

Development of Safety Performance Functions for High Speed Roadways of Saskatchewan

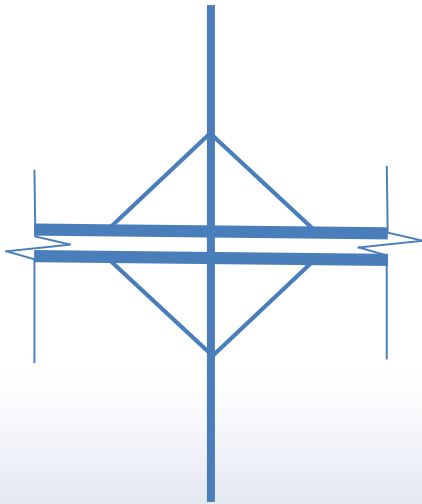
Nadeem Abbas and Peter Y. Park

Department of Civil and Geological Engineering
University of Saskatchewan

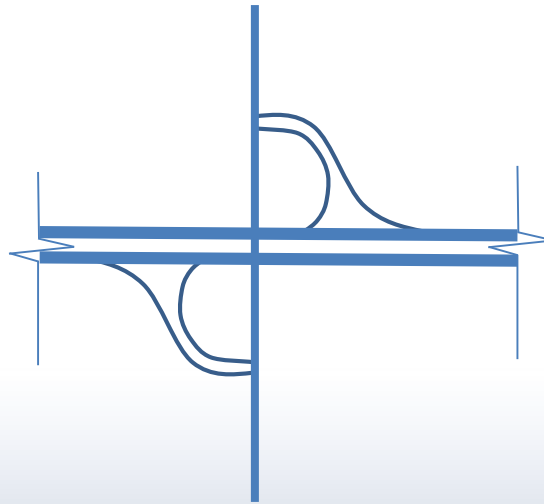
June 08, 2015

Problem Statement

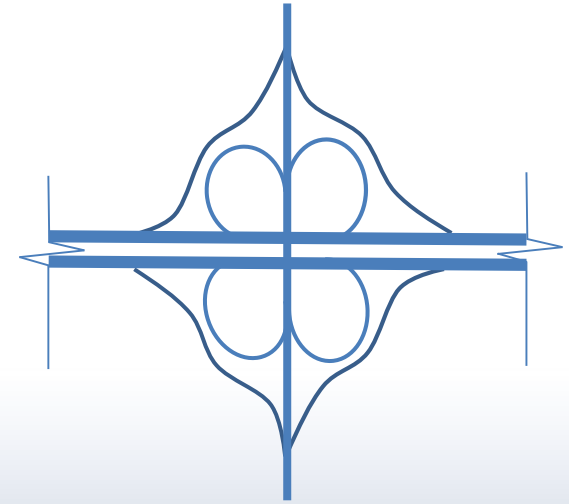
Alternative 1



Alternative 2



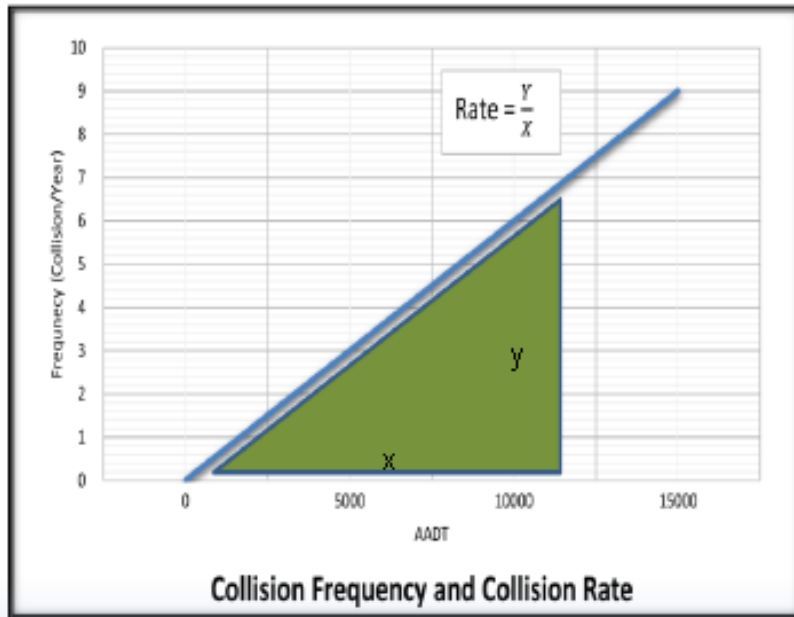
Alternative 3



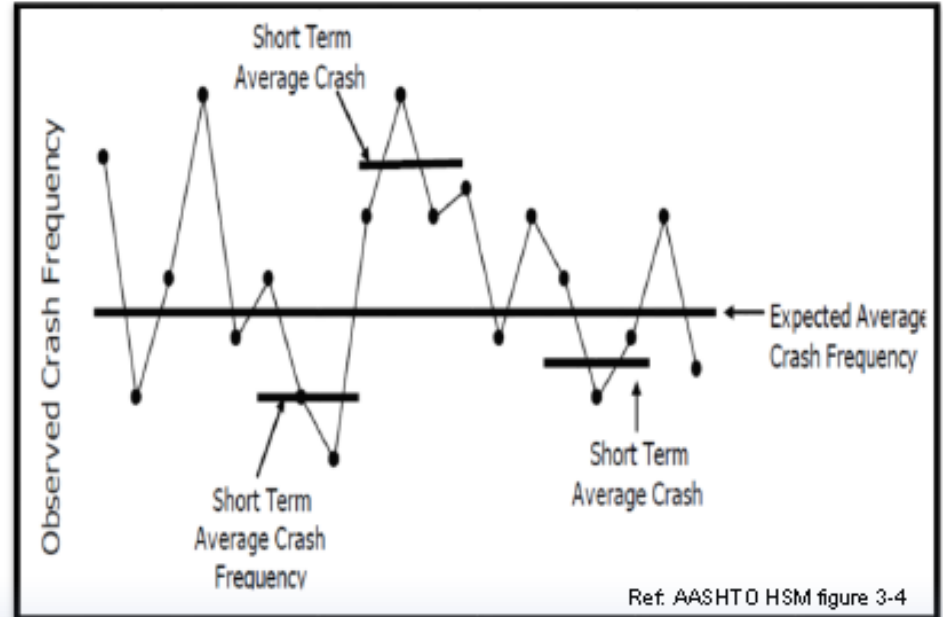
Which alternative is safer ?

Safety Measures

Collision Rate



Collision Frequency



*HSM figure 3-4

HIGHWAY SAFETY MANUAL

1st Edition

Volume 1 • 2010

HSM
Highway Safety Manual

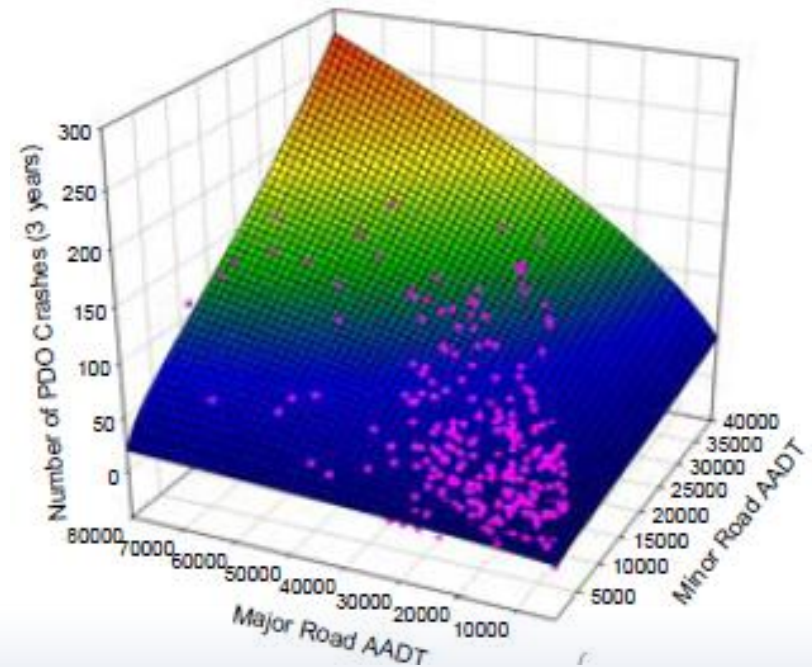
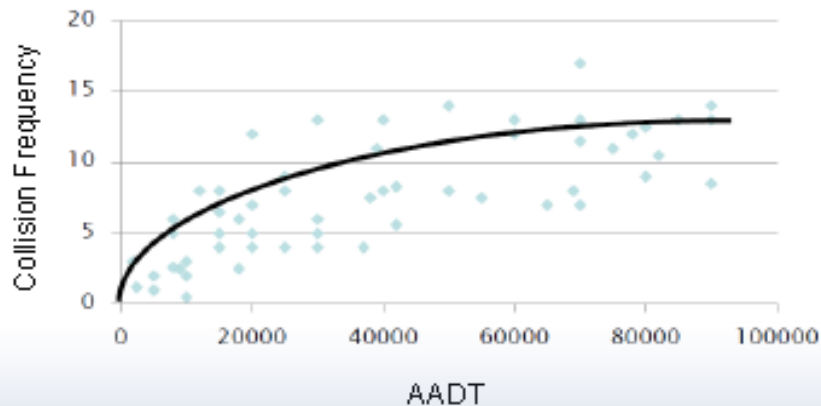
AMERICAN ASSOCIATION OF
STATE HIGHWAY AND
TRANSPORTATION OFFICIALS
AASHTO
THE VOICE OF TRANSPORTATION

LEGEND

Symbols and associated descriptions are shown in Exhibit 5-3.

Example of Safety Performance Function (SPF)

SPFs for 4-leg signalized intersection (PDO Collisions only)

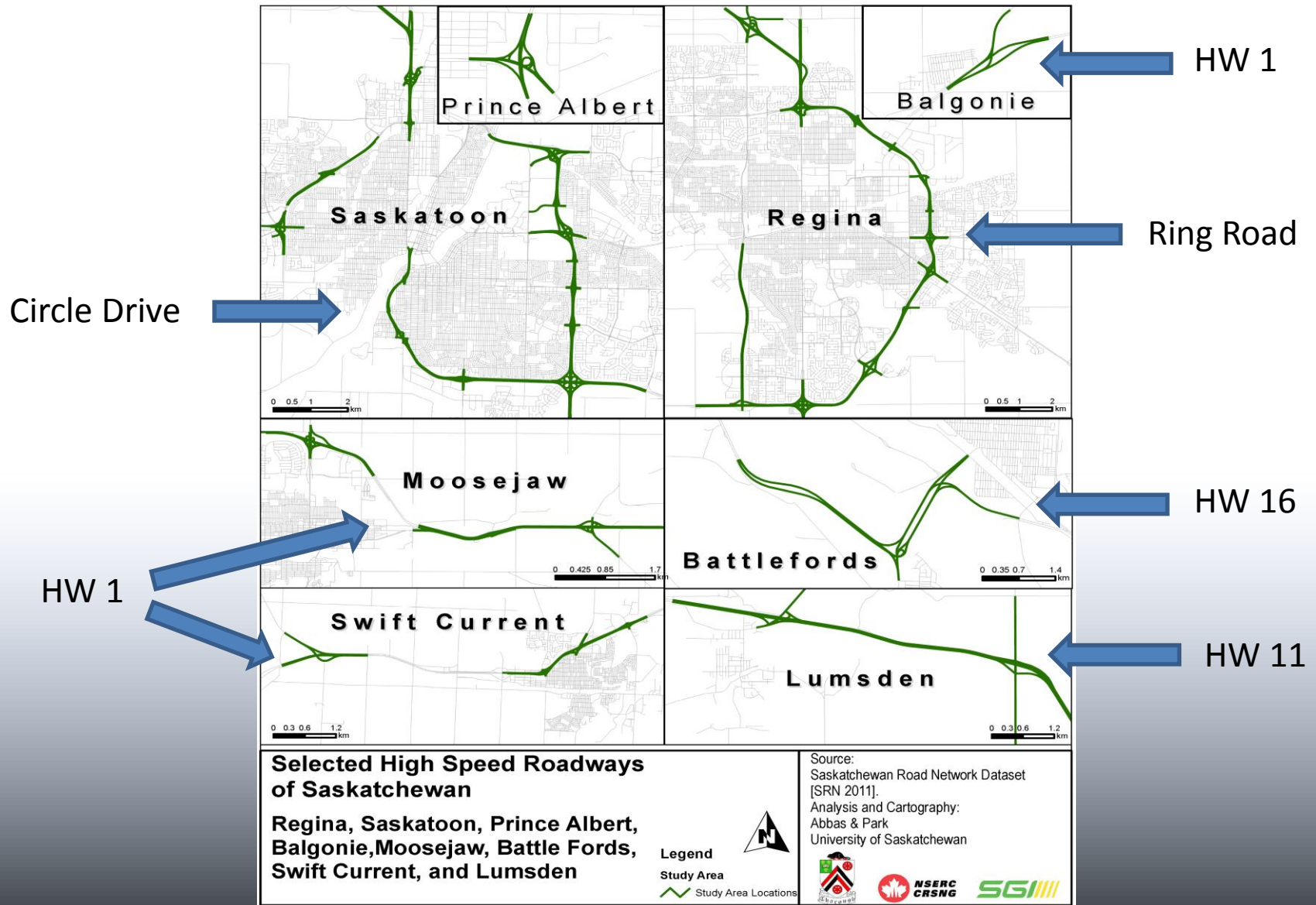


$$N = \alpha \times \left(\frac{\text{Major AADT}}{1000} \right)^\beta \times \left(\frac{\text{Minor AADT}}{1000} \right)^\gamma$$

Study Objectives

- Develop a set of safety performance functions for high speed roadways of Saskatchewan
 - Roadway configuration
 - Functional classification roadways
 - Severity type
 - Total Collisions
 - Fatal and Injury Collisions (FI)
 - Property Damage Only Collisions (PDO)

Study Area Map

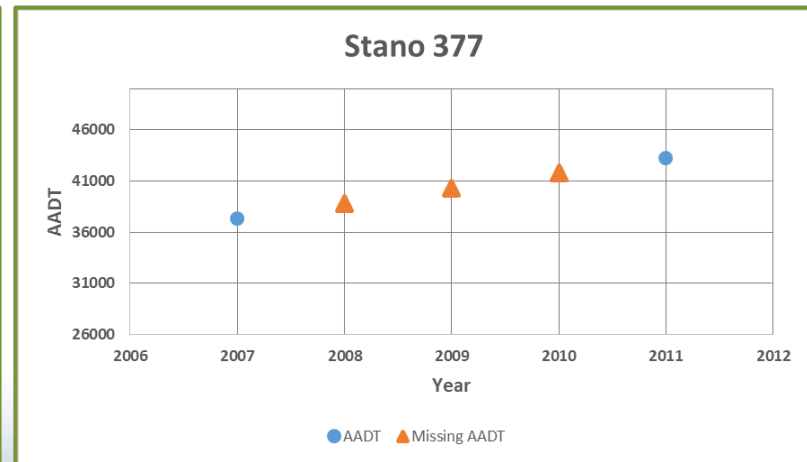
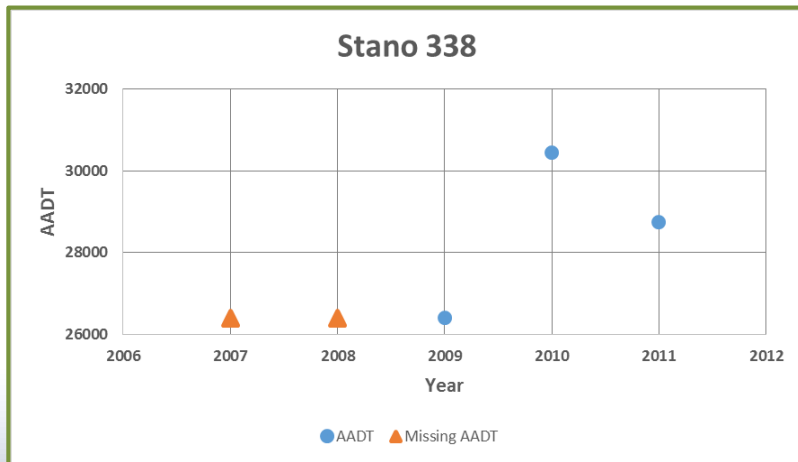


Datasets Needed

- Traffic Volumes Datasets
- Collision Dataset
- Spatial Datasets

Traffic Volume Dataset

Saskatoon						
Stano	Location	2007	2008	2009	2010	2011
338	Taylor Street: Circle Drive - Acadia Drive			26400	30450	28750
365	Circle Drive: 22nd Street - Laurier Drive		24300			
376	Circle Drive: Attridge Drive - Preston Avenue	66900	66650			
377	Attridge Drive: Circle Drive - Central Avenue	37350				43250

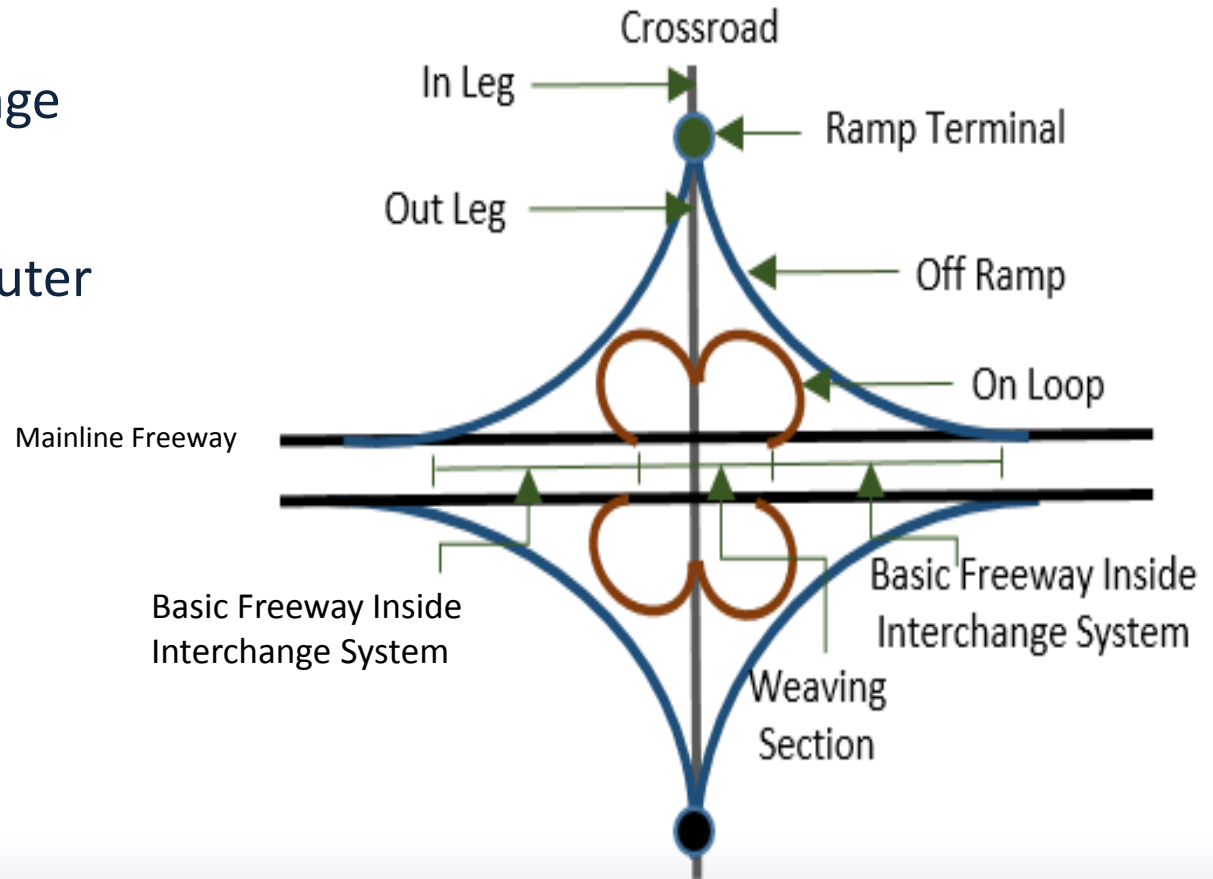


Methodology

- Identify collision locations;
- Assign traffic volume data, geometric and traffic control information;
- Develop integrated database ready to use for development of SPFs;
- Use R-Language to perform regression analysis
- Identify locations with promise (hotspots) using developed SPFs, and
- Pilot hotspots using GIS to provide a visual aid to the decision making process

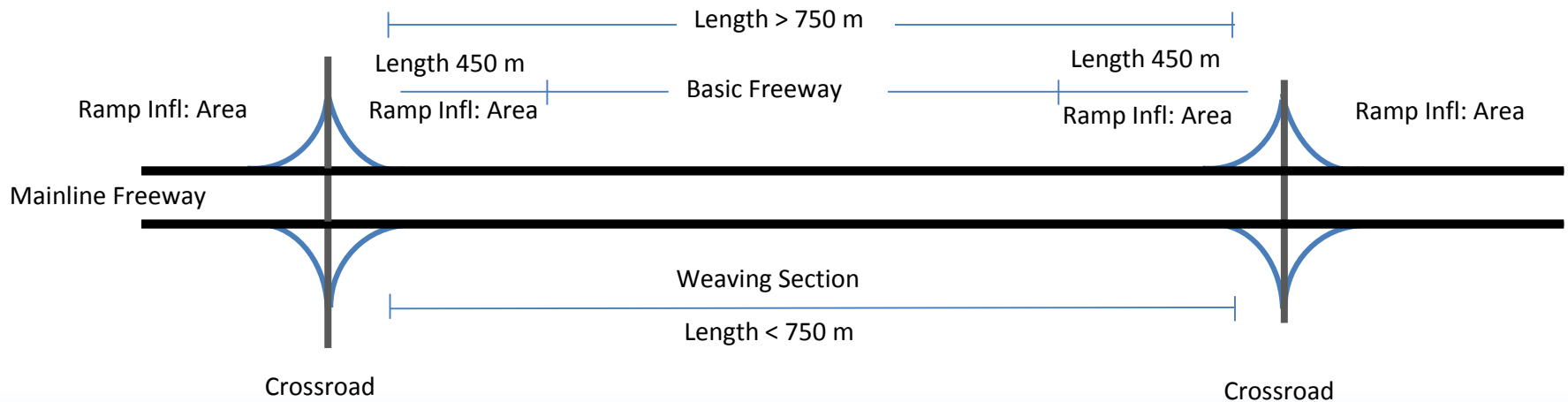
Interchange Segmentation Method

- Basic Freeway (inside Interchange System)
- Basic Freeway Outer
- On Ramp
- Off Ramp
- Weaving Section
- Ramp Terminal (signalized)
- Ramp Terminal (unsignalized)



Freeway Segmentation Method

- Basic Freeway Outer
- Ramp Influence Area
- Weaving Section



Developed SPFs

- SPFs developed using Negative Binomial (NB) distribution
- R-Language used to perform regression analysis

Site	Candidate Models	Severity Types	Total	Final Models
Basic Freeway	4	3	12	3
Basic Freeway Outer	4	3	12	3
On Ramp	4	3	12	3
Off Ramp	4	3	12	3
Ramp Influence Area	8	3	24	3
Weaving Section	10	3	30	3
Ramp Terminal (signalized)	4	3	12	3
Ramp Terminal (unsignalized)	4	3	12	3
Grand Total			126	24

Selection Criteria for SPFs

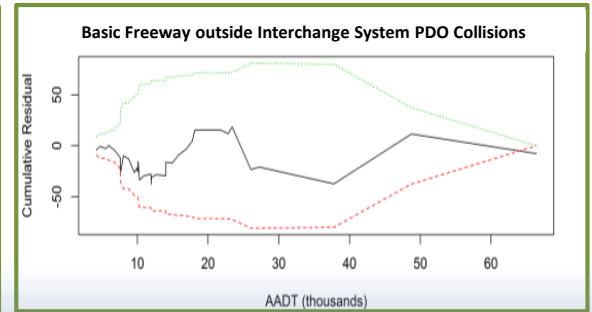
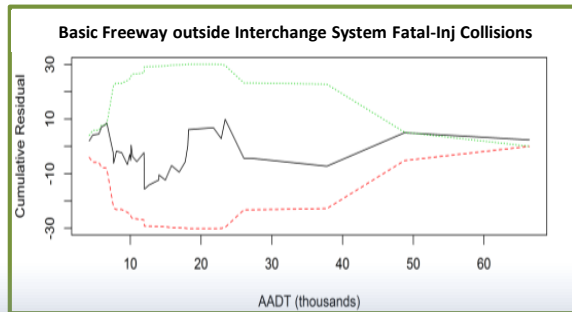
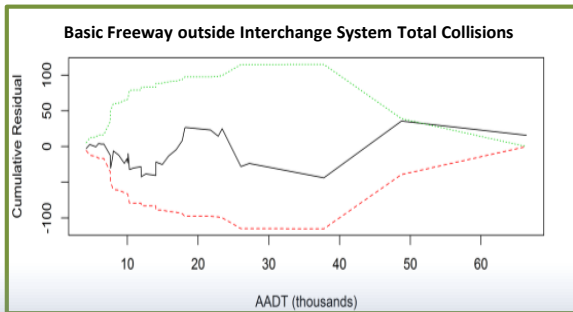
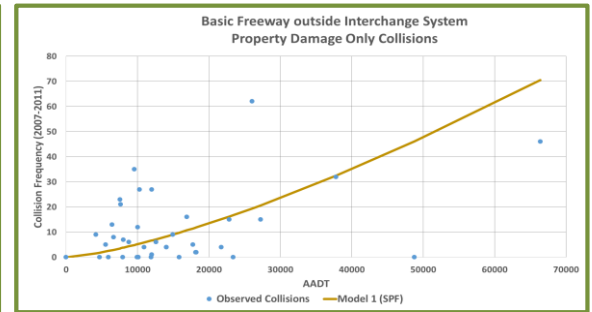
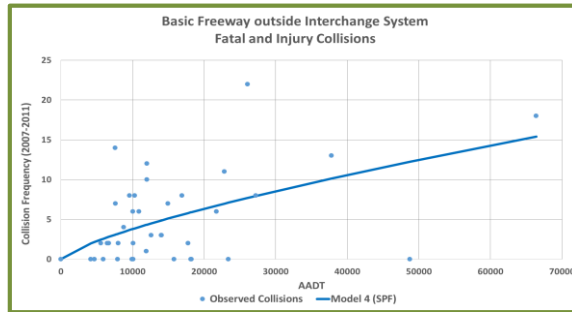
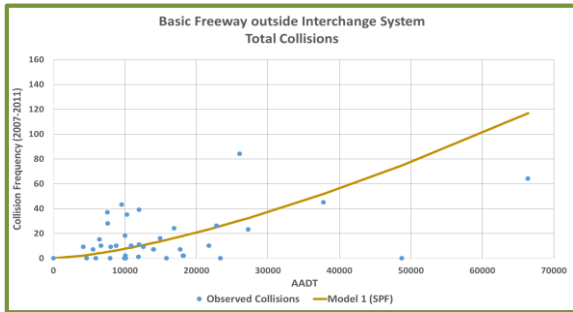
- Functional form selection
 - P-VALUE
 - Cumulative residual plots (CURE plots)
 - Overdispersion parameter
 - Akaike information criterion (AIC)
 - Bayesian information criterion (BIC)

Developed SPFs

Configuration	Total Collisions	Fatal-Injury Collisions	PDO Collisions
Basic Freeway inside I/C System	$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta 1} * exp^{\beta 2 * length}$	$N = \alpha * Length^{\beta 1} * \left(\frac{AADT}{1000}\right)^{\beta 2}$	$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta 1} * exp^{\beta 2 * length}$
Basic Freeway Outside I/C System	$N = \alpha * Length * \left(\frac{AADT}{1000}\right)^{\beta}$	$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta}$	$N = \alpha * Length * \left(\frac{AADT}{1000}\right)^{\beta}$
On Ramp		$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta}$	
Off Ramp		$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta} * Length$	
Weaving Section		$N = \alpha * \left(\frac{AADT_{total}}{1000}\right)^{\beta 1} * exp^{\beta 2 * speed}$	
Ramp Term (sig)		$N = \alpha * \left(\frac{AADT_{total}}{1000}\right)^{\beta}$	
Ramp Term (unsig)		$N = \alpha * \left(\frac{AADT_{total}}{1000}\right)^{\beta}$	
Ramp Influence Area	$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta}$	$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta} * Length$	$N = \alpha * \left(\frac{AADT}{1000}\right)^{\beta}$

Sample SPF for Basic Freeway outside Interchange System

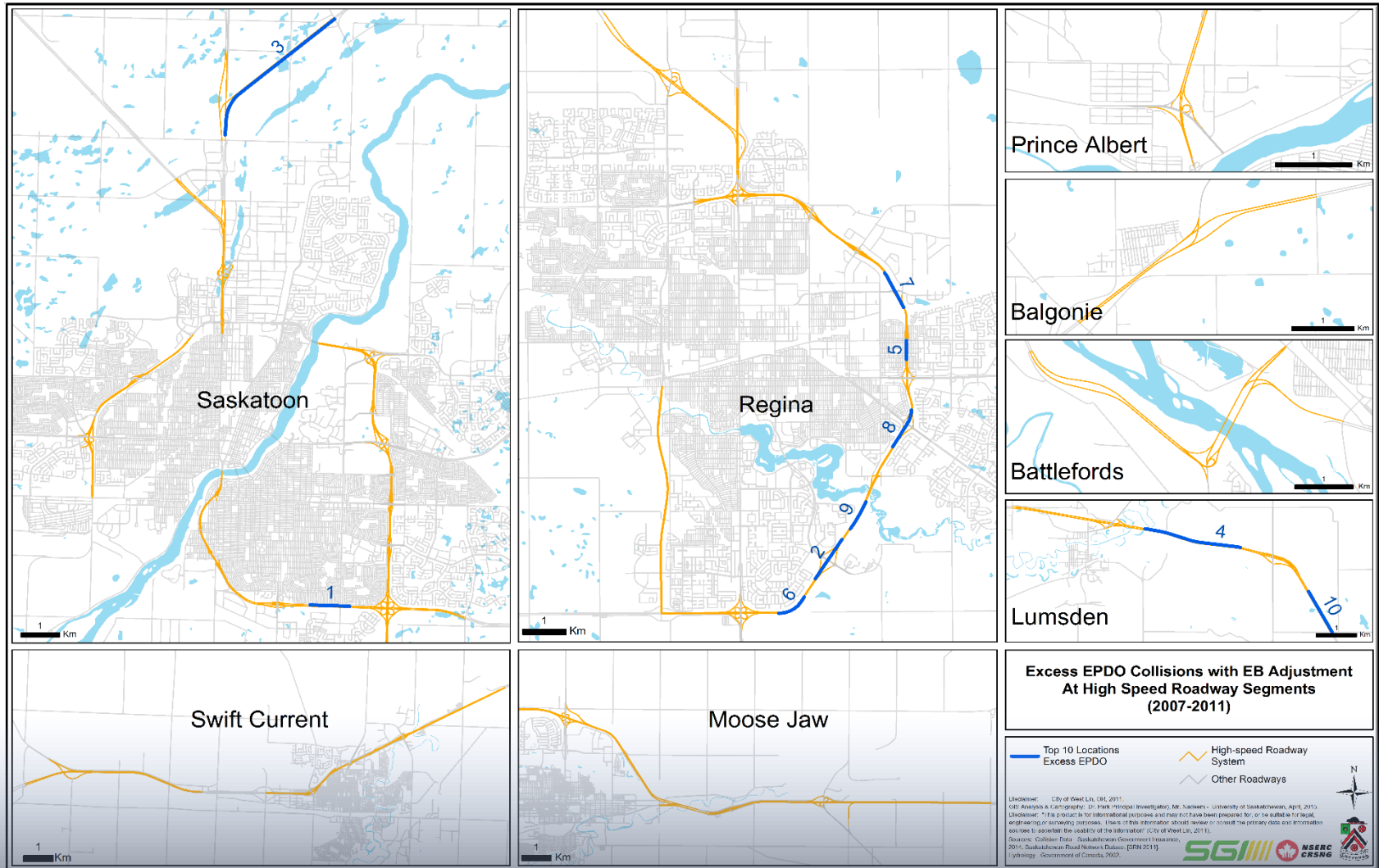
Site	Severity	α	p-value	β	p-value	Overdispersion Parameter	AIC	BIC
BFWO	Total	0.055	0.000	1.442	0.000	1.271	275.564	281.114
	FI	0.137	0.018	0.742	0.019	1.208	204.774	210.325
	PDO	0.044	0.000	1.378	0.000	1.377	246.518	252.068



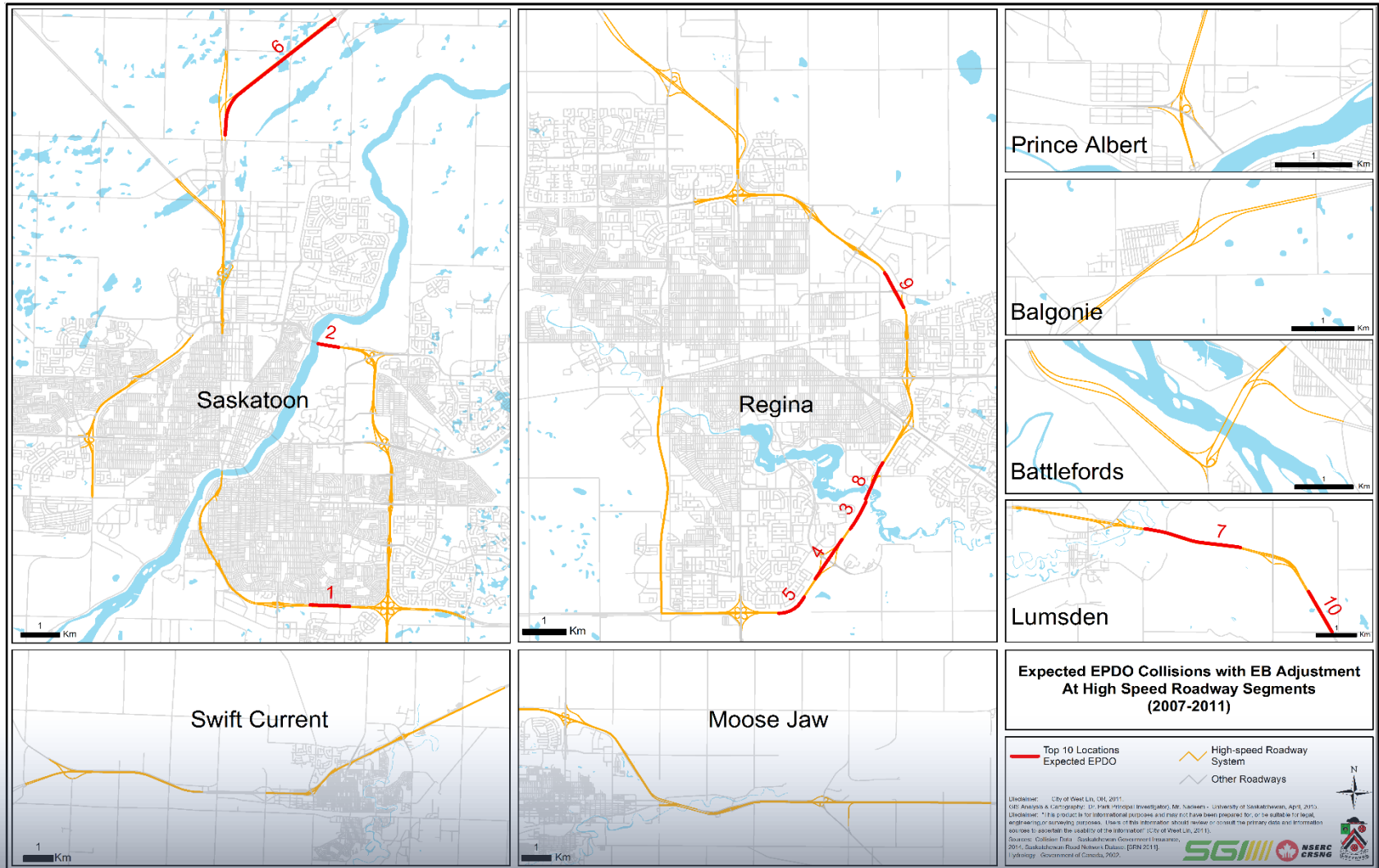
Model Validation (sample)

Estimation Data (50%)				Validation Data (50%)			
Category	Severity	MSE	R^2_{ft}	MSPE	MPB	MAD	R^2_{ft}
Basic Freeway inside I/C System	Total	872.534	0.140	374.668	4.954	12.700	-0.279
	FI	111.836	-0.105	31.641	1.559	3.178	-0.593
	PDO	540.353	0.122	239.145	3.944	10.508	-0.281

Network Screening Results

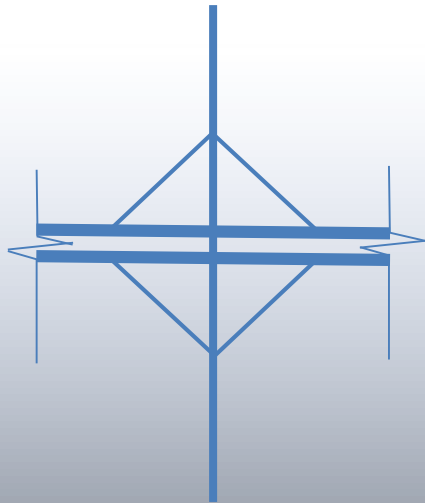


Network Screening Results

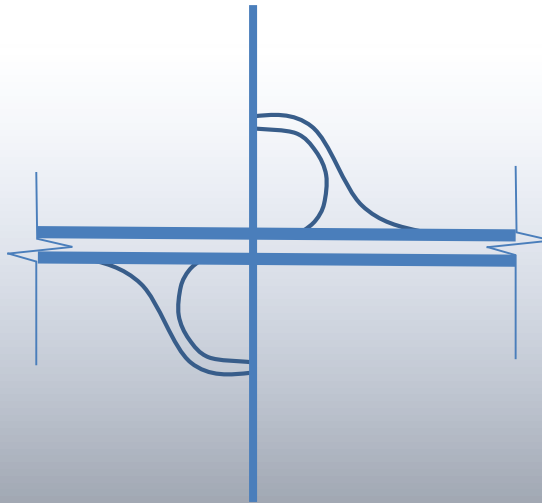


Example of Usage of SPFs

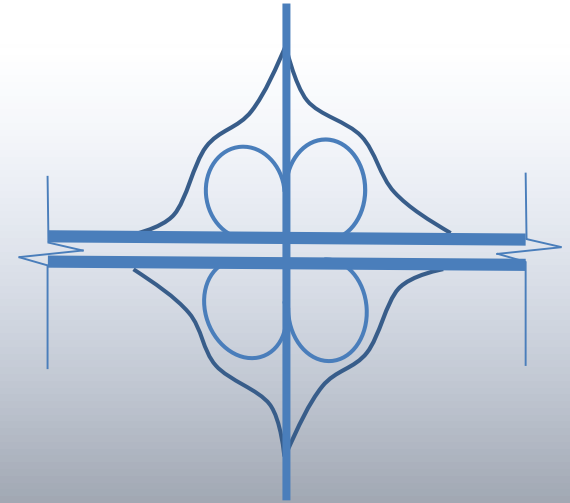
Alternative 1



Alternative 2

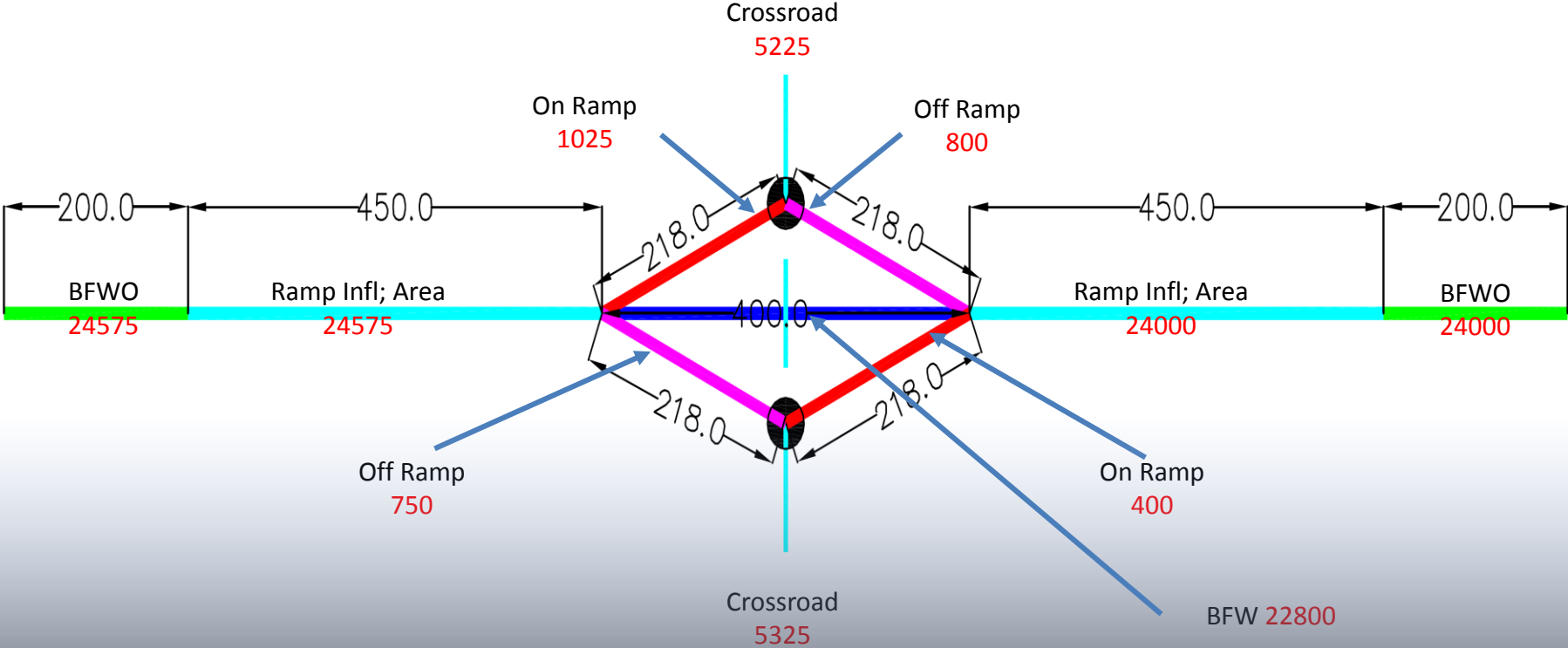


Alternative 3



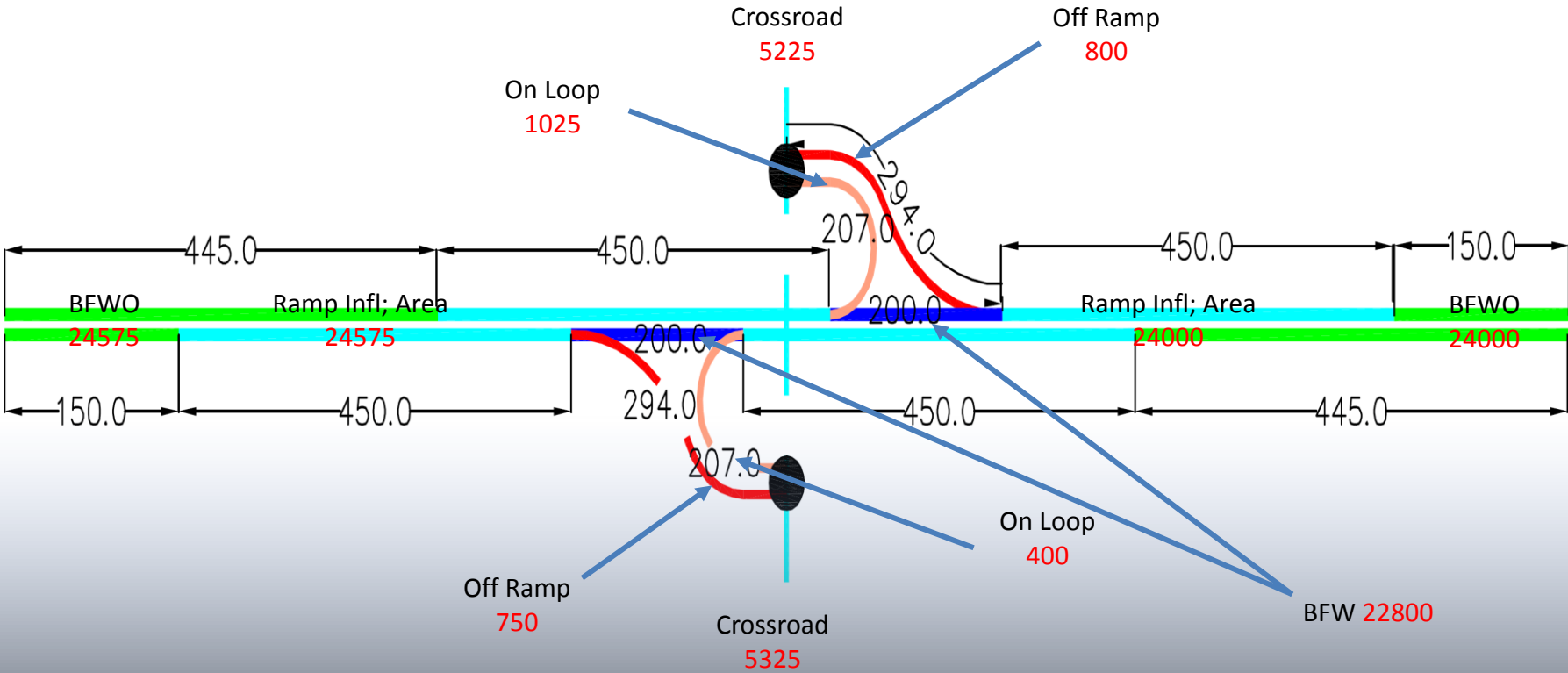
Alternative 1

Diamond Interchange



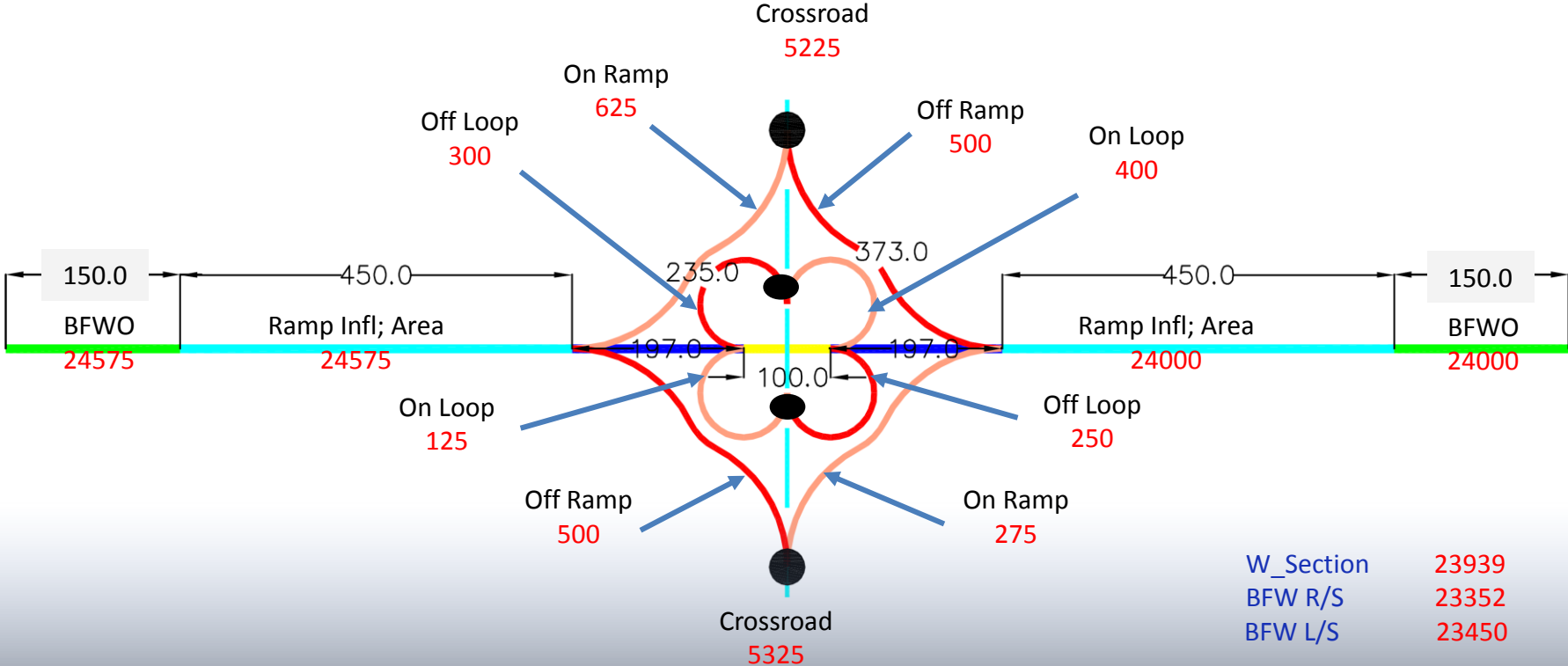
Alternative 2

Parclo Interchange

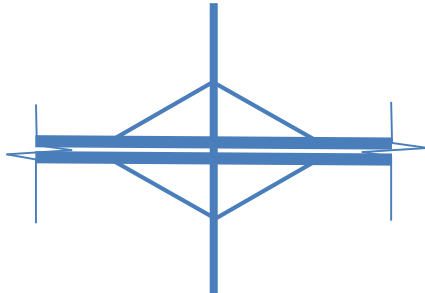


Alternative 3

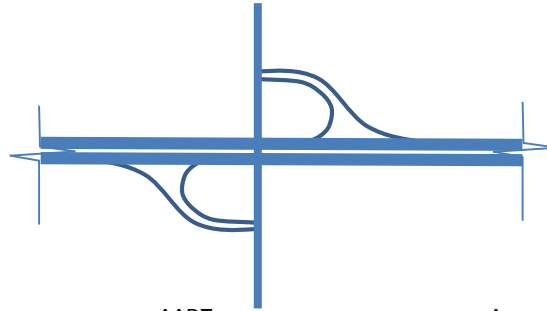
Cloverleaf Interchange



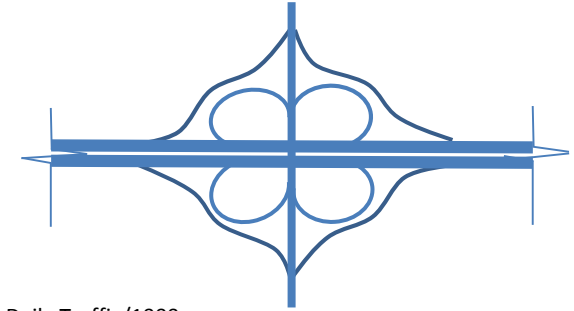
Alternative 1



Alternative 2



Alternative 3



EPDO Weights Calculation	
Severity	Weight
Fatal & Injury	47
PDO	1

AADT
Length (km)
Fatal & Injury
PDO

Annual Average Daily Traffic/1000
Unit of the Section Length
Fatal and Injury Collisions
Property Damage Only Collisions

Site	Alternative 1			Alternative 2			Alternative 3		
	FI	PDO	EPDO	FI	PDO	EPDO	FI	PDO	EPDO
BFW 1	0.122	1.146	6.890	0.019	0.738	1.621	0.018	0.748	1.609
BFW 2							0.018	0.756	1.625
BFWO 1	1.448	0.696	68.747	1.448	1.036	69.088	1.448	0.522	68.573
BFWO 2	1.474	0.719	69.976	1.474	1.071	70.328	1.474	0.539	69.796
On Ramp 1	0.028	0.084	1.416	0.028	0.084	1.416	0.020	0.058	0.979
On Ramp 2	0.014	0.041	0.701	0.014	0.041	0.701	0.011	0.031	0.530
On Loop 1							0.014	0.041	0.701
On Loop 2							0.006	0.017	0.294
Off Ramp 1	0.013	0.028	0.652	0.018	0.038	0.879	0.017	0.030	0.844
Off Ramp 2	0.013	0.026	0.627	0.017	0.036	0.846	0.017	0.030	0.844
Off Loop 1							0.008	0.011	0.394
Off Loop 2							0.007	0.009	0.354
W-Sec							0.613	1.694	30.510
RIA 1	0.432	1.279	21.568	0.432	1.279	21.568	0.432	1.279	21.568
RIA 2	0.432	1.314	21.604	0.439	1.314	21.942	0.439	1.314	21.942
Ramp Term 1	0.027	0.021	1.310	0.036	0.035	1.737	0.030	0.025	1.452
Ramp Term 2	0.023	0.016	1.100	0.034	0.031	1.644	0.027	0.021	1.287
Ramp Term 3							0.028	0.022	1.335
Ramp Term 4							0.031	0.027	1.492
Total EPDO			194.592			191.771			226.130

Acknowledgement

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- City of Saskatoon
- City of Regina
- City of Prince Albert
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Thank you

Questions?