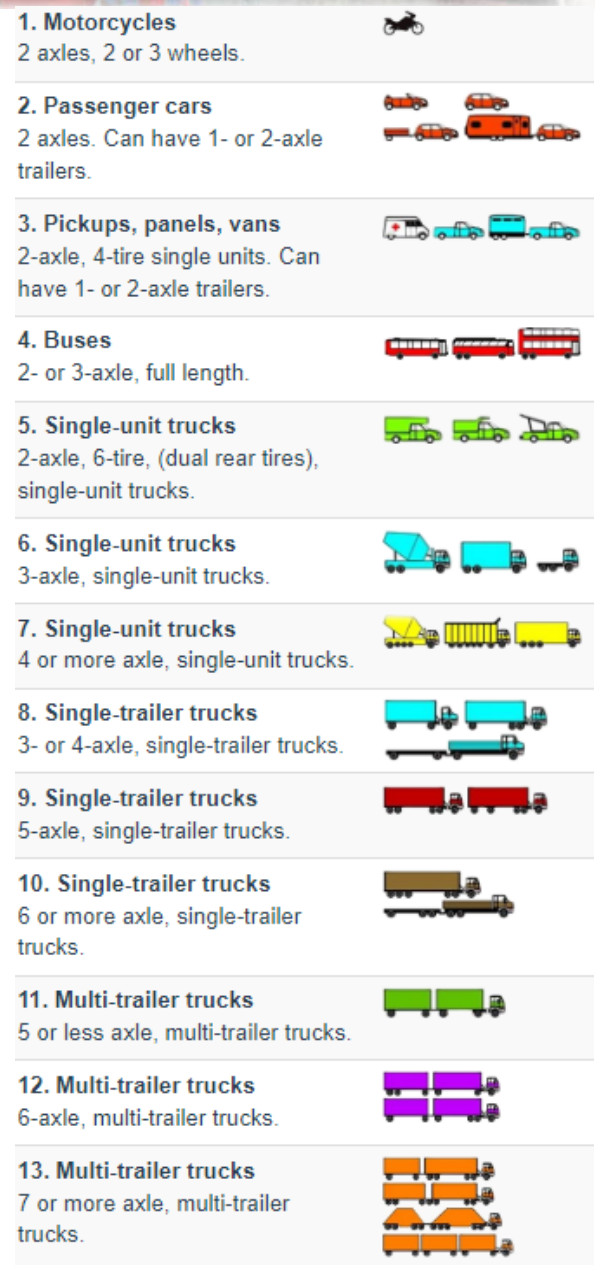
Equivalent Single Axle Loads (ESAL)

- Alaska Flexible Pavement Design Manual

Table 6-1 Summary of DOT&PF Truck Categories and FHWA Truck Classification

DOT&PF Truck Categories	FHWA Truck Classification	Load Factors
2-axle truck	Class 5	0.50
3-axle truck	Class 6 and 8	0.85
4-axle truck	Class 7 and 8	1.20
5-axle truck	Class 9 and 11	1.55
6 or more axle truck	Class 10, 12, and 13	2.24

1 ESAL represents the equivalent loading damage to the pavement structure as one pass of a single 18k dual-tire axle with all four tires at 110 psi.



B-Train Ore Truck

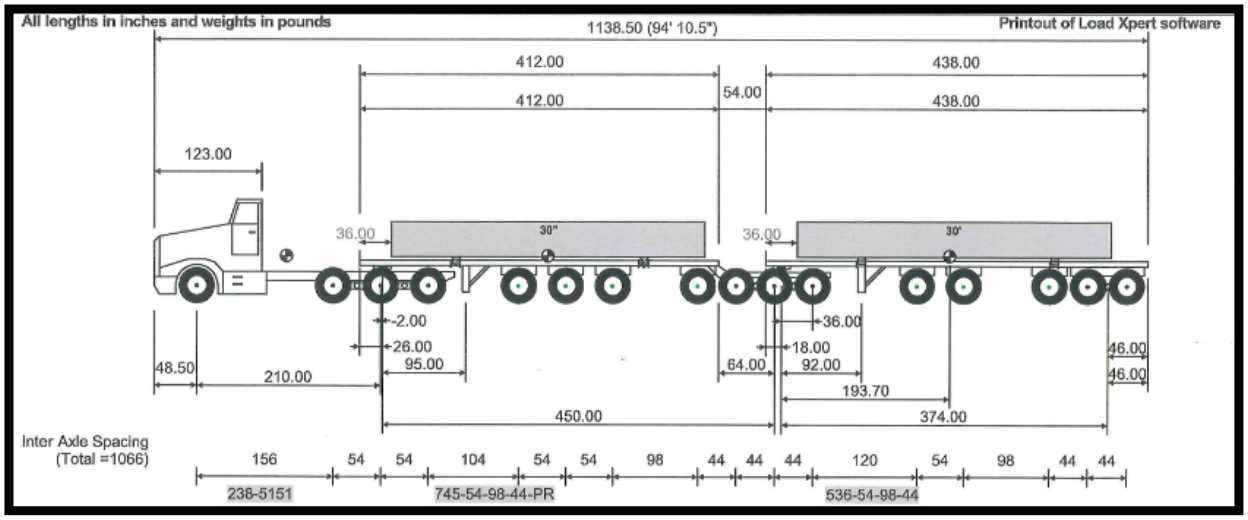
B-Train Ore Truck

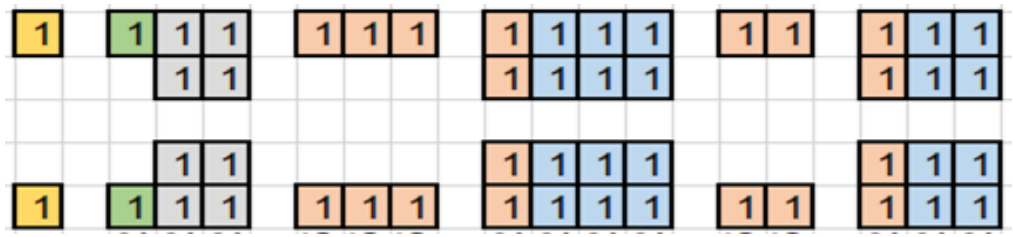
Load Factor: 3.42

Trips: 109,500

60 trips/day	365 days	5 years

ESAL: 375,000



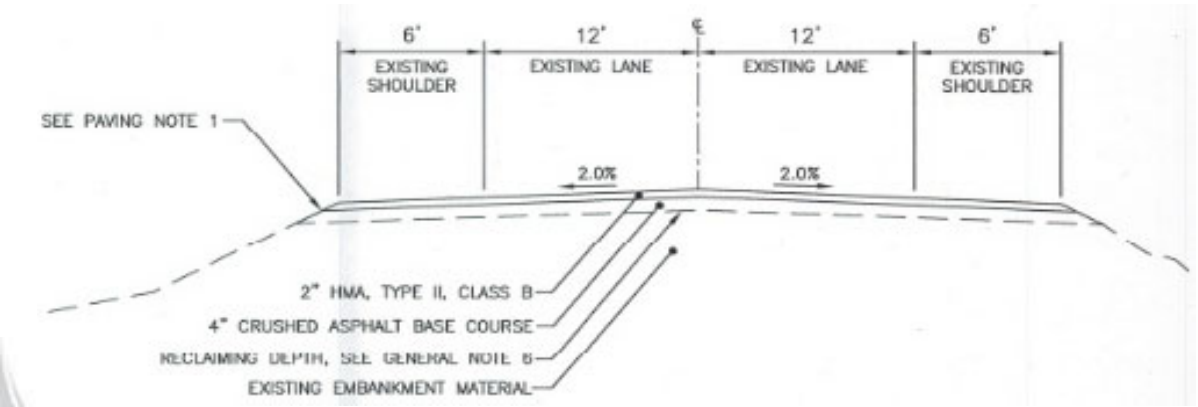


Legend
Front Steer Axle
Tractor Fixed Axle (not liftable)
Tractor Drive Axle
Trailer Lift Axle
Trailer Fixed Axle

Design Principals

- Alaska Traffic Counts
- As-Builts
- AKDOT Flexible Pavement Design

DESIGN DESIGNATIONS	
ADT (2008)	310
ADT (2030)	480
DHV	17%
PERCENT TRUCKS (T)	30.8%
DIRECTIONAL SPLIT (D)	40/60
DESIGN SPEED (V)	60 MPH
DESIGN EAL'S (15 YEARS)	412,068



Base Data

Design Period (yrs)	20
Design Construction Year	2010
Base Year	2010
Base Year Total AADT	1,357
Growth Rate % per Year	1

Manual ESALs

Lane No.	% of Base Year AADT by Lane
1	50
2	50
3	0
4	0
5	0
6	0

Truck Category	Load Factor	% AADT in Truck Category
2-Axle (Class 5)	0.50	9.12
3-Axle (Class 6, 8)	0.85	1.53
4-Axle (Class 7, 8)	1.20	0.14
5-Axle (Class 9, 11)	1.55	0.99
>=6-Axle (Class 10, 12, 13)	2.24	0.69

Computed Design ESALs 496,330

AKDOT Flexible Pavement Design

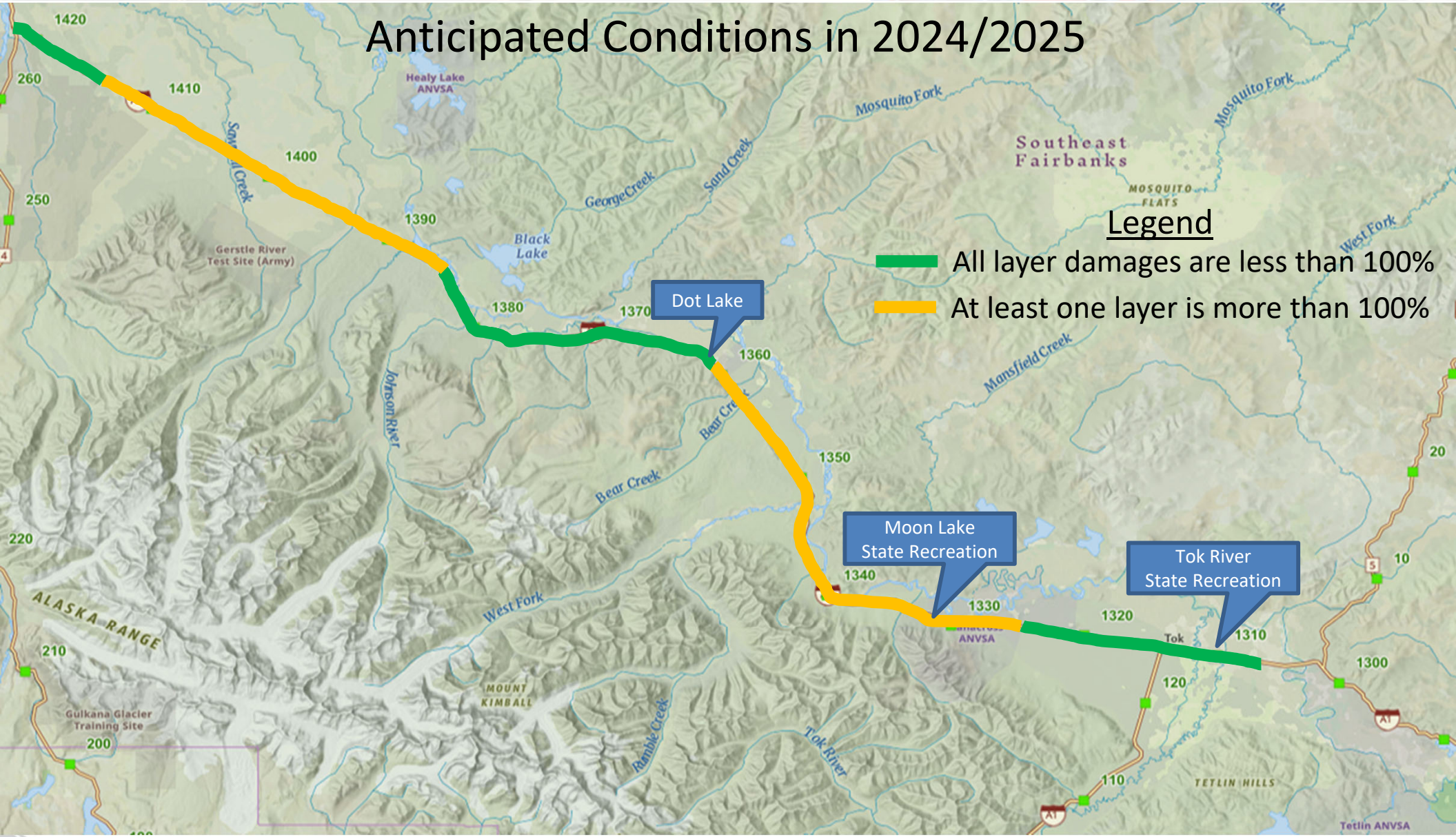
Project Name: MhanChohAkHwySeg2 | **Project Number:** 713 | **Analysis Date:** 3/17/2023 | Project Status: At least one layer damage is more than 100%.
Design Type: New Design | **Designer:** ljw | **Unit:** US Customary

Project Location:	ManhChoh			Tire Load (lbs) 4500	Load Description:	ESAL						
					Load Loc (in)							
			Design	Tire Press. (psi)	X:	0	13.5					
Design AADT:	278		Loadings	110	Y:	0	0					
Spring%:	25		115,411		Eval Loc (in)							
Summer%:	25		115,411		X:	0	6.75					
Fall%:	25		115,411		Y:	0	0					
Winter%:	25		115,411									
Total%:	100		461,644									
	Layer	Critical Z Coordinate (in)		Asphalt Properties	Season	Modulus (Ksi)	Poisson's Ratio	Tensile Micro Strain	Compressive Stress (psi)	Million Cycles to Failure	Past Damage (%)	Future Damage (%)	Total Damage (%)
			Air%:	5	Spring	450	0.30	552		0.09		130.72	130.72
Thickness (in):	2	1.99	Asphalt%:	5.5	Summer	400	0.30	444		0.20		57.84	57.84
Name:	Asphalt Concrete (Modified Asph.)		Density (pcf)	148	Fall	400	0.30	444		0.20		57.84	57.84
Use TAI:	Yes				Winter	1200	0.30	212		0.88		13.04	13.04
										Total Damage:		259.44	259.44
			Air%:		Spring	20	0.35		49.7	0.02		616.18	616.18
Thickness (in):	6	2.01	Asphalt%:		Summer	30	0.35		60.0	0.04		280.14	280.14
Name:	Aggregate Base P200<10%		Density (pcf)		Fall	30	0.35		60.0	0.04		280.14	280.14
Use TAI:					Winter	50	0.35		48.5	0.44		26.44	26.44
										Total Damage:		1202.90	1202.90
			Air%:		Spring	20	0.40		18.8	0.45		25.90	25.90
Thickness (in):	24	8.01	Asphalt%:		Summer	30	0.40		20.5	1.36		8.50	8.50
Name:	Select A P200<10%		Density:		Fall	30	0.40		20.5	1.36		8.50	8.50
Use TAI:					Winter	50	0.40		18.3	10.49		1.10	1.10
										Total Damage:		44.00	44.00
			Air%:		Spring	10	0.40		2.6	21.05		0.55	0.55
Thickness (in):	24	32.01	Asphalt%:		Summer	10	0.40		2.2	36.10		0.32	0.32
Name:	Select B P200<18%		Density:		Fall	10	0.40		2.2	36.10		0.32	0.32
Use TAI:					Winter	10	0.40		1.6	101.77		0.11	0.11
										Total Damage:		1.30	1.30
					Spring	10	0.45		1.0	497.46		0.02	0.02
Thickness (in):	0	56.01			Summer	10	0.45		0.9	746.86		0.02	0.02
Name:	Subgrade P200<30%				Fall	10	0.45		0.9	746.86		0.02	0.02
					Winter	10	0.45		0.7	1731.83		0.01	0.01
										Total Damage:		0.07	0.07

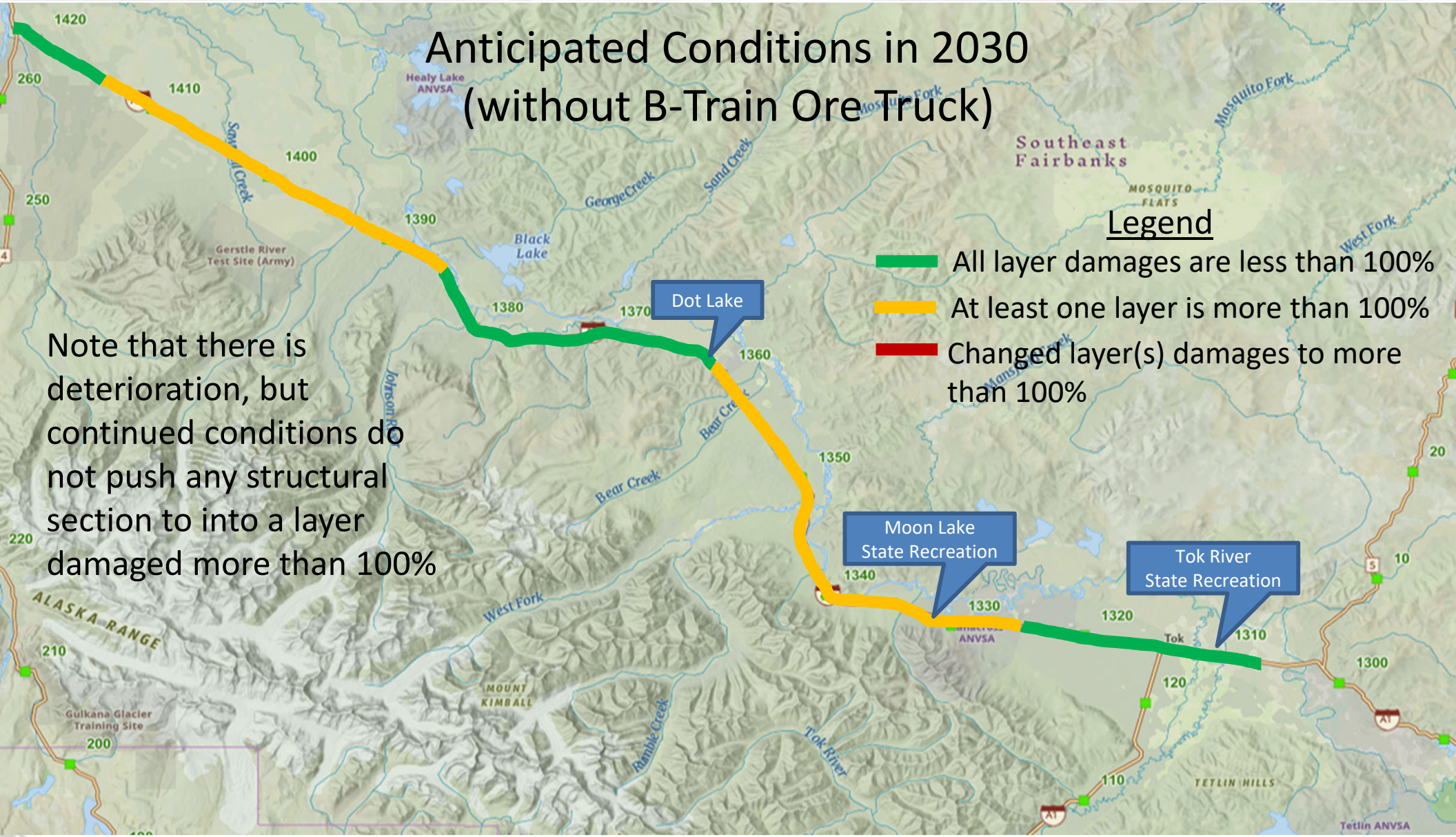
\\kin-enod-fs\KE-Files\PROJECTS\00713_ARS Corridor Action Plan\Analysis\Pavement\AsBuilt\AKhwy\AKFPDM\MhanChohAkHwySeg2-TV.xml

Alaska Highway

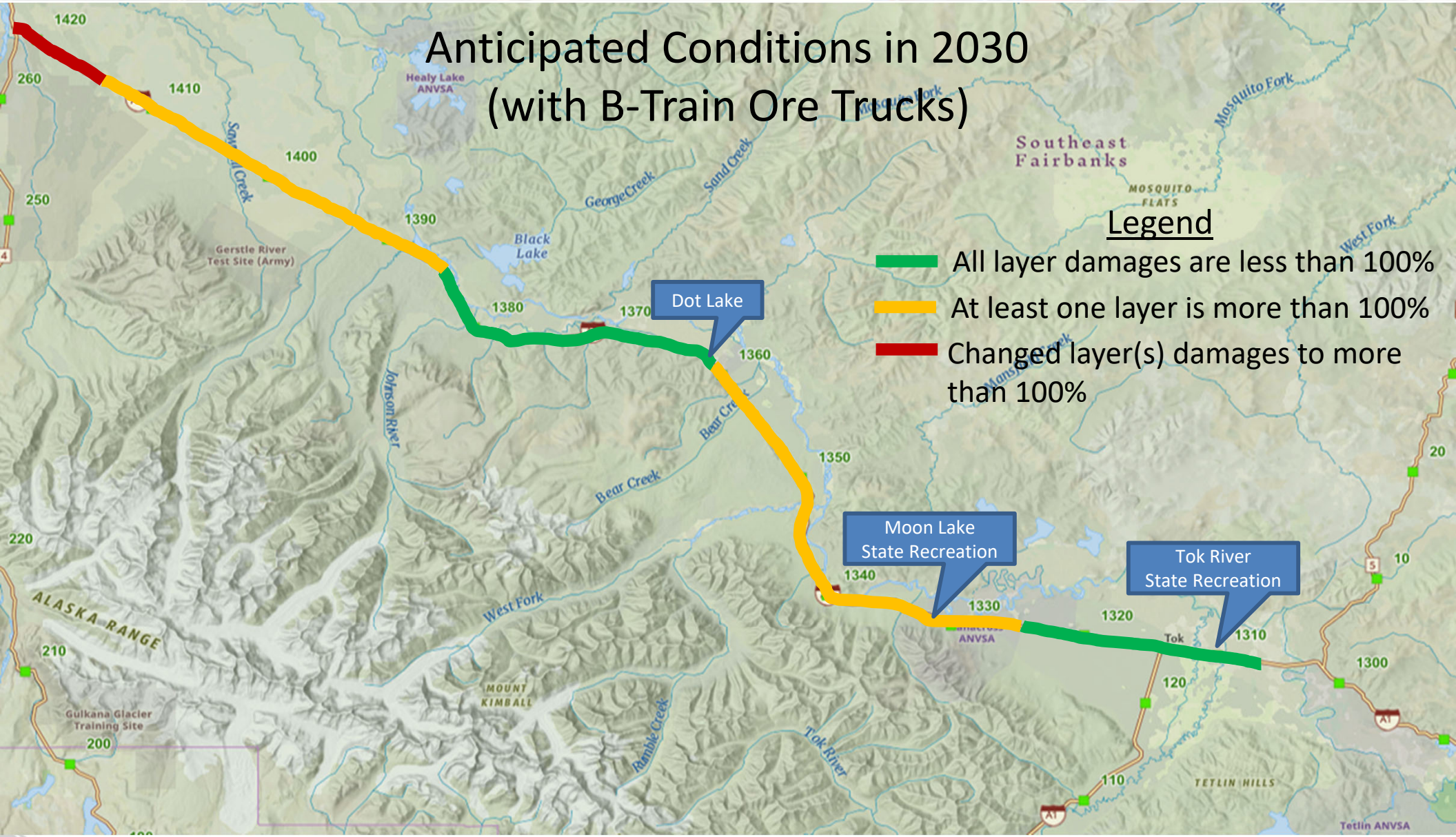
Anticipated Conditions in 2024/2025



Alaska Highway



Alaska Highway



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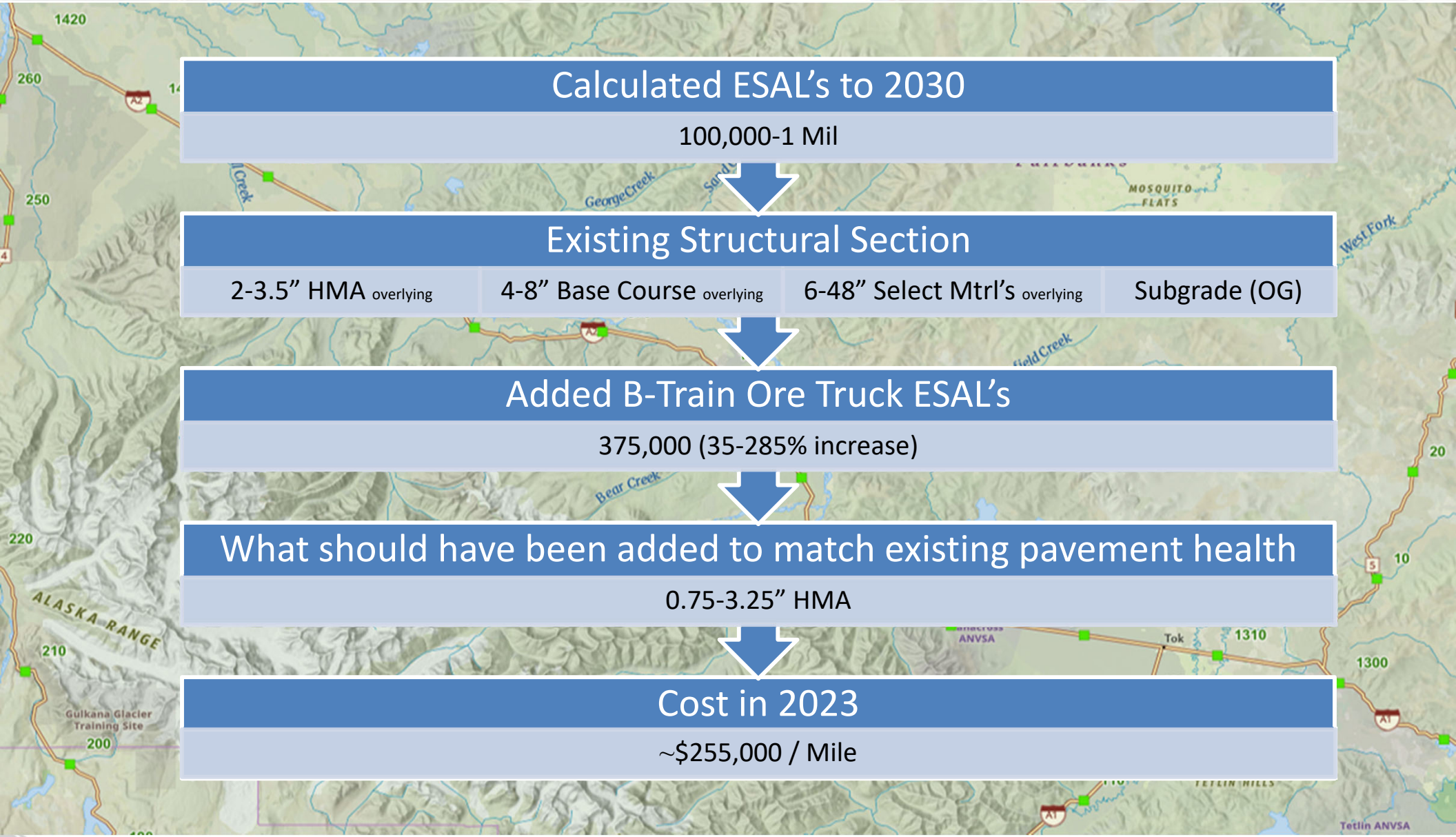


Calculated ESAL's to 2030

100,000-1 Mil

Existing Structural Section

2-3.5" HMA overlying	4-8" Base Course overlying	6-48" Select Mtrl's overlying	Subgrade (OG)

Added B-Train Ore Truck ESAL's

375,000 (35-285% increase)

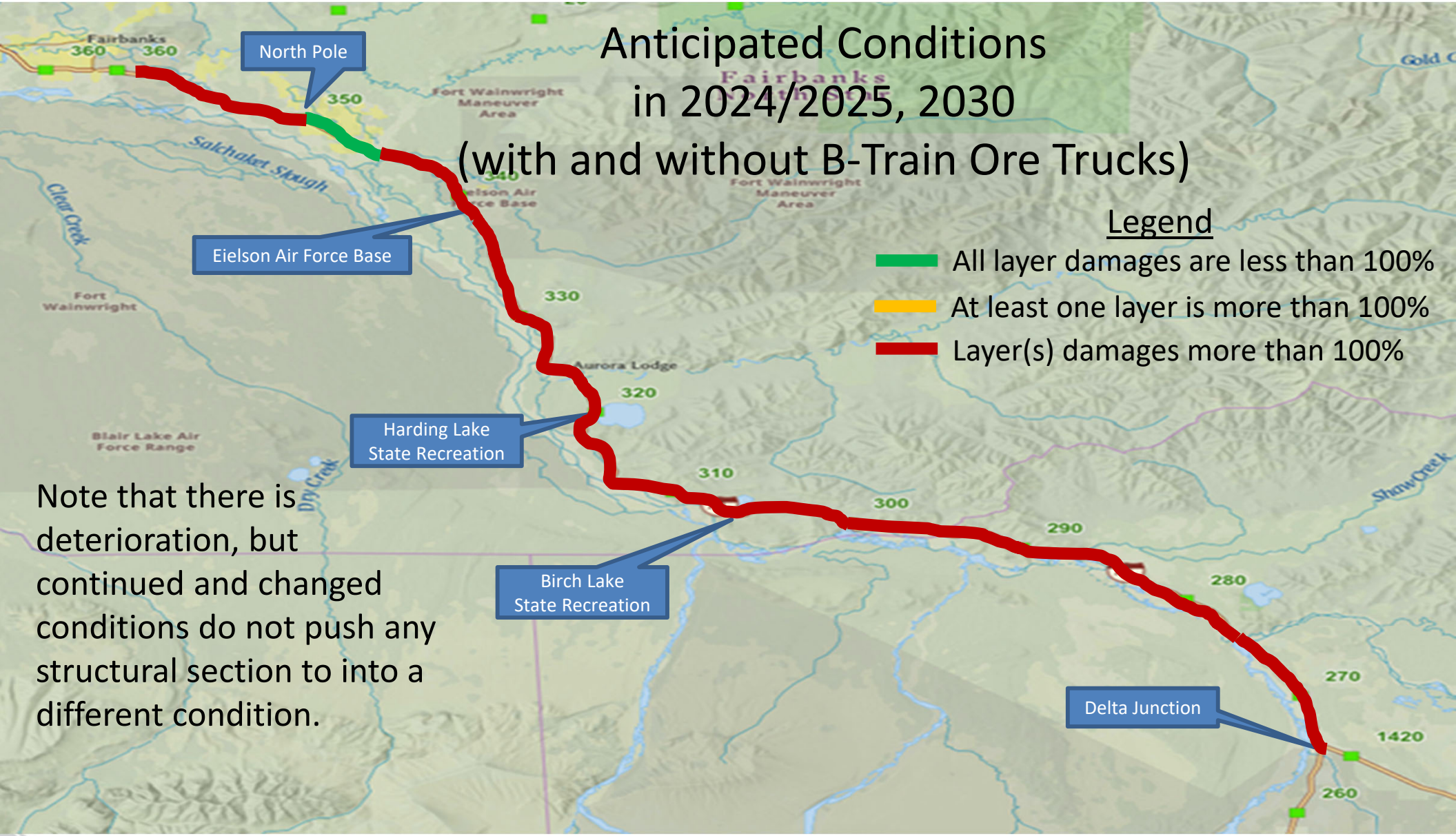
What should have been added to match existing pavement health

0.75-3.25" HMA

Cost in 2023

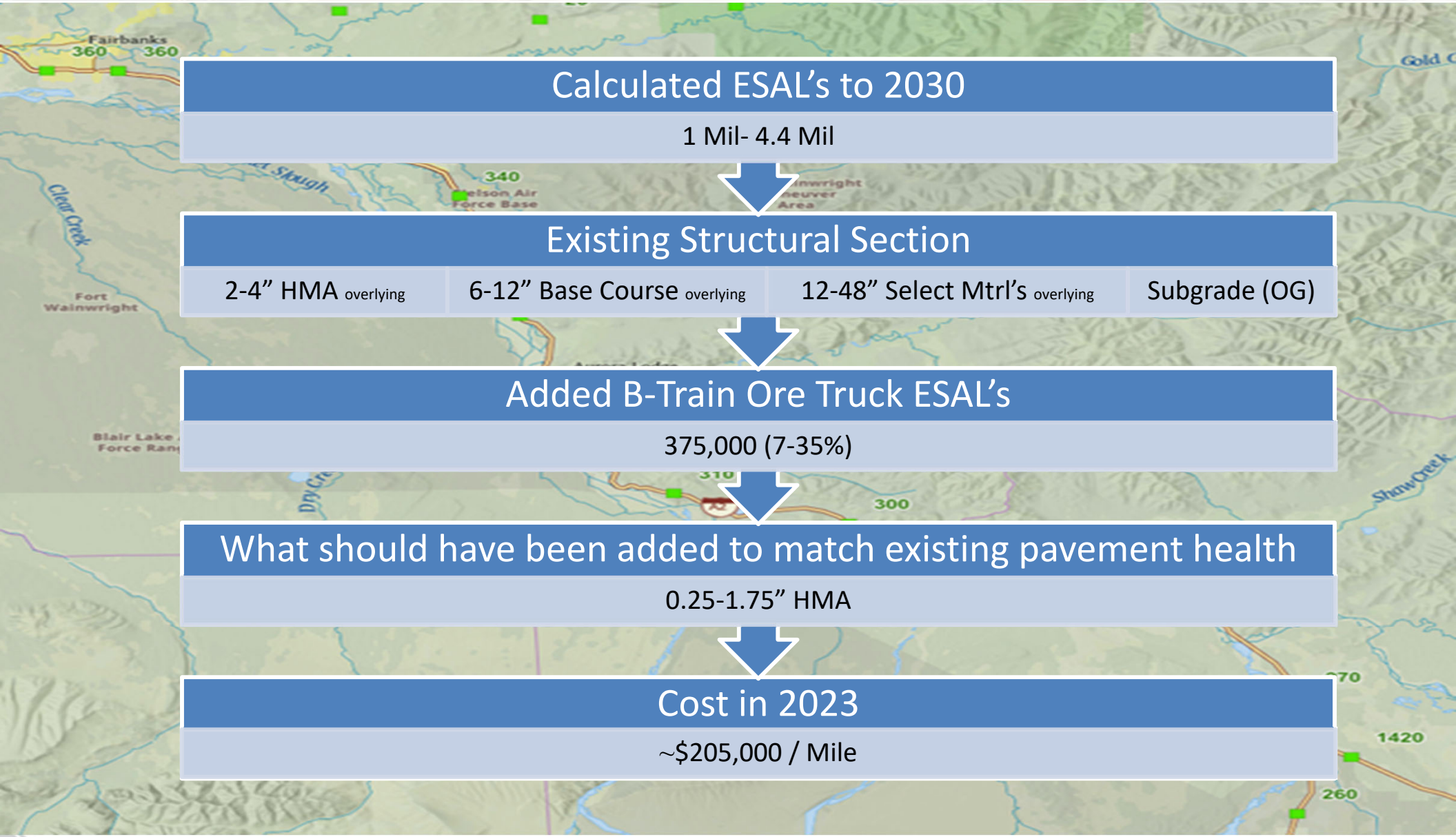
~$255,000 / Mile

Richardson Highway



Note that there is deterioration, but continued and changed conditions do not push any structural section to into a different condition.

Richardson Highway



Calculated ESAL's to 2030

1 Mil- 4.4 Mil

Existing Structural Section

2-4" HMA overlying	6-12" Base Course overlying	12-48" Select Mtrl's overlying	Subgrade (OG)

Added B-Train Ore Truck ESAL's

375,000 (7-35%)

What should have been added to match existing pavement health

0.25-1.75" HMA

Cost in 2023

~$205,000 / Mile

Steese Highway

Steese Highway

Existing ESAL's to 2030

915,000- 2.3 Mil

Existing Structural Section

2-3" HMA overlying	3-6" Base Course overlying	6-48" Select Mtrl's overlying	Subgrade (OG)

Added B-Train Ore Truck ESAL's

375,000 (16%-41%)

What should have been added to match existing pavement health

0.25-2.0" HMA

Cost in 2023

~$201,000 / Mile

Pavement Module Summary

- Rural highway segments on the corridor are in good/fair condition with respect to ruts, roughness, and cracking.
- Additional B-Train ESAL loads are over current design levels (3.4 for B-Train vs. 2.2 for other large tractor-trailer combinations).
- Roadways “depreciate” with both environmental exposure and traffic loadings, B-Train ESALS increase loading range from 30% to over 100% increase in existing ESAL loadings.
- Costs to maintain damage to levels without B-Trains ranges from $200,000 to $250,000 per mile on rural segments of the highway.
- Currently working on the M&O cost impacts.