

HIGHWAY 1416 AND RADAR HILL ROAD CORRIDOR ANALYSIS STUDY

Pennington County / Box Elder, SD

June 2024

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Chapter 1 – Existing Conditions

Introduction

Highway 1416 is an east/west corridor running parallel and to the south of I-90 through Box Elder, SD. Radar Hill Road runs north/south from its intersection with Highway 1416 to the north, to its intersection with SD 44 to the south. Expansion at the nearby Ellsworth Air Force Base is expected to occur and will lead to considerable development in the areas surrounding these roadways, leading to shifts in traffic patterns. A corridor analysis study was prepared to analyze these changes and provide recommendations to mitigate any deficiencies. This section of the corridor analysis study will address existing traffic conditions, including roadway characteristics, safety, operations, and capacity.

Study Area

Key intersections were selected for detailed analysis within the corridor study. Intersections that were identified for analysis are listed below.

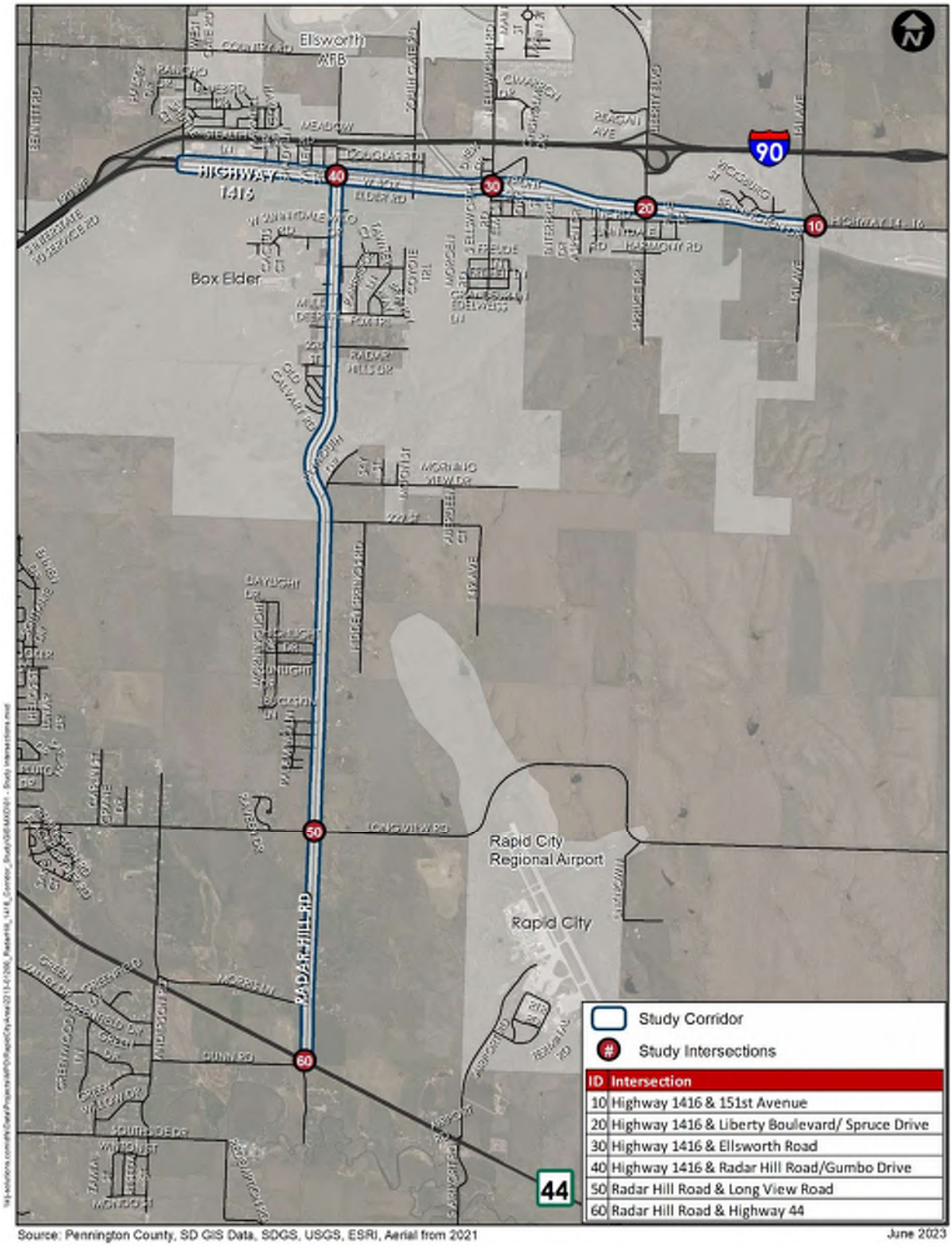
- Highway 1416 & 151st Avenue
- Highway 1416 & Liberty Boulevard/Spruce Drive
- Highway 1416 & S Ellsworth Road
- Highway 1416 & Radar Hill Road/Gumbo Drive
- Radar Hill Road & Long View Road
- Radar Hill Road & SD 44

At the start of the study, all intersections were two-way or all-way stop controlled. The intersection of Highway 1416 and Radar Hill Road/Gumbo Drive had additional stop-control in the eastbound direction on Highway 1416. Additional stop-control in the westbound direction on Highway 1416 existed at the intersections with Commercial Gate Road, S Ellsworth Road, and W Gate Road.

All northbound and southbound approaches along Highway 1416 (including the medians) were stop-controlled, except at westbound Highway 1416 and S Ellsworth Road where the northbound approach was a free movement, and the southbound approach was yield controlled. The control noted at these four intersections were atypical designs and could result in driver confusion especially with those unfamiliar with the area.

The study area and labeled intersections are shown in **Figure 1-1.**

Figure 1-1 – Study Area



Objective

The objective of this report is to collect, analyze, and document existing conditions along the Highway 1416 and Radar Hill Road corridors and present any deficiencies regarding safety, operations, and/or capacity. This section of the study will focus on the analysis of existing no-build conditions and present issues currently being experienced to be used for alternatives development and a basis of comparison for the analysis of the alternatives.

Previous Studies

There have been several previous planning efforts and studies completed in Box Elder along the study segments. These documents provide important background information to support the development of this planning study.

RAPID CITY METROPOLITAN TRANSPORTATION PLAN (2020)

The *Rapid City Metropolitan Transportation Plan (MTP)* is the Rapid City Area Metropolitan Planning Organization's (MPO) long range plan for the regional transportation system. Growth projections and the regional travel demand model generated as part of the MPO's planning process were used as primary components in establishing traffic projections for this corridor study. The MTP provides mid-term (2026-2030) recommendations to improve the Exit 63 interchange.

BOX ELDER COMPREHENSIVE PLAN (2014 REVISION)

The *Box Elder Comprehensive Plan* provides a long-term vision for the city. The intersections of Highway 1416 and W Gate Road, Radar Hill Road, S Ellsworth Road, and Liberty Boulevard are identified as needing safety and mobility improvements. The discussion of future land use identifies Highway 1416 from Exit 63 to Liberty Boulevard and Radar Hill Road extending to Highway 1416 as potential locations for an entry corridor overlay. As a member agency of the Rapid City Area Metropolitan Planning Organization (RCAMPO), Box Elder would coordinate these future plans with the MPO in a local effort to carry out a continuing, cooperative and comprehensive performance-based multi-modal transportation planning process. This involves coordination with SDDOT and the consistent application of aesthetic standards and design elements. Natural drainages along Highway 1416 that contain floodway, and 100- and 500-year floodplain are recognized as constraints that will need to be addressed in new development. Elevated crash occurrence and traffic congestion along Highway 1416 is identified as a top-priority transportation issue.

BOX ELDER STRATEGIC TRANSPORTATION PLAN (2014)

The *Box Elder Strategic Transportation Plan* was created to address a series of desired planning outcomes and transportation objectives, including the alignment of the built environment with regional and local goals, the enhancement of livability within the Box Elder community, and the identification of priorities among future transportation improvement projects. The existing traffic operations analysis includes five intersections along Highway 1416, at W Gate Road, Radar Hill Road, Commercial Gate Drive, S Ellsworth Road, and Liberty Boulevard. It is concluded that the intersection of westbound Highway 1416 with

Ellsworth Road operates at LOS F during peak hours, with all other intersections operating at LOS C. Highway 1416 intersections with W Gate Road, Radar Hill Road, and S Ellsworth Road are anticipated to require signalized or roundabout control in order to operate at LOS C or better in the year 2035. The provision of a shared-use path from W Gate Road to S Ellsworth Road along Highway 1416 is identified as a high-priority pedestrian and bicycle project. The conversion of Highway 1416 from a four-lane divided highway to a two-lane undivided roadway with a center left turn lane is identified as a near-term priority included in the contemporaneous statewide transportation improvement plan (STIP). The construction of a side path along Radar Hill Road is identified as a low-priority pedestrian and bicycle project.

HIGHWAY 1416 CORRIDOR STUDY (2010)

The *Highway 1416 Corridor Study* was commissioned by the Rapid City Area Metropolitan Planning Organization (RCAMPO) and the City of Box Elder in order to access existing traffic safety and operations along the corridor and develop recommendations for improvements. It was found that the current four-lane configuration of Highway 1416 has excess traffic-carrying capacity, providing an opportunity for reconfiguration into a non-divided city street that would improve accessibility, traffic circulation, and motorist safety. Several recommendations are made in this study, including the addition of right- and left-turn lanes at several intersections, widening of the northbound approach of the Radar Hill Road intersection, addition of pedestrian facilities where appropriate, and the development of a network model to allow for comparative analysis.

RAPID CITY AREA TRANSPORTATION IMPROVEMENT PROGRAM (2022)

The *Rapid City Area Transportation Improvement Program* (TIP) for fiscal years 2023-2026 provides a priority listing and financial plan for highway and transit projects. This document includes the design and reconstruction of Radar Hill Road at Highway 1416 to a three-lane configuration. This project is not fiscally constrained in the TIP.

Known Issues

CONGESTION AND INTERSECTION DELAY

Recent and continuing development in the study area vicinity has shifted traffic patterns and resulted in erratic lane usage, congestion from turning movements, and intersection delay along the study corridors. Median storage can also become congested furthering delay by impeding movements upstream.

FUTURE DEVELOPMENT

Ellsworth Airforce Base, a major economic driver in the Box Elder region, is anticipated to experience rapid growth in the coming years and will likely have an influence on travel patterns along and near Highway 1416 and Radar Hill Road. Two new schools are also anticipated to be constructed near the study area, as well as a public park south of Highway 1416.

CRASH HISTORY

As noted in the *Box Elder Strategic Transportation Plan,* multiple intersections along Highway 1416 are configured with a split between the eastbound and westbound directions, creating unusual intersection geometry and traffic control that is counter-intuitive. Five of the top nine high-crash intersections in Box Elder (2008-2012) are located along Highway 1416, with angle and rear-end crashes particularly prominent at these intersections.

CORRIDOR CONSTRAINTS

Box Elder Road runs parallel to westbound Highway 1416 from east of S Ellsworth Road to west of W Gate Road. The median separating the two roadways is approximately 45 feet wide, considerably closer than the 120-foot-wide median separating eastbound and westbound Highway 1416. Box Elder Road is meant to operate as a frontage road to Highway 1416, providing access to businesses and homes. The narrow median has very limited storage, and though the northbound approaches onto Box Elder Road are uncontrolled, vehicles attempting to turn left onto Box Elder Road can cause queueing in the narrow median spilling over to the westbound approach of Highway 1416.

To the south, the Rapid City, Pierre, and Eastern railroad has a single railroad track that runs parallel to eastbound Highway 1416 throughout the study area, separated by a median ditch approximately 60 feet wide. The railroad restricts right-of-way along the south edge of the study area, as the railroad is unlikely to relinquish any right-of-way for highway purposes. Of the three study intersections that intersect at-grade with the railroad tracks (Liberty Boulevard, S Ellsworth Road, and Radar Hill Road), only the Radar Hill Road crossing has flashing-light signals and gate arms. The crossings at S Ellsworth Road and Liberty Boulevard are yield-controlled. The proximity of Highway 1416 to the railroad tracks leads to severe safety concerns regarding vehicle-rail collisions and can lead to operational concerns with queueing on Highway 1416. A crossing diagnostic inspection could be held to further investigate the safety conditions of the crossing.

LACK OF PEDESTRIAN FACILITIES

No dedicated sidewalks, paths, or trails exist within the study area. There are also no dedicated or marked crossing locations on Highway 1416 or Radar Hill Road within the study area.

LACK OF BICYCLE FACILITIES

As noted in the *Rapid City Area Bicycle and Pedestrian Master Plan*, very limited bicycle facilities exist in Box Elder. Major streets connecting the area to surrounding jurisdictions have high speeds and volumes that reduce safety for cycling.

Planned Improvements

The City of Box Elder plans to complete an active transportation plan by the spring of 2024. A recent assessment of walking and biking routes was completed in conjunction with the USDOT Safe Streets and Roads for All (SS4A) grant.

The I-90 interchange connecting to Highway 1416 (Exit 63) is also planned to be reconstructed. The proposed design is a diverging diamond interchange, with construction expected to begin in 2027 (depending on federal funding availability). The interchange reconstruction was spurred by issues regarding safety, congestion, capacity, accessibility and connectivity, and a lack of pedestrian facilities. This project also recommends consolidating the Highway 1416 and W Gate Road intersection into one signalized intersection.

General road repairs are expected to take place during the summer of 2023 along Radar Hill Road between Highway 1416 and Long View Road. The repairs are expected to address issues of severe degradation and potholes along this section of the corridor. The City of Box Elder Active Transportation Recommendations document also provides the following recommendations within the study area:

- Installing sidewalks along Highway 1416 from W Gate Road to Liberty Boulevard, and along Radar Hill Road from Highway 1416 to Box Elder city limits.
- Implementing multimodal connection nodes on Highway 1416 at the I-90 interchange, Radar Hill Road, and Liberty Boulevard.
- Converting the intersection of Highway 1416 and Liberty Boulevard to a roundabout and installing a traffic signal and dedicated crosswalks at Highway 1416 and S Ellsworth Road.
- Creating a Farmers' Market or city park near the I-90 interchange.
- Extending Cheyenne Road to connect to Radar Hill Road (with a connection point at the 228th Street intersection).

Existing Conditions

Corridor Characteristics

FUNCTIONAL CLASSIFICATIONS

Highway 1416 is classified as an Urban Minor Arterial within the study area. Radar Hill Road is classified as an Urban Major Collector between Highway 1416 and Long View Road. From Long View Road to SD 44, Radar Hill Road is classified as a Rural Major Collector. The functional classifications for roadways within the study area are shown in **Figure 1-2**.

LAND USE

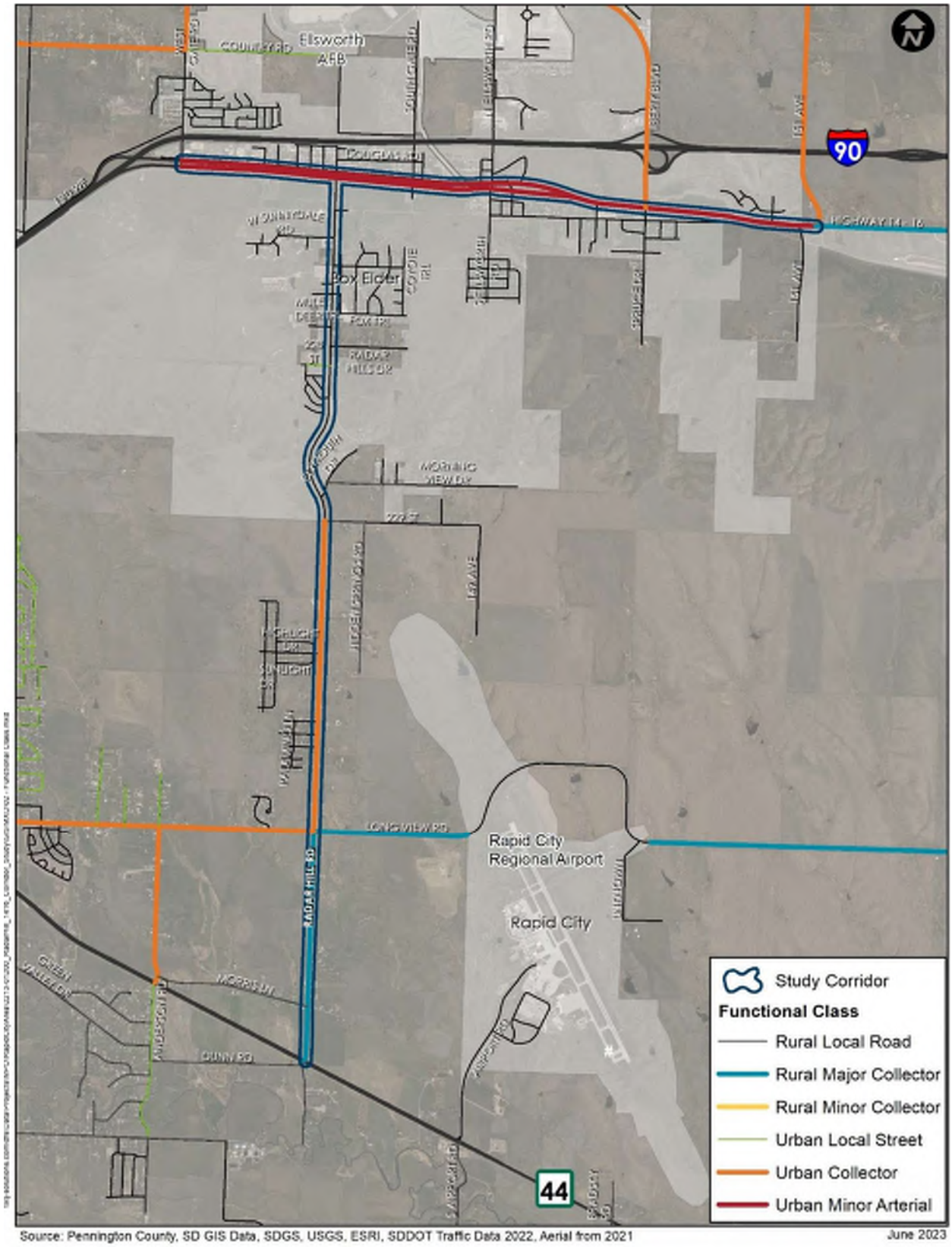
Several land use categories are present adjacent to Highway 1416 and Radar Hill Road within the study area. The land along the north side of Highway 1416 is primarily industrial, high-density residential, and open space and park land. A large parcel north of Highway 1416 between Hillview Drive and Liberty Boulevard is classified as highway service land. The south side of Highway 1416 is bounded by the railroad.

Land surrounding Radar Hill Road is primarily low-, mid-, and high-density residential, as well as industrial and highway service. There are small parcels dedicated to industrial space near Mule Deer Trail, Fox Trail, and Plymouth Drive. The remaining area surrounding the study area is primarily agricultural.

Box Elder city limits end near Old Cavalry Road. The areas adjacent to Radar Hill Road between 229th Street and SD 44 are under Pennington County jurisdiction. This land is primarily residential and agricultural.

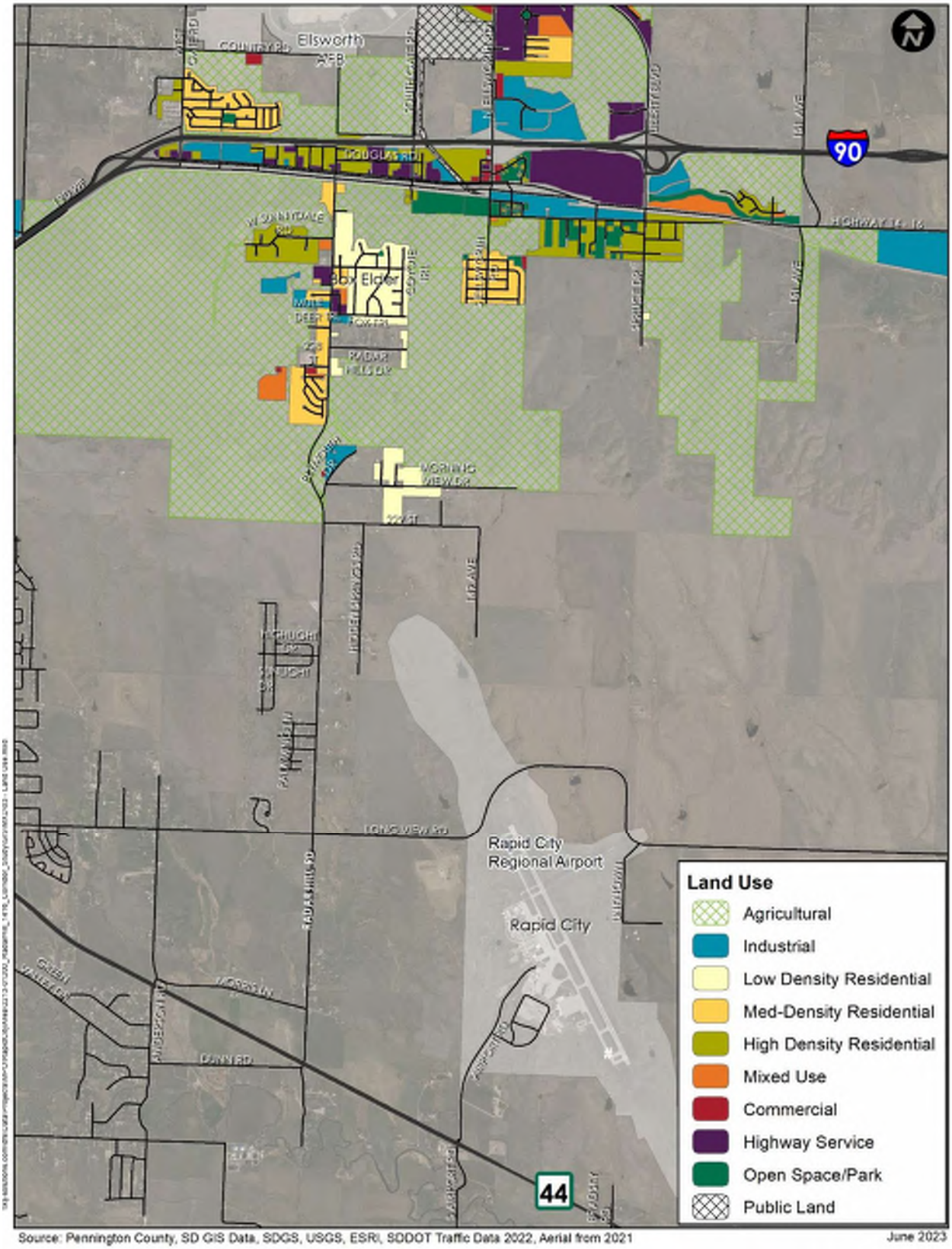
Land use is presented in **Figure 1-3**, using data provided by Pennington County.

Figure 1-2 – Road Functional Classifications



Source: Pennington County, SD GIS Data, SDGS, USGS, ESRI, SDDOT Traffic Data 2022, Aerial from 2021 June 2023

Figure 1-3 – Land Use



RIGHT-OF-WAY (ROW)

Right-of-way (ROW) is the available space owned by the County on which its roads and highways reside. ROW is often the constraining factor in developing alternatives, because acquiring additional ROW can be costly, increase project delivery deadlines, or stop a project altogether. The ROW of Highway 1416 directly adjacent to the Rapid City, Pierre, and Eastern railroad ROW. ROW widths vary along the corridor, depending on the location. ROW information will need to be verified through the project development, as the widths shown were obtained from publicly available GIS information. Cross-section widths along the corridor are shown in **Figure 1-4**.

Highway 1416

- W Gate Road to Radar Hill Road – Generally ranges from 300 to 320 ft.
- From Radar Hill Road to S Ellsworth Road – Generally ranges from 300 to 350 ft.
- From S Ellsworth Road to End of divided roadway – Generally ranges from 200 ft to 400 ft.
- Start of undivided roadway to 151st Avenue – Generally ranges from 90 ft to 120 ft.

Radar Hill Road

- Highway 1416 to Creekside Drive – Generally ranges from 70 to 120 ft.
- Creekside Drive to 228th Street – Generally ranges from 66 to 90 ft.
- 228th Street to 229th Street – Generally 100 ft
- 229th Street to Long View Road – Generally ranges from 85 ft to 110 ft.
- Long View Road to SD 44 – Generally ranges from 66 to 85 ft.

SPEED

Figure 1-5 shows the posted speed limits in the study area.

Highway 1416

Highway 1416 has a posted speed limit of 65 miles per hour (mph) between 151st Avenue and east of Liberty Boulevard. Between Liberty Boulevard and S Ellsworth Road, the speed limit drops to 50 mph. West of S Ellsworth Road, the speed limit is 55 mph through the remainder of the study area to W Gate Road.

Radar Hill Road

Radar Hill Road has a posted speed limit of 45 mph between Highway 1416 and 229th Street. Between 229th Street and SD 44, Radar Hill Road has a posted speed limit of 50 mph.

Figure 1-4 – Cross-Sections

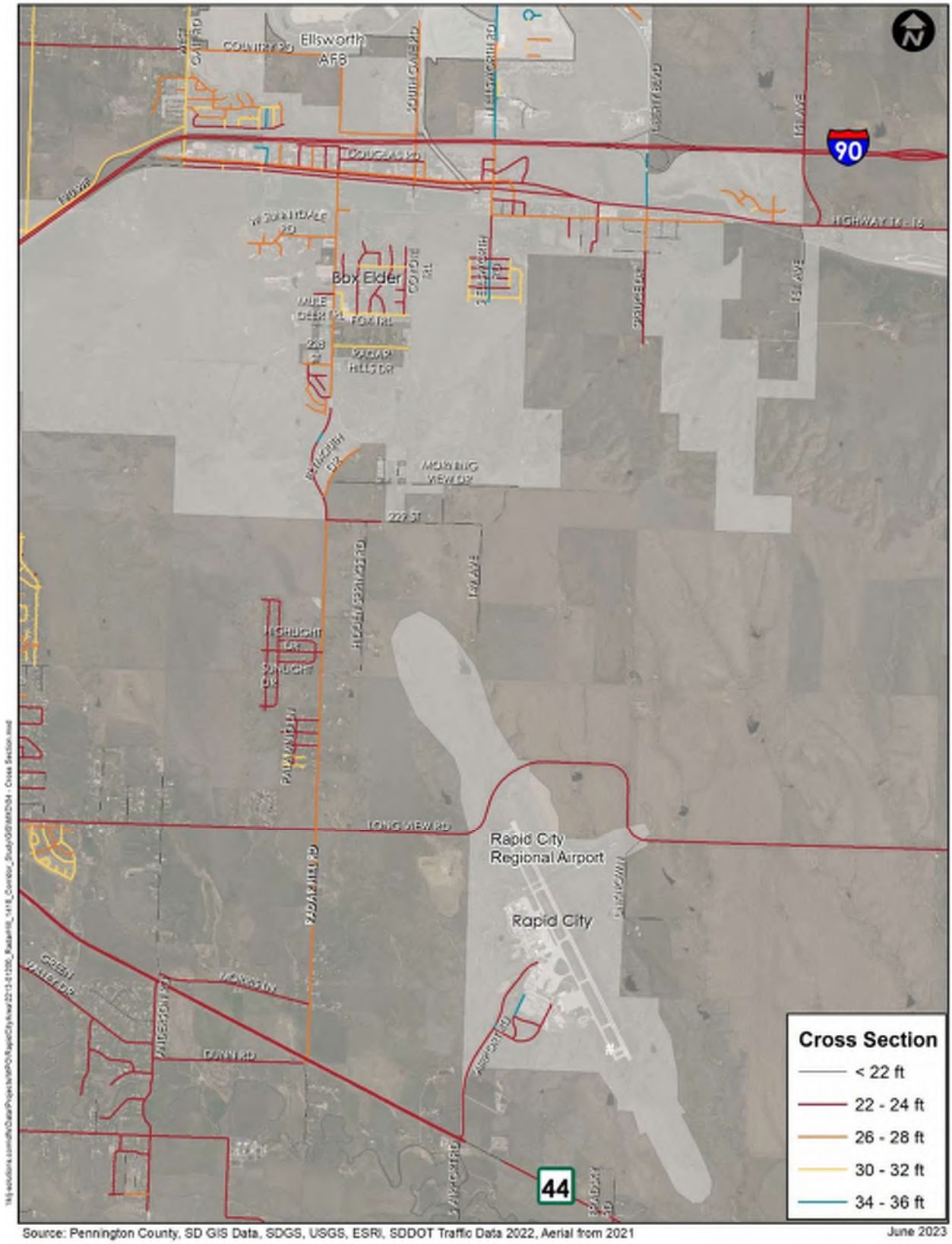


Figure 1-5 – Speed Limit



ACCESS MANAGEMENT

Access management is the process of balancing the competing needs of mobility and land access. Access locations introduce conflict points into the traffic stream. Allowing dense, uncontrolled access spacing results in safety, operational, and aesthetic deficiencies.

SDDOT's *Road Design Manual* (Chapter 17 – Access Management) states the minimum desirable spacing of access points in both Urban Fringe and Rural areas is **five accesses per side per mile**. Along the Highway 1416 and Radar Hill Road study corridors, the number of intersection and driveway accesses along each side of the roadway were calculated. Highway 1416 was split into three distinct segments: the undivided segment between 151st Avenue and the directional split, westbound Highway 1416 to W Gate Road, and eastbound Highway 1416 to the directional split. Radar Hill Road was analyzed as a single segment. For each segment, the average number of accesses per side per mile was calculated and compared to the SDDOT threshold of five accesses per side per mile. Access management results are shown in **Table 1-1**.

Table 1-1 – Access Management Results

Segment	Length *(mi)*	Side	Intersection Accesses	Driveway Accesses	Total Accesses	Total Accesses *(per side per mile)*	Intersection Accesses *(per side per mile)*
Hwy 1416 *151st Ave to EB/WB split*	1.58	North	4	3	7	**4.4**	2.5
		South	3	2	5	3.2	1.9
WB Hwy 1416 *EB/WB split to W Gate Rd*	2.54	North	8	0	8	3.1	3.1
		South	7	0	7	2.8	2.8
EB Hwy 1416 *W Gate Rd to EB/WB split*	2.50	North	7	0	7	2.8	2.8
		South	5	0	5	2.0	2.0
Radar Hill Rd *Hwy 1416 to SD 44*	5.43	West	17	17	34	**6.3**	3.1
		East	15	31	46	**8.5**	2.8

Existing accesses along Highway 1416 meet SDDOT standards. Accesses along Radar Hill Road do not meet SDDOT standards, particularly on the east side of the roadway. Intersection access spacing does meet requirements along Radar Hill Road.

The southbound approach of EB Highway 1416 and S Ellsworth Road is also offset from the northbound approach. This intersection is classified as a negative offset, as defined by the SDDOT *Road Design Manual* (Chapter 17 – *Access Management*). This offset poses a safety risk for several movements, therefore geometric realignment should be considered.

LIGHTING

Highway 1416

Roadway lighting is present at the following intersections along Highway 1416:

- Trenton Lane – single pole in the northeast corner of the intersection
- Liberty Boulevard – three poles illuminating the southbound, eastbound, and westbound approaches
- S Ellsworth Road – four poles illuminating the southbound, eastbound, and westbound approaches, as well as the median
- Radar Hill Road – four poles illuminating the southbound, eastbound, and westbound approaches, as well as the median
- W Gate Road – four poles illuminating the southbound, eastbound, and westbound approaches, as well as the median

No other intersections or segments along the Highway 1416 study corridor are lit.

Radar Hill Road

Roadway lighting is present at the following intersections along Radar Hill Road:

- Highway 1416 – four poles illuminating the southbound, eastbound, and westbound approaches, as well as the median
- Wilo Drive – single overhead light mounted on a telephone pole in the northeast corner of the intersection
- Mule Deer Trail – single pole in the southeast corner of the intersection
- Fox Trail – single pole in the northeast corner of the intersection
- Flying Eagle Drive – single overhead light mounted on a telephone pole in the northwest corner of the intersection
- Radar Hills Drive – single overhead light mounted on a telephone pole in the northeast corner of the intersection
- 228th Street – single pole in the southwest corner of the intersection
- Old Cavalry Road – single overhead light mounted on a telephone pole in the southeast corner of the intersection

No other intersections or segments along the Radar Hill Road study corridor are lit.

ENVIRONMENTAL JUSTICE OVERVIEW

The US Environmental Protection Agency's (EPA) Environmental Justice Screening and Mapping tool (EJSCREEN) was used to review the presence of readily identifiable low-income and minority populations by evaluating their percentages. The Environmental Justice (EJ) study area for this review included the project roadways: Highway 1416 and Radar Hill Road in Box Elder, Pennington County, South Dakota and a 0.25-mile buffer surrounding the roadways. Data obtained from EJSCREEN and US Census Bureau were used to determine percentages of low-income and minority populations within the EJ study area and the City of Box Elder. This limited analysis did not include investigating the presence of community facilities in the EJ study area that serve minority and low-income populations, or businesses in the EJ study area that are owned by, employ, and serve minority and low-income populations.

For the purposes of this review, the smallest unit of geography (i.e., city) was used for comparison with the EJ study area. An EJ population is identified when:

1. The minority or low-income population of a study area exceeds 50 percent, or
2. The minority or low-income population percentage is at least 10 percentage points higher than the city average.

As shown in **Table 1-2**, the minority and low-income populations in the entire study area do not exceed 50 percent and are not at least 10 percentage points higher than the average for the City of Box Elder. Therefore, an EJ population is not present in the EJ study area.

Table 1-2 – Minority and Low-Income Populations

Demographic	Study Area	City of Box Elder
Minority Population	21%	22%
Low-Income Population	23%	28%

MULTIMODAL FACILITY

No dedicated sidewalks, paths, or trails exist within the study area. There are also no dedicated or marked crossing locations on Highway 1416 or Radar Hill Road within the study area.

The South Dakota Road Design Manual (Chapter 7 – Cross Sections; Chapter 16 – Miscellaneous) states that shoulders considered to be bikeable should be paved and a minimum of four feet in width. There is an unpaved shoulder along the north edge of westbound Highway 1416, between the median split near Cottonwood Drive and the I-90 on-ramp. This shoulder is a six-foot unpaved shoulder that does not meet design requirements for bikeability. There is no shoulder serving the eastbound direction of Highway 1416.

Radar Hill Road has a six-foot paved shoulder on the east and west sides of the roadway, between Wilo Drive and Creekside Drive. There is also a 10-foot paved shoulder on both sides of Radar Hill Road between 228th Street and 229th Street.

Though some existing shoulders within the Radar Hill Road corridor meet bicycle lane design requirements, there are sections of both the Highway 1416 corridor and the Radar Hill Road corridor that are not accessible via non-motorized modes of travel. Highway 1416 and Radar Hill Road are also high-speed corridors, with vehicular speed limits ranging from 45 to 65 miles per hour, which reduces safety for bicyclists and pedestrians utilizing the shoulders.

Pedestrian Level of Service (PLOS) and Bicycle Level of Service (BLOS) analyses were conducted and are discussed later in this report. Shoulder widths throughout the study area (paved and unpaved) are shown in **Figure 1-6**.

ADJACENT FACILITIES

There are parallel facilities on either side of Highway 1416. South of Highway 1416 is an active railroad line. The distance between the edge of roadway and the rail line can vary from 65 to 210 feet. In areas where the distance between facilities is lesser, as it is at the Radar Hill Road and Ellsworth Drive intersections, queueing in the northbound direction can cross the railroad creating a potential safety risk.

Box Elder Road runs parallel to Highway 1416 on the north side of the roadway. The roadways are separated by a 50-foot grass median. Due to the short distance between the roadways, southbound queues at the Highway 1416 intersections can create potential operational and safety deficiencies at the adjacent Box Elder Road intersections.

Traffic Volumes

Traffic volumes were collected by KLJ at five of the six study intersections on Tuesday, May 9, 2023, and traffic volumes at Highway 1416 and 151st Avenue were collected on Tuesday, May 23, 2023. Volumes were collected for a 13-hour period and included pedestrian and bicycle movements.

The intersections of Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Road/Gumbo Drive were modeled with the westbound and eastbound directions of Highway 1416 separately. There is a large median (approximately 120 feet) separating the eastbound and westbound directions, with additional stop control at the northbound and southbound approaches between the two highway movements. The volumes were collected with each eastbound and westbound intersection operating as one and were balanced appropriately as distinct eastbound and westbound intersections.

The 2022 Average Daily Traffic (ADT) volumes are shown in **Figure 1-7** and they were collected by Pennington County. The AM and PM peak turning movement counts are shown in **Table 1-3** and **Table 1-4**, respectively. Raw traffic volume counts can be found in **Appendix A**.

Figure 1-6 – Shoulder Width

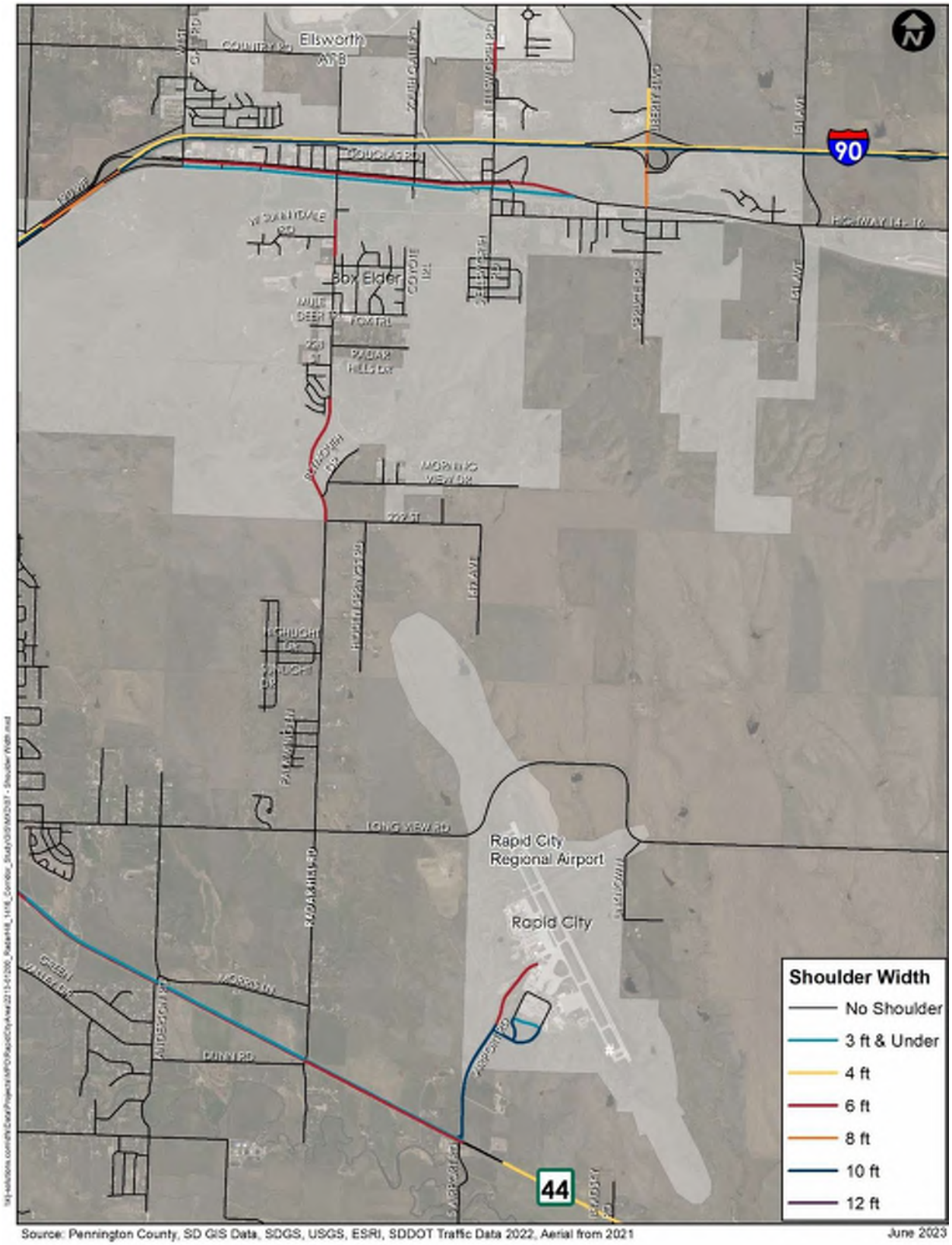


Figure 1-7 – 2022 Daily Traffic Volumes

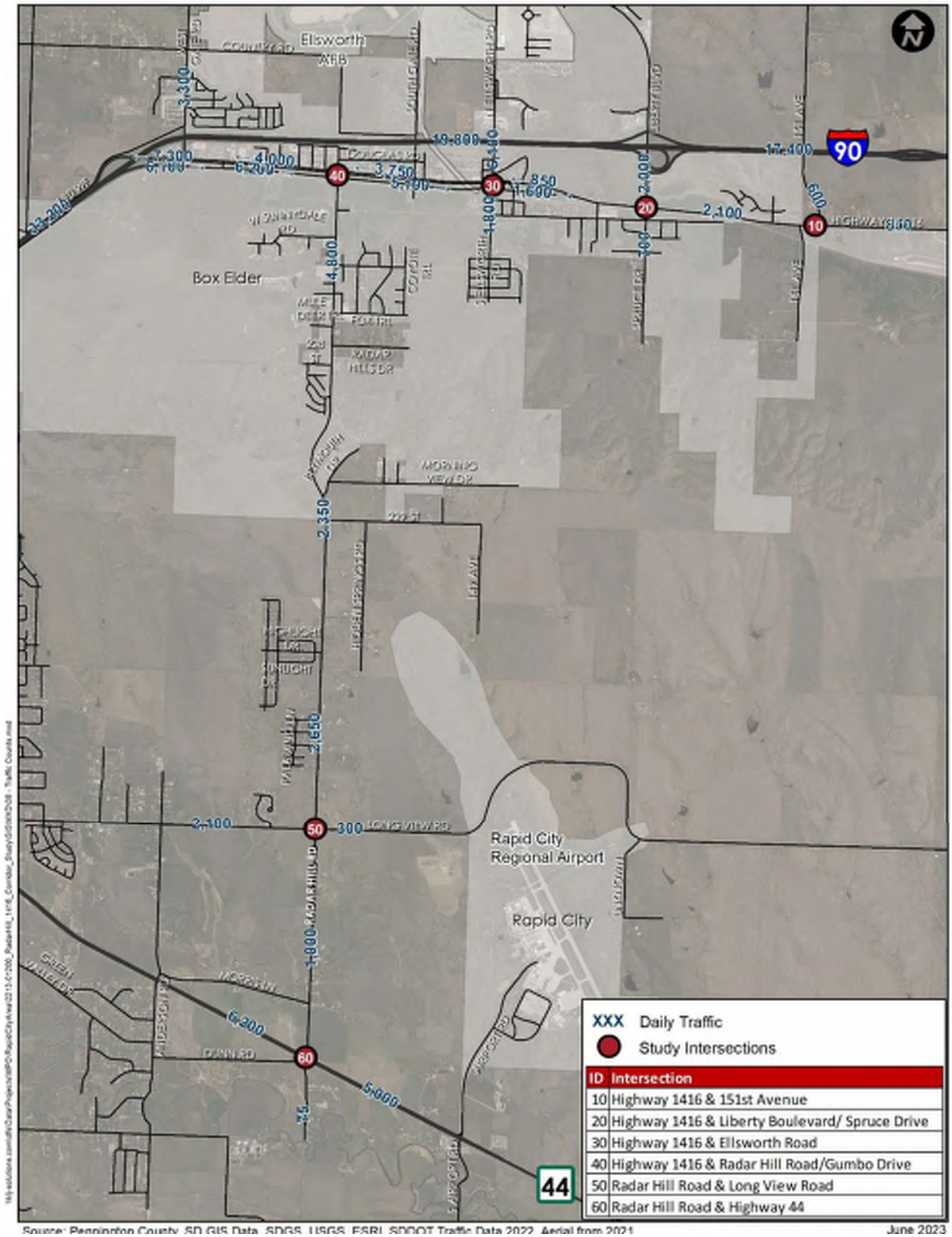


Table 1-3 – Turning Movement Counts (AM Peak)

Intersection	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Highway 1416 and 151st Ave	-	-	-	5	-	34	7	38	-	-	94	8
Highway 1416 and Liberty Blvd	3	32	2	20	8	28	134	23	2	1	15	139
Highway 1416 and S Ellsworth Rd*	86	56	7	10	16	194	618	115	15	0	44	13
Highway 1416 and Radar Hill Rd*	167	1	236	8	9	16	4	527	55	79	334	5
Radar Hill Rd and Long View Rd	1	24	3	3	38	102	70	6	1	5	16	9
Radar Hill Rd and SD 44	4	0	1	19	2	10	15	217	5	2	207	17

**Intersection split between eastbound and westbound Highway 1416. See split counts below.*

NB – Northbound; SB – Southbound; EB – Eastbound; WB – Westbound

L – Left; T – Through; R – Right

Table 1-3a – Turning Movement Counts (AM Peak)

Intersection	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
WB Highway 1416 and S Ellsworth Rd	86	674	-	-	26	194	-	-	-	0	44	13
EB Highway 1416 and S Ellsworth Rd	-	142	7	10	16	-	618	115	15	-	-	-
WB Highway 1416 and Radar Hill Rd	167	5	-	-	17	16	-	-	-	79	334	5
EB Highway 1416 and Radar Hill Rd	-	168	236	8	88	-	4	527	55	-	-	-

NB – Northbound; SB – Southbound; EB – Eastbound; WB – Westbound

L – Left; T – Through; R – Right

Table 1-4 – Turning Movement Counts (PM Peak)

Intersection	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
Highway 1416 and 151st Ave	-	-	-	3	-	15	36	84	-	-	50	1
Highway 1416 and Liberty Blvd	7	10	0	110	20	54	37	42	12	3	27	54
Highway 1416 and S Ellsworth Rd*	36	37	6	6	59	256	291	79	143	14	71	6
Highway 1416 and Radar Hill Rd*	112	9	116	4	9	10	19	401	193	184	531	3
Radar Hill Rd and Long View Rd	1	46	4	7	37	107	127	10	1	2	6	4
Radar Hill Rd and SD 44	6	1	0	23	7	24	39	132	12	1	221	24

**Intersection split between eastbound and westbound Highway 1416. See split counts below.*

NB – Northbound; SB – Southbound; EB – Eastbound; WB – Westbound

L – Left; T – Through; R – Right

Table 1-4a – Turning Movement Inputs for Operations Analysis (PM Peak)

Intersection	NBL	NBT	NBR	SBL	SBT	SBR	EBL	EBT	EBR	WBL	WBT	WBR
WB Highway 1416 and S Ellsworth Rd	36	328	-	-	65	256	-	-	-	14	71	6
EB Highway 1416 and S Ellsworth Rd	-	73	6	6	73	-	291	79	143	-	-	-
WB Highway 1416 and Radar Hill Rd	112	28	-	-	13	10	-	-	-	184	531	3
EB Highway 1416 and Radar Hill Rd	-	121	116	4	193	-	19	401	193	-	-	-

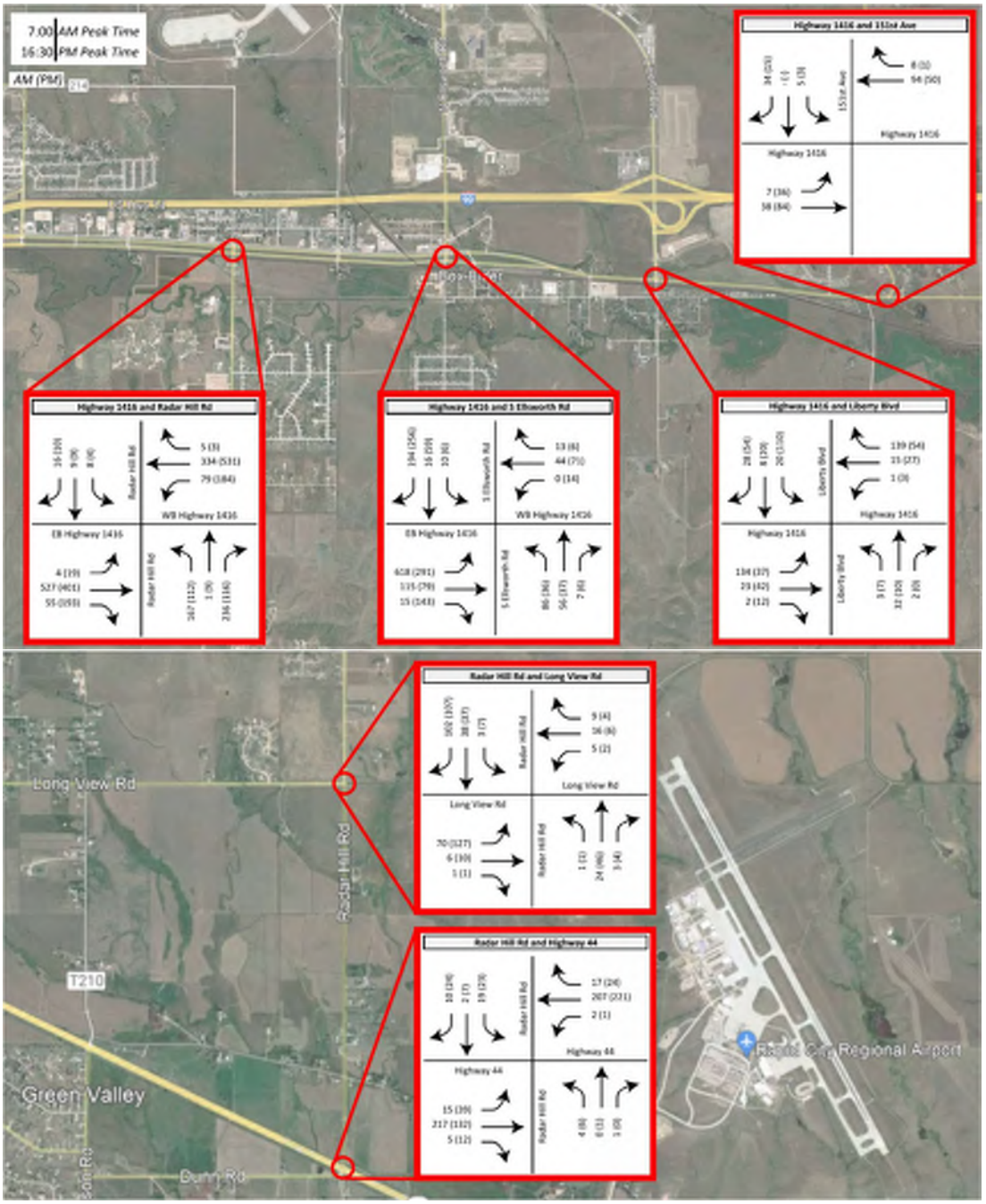
NB – Northbound; SB – Southbound; EB – Eastbound; WB – Westbound

L – Left; T – Through; R – Right

Traffic Patterns

13-hour counts were collected from 5:30 AM to 6:30 PM. The AM peak in vehicular volume was determined to begin at approximately 7:00 AM, and the PM peak begins at approximately 4:30 PM. The peak hours determined from KLJ's data collection and analysis was validated using StreetLight. The intersections of Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Road experienced the highest volumes out of all study intersections. The AM and PM peak turning movement counts are shown in **Figure 1-8**.

Figure 1-8 – Peak Hour Turning Movement Counts



Crash Analysis

Reviewing historic crash information can help identify existing deficiencies that can be addressed through this study. Ten years of crash records from January 1, 2013, through December 31, 2022, were requested from SDDOT. There were 357 crashes reported during the analysis period in the study area. The density of vehicular crashes along the study area and the location of crash events are shown in **Figure 1-9**. There was a high number of crashes, particularly at the intersections of Highway 1416 with W Gate Road, Radar Hill Road, Commercial Gate Road, and S Ellsworth Road. The summary of crashes for study intersections only are shown in **Table 1-5**.

Table 1-5 – Crashes at Study Intersections

Intersection with Highway 1416	Incapacitating	Non-Incapacitating	Possible Injury	Non-Injury	TOTAL
151st Ave	-	-	1	1	**2**
Liberty Blvd / Spruce Dr	1	-	2	5	**8**
S Ellsworth Rd	1	1	6	17	**25**
Commercial Gate Rd*	-	4	3	19	**26**
Radar Hill Rd	7	23	18	53	**101**
W Gate Rd*	1	3	6	17	**27**
TOTAL	**10**	**31**	**36**	**112**	**189**
Intersection with Radar Hill Road	**Incapacitating**	**Non-Incapacitating**	**Possible Injury**	**Non-Injury**	**TOT**
Long View Rd	-	-	-	-	**0**
SD 44	1	-	-	4	**5**
TOTAL	**1**	**0**	**0**	**4**	**5**

**Not among the intersections for study but added for statistics and reporting purposes.*

The corridor was divided into the following analysis segments based on engineering judgement and local knowledge:

- Crash Segment A: Highway 1416 – From 151st Avenue to west of Cottonwood Drive
- Crash Segment B: Highway 1416 – From west of Cottonwood Drive to Radar Hill Road
- Crash Segment C: Highway 1416 – From Radar Hill Road to W Gate Road
- Crash Segment D: Radar Hill Road – From Highway 1416 to 229th Street
- Crash Segment E: Radar Hill Road – From 229th Street to Long View Road
- Crash Segment F: Radar Hill Road – From Long View Road to SD 44

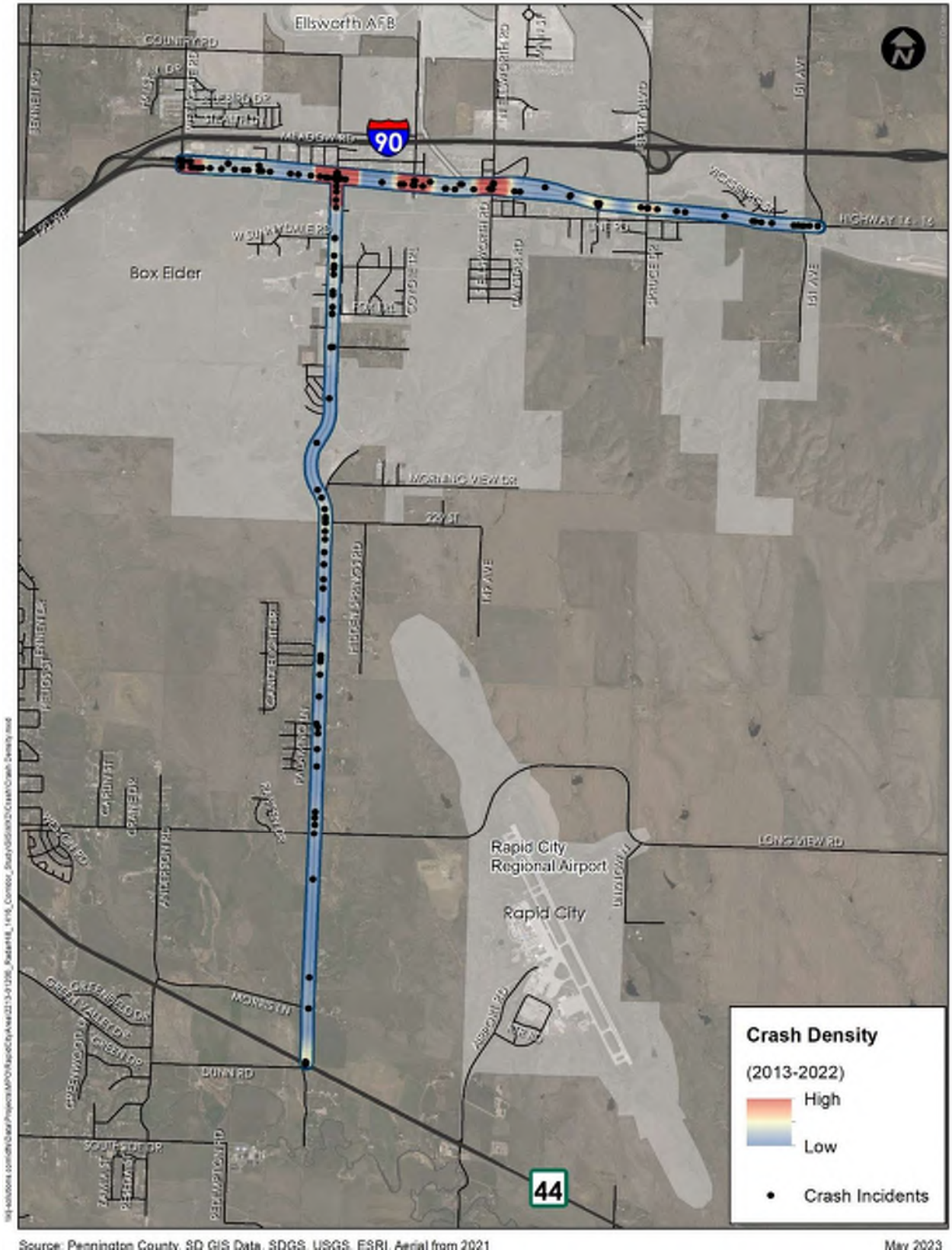
The summary of non-junction related crashes for crash segments are shown in **Table 1-6**.

Table 1-6 – Non-Junction Related Crashes

Crash Segment ID	Fatal injury	Incapacitating	Non-incapacitating	Possible Injury	No injury	Wild animal hit	TOT
A	1	3	3	4	7	3	**21**
B	-	-	5	4	11	7	**27**
C	1	2	6	2	23	-	**34**
D	-	1	5	4	14	3	**27**
E	-	3	-	2	14	2	**21**
F	-		-	2	1	4	**7**
TOTAL	**2**	**9**	**19**	**18**	**70**	**19**	**137**

- There were 82 non-junction related crashes reported along Highway 1416 during the analysis period, which corresponds to 8.2 crashes per year.
- There were 55 non-junction related crashes reported along Radar Hill Road during the analysis period, which corresponds to 5.5 crashes per year.

Figure 1-9 – Crash Density (Year 2013-2022)



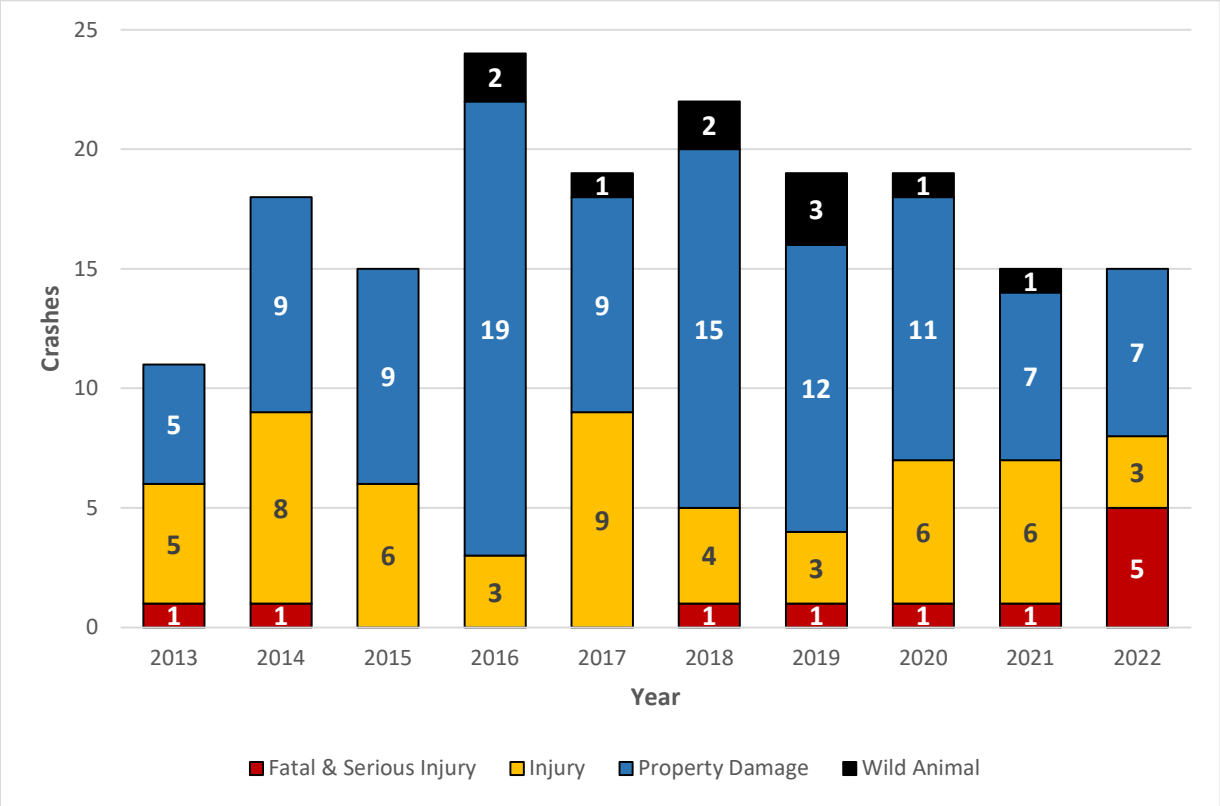
CRASH TRENDS AND PATTERNS

The trend and pattern of corridor crashes by year and month were analyzed from crash records.

Highway 1416

There were 177 crashes reported in the Highway 1416 segments of the study area during the analysis period. This corresponds to 17.7 crashes per year. The ten-year crash summary at Highway 1416 roadway is shown in **Figure 1-10**.

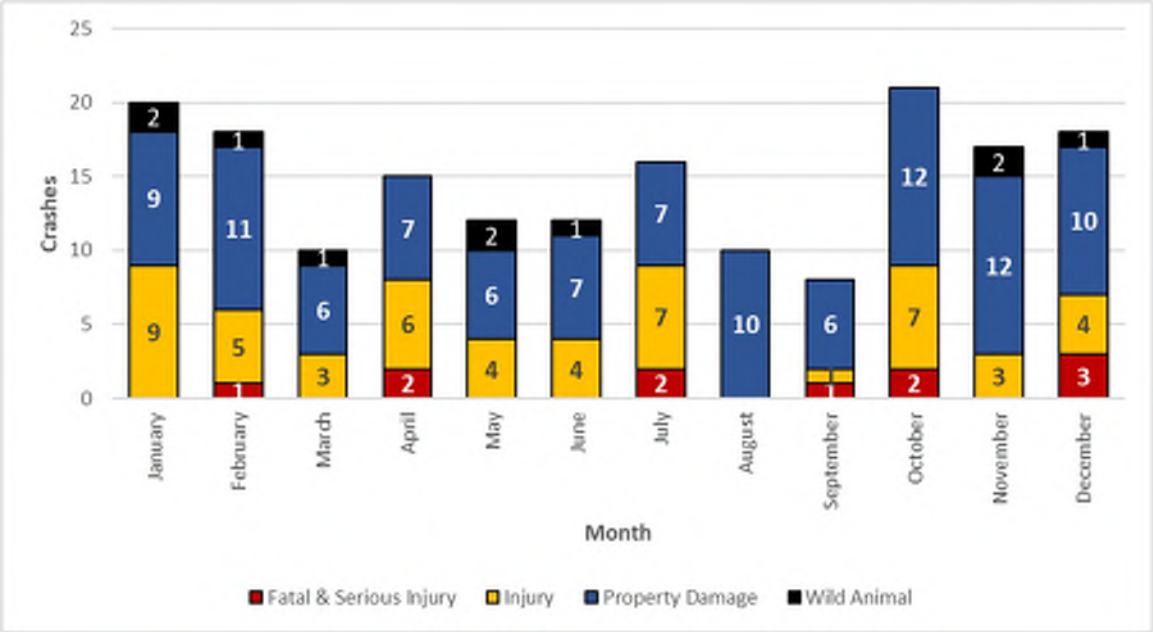
Figure 1-10 – Highway 1416 Segment and Intersection Ten-Year Crash Summary (Year 2013-2022)



The number of crashes has varied during the analysis period. The total crashes peaked in 2014, and recently there has been a modest drop in crashes. This may be attributed to recent improvements made on the Highway 1416 corridor with stop signs added to the main line in a single direction at the intersections of West Gate Road, Radar Hill Road, and S Ellsworth Road. The number of fatal and incapacitating crashes have been highest in 2022, with two fatal and three incapacitating crashes.

The trends of crashes by months of the year are shown in **Figure 1-11**. Frequency of crashes were generally high from October through February. This timeframe coincides with the typical winter months and snowy/icy roadways.

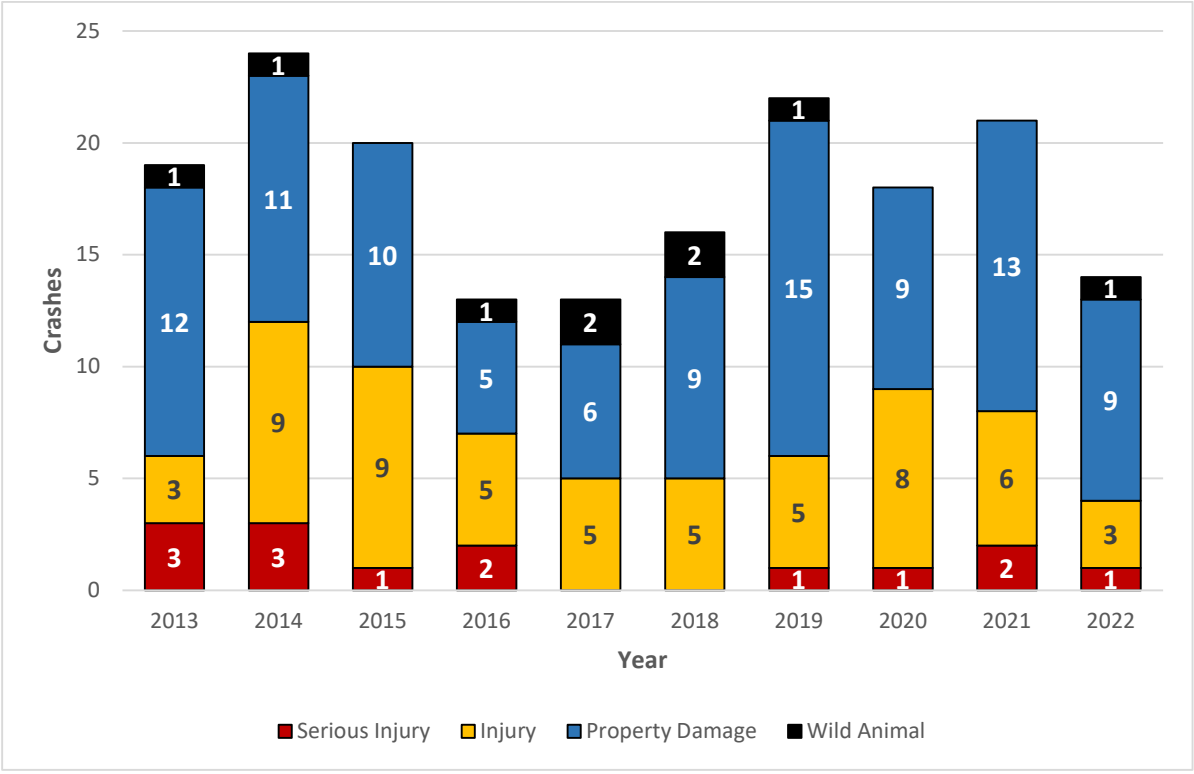
Figure 1-11 – Highway 1416 Crashes by Month (Years 2013-2022)



Radar Hill Road

There were 180 crashes reported in the Radar Hill Road segment of the study area during the analysis period. This corresponds to 18 crashes per year. The ten-year crash summary at Radar Hill Road segment of the study is shown in **Figure 1-12**.

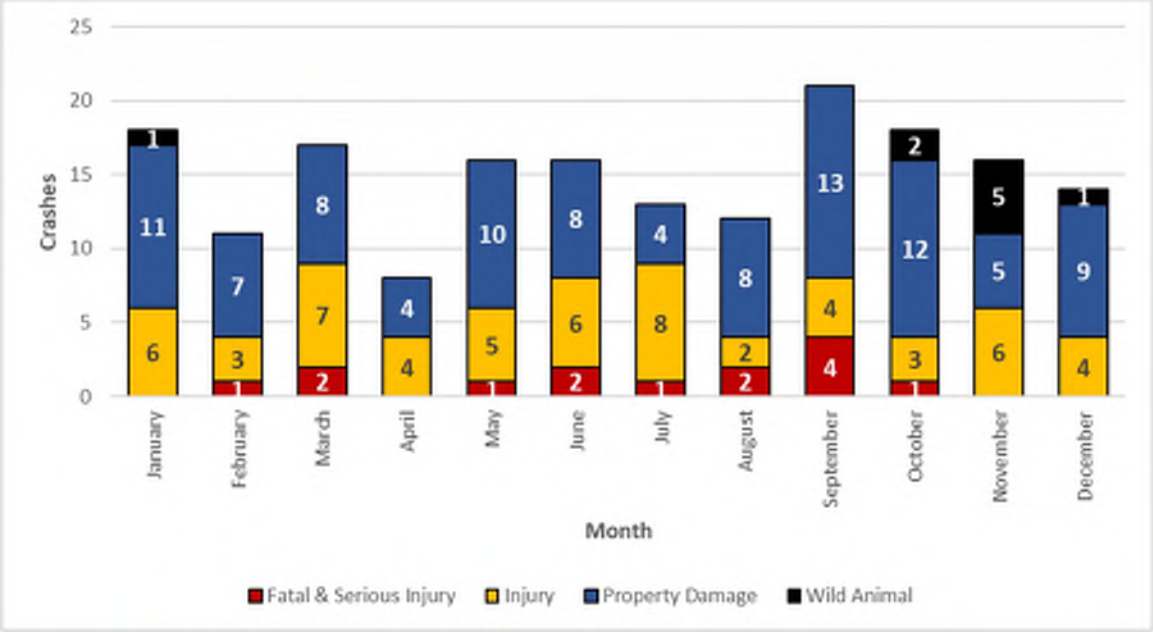
Figure 1-12 – Radar Hill Road Ten-Year Crash Summary (Years 2013-2022)



The number of crashes has varied during the analysis period. There were no fatal crashes reported during the analysis period on the Radar Hill Road corridor.

The trends of crashes by months of the year are shown in **Figure 1-13**. Frequency of crashes were generally high from September through January.

Figure 1-13 – Radar Hill Road Crashes by Month (Years 2013-2022)



FATAL CRASHES ON BOTH CORRIDORS

There were two (2) fatal and twenty (20) incapacitating injury crashes reported in the study area during the analysis period. The first fatal crash incident, which was reported in September 2014 took place at the intersection of Highway 1416 with Cottonwood Drive. The incident involved the collision of a motorist with an oncoming train. The railroad crossing at Cottonwood Drive near Highway 1416 is yield controlled. The second fatal crash incident, which was reported in February 2018 took place at the intersection of Eastbound Highway 1416 with Radar Hill Road. The incident involved a pedestrian and a motorist under the influence which occurred during dark conditions and the intersection was not well illuminated.

CRASHES INVOLVING PEDESTRIAN/BICYCLIST

There was one pedestrian- and three bicyclist-involved crashes reported during the analysis period. The only pedestrian crash incident was a fatal crash that was described previously in the report.

The first crash involving a bicyclist was reported in July 2014 near the intersection of Radar Hill Road with 229th Street. The incident involved the collision of a bicyclist with a lightweight truck and occurred under dark conditions with no streetlight illumination. The bicyclist experienced an incapacitating injury.

The second crash involving a bicyclist was reported in September 2016 at the intersection of Highway 1416 and Radar Hill Road. The incident involved the collision of a bicyclist traveling northbound to cross

Highway 1416 with an oncoming vehicle traveling westbound. The bicyclist experienced an incapacitating injury.

The third crash involving a bicyclist was reported in November 2020 at the intersection of Highway 1416 with W Gate Road. The incident involved the collision of a bicyclist traveling southbound to cross Highway 1416 with an oncoming vehicle traveling westbound. The bicyclist experienced a possible injury.

CRASHES WITH TRAIN

There were five crashes reported that involved collision of a vehicle with an oncoming train. There were three crashes reported for the intersection of Highway 1416 with Radar Hill Road, of which two resulted in non-incapacitating and one non-injury crashes. The major contributing factor for the crashes were failure to yield. The railroad crossing at Radar Hill Road is controlled by flashing lights and gates. There were two crashes reported at the railroad crossing with Cottonwood Drive, of which one resulted in a fatality and the other resulted in no injury. The major contributing factor for the crashes were failure to yield. The railroad crossing at 151st Avenue is controlled by a yield sign at each approach.

CRASH COLLISION TYPES

Identifying crash types at roadways assists in developing countermeasures to mitigate or minimize the crash type. Angle (120 crashes) and rear-end (43 crashes) were the most typical crash types at the study intersections along Highway 1416. **Figure 1-14** on the following page shows the crashes by crash type at the study intersections during the analysis period. The larger the pie chart, the more crashes that occurred at the corresponding intersection.

The non-junction related crashes by collision types are summarized in **Table 1-7**.

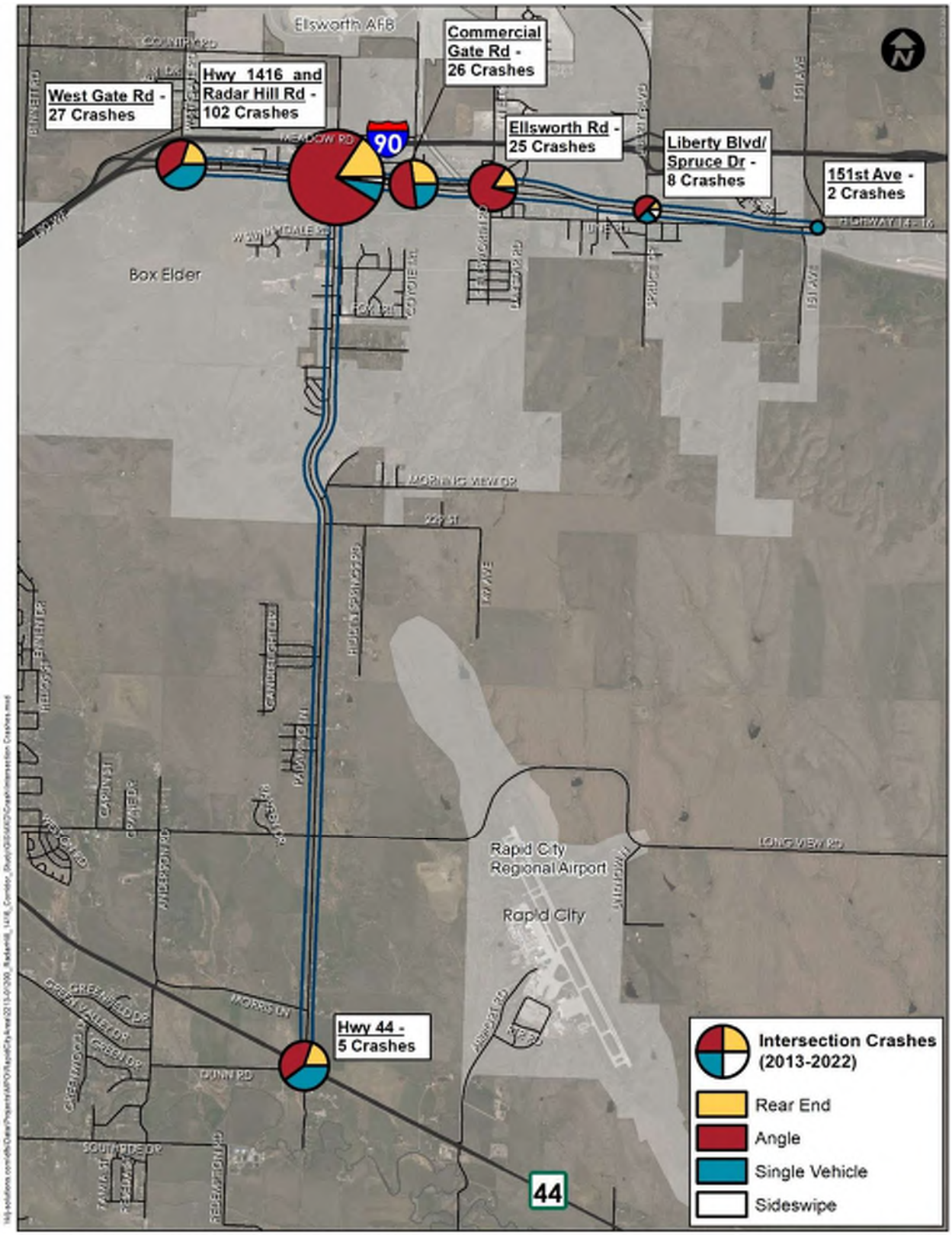
Table 1-7 – Non-Junction Related Crashes by Collision Types

Crash Segment ID	Manner of Collision						Total
	Single-Vehicle	Rear-End	Angle	Head-On	Sideswipe	Wild Animal	
A	18	1		2			**21**
B	21	3	1	1	1		**27**
C	18	12	1		2	1	**34**
D	15	9	1	1		1	**27**
E	17	1		1	1	1	**21**
F	6					1	**7**
TOTAL	**95**	**26**	**3**	**5**	**4**	**4**	**137**

- Crash Segment A: Highway 1416 – From 151st Avenue to west of Cottonwood Drive
- Crash Segment B: Highway 1416 – From west of Cottonwood Drive to Radar Hill Road
- Crash Segment C: Highway 1416 – From Radar Hill Road to W Gate Road
- Crash Segment D: Radar Hill Road – From Highway 1416 to 229th Street
- Crash Segment E: Radar Hill Road – From 229th Street to Long View Road
- Crash Segment F: Radar Hill Road – From Long View Road to SD 44.

Most (95 crashes, or 69 percent) of the non-junction related crashes involved a single-vehicle (i.e., run-off-road, rollover, etc.).

Figure 1-14 – Intersection Crashes by Collision Type (Ten-Year Crashes from 2013-2022)



Source: Pennington County, SD GIS Data, SDGS, USGS, ESRI, Aerial from 2021 June 2023

CRASH HOTSPOTS

Using the trends identified earlier, additional analysis and evaluation was completed in the study area for the intersections and segments that experienced a high frequency of crashes. This crash hotspot analysis is used to identify specific combinations of crash type and direction to further understand the specific issues at the study intersections and segments.

Highway 1416 and Radar Hill Road

The intersection of Highway 1416 and Radar Hill Road experienced the highest number of crashes during the analysis period with 102 crashes. Angle crashes were the most predominant type of crashes (77 crashes, or 75.5 percent) at the intersection. The intersection of Highway 1416 with Radar Hill Road is a divided intersection where the eastbound and westbound approaches of Highway 1416 operate as independent intersections with Radar Hill Road due to the large median (approximately 120 feet) between them.

The intersection of eastbound Highway 1416 and Radar Hill Road experienced 36 angle crashes during the ten-year analysis period. The intersection was converted to an all-way stop-control (AWSC) intersection in 2020. Prior to that, the intersection operated as a side-street stop-controlled intersection with stops on the northbound and southbound approaches. Between 2013 and 2019, the intersection experienced 30 angle crashes, which corresponds to 4.3 angle crashes per year. The major contributing factor to the angle crashes was failure to yield. The number of crashes involving eastbound- and northbound-traveling vehicles, and eastbound- and southbound-traveling vehicles were equal. The rate of angle crashes reduced between 2020 and 2022 (while operating as an AWSC intersection), with the intersection experiencing six angle crashes that corresponds to two angle crashes per year. However, the rate of rear-end crashes went up from six crashes in seven years between 2013 and 2019 (0.9 rear-end crashes per year) to six crashes in three years between 2020 and 2022 (two rear-end crashes per year). Rear-end crashes generally occurred along the eastbound approach and northbound approach.

The intersection of westbound Highway 1416 and Radar Hill Road experienced 41 angle crashes. The major contributing factor to the angle crashes was failure to yield. The intersection operates as a side-street stop-controlled intersection with stops on the northbound and southbound approaches. Most of the angle crashes involved vehicles traveling northbound and westbound (20 crashes).

Highway 1416 and S Ellsworth Road

There were 25 crashes reported at the intersection of Highway 1416 and S Ellsworth Road during the analysis period. Angle crashes were the most prominent type of crashes (20 crashes, or 80-percent) at the intersection. The intersection of Highway 1416 with S Ellsworth Road is a divided intersection, with a median of approximately 150 feet. Due to the large median, the westbound and eastbound approaches of Highway 1416 are controlled as independent intersections with S Ellsworth Road.

The intersection of eastbound Highway 1416 and S Ellsworth Road experienced 12 crashes, with 10 angle crashes. The number of crashes involving eastbound- and northbound-traveling vehicles, and eastbound- and southbound-traveling vehicles were equal. The major contributing factors to the angle crashes were failure to yield. The northbound approach of the intersection has a negative offset which creates additional conflict points for motorists and increases the crash potential due to poor driver visual cognition of conflicting traffic.

The intersection of westbound Highway 1416 and S Ellsworth Road experienced 13 crashes, with 10 angle crashes. There were seven angle crashes involving northbound- and westbound-traveling vehicles. The intersection is controlled by side-street stop signs. The stop signs were moved from the S Ellsworth Rd approaches to the westbound approach of Highway 1416 in 2020. The northbound approach is uncontrolled, and the southbound approach is yield-controlled. The number of crashes were reduced from 10 crashes between 2013 and 2018 (1.4 crashes per year) to three crashes between 2020 to 2022 (one crash per year).

Segment Lighting

The segments of Highway 1416 and Radar Hill Road within the study area do not currently have continuous lighting. The non-junction related crashes by lighting conditions in the study area are summarized in **Table 1-8**.

Table 1-8 – Non-Junction Related Crashes by Lighting Conditions

Segment	Dark conditions with No street Lighting	Day conditions or dark conditions with some street lighting	Total
A	12	9	**21**
B	12	15	**27**
C	13	21	**34**
D	7	20	**27**
E	10	11	**21**
F	5	2	**7**
TOTAL	**59**	**78**	**137**

- Crash Segment A: Highway 1416 – From 151st Avenue to west of Cottonwood Drive
- Crash Segment B: Highway 1416 – From west of Cottonwood Drive to Radar Hill Road
- Crash Segment C: Highway 1416 – From Radar Hill Road to W Gate Road
- Crash Segment D: Radar Hill Road – From Highway 1416 to 229th Street
- Crash Segment E: Radar Hill Road – From 229th Street to Long View Road
- Crash Segment F: Radar Hill Road – From Long View Road to SD 44

There were 59, or 43-percent, non-junction related crashes reported during the analysis period that occurred under dark conditions with non-roadway lighting. There were 95 single-vehicle non-junction crashes reported for the study area during the analysis period (as shown **Table 1-7**). This includes 41, or 43 percent, single-vehicle non-junction related crashes that occurred during dark conditions where street lighting was non-existent.

Capacity Analysis and Demand

Intersection Capacity Analysis

Intersection capacity analysis was conducted using HCS 2023 software for each of the study intersections, using both AM and PM peak vehicular and pedestrian volumes. Intersection performance was measured based on delay and Level of Service (LOS). The methodology for vehicular and pedestrian LOS is described in the following sections.

VEHICULAR LEVEL OF SERVICE (VLOS)

Vehicular Level of Service (VLOS) is a function of average delay per vehicle. LOS "A" represents free-flow traffic, whereas LOS "F" represents unacceptable delay. LOS "D" or better is considered acceptable for Minor Arterials and Collectors, in accordance with SDDOT standards. LOS delay thresholds are presented in **Table 1-9**.

Table 1-9 – Intersection Level of Service Thresholds

Level of Service	Average Delay / Vehicle	
	Stop, Yield, and Roundabout Intersections	Signalized Intersections
A	< 10 seconds	< 10 seconds
B	10 to 15 seconds	10 to 20 seconds
C	15 to 25 seconds	20 to 35 seconds
D	25 to 35 seconds	35 to 55 seconds
E	35 to 50 seconds	55 to 80 seconds
F	> 50 seconds	> 80 seconds

LOS for two-way stop controlled (TWSC) intersections is currently undefined by the Highway Capacity Manual (HCM). Major roadway through and right-turn movements generally experience no delay, as they are uncontrolled and do not need to yield to any conflicting movements. However, vehicles turning left or crossing the major street can experience significant delay. For this reason, LOS assigned to TWSC intersections in this study were determined based on the delay experienced by side street approaches and left-turning movements, weighted by movement volume. All-way stop controlled (AWSC) intersection LOS was determined based on methodology presented in the HCM. None of the study intersections are currently signalized or roundabout controlled.

The intersections of Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Road were modeled as separate intersections due to large median separation between eastbound and westbound approaches, as well as differences in stop-control in each approach. The intersection delay and LOS were measured as a weighted average of all approaches experiencing delay by the volume of each approach.

Vehicular LOS results for each intersection are shown in **Table 1-10**. The intersection delay is presented based on methodology described above. The corresponding LOS value for the intersection delay is shown, as well as the LOS value for the worst approach. Detailed Vehicular Level of Service results can be found in **Appendix B**.

Table 1-10 – Existing Intersection Vehicular Capacity Analysis

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	*LOS**	*Delay (sec/veh)*	*LOS**
Highway 1416 and 151st Ave	9.1	A / A	8.0	A / A
Highway 1416 and Liberty Blvd	9.8	A / B	10.2	B / B
Highway 1416 and S Ellsworth Rd	677.2	**F / F**	13.5	**B / E**
Highway 1416 and Radar Hill Rd	26.9	**D / E**	32.8	**D / F**
Radar Hill Rd and Long View Rd	8.4	A / A	8.8	A / A
Radar Hill Rd and SD 44	10.5	B / B	2.6	A / B

**[Intersection LOS] / [Worst approach LOS]*

AM Peak

During the AM peak, it was determined that the intersection of Highway 1416 and S Ellsworth Road experiences severely unacceptable delay and LOS, with both the intersection and worst approach reaching LOS F. The unacceptable conditions are primarily caused by a significant number of eastbound vehicles making a left turn at the intersection. On the recorded day, this uncontrolled movement had 618 vehicles during the peak hour. This equates to approximately one vehicle every 6 seconds for the entire hour leaving few gaps for all other movements.

The intersection of Highway 1416 and Radar Hill Road also experiences severely unacceptable delay and LOS, with the worst approach reaching LOS E. The worst approach at this intersection is the northbound approach of the eastbound portion of Highway 1416 (south of the median). The unacceptable delay at this approach is the result of the minimal storage space in the median separating eastbound and westbound Highway 1416 being exceeded by queueing vehicles, which causes queueing and delays for vehicles attempting to enter the median.

All other intersections operate under acceptable delay and LOS during the AM peak.

PM Peak

During the PM peak, it was determined that the intersection of Highway 1416 and S Ellsworth Road experiences unacceptable delay and LOS, with the worst approach reaching LOS E. The worst approach at this intersection is the southbound approach of the eastbound portion of Highway 1416 (south of the median). High eastbound volumes at this intersection make it difficult for drivers to find acceptable gaps to cross or merge onto the highway. This intersection also experiences higher southbound volumes during the PM peak as vehicles travel away from the Ellsworth Air Force Base.

The Highway 1416 and Radar Hill Road intersection also experiences severely unacceptable delay and LOS, with the worst approach reaching LOS F. The worst approaches at this intersection are the northbound and eastbound left/thru approaches of the eastbound portion of Highway 1416 (south of the median). Minimal median storage causes significant queueing and delays for vehicles attempting to enter the median.

All other intersections operate under acceptable delay and LOS during the PM peak.

PEDESTRIAN AND BICYCLE LEVEL OF SERVICE (PLOS/BLOS)

Pedestrian Level of Service (PLOS) and Bicycle Level of Service (BLOS) are measures of a segment's walkability and bikeability. The *Highway Capacity Manual* provides a PLOS and BLOS calculation for segments, incorporating roadway design, adjacent vehicular volume, presence of parking and other buffers, and existing pedestrian and bicycle facilities. The segments are scored with LOS A through F, with LOS A representing satisfactory facilities for bicycles and pedestrians, and LOS F representing a facility that is unsuitable for bicycles and pedestrians. A score value that corresponds to PLOS and BLOS characteristics within a given system is shown in **Table 1-11**.

Table 1-11 – PLOS and BLOS Scoring Thresholds

Score Range	PLOS or BLOS
≤ 1.50	A
≥1.51 and ≤2.50	B
≥2.51 and ≤3.50	C
≥3.51 and ≤4.50	**D**
≥4.51 and ≤5.50	**E**
≥5.51	**F**

The study area was split into eight segments for the PLOS and BLOS analysis, due to difference in directional ADT, speed limit changes, and the presence and width of shoulders. The segment descriptions and PLOS and BLOS results are shown in **Table 1-12**. Detailed PLOS and BLOS results can be found in **Appendix C.**

Table 1-12 – Existing Pedestrian LOS (PLOS) and Bicycle LOS (BLOS) Results

Segment	PLOS		BLOS	
	Score	*LOS*	*Score*	*LOS*
Highway 1416 *151st Ave to Liberty Blvd*	4.92	**E**	4.20	**D**
WB Highway 1416 *Liberty Blvd to S Ellsworth Rd*	4.08	**D**	4.08	**D**
WB Highway 1416 *S Ellsworth Rd to W Gate Rd*	4.55	**E**	4.87	**E**
EB Highway 1416 *Liberty Blvd to S Ellsworth Rd*	4.06	**D**	4.89	**E**
EB Highway 1416 *S Ellsworth Rd to W Gate Rd*	4.57	**E**	4.90	**E**
Radar Hill Rd *Highway 1416 to 228th St*	4.02	**D**	4.26	**D**
Radar Hill Rd *228th St to 229th St*	3.07	C	1.50	A
Radar Hill Rd *229th St to SD 44*	3.92	**D**	3.81	**D**

PLOS and BLOS scores are generally unfavorable throughout the study area. This is primarily due to a lack of walkable and bikeable facilities. The Radar Hill Road segment from 228th Street to 229th Street has a ten-foot shoulder on both sides of the roadway, which contributes to the increased PLOS, and the satisfactory BLOS.

Providing adequate pedestrian and bicycle facilities along Highway 1416 and Radar Hill Road is expected to increase the PLOS and BLOS.

Summary

Corridor Characteristics

- The access management analysis determined that Radar Hill Road exceeds SDDOT standards of five accesses per side per mile between Highway 1416 and SD 44, with an average of 6.3 and 8.5 accesses per mile, on the west and east sides, respectively.
- A negative offset exists on S Ellsworth Road at the intersection with eastbound Highway 1416. Realignment of this intersection to remove the negative offset should be considered.
- The only existing multimodal facilities within the study area consists of a ten-foot shoulder on both sides of Radar Hill Road between 228th Street and 229th Street. No dedicated sidewalks or bike lanes exist within the study area.
- Proximity to Box Elder Road to the north and the railroad tracks to the south limits available right-of-way for Highway 1416. The proximity also leads to safety and operational concerns at the intersections along Box Elder Road and the railroad.
- The northbound queues entering Highway 1416 at Radar Hill Road and Ellsworth Drive can extend to the railroad tracks causing safety concerns. Likewise, the southbound approaches onto Highway 1416 can extend across Box Elder Road causing delays and safety concerns with the intersections of the frontage road.
- The atypical traffic control at Highway 1416's intersections with Radar Hill Road, Commercial Gate Road, and Ellsworth Drive could lead to driver confusion and become a potential safety hazard.

Safety

- There were 357 crashes reported during the 10-year analysis period in the study area.
- There were 177 crashes reported in the Highway 1416 segments of the study area.
- There were 180 crashes reported in the Radar Hill Road segment of the study area.
- There were two (2) fatal and twenty (20) incapacitating injury crashes reported.
- There was one pedestrian-related crash and three crashes involving bicyclists reported.
- The frequency of crashes was generally high along the intersections of Highway 1416 with W Gate Road, Radar Hill Road, Commercial Gate Road, and S Ellsworth Road.
- Angle (120 crashes) and rear-end (43 crashes) were the most typical crash types at the study intersections along Highway 1416.

- Most (95 crashes, or 69 percent) of the non-junction related crashes were single-vehicle related, like run-off-road, roll over, etc. This includes 41, or 43 percent, single-vehicle non-junction related crashes that occurred during dark conditions where street lighting were minimum to non-existent.
- The intersection of Highway 1416 and Radar Hill Road experienced the highest number of crashes during the analysis period, with 102 crashes. Angle crashes were the most prominent type of crashes (77 crashes, or 75.5 percent) at the intersection.
- There were 25 crashes reported at the Highway 1416 and S Ellsworth Road intersection during the analysis period. Angle crashes were the most prominent type of crashes (20 crashes, or 80 percent) at the intersection.

Traffic Volumes

- KLJ collected traffic volumes at six study intersections on May 9 and May 23, 2023.
- The AM peak was determined to be 7:00 AM, and the PM peak was determined to be 4:30 PM. These peak times were validated using StreetLight data.

Capacity Analysis

- Highway 1416 and S Ellsworth Road operates at LOS F during the AM peak, and LOS E during the PM peak.
- Highway 1416 and Radar Hill Road operates at LOS E during the AM peak, and LOS F during the PM peak, brought on by queueing in the median.
- All other study intersections operate under acceptable delay and LOS during the AM and PM peaks.
- The majority of the segments within the study area operate under unacceptable Pedestrian LOS (PLOS) and Bicycle LOS (BLOS), due to a lack of dedicated pedestrian and bicycle facilities.

Chapter 2 – Future Conditions

Future Volumes

Existing traffic counts were collected by KLJ in May of 2023 at the six study intersections. These volumes were projected to the 2030 and 2050 analysis years. The basis of the growth was derived from the Rapid City Area MPO regional model. However, the model does not currently account for some planned developments in the study area. The projection for the general background growth was adjusted to account for anticipated growth due to expansion of the Ellsworth Air Force Base. Annual growth rates were estimated using the Rapid City Area MPO regional model. Furthermore, additional traffic due to the development of two new schools and a multi-family housing development directly adjacent to the study area were also incorporated into the future volume counts. The methodology for the development of the volumes used in the analysis is included in this section.

Annual Growth Rate

Annual growth rates by movement at each of the study intersections were developed using Average Daily Traffic (ADT) values within the study area, and accounting for additional growth expected from the Ellsworth Air Force Base. ADTs for the years 2018 and 2045 were provided by the Rapid City Area MPO along the relevant segments of the Highway 1416 and Radar Hill Road corridors. The Ellsworth Air Force Base is expected to expand by approximately 4,000 people by the year 2030, which represents a population growth of 2.30% in the City of Box Elder. This growth rate was applied to the anticipated growth between the 2018 and 2045 ADTs to develop an annual growth rate using **Equation 1**.

Equation 1 – Annual Growth Rate

$$Annual\ Growth\ Rate = \left(\frac{ADT2045 * (1 + 2.30\%)}{ADT2018}\right)^{\frac{1}{2045-2018}} - 1$$

This equation provided annual growth rate by approach, which was then averaged between relevant movements to determine annual growth rate by movement, as ADT is bi-directional (e.g., the annual growth rate applied to northbound left movements was an average of the *northbound* annual growth rate and the *eastbound* annual growth rate). The annual growth rates by movement are presented in **Table 2-1**.

Table 2-1 – Annual Growth Rate by Movement

	Northbound			Southbound			Eastbound			Westbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Highway 1416 and 151st Ave	-	-	-	0.61%	-	0.61%	0.61%	0.45%	-	-	0.45%	0.61%
Highway 1416 and Liberty Blvd	0.30%	0.19%	0.30%	0.24%	0.19%	0.24%	0.24%	0.30%	0.30%	0.30%	0.30%	0.24%
WB Highway 1416 and S Ellsworth Rd	0.61%	0.76%	-	-	0.76%	0.91%	-	-	-	0.75%	0.89%	0.90%
EB Highway 1416 and S Ellsworth Rd	-	0.61%	0.89%	0.61%	0.61%	-	0.71%	0.81%	0.81%	-	-	-
WB Highway 1416 and Radar Hill Rd	0.62%	0.62%	-	-	0.62%	0.61%	-	-	-	0.69%	0.77%	0.77%
EB Highway 1416 and Radar Hill Rd	-	0.62%	0.77%	0.62%	0.62%	-	0.69%	0.77%	0.77%	-	-	-
Radar Hill Rd and Long View Rd	1.67%	1.01%	0.78%	0.92%	1.01%	1.82%	1.82%	1.58%	1.67%	0.78%	1.58%	0.92%
Radar Hill Rd and SD 44	0.91%	0.91%	0.91%	0.91%	0.91%	0.91%	0.91%	0.91%	0.91%	0.91%	0.91%	0.91%

L – Left; T – Through; R – Right

The annual growth rates were then applied to the existing (2023) volumes and projected to design years 2030 and 2050 for the AM and PM peaks.

Future Development

There have been two Traffic Impact Studies (TISs) completed that are expected to have measurable impact on the study intersections before the 2030 analysis year. One TIS discussed impacts from two different developments (Box Elder High School and Multi-Family Housing). These TISs were reviewed, and the additional trips expected due to the new developments were included in the projected traffic volumes for this study.

BOX ELDER HIGH SCHOOL (2021)

A new high school is proposed to be constructed on a 60-acre site between 151st Avenue and Liberty Boulevard, north of Highway 1416. This school is anticipated have 1,400 students and generate 728 trips during the AM school peak, and 196 trips during the PM school peak.

The additional volumes anticipated at each of the study intersections during the AM and PM peaks is shown in **Table 2-2**. The afternoon school peak (based on afternoon dismissal time) does not fall during the network PM peak; therefore, additional trips were added based on the PM peak of adjacent traffic. No additional trips are expected at the intersections of Radar Hill Road and Long View Drive, or Radar Hill Road and SD 44.

Table 2-2 – Box Elder High School – Additional Trips

	Northbound			Southbound			Eastbound			Westbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Highway 1416 and 151st Ave				5 (1)		89 (36)	165 (32)	1			1	9 (2)
Highway 1416 and Liberty Blvd		17 (3)	7 (1)	37 (8)	8 (4)	89 (38)	182 (35)	121 (24)		4 (2)	59 (26)	24 (8)
WB Highway 1416 and S Ellsworth Rd					49 (9)					24 (10)	100 (43)	24 (10)
EB Highway 1416 and S Ellsworth Rd			49 (9)	49 (9)	24 (10)			205 (39)				
WB Highway 1416 and Radar Hill Rd										19 (11)	80 (32)	1
EB Highway 1416 and Radar Hill Rd			63 (9)	2				140 (30)				

L – Left; T – Through; R – Right
AM (PM)

MULTI-FAMILY HOUSING

A new multi-family housing development is expected to be constructed before the 2030 analysis year. The additional trips generated by this development were included in the TIS for the Box Elder High School. The multi-family housing development is anticipated to be developed south of the High School, north of Highway 1416, and between Liberty Boulevard and 151st Avenue. The development is expected to have 200 dwelling units and generate 80 trips during the AM network peak, and 102 trips during the PM network Peak.

The additional volumes anticipated at each of the study intersections during the AM and PM peaks is shown in **Table 2-3**. No additional trips are expected at the intersections of Radar Hill Road and Long View Drive, or Radar Hill Road and SD 44.

Table 2-3 – Multi-Family Housing Development – Additional Trips

	Northbound			Southbound			Eastbound			Westbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Highway 1416 and 151st Ave				(1)		21 (13)	6 (22)					1 (1)
Highway 1416 and Liberty Blvd		1 (2)	(1)	2 (5)	2 (1)	23 (14)	7 (24)	5 (16)		1 (1)	15 (10)	5 (3)
WB Highway 1416 and S Ellsworth Rd					2 (6)					6 (4)	26 (16)	6 (4)
EB Highway 1416 and S Ellsworth Rd			2 (6)	2 (6)	6 (4)			8 (27)				
WB Highway 1416 and Radar Hill Rd										5 (4)	21 (12)	
EB Highway 1416 and Radar Hill Rd			2 (6)	1				5 (21)				

L – Left; T – Through; R – Right
AM (PM)

DOUGLAS SCHOOL DISTRICT (2022)

A new elementary school is anticipated to be constructed on a site along Creekside Drive between Coyote Trail and Morgen Road. This school is anticipated have 600 students and generate 450 trips during the AM peak, and 96 trips during the PM peak.

The additional volumes anticipated at each of the study intersections during the AM and PM peaks is shown in **Table 2-4**. The afternoon school peak does not fall during the network PM peak; therefore, additional trips were added based on the PM peak of adjacent traffic. No additional trips are expected at the intersections of Radar Hill Road and Long View Drive, or Radar Hill Road and SD 44.

Table 2-4 – Douglas School District Elementary School – Additional Trips

	Northbound			Southbound			Eastbound			Westbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Highway 1416 and 151st Ave												
Highway 1416 and Liberty Blvd												
WB Highway 1416 and S Ellsworth Rd		41 (10)			49 (9)							
EB Highway 1416 and S Ellsworth Rd		41 (10)			49 (9)							
WB Highway 1416 and Radar Hill Rd	4 (1)	22 (4)			19 (4)							
EB Highway 1416 and Radar Hill Rd		21 (5)			19 (4)				5 (1)			

L – Left; T – Through; R – Right
AM (PM)

Future Volumes

The future volumes for the analysis years 2030 and 2050 were determined by applying the annual growth rates (**Table 2-1**) to the existing 2023 turning movement counts and adding the expected volumes due to the three new developments described above (**Table 2-2, Table 2-3**, and **Table 2-4**). The projected volumes for the AM and PM peaks of the build year 2030 are shown in **Table 2-5** and **Table 2-6**, respectively.

Table 2-5 – Projected Volumes – 2030 (AM Peak)

2030 No-Build Volumes ***AM Peak – 7:00***	**Northbound**			**Southbound**			**Eastbound**			**Westbound**		
	L	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**
Highway 1416 and 151st Ave	-	-	-	11	-	146	179	41	-	-	99	19
Highway 1416 and Liberty Blvd	4	51	10	60	19	141	326	150	3	7	90	171
WB Highway 1416 and S Ellsworth Rd	90	752	-	-	128	207	-	-	-	30	173	44
EB Highway 1416 and S Ellsworth Rd	-	190	59	62	96	-	650	335	16	-	-	-
WB Highway 1416 and Radar Hill Rd	179	28	-	-	37	17	-	-	-	107	454	7
EB Highway 1416 and Radar Hill Rd	-	197	314	12	111	-	5	702	64	-	-	-
Radar Hill Rd and Long View Rd	2	26	4	4	41	116	80	7	2	6	18	10
Radar Hill Rd and SD 44	5	2	2	21	3	11	16	232	6	3	221	19

L – Left; T – Through; R – Right

Table 2-6 – Projected Volumes – 2030 (PM Peak)

2030 No-Build Volumes ***PM Peak – 16:30***	**Northbound**			**Southbound**			**Eastbound**			**Westbound**		
	L	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**
Highway 1416 and 151st Ave	-	-	-	6	-	65	92	87	-	-	52	5
Highway 1416 and Liberty Blvd	8	16	2	125	26	107	97	83	13	7	64	66
WB Highway 1416 and S Ellsworth Rd	38	356	-	-	93	273	-	-	-	29	135	21
EB Highway 1416 and S Ellsworth Rd	-	87	22	22	100	-	306	150	152	-	-	-
WB Highway 1416 and Radar Hill Rd	118	34	-	-	18	11	-	-	-	209	605	4
EB Highway 1416 and Radar Hill Rd	-	132	138	5	206	-	20	475	205	-	-	-
Radar Hill Rd and Long View Rd	2	50	5	8	40	122	145	12	2	3	7	5
Radar Hill Rd and SD 44	7	2	2	25	8	26	42	141	13	2	236	26

L – Left; T – Through; R – Right

The projected volumes for the AM and PM peaks of the design year 2050 are shown in **Table 2-7** and **Table 2-8**, respectively.

Table 2-7 – Projected Volumes – 2050 (AM Peak)

2050 No-Build Volumes ***AM Peak – 7:00***	**Northbound**			**Southbound**			**Eastbound**			**Westbound**		
	L	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**	**L**	**T**	**R**
Highway 1416 and 151st Ave	-	-	-	11	-	151	180	44	-	-	108	20
Highway 1416 and Liberty Blvd	4	52	10	61	19	142	333	151	3	7	91	178
WB Highway 1416 and S Ellsworth Rd	102	868	-	-	132	248	-	-	-	30	182	47
EB Highway 1416 and S Ellsworth Rd	-	209	60	63	98	-	748	356	19	-	-	-
WB Highway 1416 and Radar Hill Rd	202	28	-	-	40	19	-	-	-	120	512	8
EB Highway 1416 and Radar Hill Rd	-	220	356	13	123	-	5	794	73	-	-	-
Radar Hill Rd and Long View Rd	2	32	4	4	50	166	114	10	2	7	25	12
Radar Hill Rd and SD 44	6	2	2	25	3	13	20	278	7	3	265	22

L – Left; T – Through; R – Right

Table 2-8 – Projected Volumes – 2050 (PM Peak)

2050 No-Build Volumes *PM Peak – 16:30*	Northbound			Southbound			Eastbound			Westbound		
	L	T	R	L	T	R	L	T	R	L	T	R
Highway 1416 and 151st Ave	-	-	-	6	-	67	97	95	-	-	57	5
Highway 1416 and Liberty Blvd	8	16	2	131	27	110	99	86	13	7	66	69
WB Highway 1416 and S Ellsworth Rd	43	413	-	-	104	327	-	-	-	32	150	22
EB Highway 1416 and S Ellsworth Rd	-	96	23	23	109	-	352	165	178	-	-	-
WB Highway 1416 and Radar Hill Rd	134	38	-	-	20	12	-	-	-	237	697	4
EB Highway 1416 and Radar Hill Rd	-	148	158	5	232	-	23	545	239	-	-	-
Radar Hill Rd and Long View Rd	2	61	5	9	49	174	207	16	2	3	10	6
Radar Hill Rd and SD 44	8	2	2	30	9	31	50	169	16	2	283	31

L – Left; T – Through; R – Right

Capacity Analysis and Demand

Intersection Capacity Analysis

Intersection capacity analysis was conducted using HCS 2023 software for each of the study intersections, using both AM and PM peak vehicular volumes. Intersection performance was measured based on delay and Level of Service (LOS). The vehicular Level of Service was determined using the methodology described in Existing Conditions. Detailed Vehicular Level of Service results can be found in **Appendix D.**

LEVEL OF SERVICE RESULTS – 2030

The LOS results under 2030 projected conditions are presented in **Table 2-9**.

Table 2-9 – Future Intersection Vehicular Capacity Analysis Results (2030)

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	*LOS**	*Delay (sec/veh)*	*LOS**
Highway 1416 and 151st Ave	9.0	A / B	6.5	A / A
Highway 1416 and Liberty Blvd	116.5	**F / F**	12.7	B / C
Highway 1416 and S Ellsworth Rd	4493.0	**F / F**	90.6	**F / F**
Highway 1416 and Radar Hill Rd	66.5	**F / F**	68.7	**F / F**
Radar Hill Rd and Long View Rd	8.6	A / A	9.1	A / A
Radar Hill Rd and SD 44	11.0	B / B	2.8	A / B

**[Intersection LOS] / [Worst approach LOS]*

AM Peak

During the AM peak under forecasted 2030 conditions, it was determined that the Intersection of Highway 1416 and Liberty Boulevard is expected to experience unacceptable delay and LOS, with both the intersection and worst approach reaching LOS F. The unacceptable conditions are due to northbound and southbound vehicles experiencing significant delay, as they are unable to find an acceptable gap in the high eastbound and westbound volumes.

The intersection of Highway 1416 and S Ellsworth Road is also expected to experience severely unacceptable delay and LOS during the AM peak in 2030, with both the intersection and worst approach reaching LOS F. These conditions were reached under existing conditions as well. The unacceptable conditions are primarily caused by a significant number of eastbound vehicles making a left turn, causing severe queueing in the median separating eastbound and westbound Highway 1416. The eastbound approach at this intersection is free flowing (i.e., there is no stop control at this approach). However, some delay is still experienced, as the high volume of left-turning vehicles exceeds the capacity of a single lane. This queueing causes spillback for eastbound movements, as well as northbound vehicles along S Ellsworth Road.

The intersection of Highway 1416 and Radar Hill Road is also expected to experience unacceptable delay and LOS during the AM peak in 2030, with both the intersection and worst approach reaching LOS F. These conditions were reached under existing conditions as well. The unacceptable conditions are primarily caused by a high northbound volume, and vehicles being unable to find an acceptable gap to cross or enter Highway 1416 due to high eastbound and westbound volumes. Minimal storage space in the median separating eastbound and westbound Highway 1416 also causes significant queuing and spillback affecting the northbound movements, as well as eastbound vehicles attempting to turn left.

All other study intersections are expected to operate under acceptable delay and LOS during the AM peak in 2030.

PM Peak

During the PM peak under projected 2030 conditions, it was determined that the intersection of Highway 1416 and S Ellsworth Road is expected to experience unacceptable delay and LOS, with the intersection reaching LOS C, and the worst approach reaching LOS F. The worst approach at this intersection during the PM peak is the southbound approach of the eastbound portion of Highway 1416 (south of the median). High eastbound volumes at this intersection make it difficult for southbound vehicles to find acceptable gaps to cross or enter Highway 1416, causing significant queueing and delay that impacts the southbound and westbound vehicles. This intersection also experiences higher southbound volumes during the PM peak as vehicles travel away from the Ellsworth Air Force Base.

The intersection of Highway 1416 and Radar Hill Road is also expected to experience unacceptable delay and LOS during the PM peak in 2030, with the intersection reaching LOS E and the worst approach reaching LOS F. The worst approaches at this intersection during the PM peak are the northbound and eastbound approaches of the eastbound portion of Highway 1416 (south of the median). Minimal storage space in the median and high eastbound left volumes cause significant queueing and delay that affects eastbound and northbound vehicles.

All other study intersections are expected to operate under acceptable delay and LOS during the PM peak in 2030.

LEVEL OF SERVICE RESULTS – 2050

The LOS results under 2050 projected conditions are presented in **Table 2-10**.

Table 2-10 – Future Intersection Vehicular Capacity Analysis Results (2050)

Intersection	AM Peak		PM Peak	
	Delay (sec/veh)	*LOS**	*Delay (sec/veh)*	*LOS**
Highway 1416 and 151st Ave	9.8	A / B	8.4	A / A
Highway 1416 and Liberty Blvd	152.5	**F / F**	13.1	B / C
Highway 1416 and S Ellsworth Rd	15432.5	**F / F**	166.1	**F / F**
Highway 1416 and Radar Hill Rd	202.5	**F / F**	359.3	**F / F**
Radar Hill Rd and Long View Rd	9.4	A / A	13.3	B / C
Radar Hill Rd and SD 44	11.9	B / B	2.9	A / B

**[Intersection LOS] / [Worst approach LOS]*

AM Peak

During the AM peak under projected 2050 conditions, it was determined that the intersection of Highway 1416 and Liberty Boulevard is expected to experience unacceptable delay and LOS, with both the intersection and worst approach reaching LOS F. These conditions were met under 2030 conditions and are expected to worsen with continued growth in the surrounding network.

The intersection of Highway 1416 and S Ellsworth Road is also expected to experience severely unacceptable delay and LOS during the AM peak in 2050, with both the intersection and worst approach reaching LOS F. These conditions were reached under existing conditions, as well as projected 2030 conditions, and are expected to worsen with continued growth in the surrounding network.

The intersection of Highway 1416 and Radar Hill Road is also expected to experience severely unacceptable delay and LOS during the AM peak in 2050, with both the intersection and worst approach reaching LOS F. Unacceptable conditions were reached under existing conditions, as well as projected 2030 conditions, and are expected to worsen with continued growth in the surrounding network.

All other study intersections are expected to operate under acceptable delay and LOS during the AM peak in 2050.

PM Peak

During the PM peak under projected 2050 conditions, it was determined that the intersection of Highway 1416 and S Ellsworth Road is expected to experience unacceptable delay and LOS, with the intersection reaching LOS D, and the worst approach reaching LOS F. Unacceptable conditions were reached under existing conditions, as well as projected 2030 conditions, and are expected to worsen with continued growth in the surrounding network.

The intersection of Highway 1416 and Radar Hill Road is also expected to experience severely unacceptable delay and LOS during the PM peak in 2050, with both the intersection and worst approach reaching LOS F. Unacceptable conditions were reached under existing conditions, as well as projected 2030 conditions, and are expected to worsen with continued growth in the surrounding network.

All other study intersections are expected to operate under acceptable delay and LOS during the PM peak in 2050.

Signal Warrant Analysis

The *Manual on Uniform Traffic Control Devices* (MUTCD) provides guidance and standards for the installation of traffic control methods. Intersection control warrant analysis was conducted at the intersections of Highway 1416 and Liberty Boulevard, Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Road. Warrants are met based on the number of hours volume criteria are met. The 13-hour volume was projected to 2030 and 2050 using the annual growth rates presented in Table 2-1, with additional volumes added during the AM and school peaks due to the anticipated school developments.

The most commonly analyzed signal warrants are the following:

- **Warrant 1: Eight-Hour Vehicular Volume** – Specific volume thresholds must be met for at least eight hours of an average day.
  - **Warrant 1a** – This warrant applies to locations where a large volume of intersecting traffic is the primary reason for installing a traffic signal.
  - **Warrant 1b** – This warrant applies to locations where Warrant 1a is not met, and where volumes on the major road is so heavy that minor road traffic is unable to enter or cross the major road.
- **Warrant 2: Four-Hour Vehicular Volume** – Specific volume thresholds must be met for at least four hours of an average day. This warrant applies to locations where the volume of intersecting traffic is the primary reason for installing a traffic signal.
- **Warrant 3: Peak Hour** – Specific volume thresholds must be met during a peak hour of an average day. This warrant applies to locations that have higher-than-average volumes during peak hours, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.
- **Warrant 7: Crash Experience** – Specific volume thresholds (similar to Warrants 1a and 1b) must be met for at least eight hours of an average day, and five or more reported crashes of types susceptible to correction by a traffic signal have occurred within one year.
- **MWSA: Multi-Way Stop Application** – This warrant is to determine if the implementation of a multi-way stop control is warranted at an intersection. Specific volume thresholds must be met for at least eight hours of an average day, or five or more reported crashes of types susceptible to correction by a multi-way stop installation have occurred within one year. This warrant applies to locations where the volume of traffic on the intersecting roads is approximately equal.

The signal warrant analysis results for 2030 and 2050 are presented in **Table 2-11** and **Table 2-12, r**espectively. Detailed Signal Warrant Analysis results can be found in **Appendix E.**

Table 2-11 – Signal Warrant Analysis Results (2030)

No-Build (2030)	1a	1b	2	3	7	MWSA
Highway 1416 and Liberty Blvd	1 / 8	1 / 8	1 / 4	0 / 1	1 / 8	4 / 8
Highway 1416 and S Ellsworth Rd	7 / 8	4 / 8	**7 / 4**	**4 / 1**	7 / 8	**14 / 8**
Highway 1416 and Radar Hill Rd	**13 / 8**	**9 / 8**	**11 / 4**	**6 / 1**	**9 / 8**	6 / 8

Table 2-12 – Signal Warrant Analysis Results (2050)

No-Build (2050)	1a	1b	2	3	7	MWSA
Highway 1416 and Liberty Blvd	1 / 8	1 / 8	1 / 4	0 / 1	1 / 8	4 / 8
Highway 1416 and S Ellsworth Rd	**10 / 8**	5 / 8	**9 / 4**	**5 / 1**	**8 / 8**	**15 / 8**
Highway 1416 and Radar Hill Rd	**13 / 8**	**13 / 8**	**13 / 4**	**8 / 1**	**11 / 8**	**9 / 8**

A signal is warranted at the intersections of Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Road under 2030 and 2050 projected conditions.

Standard signal warrants are not met at the intersection of Highway 1416 and Liberty Boulevard. However, MUTCD **Signal Warrant 9: Intersection Near a Grade Crossing** is met at this intersection. This warrant is intended to apply to locations near an at-grade railroad crossing that is currently stop- or yield-controlled and is within 140 feet of the intersection stop line. Specific volume thresholds must be met during the highest traffic volume hour during which rail traffic uses the crossing, and the thresholds vary based on the railroad crossing distance from the intersection stop line. If a traffic signal is installed at an intersection due to this warrant, the MUTCD recommends that the signal shall have actuation on the minor street, preemption control shall be provided, and the railroad crossing shall have flashing-light signals. The intersection of Highway 1416 and Liberty Boulevard was also very close to meeting **Signal Warrant 3: Peak Hour** under projected 2050 no-build conditions. However, only meeting this warrant, does not typically merit the installation of a full-time operating signal. This intersection will have to be monitored and reevaluated periodically to determine if intersection control is warranted after the area around it continues to develop.

Summary

Traffic Volumes

- Traffic volumes collected in 2023 were projected to design years 2030 and 2050 using growth rates developed from ADT data provided by the Rapid City Area MPO, accounting for additional growth due to anticipated expansion of the Ellsworth Air Force Base.
- Additional trips generated by three new developments near the study area were added to the projected AM and PM peak volumes. Two of the new developments are schools, and the afternoon peaks do not occur during the network PM peak, so additional trips were conservatively added based on the PM peak of adjacent traffic.

Capacity Analysis

- Highway 1416 and Liberty Boulevard is expected to operate at LOS F during the AM peak under 2030 and 2050 projected no-build conditions.
- Highway 1416 and S Ellsworth Road is expected to operate at LOS F during both the AM and PM peak under 2030 and 2050 projected no-build conditions.
- Highway 1416 and Radar Hill Road is expected to operate at LOS F during both the AM and PM peak under 2030 and 2050 projected no-build conditions.
- Delay and LOS at these intersections are expected to worsen with continued growth in the surrounding network.
- All other study intersections are expected to operate under acceptable delay and LOS during the AM and PM peaks under 2030 and 2050 projected no-build conditions.

Signal Warrant Analysis

- A signal is warranted at the intersections of Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Road under 2030 and 2050 projected no-build conditions.
- The intersection of Highway 1416 and Liberty Boulevard meets the requirements of Signal Warrant 9 due to its proximity to an at-grade railroad crossing. This intersection was very close to meeting Signal Warrant 3 under projected 2050 no-build conditions.

Chapter 3 – Alternatives Analysis

Interim Alternatives

Due to severe deficiencies in vehicular Level of Service found in the existing 2023 analysis, interim alternatives were analyzed to provide short-term relief as more permanent solutions continue to develop. The intersections of Highway 1416 and S Ellsworth Road and Highway 1416 and Radar Hill Road were analyzed assuming all-way stop control for the interim scenario. The results of this analysis, along with existing no-build results for comparison, are shown in **Table 3-1**.

Table 3-1 – Interim Alternative Results

Intersection	Scenario	Existing - 2023				Future - 2030			
		AM Peak		PM Peak		AM Peak		PM Peak	
		Delay (s/veh)	*LOS**	*Delay (s/veh)*	*LOS**	*Delay (s/veh)*	*LOS**	*Delay (s/veh)*	*LOS**
Highway 1416 and S Ellsworth Rd	No-Build	598.3	F / F	10.1	B / E	4493.0	F / F	90.6	F / F
	Interim	347.5	F	12.0	B	928.4	F	15.0	B
Highway 1416 and Radar Hill Rd	No-Build	26.9	D / E	32.8	D / F	66.5	F / F	68.7	F / F
	Interim	19.2	C	17.5	C	38.8	E	22.0	C

**[Intersection LOS] / [Worst approach LOS] (for TWSC)*

While all-way stop control at the intersections listed above is not expected to bring the intersections to acceptable operations, the delay and Level of Service is expected to improve significantly. At the time of this report, all-way stop control has been implemented as a short-term solution for the intersections of Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Drive, while more permanent and effective alternatives are analyzed, funded, and implemented.

Alternatives Development

Based on Future Conditions results, it was determined that the intersections of Highway 1416 and 151st Avenue, and Radar Hill Road and Long View Road, and Radar Hill Road and SD 44 are expected to operate under acceptable conditions in the projected 2030 build year and 2050 design year, and therefore no intersection alternatives are proposed for these locations other than the TWLTL being added to the Radar Hill Road corridor.

Bicycle and Pedestrian Level of Service (LOS) was determined for segments along Highway 1416 and Radar Hill Road in the Existing Conditions Report for this study. Bicycle and Pedestrian LOS was determined to be inadequate for the majority of the segments along both corridors, aside from a portion of Radar Hill Road between 228th Street and 229th Street, where ten-foot shoulders are present on both sides of the roadway. Though no intersection alternatives are proposed along the Radar Hill Road corridor, the

implementation of a shared-use path along Highway 1416 and the city owned portion of Radar Hill Road as well as widened shoulders on the remainder of Radar Hill Road are expected to greatly improve the Bicycle and Pedestrian LOS.

The intersections of Highway 1416 and Liberty Boulevard, Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Road are expected to operate under unacceptable conditions for both the build year and design year. For this reason, alternative designs for each intersection were proposed to mitigate these deficiencies.

The Highway 1416 corridor is proposed to be converted to a urban corridor to remove the large median separating eastbound and westbound travel. The median area occupies otherwise developable land and the two-stage crossing required perpendicular to Highway 1416 causes severe deficiencies in queueing and delay. It is recommended that Highway 1416 be converted to a combination of a three-lane and five-lane urban corridor, with the centerline aligning more closely with the current westbound travel lanes of Highway 1416 to provide more distance from the adjacent railroad.

Due to existing travel patterns and volumes, all alternatives assume that Highway 1416 is a two-lane rural corridor from 151st Avenue to S Ellsworth Road with dedicated left-turn lanes at the Liberty Boulevard intersection. West of the intersection with S Ellsworth Road, Highway 1416 becomes a four-lane semi-urban corridor.

Conceptual designs for each alternative can be found in **Appendix F**. The development of alternatives for each intersection is discussed in the following paragraphs. While no roundabout warrant methodology currently exists, signal warrants have been generally accepted to apply to roundabouts as well. If signal warrants are met, it can be assumed that a roundabout alternative is warranted as well. Ultimate alternative selection will be based on the anticipated results presented in this report, as well as implementation cost, necessary right-of-way, and stakeholder involvement.

Highway 1416 and Liberty Boulevard

As determined in the Future Conditions chapter of this study, the intersection of Highway 1416 and Liberty Boulevard did not meet signal warrant thresholds for the 2030 build year or 2050 design year. However, **Signal Warrant 9: Intersection Near a Grade Crossing** was met, due to high volumes and its proximity to a railroad crossing that is currently yield-controlled. The alternatives selected for this intersection included a traffic signal, and a single-lane roundabout. The Box Elder Comprehensive Plan (2014) also identifies this intersection as needing safety and mobility improvements.

Capacity analysis results showed that this intersection is expected to operate at LOS F during the AM peak by 2030 under no-build conditions. This is primarily due to significant queueing in the northbound and southbound approaches, as the eastbound and westbound movements experience high volumes and high speeds. Recent development near this intersection is also expected to generate additional trips traveling through this intersection. A traffic signal or roundabout can be reasonably expected to mitigate these deficiencies, if either is shown to be both warranted and feasible.

Highway 1416 and S Ellsworth Road

The intersection of Highway 1416 and S Ellsworth Road met criteria for three signal warrants, as well as the multi-way stop application warrant, in both the build year and design year. This intersection experiences high volumes making eastbound left-turn movements, particularly during the AM peak, and high southbound right-turn movements, as vehicles travel to and from the Ellsworth Air Force Base north of the study area. Current roadway geometry requires eastbound left-turning movements to occur in two stages, with additional stopping and delay at the median separating eastbound and westbound travel along Highway 1416. This configuration paired with exceptionally high eastbound left-turn movements results in Level of Service failure during the AM and PM peaks. Intersection signalization was considered, with dual left-turn lanes at the eastbound approach to accommodate the high volumes, and a single eastbound through lane. A single-lane roundabout and hybrid roundabout were also analyzed. A fourth alternative was also developed for this intersection that includes a displaced left-turn at the eastbound approach, where eastbound left-turning vehicles cross conflicting westbound through traffic at a signalized crossing before making a left turn onto S Ellsworth Road.

All alternatives developed at the intersection of Highway 1416 and S Ellsworth Road assume that Highway 1416 is a three-lane corridor east of this intersection, and a five-lane corridor west of the intersection.

Highway 1416 and Radar Hill Road

The intersection of Highway 1416 and Radar Hill Road met criteria for all signal warrants analyzed in both 2030 and 2050. This intersection experiences high volumes in the northbound approach. Minimal storage space in the median separating eastbound and westbound Highway 1416 causes significant queueing and spillback affecting the northbound movements, as well as eastbound vehicles attempting to turn left. A signalized alternative was analyzed, with dedicated left-turn lanes added to all approaches.

Multiple roundabout alternatives were also considered. The first roundabout alternative included a 2x1 design, with two lanes at the eastbound and westbound approaches, and single lanes at the northbound and southbound approaches. The second roundabout was a 2x1 design, with a channelized northbound right lane to accommodate high volumes making this movement during the AM and PM peaks. The third roundabout design included a two-lane westbound approach, and a single-lane eastbound approach, to better align with the off-ramp design of the I-90 interchange to the west. This design also includes a channelized northbound right.

Alternatives Summary

The final alternatives selected for analysis for each of the study intersections are described below.

HIGHWAY 1416 AND LIBERTY BOULEVARD

- No Build: TWSC – This alternative includes the intersection remain a stop controlled on the Liberty Boulevard approaches for the time being with the addition of a dedicated left-turn lane for the westbound approach.
- Alternative 1: Signalized Intersection – This alternative includes the implementation of a traffic signal at the intersection, as well as the addition of dedicated left-turn lanes to all approaches.

» Alternative 2: Single-Lane Roundabout – This alternative includes the implementation of a single-lane roundabout.

HIGHWAY 1416 AND S ELLSWORTH ROAD

S Ellsworth Road is the intersection where Highway 1416 is proposed to transition from a three-lane to a five-lane urban corridor. All alternatives analyzed have a single-lane approach in each direction on the east side of the intersection, and a two-lane approach in each direction on the west side of the intersection. It should be noted that alternatives 2 and 3 do include a lane drop where an eastbound mainline-lane terminates as a left-turn lane. Typically, designs such as these are discouraged as they can create weaving conflicts near intersection. However, due to the high number of left-turning vehicles compared to through moving on the eastbound approach, it is not anticipated that such an issue will arise.

» Alternative 1: Signalized Intersection – This alternative includes the implementation of a traffic signal at the intersection, as well as the addition of dedicated left-turn lanes to all approaches, as well as dual eastbound left-turn lanes and a single eastbound through lane.
» Alternative 2: Single-Lane Roundabout – This alternative includes the implementation of a single-lane roundabout.
» Alternative 3: Hybrid Roundabout – This alternative includes the implementation of a hybrid 2x1 roundabout. The roundabout has an additional dedicated eastbound left-turn lane to accommodate for high volumes, with two circulating lanes at the eastbound and northbound approaches. This design also includes a yield-controlled channelized southbound right-turn lane. Due to the high southbound right-turning volume, this alternative was developed to allow the volumes making this movement to pass by the roundabout without needing to circulate. An acceleration lane for this movement could be considered based on the results of this report, but the analysis was completed assuming this approach includes only a channelized right-turn lane, to remain cost conservative.
» Alternative 4: Displaced Eastbound Left – This alternative includes the implementation of a displaced eastbound left-turn movement. This alternative design includes the eastbound left-turn lane crossing the westbound through traffic at a signalized location west of the intersection with S Ellsworth Road. The eastbound left-turning traffic would then make the left-turning movement at another signal located at S Ellsworth Road.

HIGHWAY 1416 AND RADAR HILL ROAD

» Alternative 1: Signalized Intersection – This alternative includes the implementation of a traffic signal at the intersection, as well as the addition of dedicated left-turn lanes to all approaches.
» Alternative 2: 2x1 Roundabout – This alternative includes the implementation of a 2x1 roundabout, with two lanes in the eastbound and westbound directions, and one lane in the northbound and southbound directions.
» Alternative 3: 2x1 Roundabout with Channelized NBR – This alternative includes the implementation of a 2x1 roundabout with two lanes in the eastbound and westbound directions. The northbound approach includes a single lane for through and left-turning traffic, and a channelized right turn lane to accommodate high volumes. The southbound approach at Gumbo Drive is closed allowing for safer movement on Box Elder Road.

» Alternative 4: Hybrid Roundabout – This alternative includes the implementation of a roundabout with two lanes in westbound direction, and a single lane in the eastbound direction. The northbound approach includes a single lane for through and left-turning traffic, and a channelized right turn lane to accommodate high volumes. The southbound approach at Gumbo Drive is closed allowing for safer movement on Box Elder Road.

Crash Modification Factors

Crash modification factors (CMFs) are an effective tool for analyzing alternative designs and estimating their respective safety benefit. CMFs are a multiplicative factor that indicates the proportion of crashes that would be expected after implementing a countermeasure. CMFs with a value less than 1.0 indicate a decrease in expected crashes, and CMFs greater than 1.0 indicate an increase in expected crashes. The Federal Highway Administration (FHWA)'s CMF Clearinghouse website provides a toolbox of CMF values determined through extensive research based on crash data. The CMF Clearinghouse presents each CMF, along with the quality (a measure of research reliability, rated on a scale of one (worst) to five (best)), as well as crash types, crash severities, and area types that the CMF can reasonably be applied to.

CMFs for each of the proposed intersection alternatives are shown in **Table 3-2**.

Table 3-2 – Highway 1416 Crash Modification Factors

Countermeasure	CMF	Crash Type	Crash Severity	Area Type	Quality
Signalized Intersection *Install a traffic signal (major road speed limit at least 40 mph)*	**0.95** *(CMF ID: 322)*	All	All	Urban	3/5
	0.33 *(CMF ID: 323)*	Angle	All	Urban	4/5
	2.43 *(CMF ID: 324)*	Rear-End	All	Urban	4/5
Single-Lane Roundabout *Conversion of stop-controlled intersection into single-lane roundabout*	**0.28** *(CMF ID: 206)*	All	All	Urban	4/5
	0.42 *(CMF ID: 207)*	All	All	Rural	4/5
	0.12 *(CMF ID: 210)*	All	A, B, C	Urban	4/5
	0.18 *(CMF ID: 211)*	All	A, B, C	Rural	4/5
2x1 Roundabout *Conversion of stop-controlled intersection into multi-lane roundabout*	**0.95** *(CMF ID: 208)*	All	All	Urban	4/5
	0.004 *(CMF ID: 6159)*	All	K, A, B, C	Not specified	2/5
	2.073 *(CMF ID: 6158)*	All	All	Not specified	2/5
	6.016 *(CMF ID: 6160)*	All	O	Not specified	2/5

Crash Severity: K – Fatality; A – Serious injury; B – Minor injury; C – Possible injury; O – Property damage only

Countermeasure	CMF	Crash Type	Crash Severity	Area Type	Quality
Channelized Right-Turn Lane *Provide Right Turn Channelization*	**0.734** *(CMF ID: 11154)*	All	All	Not specified	3/5
	0.616 *(CMF ID: 11152)*	All	K, A, B, C	Not specified	3/5
	0.786 *(CMF ID: 11153)*	All	O	Not specified	2/5
Displaced Left *Convert intersection to a displaced left turn intersection*	**1.112** *(CMF ID: 10889)*	All	All	Urban and suburban	2/5
	1.224 *(CMF ID: 10890)*	All	K, A, B, C	Urban and suburban	2/5
	1.069 *(CMF ID: 10891)*	All	O	Urban and suburban	2/5
	1.244 *(CMF ID: 10894)*	Angle	All	Urban and suburban	2/5
	0.946 *(CMF ID: 10895)*	Rear-end	All	Urban and suburban	2/5
	0.713 *(CMF ID: 10896)*	Head-on	All	Urban and suburban	2/5
	1.519 *(CMF ID: 10892)*	Single vehicle	All	Urban and suburban	2/5
	0.612 *(CMF ID: 10893)*	Other	All	Urban and suburban	2/5

Crash Severity: K – Fatality; A – Serious injury; B – Minor injury; C – Possible injury; O – Property damage only

Capacity Analysis and Demand

Intersection Capacity Analysis

Intersection capacity analysis was conducted using HCS 2023 software for each of the alternatives described previously, using both AM and PM peak vehicular volumes under 2030 and 2050 scenarios. Intersection performance was measured based on delay and Level of Service (LOS). The methodology for vehicular LOS is described in the following section.

VEHICULAR LEVEL OF SERVICE (VLOS)

Vehicular Level of Service (VLOS) is a function of average delay per vehicle. LOS "A" represents free-flow traffic, whereas LOS "F" represents unacceptable delay. LOS "D" or better is considered acceptable for Minor Arterials and Collectors, in accordance with SDDOT standards. LOS delay thresholds are presented in **Table 3-3**.

Table 3-3 – Intersection Level of Service Thresholds

Level of Service	Average Delay / Vehicle	
	Stop, Yield, and Roundabout Intersections	Signalized Intersections
A	< 10 seconds	< 10 seconds
B	10 to 15 seconds	10 to 20 seconds
C	15 to 25 seconds	20 to 35 seconds
D	25 to 35 seconds	35 to 55 seconds
E	35 to 50 seconds	55 to 80 seconds
F	> 50 seconds	> 80 seconds

Vehicular LOS results for each intersection are presented and discussed in the following section. The intersection delay is presented based on methodology described above. The corresponding LOS value for the intersection delay is shown, as well as the LOS value for the worst approach. Detailed Vehicular Level of Service results can be found in **Appendix G**.

Highway 1416 and Liberty Boulevard

The LOS results for alternatives at Highway 1416 and Liberty Boulevard, under 2030 and 2050 conditions, are presented in **Table 3-4**.

Table 3-4 – Highway 1416 and Liberty Boulevard Alternatives Analysis Results

Alternative	2030				2050			
	AM Peak		PM Peak		AM Peak		PM Peak	
	Delay (s/veh)	*LOS**	*Delay (s/veh)*	*LOS**	*Delay (s/veh)*	*LOS**	*Delay (s/veh)*	*LOS**
No-Build: TWSC	116.5	**F / F**	12.7	B / C	152.5	**F / F**	13.1	B / C
Alt 1: Signal	17.0	B	8.8	A	17.4	B	9.8	A
Alt 2: 1x1 RAB	8.2	A	5.3	A	8.4	A	5.4	A

**[Intersection LOS] / [Worst approach LOS] (for TWSC)*

ALTERNATIVE 1

Delay and LOS results for Alternative 1: Signalized Intersection show that the implementation of a traffic signal at the intersection of Highway 1416 and Liberty Boulevard is expected to mitigate delay and LOS deficiencies expected during the AM and PM peaks, under both 2030 and 2050 scenarios. The intersection is expected to operate at LOS C during the AM and PM peaks in 2030 and 2050 with the implementation of a traffic signal. Additional traffic timing optimization could further improve LOS results.

ALTERNATIVE 2

Delay and LOS results for Alternative 2: Single-Lane Roundabout show that the implementation of a single-lane roundabout at the intersection of Highway 1416 and Liberty Boulevard is expected to mitigate delay

and LOS deficiencies expected during the AM and PM peaks, under both 2030 and 2050 scenarios. The intersection is expected to operate at LOS A during the AM and PM peaks in 2030 and 2050 with the implementation of a single-lane roundabout.

Highway 1416 and S Ellsworth Road

The LOS results for alternatives at Highway 1416 and S Ellsworth Road, under 2030 and 2050 conditions, are presented in **Table 3-5**.

Table 3-5 – Highway 1416 and S Ellsworth Road Alternatives Analysis Results

Alternative	2030				2050			
	AM Peak		PM Peak		AM Peak		PM Peak	
	Delay (s/veh)	LOS*	Delay (s/veh)	LOS*	Delay (s/veh)	LOS*	Delay (s/veh)	LOS*
No-Build: TWSC	4493.0	F / F	90.6	F / F	15432.5	F / F	166.1	F / F
Alt 1: Signal, dual EBL	19.9	B	17.5	B	39.4	D	20.1	C
Alt 2: 1x1 RAB	133.3	F	9.0	A	287.3	F	11.0	B
Alt 3: Hybrid RAB	11.8	B	5.7	A	15.8	C	6.4	A
Alt 4: Displaced EBL	13.6	B	7.4	A	12.0	B	7.9	A

**[Intersection LOS] / [Worst approach LOS] (for TWSC)*

ALTERNATIVE 1

Delay and LOS results for Alternative 1: Signalized Intersection show that the implementation of a traffic signal at the intersection of Highway 1416 and S Ellsworth Road is expected to mitigate delay and LOS deficiencies expected during the AM and PM peaks, under both 2030 and 2050 scenarios. The intersection is expected to operate at LOS C during the AM and PM peaks in 2030 and the AM peak of 2050, and it is expected to operate at LOS D during the PM Peak in 2050, with the implementation of a traffic signal. Additional traffic timing optimization could further improve LOS results.

ALTERNATIVE 2

Delay and LOS results for Alternative 2: Single-Lane Roundabout show that the implementation of a single-lane roundabout at the intersection of Highway 1416 and S Ellsworth Road is not expected to mitigate delay and LOS deficiencies expected during the AM and PM peaks, under 2030 and 2050 scenarios. The intersection is expected to operate at LOS F during the AM peak in 2030 and 2050 with the implementation of a single-lane roundabout. Based on this analysis, it was determined that a single-lane roundabout is not expected to have the capacity to support the high volumes traveling to the Ellsworth Air Force Base.

ALTERNATIVE 3

Delay and LOS results for Alternative 3: Hybrid Roundabout show that the implementation of a hybrid roundabout at the intersection of Highway 1416 and S Ellsworth Road, with additional capacity supporting

eastbound left-turning volumes, is expected to mitigate delay and LOS deficiencies expected during the AM and PM peaks, under 2030 and 2050 scenarios. The intersection is expected to operate at LOS B during the AM peak in 2030 and 2050, and LOS A during the PM peak in 2030 and 2050 with the implementation of a hybrid roundabout.

ALTERNATIVE 4

Delay and LOS results for Alternative 4: Displaced Eastbound Left show that the implementation of a signalized displaced left-turn in the eastbound approach of Highway 1416 and S Ellsworth Road is expected to mitigate delay and LOS deficiencies expected during the AM and PM peaks, under 2030 and 2050 scenarios. The intersection is expected to operate at LOS B during the AM peaks and LOS A during the PM peaks in both 2030 and 2050 with the implementation of a displaced eastbound left-turn lane.

Highway 1416 and Radar Hill Road

The LOS results for alternatives at Highway 1416 and Radar Hill Road, under 2030 and 2050 conditions, are presented in **Table 3-6**.

Table 3-6 – Highway 1416 and Radar Hill Road Alternatives Analysis Results

Alternative	2030				2050			
	AM Peak		PM Peak		AM Peak		PM Peak	
	Delay (s/veh)	LOS*	Delay (s/veh)	LOS*	Delay (s/veh)	LOS*	Delay (s/veh)	LOS*
No-Build: TWSC	66.5	F / F	68.7	F / F	202.5	F / F	359.3	F / F
Alt 1: Signal	20.9	C	18.8	B	26.2	C	19.9	B
Alt 2: 2x1 RAB	16.4	C	7.0	A	63.8	F	8.1	A
Alt 3: 2x1 RAB (ch. NBR)	9.2	A	6.7	A	13.1	B	7.7	A
Alt 4: Hybrid RAB	14.0	B	10.4	B	24.2	C	16.1	C

**[Intersection LOS] / [Worst approach LOS] (for TWSC)*

ALTERNATIVE 1

Delay and LOS results for Alternative 1: Signalized Intersection show that the implementation of a traffic signal at the intersection of Highway 1416 and Radar Hill Road is expected to mitigate delay and LOS deficiencies expected during the AM and PM peaks, under 2030 and 2050 scenarios. The intersection is expected to operate at LOS C during the AM peaks and LOS B during the PM peaks in both 2030 and 2050 with the implementation of a traffic signal. Alternative 2

Delay and LOS results for Alternative 2: 2x1 Roundabout show that the implementation of a 2x1 roundabout at the intersection of Highway 1416 and Radar Hill Road, with two lanes in the eastbound and westbound directions, is expected to mitigate delay and LOS deficiencies during the AM and PM peaks under 2030 scenarios, but the intersection is expected to remain at LOS F during the AM peak in 2050. High northbound left and right volumes contribute significantly to this deficiency.

ALTERNATIVE 3

Delay and LOS results for Alternative 3: 2x1 Roundabout with Channelized NBR show that the implementation of a 2x1 roundabout, along with a channelized northbound right-turn lane at the intersection of Highway 1416 and Radar Hill Road is expected to mitigate delay and LOS deficiencies during the AM and PM peaks under 2030 and 2050 scenarios. The intersection is expected to operate at LOS A during the AM and PM peaks in 2030, at LOS B during the AM peak in 2050, and LOS A during the PM peak in 2050.

ALTERNATIVE 4

Delay and LOS results for Alternative 4: Hybrid Roundabout show that the implementation of a hybrid roundabout, with single lanes in the eastbound and southbound approaches, two lanes in the westbound approach, and a channelized northbound right-turn lane at the intersection of Highway 1416 and Radar Hill Road is expected to mitigate delay and LOS deficiencies during the AM and PM peaks, under 2030 and 2050 scenarios. The intersection is expected to operate at LOS B during the AM and PM peaks in 2030, and LOS C during the AM and PM peaks in 2050.

Design

Right-of-Way Impacts

Right-of-way was evaluated based on GIS data provided by the City of Rapid City and Pennington County. Based on this data, it is anticipated that this project would have minimal impact on the ROW. However, the data provided is not official, and land survey of property lines would need to be completed to confirm this.

Currently, the Radar Hill Road 3 lane alternative shows minimal property impacts at maximum of 4' based on available data. If those impacts are still present in preliminary design after a property survey is done, alignment tapering can be done to avoid the impacts to the properties if desired by the governing jurisdiction.

Anticipated Cost

An anticipated preliminary cost comparison analysis was completed. The results are shown in **Table 3-7.** The cost estimates assumed 3% annual inflation, a 20% contingency, and an asphalt concrete depth of 8 inches on 14 inches of aggregate base. The city cost estimates shown on the Highway 1416 corridor stem from improvements to approaches on city owned roadways at study intersections. As shown, the lowest-cost alternative for Highway 1416 is Alternative 3 with roundabouts at the Radar Hill Road and S Ellsworth Road intersections. Traffic signals can be more expensive than roundabouts due primarily to the amount of grading and pavement widening necessary. Additionally, the cost of traffic signals was increased due to the lack of existing supporting infrastructure needed.

Preliminary estimates of engineering final design costs are shown in **Table 3-8**. This estimate includes 20% contingency, and does not include construction support, or right-of-way processes.

Table 3-7 – Preliminary Cost Estimates

KLJ	PRELIMINARY COST ESTIMATE SUMMARY							
HWY 1416/ RADAR HILL ROAD ALTERNATIVES	ALTERNATIVE COSTS	ESTIMATED COUNTY COST (A)	ESTIMATED CITY COST (B)	CURB & GUTTER OUTSIDE EDGES OF 1416 COST (C)	RECONSTRUCT FROM LIBERTY BLVD TIE TO 151ST ST COST (2 LANE URBAN W/SIDEWALK) (D)	CONSTRUCTION ENGINEERING (A+B+C+D) * 8% = E	TOTAL CONSTRUCTION COST (A+B+C+D+E) = F	DESIGN ENGINEERING F * 12% = G
HWY 1416								
ALTERNATIVE 1 - SIGNALIZED INTERSECTIONS AT RADAR HILL & ELLSWORTH, 3/4 AT COMMERCIAL GATE, 2 WAY STOP AT LIBERTY	2023 CONSTRUCTION COST	$ 16,537,466	$ 2,993,825	$ 1,180,080	$ 2,950,500	$ 1,892,950	$ 25,554,821	$ 3,066,579
	2030 CONSTRUCTION COST	$ 20,338,997	$ 3,682,027	$ 1,451,350	$ 3,628,743	$ 2,328,089	$ 31,429,206	$ 3,771,505
ALTERNATIVE 2 - SIGNALIZED INTERSECTIONS AT RADAR HILL, DISPLACED LEFT AT ELLSWORTH, 3/4 AT COMMERCIAL GATE, 2 WAY STOP AT LIBERTY	2023 CONSTRUCTION COST	$ 17,936,716	$ 2,793,684	$ 1,180,080	$ 2,950,500	$ 1,988,878	$ 26,849,858	$ 3,221,983
	2030 CONSTRUCTION COST	$ 22,059,899	$ 3,435,878	$ 1,451,350	$ 3,628,743	$ 2,446,070	$ 33,021,939	$ 3,962,633
ALTERNATIVE 3 - ROUNDABOUTS AT RADAR HILL & ELLSORTH, 3/4 AT COMMERCIAL GATE, 2 WAY STOP AT LIBERTY	2023 CONSTRUCTION COST	$ 16,128,683	$ 2,871,958	$ 1,180,080	$ 2,950,500	$ 1,850,498	$ 24,981,719	$ 2,997,806
	2030 CONSTRUCTION COST	$ 19,836,246	$ 3,532,146	$ 1,451,350	$ 3,628,743	$ 2,275,879	$ 30,724,363	$ 3,686,924
COST AT LIBERTY TO ADD A SIGNAL (WHEN WARRANTS ARE MET)	2023 CONSTRUCTION COST	$ 315,000	$ 105,000	$ 1,180,080	$ 2,950,500	$ 364,046	$ 4,914,626	$ 589,755
	2030 CONSTRUCTION COST	$ 387,410	$ 129,137	$ 1,451,350	$ 3,628,743	$ 447,731	$ 6,044,371	$ 725,324
RADAR HILL RD								
ALTERNATIVE 1 - 2 LANE URBAN WITH WALK	2023 CONSTRUCTION COST	$ 7,351,400	$ 5,253,409	$ -	$ -	$ 1,008,385	$ 13,613,194	$ 1,633,583
	2030 CONSTRUCTION COST	$ 9,041,295	$ 6,461,031	$ -	$ -	$ 1,240,186	$ 16,742,511	$ 2,009,101
ALTERNATIVE 2 - 3 LANE URBAN WITH WALK	2023 CONSTRUCTION COST	$ 7,365,795	$ 5,849,960	$ -	$ -	$ 1,057,260	$ 14,273,016	$ 1,712,762
	2030 CONSTRUCTION COST	$ 9,058,999	$ 7,194,713	$ -	$ -	$ 1,300,297	$ 17,554,009	$ 2,106,481
ALTERNATIVE 3 - PAVEMENT RECONSTRUCTION	2023 CONSTRUCTION COST	$ 6,091,419	$ 2,220,414	$ -	$ -	$ 664,947	$ 8,976,780	$ 1,077,214
	2030 CONSTRUCTION COST	$ 7,491,677	$ 2,730,829	$ -	$ -	$ 817,800	$ 11,040,307	$ 1,324,837

NOTE:
2030 CONSTRUCTION COST ASSUMES 3% ANNUAL INFLATION
ALL COSTS INCLUDE 20% CONTINGENCY
PAVEMENT ASSUMPTION IS 8" OF ASPHALT CONCRETE ON 14" OF AGGREAGTE BASE
A COST OF $750,000 BIRDGE/ STRUCTURE REPLACEMENT IS INCLUDED WITH RADAR HILL ALTERNATIVES 1 & 2

Table 3-8 – Preliminary Estimate of Engineering Final Design Cost

PRELIMINARY ESTIMATE OF ENGINEERING FINAL DESIGN COST

ITEM NO.		DESCRIPTION OF ITEM		City Line Item Subtotal	County Line Item Subtotal	Line Item Subtotal	
1		Project Management		$152,433	$140,707	$293,140	
2		Quality Control		$87,936	$81,172	$169,108	
3		Public Outreach		$40,022	$36,943	$76,965	
4		Survey		$86,561	$79,903	$166,464	
		Detailed Design					
5		Environmental		$120,869	$111,571	$232,440	
6		Hydraulics Engineering		$28,260	$26,086	$54,346	
7		Utilities		$47,715	$44,044	$91,759	
8		Structural Design		$73,322	$67,682	$141,005	
9		Geotechnical Design		$52,425	$48,392	$100,817	
10.2		Special Provisions		$30,042	$27,731	$57,773	
10.3		Engineers Cost Estimate		$50,613	$46,720	$97,332	
10.5		Plan Review & Approval		$95,930	$88,551	$184,481	
10.5.2		60% Plans		$399,650	$368,908	$768,558	
10.5.3		90% Plans		$415,732	$383,752	$799,484	
10.5.4		100% Plans		$8,655	$7,989	$16,644.00	
10.5.5		Final Plans		$2,513	$2,319	$4,832.00	
TOTAL CITY:					$1,692,627		
TOTAL COUNTY:					$1,562,471		
2023 Engineering Cost TOTAL:						$3,255,148	
2030 Engineering Cost TOTAL:						$3,686,646	

Summary

Interim Alternatives

» All-way stop control is recommended (and has been implemented) as a short-term solution for the intersections of Highway 1416 and S Ellsworth Road, and Highway 1416 and Radar Hill Drive, while more permanent and effective alternatives are analyzed, funded, and implemented.

Alternatives

» Alternatives developed and analyzed at **Highway 1416 and Liberty Boulevard** included the following:
  - Alternative 1 – signalized intersection, with left-turn lanes at each approach
  - Alternative 2 – single-lane roundabout

» Alternatives developed and analyzed at **Highway 1416 and S Ellsworth Road** included the following:
  - Alternative 1 – signalized intersection, with left-turn lanes at each approach, and a dual left-turn at the eastbound approach
  - Alternative 2 – single-lane roundabout
  - Alternative 3 – hybrid roundabout, with a dedicated eastbound left-turn lane
  - Alternative 4 – displaced eastbound left, with signalization at the intersection, as well as the eastbound left crossing

» Alternatives developed and analyzed at **Highway 1416 and Radar Hill Road** included the following:
  - Alternative 1 – signalized intersection, with left-turn lanes at each approach
  - Alternative 2 – 2x1 roundabout, with two travel lanes at the eastbound and westbound approaches
  - Alternative 3 – 2x1 roundabout, with two travel lanes at the eastbound and westbound approaches, and a channelized northbound right-turn lane
  - Alternative 4 – hybrid roundabout, with a single-lane at the eastbound approach, two travel lanes in the westbound approach, and a channelized northbound right-turn lane

» No alternatives were proposed or analyzed at the intersections of Highway 1416 and 151st Avenue, Radar Hill Road and Long View Drive, or Radar Hill Road and SD 44, as these intersections are expected to operate under acceptable conditions in 2050 with no geometric improvements.

Capacity Analysis

» The following alternatives are expected to operate under unacceptable delay and LOS in the projected scenarios:
  - Highway 1416 and S Ellsworth Road – Alternative 2: 1x1 Roundabout is expected to operate at LOS F during the AM peaks in 2030 and 2050.
  - Highway 1416 and Radar Hill Road – Alternative 2: 2x1 Roundabout is expected to operate at LOS F during the AM peak in 2050.

» All other alternatives presented in this report are expected to operate under acceptable delay and LOS and are expected to improve delay and LOS conditions as compared to the no-build scenarios.

Recommendations

Based on the capacity results discussed in this report, safety considerations analyzed for the Existing Conditions chapter, and preliminary cost estimates, the following recommendations were developed for each of the study intersections that require improvement:

- Safety and capacity issues are present now, and they are expected to become worse as traffic increases. Efforts to correct these deficiencies should be undertaken as soon as adequate funding can be found.
- Highway 1416 and Liberty Boulevard – once warranted, the implementation of a **traffic signal** is recommended at this intersection, due to significant improvements in delay and LOS. Spatial constraints due to the proximity to the BNSF railroad, utilities, and wetlands made it difficult to implement the single-lane roundabout alternative.
- Highway 1416 and S Ellsworth Road – the implementation of a **hybrid roundabout** is recommended at this intersection, due to significant improvements in delay and LOS. High cost, spatial constraints, public opinion, and construction impacts made the displaced eastbound left-turn alternative a less desirable option. The hybrid roundabout alternative was also shown to be less expensive and expected to be more efficient and safer than the signalized alternative.
- Highway 1416 and Radar Hill Road – the implementation of a **2x1 roundabout with a channelized northbound right-turn lane** is recommended at this intersection, due to significant improvements in delay and LOS. The roundabout alternative was also shown to be less expensive and expected to be safer than the signalized alternative.



Appendices

Appendix A: Raw Traffic Counts

Time	NB Utrn	NB Left	NB Thru	NB Right	EB Ped & Bikes	WB Ped & Bikes	SB Utrn	SB Left	SB Thru	SB Right	EB Ped & Bikes	WB Ped & Bikes	EB Utrn	EB Left	EB Thru	EB Right	NB Ped & Bikes	SB Ped & Bikes	WB Utrn	WB Left	WB Thru	WB Right	NB Ped & Bikes	SB Ped & Bikes
		NBL	NBT	NBR				SBL	SBT	SBR				EBL	EBT	EBR				WBL	WBT	WBR		
00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	0	0	0	0	0	0	0	1	0	11	0	0	0	4	4	0	0	0	0	0	12	0	0	0
06:00	0	0	0	0	0	0	0	5	0	22	0	0	0	4	8	0	0	0	0	0	56	1	0	0
07:00	0	0	0	0	0	0	0	5	0	34	0	0	0	7	38	0	0	0	0	0	94	8	0	0
08:00	0	0	0	0	0	0	0	2	0	16	0	0	0	15	30	0	0	0	0	0	40	3	0	0
09:00	0	0	0	0	0	0	0	2	0	16	0	0	0	7	21	0	0	0	0	0	41	3	0	0
10:00	0	0	0	0	0	0	0	3	0	13	0	0	0	12	35	0	0	0	1	0	30	1	0	0
11:00	0	0	0	0	0	0	0	2	0	16	0	0	0	13	36	0	0	0	0	0	34	2	0	0
12:00	0	0	0	0	0	0	0	3	0	23	0	0	0	24	41	0	0	0	0	0	31	2	0	0
13:00	0	0	0	0	0	0	0	4	0	13	0	0	0	16	32	0	0	0	1	0	31	3	0	0
14:00	0	0	0	0	0	0	0	4	0	12	0	0	0	19	45	0	0	0	0	0	33	4	0	0
15:00	0	0	0	0	0	0	0	2	0	10	0	0	0	12	59	0	0	0	0	0	27	3	0	0
16:00	0	0	0	0	0	0	0	3	0	14	0	0	1	33	82	0	0	0	0	0	34	1	0	0
17:00	0	0	0	0	0	0	0	2	0	19	0	0	0	30	75	0	0	0	0	0	55	2	0	0
18:00	0	0	0	0	0	0	0	3	0	8	0	0	0	15	24	0	0	0	0	0	16	2	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Time	NB Utrn	NB Left	NB Thru	NB Right	EB Ped & Bikes	WB Ped & Bikes	SB Utrn	SB Left	SB Thru	SB Right	EB Ped & Bikes	WB Ped & Bikes	EB Utrn	EB Left	EB Thru	EB Right	NB Ped & Bikes	SB Ped & Bikes	WB Utrn	WB Left	WB Thru	WB Right	NB Ped & Bikes	SB Ped & Bikes
		NBL	NBT	NBR				SBL	SBT	SBR				EBL	EBT	EBR				WBL	WBT	WBR		
00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	0	1	7	0	0	0	0	10	1	5	0	0	0	13	3	1	0	0	0	0	3	23	0	0
06:00	0	1	18	0	0	0	0	21	6	19	0	0	0	61	10	2	0	0	0	0	8	100	0	0
07:00	0	5	33	3	0	0	1	23	9	39	0	0	0	124	21	1	0	0	0	2	15	126	0	0
08:00	0	2	13	1	0	0	0	20	8	26	0	0	0	26	13	1	0	0	0	2	16	59	0	0
09:00	0	4	14	0	0	0	0	25	10	23	0	0	0	35	11	4	0	0	0	0	9	39	0	0
10:00	0	2	9	0	0	0	2	17	6	17	0	0	0	14	8	4	0	0	0	1	1	22	0	0
11:00	0	3	10	1	0	0	1	27	9	27	0	0	0	28	22	7	0	0	0	3	12	35	0	0
12:00	0	3	7	0	0	0	0	33	7	28	0	0	0	46	23	2	0	0	0	1	11	39	0	0
13:00	0	4	14	2	0	0	0	54	12	35	0	0	0	37	25	3	0	1	0	0	16	37	0	0
14:00	0	6	16	0	0	0	0	39	15	30	0	0	0	37	19	6	1	0	0	1	16	35	0	0
15:00	0	4	18	3	0	0	1	71	20	65	0	0	0	46	33	2	0	0	0	1	14	51	0	0
16:00	0	0	15	1	0	0	0	82	22	49	0	0	0	44	42	12	0	0	0	3	19	47	0	0
17:00	0	8	15	1	0	0	2	92	24	51	0	0	0	39	46	9	0	2	0	4	25	51	0	0
18:00	0	0	11	1	0	0	0	26	8	13	0	0	0	13	18	3	2	0	0	1	4	17	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Time	NB Utrn	NB Left	NB Thru	NB Right	EB Ped & Bikes	WB Ped & Bikes	SB Utrn	SB Left	SB Thru	SB Right	EB Ped & Bikes	WB Ped & Bikes	EB Utrn	EB Left	EB Thru	EB Right	NB Ped & Bikes	SB Ped & Bikes	WB Utrn	WB Left	WB Thru	WB Right	NB Ped & Bikes	SB Ped & Bikes
		NBL	NBT	NBR				SBL	SBT	SBR				EBL	EBT	EBR				WBL	WBT	WBR		
00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	0	16	7	2	0	0	0	1	1	31	0	0	0	154	15	2	0	0	0	0	10	0	0	0
06:00	0	46	35	7	0	0	0	3	3	85	0	0	0	621	66	8	0	0	0	2	16	7	0	0
07:00	0	86	56	7	0	0	0	10	16	194	0	0	0	618	115	15	0	0	0	0	44	13	0	0
08:00	0	36	15	5	0	0	0	4	9	130	0	0	1	263	29	10	0	0	0	4	33	7	0	0
09:00	0	24	18	2	0	0	0	8	14	134	0	0	0	212	39	16	0	0	0	2	24	8	0	0
10:00	0	21	11	4	0	0	0	10	14	138	0	0	0	197	42	15	0	0	0	6	36	6	0	0
11:00	0	23	9	2	0	0	0	5	18	156	0	0	0	217	50	26	0	0	0	0	37	3	0	0
12:00	0	22	15	7	0	0	0	13	25	175	0	0	0	279	55	35	0	0	0	3	38	10	0	0
13:00	0	27	19	7	0	0	0	3	10	150	0	0	0	252	62	18	0	0	0	5	40	7	1	0
14:00	0	23	20	3	0	0	0	4	23	170	0	0	0	280	58	32	0	0	0	1	49	13	0	0
15:00	0	28	21	7	0	0	0	9	47	334	0	0	0	263	61	48	0	0	0	6	62	13	0	0
16:00	0	30	26	6	0	0	0	9	45	300	0	0	0	286	78	75	0	1	0	6	63	7	1	1
17:00	0	42	32	4	0	0	0	7	72	237	0	0	1	257	82	152	0	1	0	17	65	3	0	0
18:00	0	25	8	0	0	0	0	0	13	111	0	0	0	85	31	43	0	0	0	2	14	1	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Time	NB Utrn	NB Left	NB Thru	NB Right	EB Ped & Bikes	WB Ped & Bikes	SB Utrn	SB Left	SB Thru	SB Right	EB Ped & Bikes	WB Ped & Bikes	EB Utrn	EB Left	EB Thru	EB Right	NB Ped & Bikes	SB Ped & Bikes	WB Utrn	WB Left	WB Thru	WB Right	NB Ped & Bikes	SB Ped & Bikes
		NBL	NBT	NBR				SBL	SBT	SBR				EBL	EBT	EBR				WBL	WBT	WBR		
00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	0	47	1	36	0	0	0	1	2	8	0	0	0	1	143	11	0	0	0	13	48	1	0	0
06:00	0	116	0	170	0	0	0	2	2	14	0	0	0	2	524	32	0	0	0	32	137	5	0	0
07:00	0	167	1	236	0	0	0	8	9	16	0	0	0	4	527	55	0	0	0	79	334	5	0	0
08:00	0	81	7	56	0	0	0	3	9	26	0	0	2	7	243	49	0	0	0	51	202	7	0	0
09:00	0	68	8	59	0	0	0	6	4	10	0	0	1	15	223	46	0	0	0	46	196	2	0	0
10:00	0	64	3	62	0	0	0	3	2	9	0	0	1	9	201	55	0	0	0	55	234	3	0	0
11:00	0	57	3	50	0	0	0	2	3	12	0	0	0	16	250	69	0	0	0	76	295	3	0	0
12:00	0	56	9	88	0	0	0	5	5	20	0	0	0	12	294	75	0	0	0	66	227	2	0	0
13:00	0	68	6	61	0	0	0	1	8	18	0	0	1	16	288	73	0	0	0	65	230	4	0	0
14:00	0	66	2	87	0	0	0	5	9	16	0	0	0	23	292	87	0	0	0	74	316	8	0	0
15:00	0	69	7	82	0	0	0	3	3	10	0	0	0	17	291	104	0	0	0	195	509	5	0	0
16:00	0	89	9	101	0	0	0	5	5	11	0	0	0	19	357	162	0	0	0	182	627	7	0	0
17:00	0	117	8	125	0	0	0	3	8	9	0	0	0	25	377	185	0	0	0	136	437	2	0	0
18:00	0	31	3	26	0	0	0	1	4	6	0	0	0	7	131	70	0	0	0	29	124	4	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Time	NB Utrn	NB Left	NB Thru	NB Right	EB Ped & Bikes	WB Ped & Bikes	SB Utrn	SB Left	SB Thru	SB Right	EB Ped & Bikes	WB Ped & Bikes	EB Utrn	EB Left	EB Thru	EB Right	NB Ped & Bikes	SB Ped & Bikes	WB Utrn	WB Left	WB Thru	WB Right	NB Ped & Bikes	SB Ped & Bikes
		NBL	NBT	NBR				SBL	SBT	SBR				EBL	EBT	EBR				WBL	WBT	WBR		
00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	0	0	11	3	0	0	0	0	12	21	0	0	0	14	0	1	0	0	0	0	1	1	0	0
06:00	0	0	32	2	0	0	0	3	30	73	0	0	0	64	2	2	0	0	0	3	8	6	0	0
07:00	0	1	16	3	0	0	0	4	42	105	0	0	0	65	5	0	0	0	0	3	16	8	0	0
08:00	0	0	11	6	0	0	0	7	27	55	0	0	0	46	7	1	0	0	0	7	8	8	0	0
09:00	0	2	23	7	0	0	0	6	27	49	0	0	0	40	11	4	0	0	0	8	10	6	0	0
10:00	0	1	27	5	0	0	0	6	26	53	0	0	0	32	7	0	0	0	0	4	9	7	0	0
11:00	0	1	23	5	0	0	0	8	32	48	0	0	0	50	6	3	0	0	0	6	7	6	0	0
12:00	1	1	30	6	0	0	0	6	23	47	0	0	0	57	5	4	0	0	0	5	5	8	0	0
13:00	0	0	20	4	0	0	0	7	20	59	0	0	0	49	4	0	0	0	0	6	9	8	0	0
14:00	0	0	26	6	0	0	0	9	29	72	0	0	0	47	3	1	0	0	0	7	4	6	0	0
15:00	0	2	34	7	0	0	0	4	40	87	0	0	0	80	8	0	0	0	0	4	5	8	0	0
16:00	0	1	44	7	0	0	0	8	40	94	0	0	0	118	8	1	0	0	0	4	9	5	0	0
17:00	0	3	43	2	0	0	0	6	36	93	0	0	0	102	9	1	0	0	0	1	4	3	0	0
18:00	0	2	13	1	0	0	0	3	14	22	0	0	0	43	3	2	0	0	0	1	1	1	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Time	NB Utrn	NB Left	NB Thru	NB Right	EB Ped & Bikes	WB Ped & Bikes	SB Utrn	SB Left	SB Thru	SB Right	EB Ped & Bikes	WB Ped & Bikes	EB Utrn	EB Left	EB Thru	EB Right	NB Ped & Bikes	SB Ped & Bikes	WB Utrn	WB Left	WB Thru	WB Right	NB Ped & Bikes	SB Ped & Bikes
		NBL	NBT	NBR				SBL	SBT	SBR				EBL	EBT	EBR				WBL	WBT	WBR		
00:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05:00	0	1	1	1	0	0	0	7	3	3	0	0	0	7	60	0	0	0	0	0	42	6	0	0
06:00	0	5	6	3	0	0	0	11	5	17	0	0	0	12	159	3	0	0	0	0	107	12	0	0
07:00	0	11	1	2	0	0	0	9	5	25	0	0	0	15	170	4	0	0	0	2	150	4	0	0
08:00	0	6	4	3	0	0	0	16	0	20	0	0	0	15	147	3	0	0	0	3	103	2	0	0
09:00	0	2	2	1	0	0	0	17	3	23	0	0	0	17	177	5	0	0	0	5	135	16	0	0
10:00	0	4	0	3	0	0	0	20	2	10	0	0	0	15	202	8	0	0	0	2	228	15	0	0
11:00	0	7	0	2	0	0	0	21	2	17	0	0	0	24	164	2	0	0	0	4	192	10	0	0
12:00	0	5	3	2	0	0	0	15	6	21	0	0	0	21	168	7	0	0	0	3	253	14	0	0
13:00	0	1	2	5	0	0	0	6	4	14	0	0	0	20	121	4	0	0	0	0	155	6	0	0
14:00	0	8	2	1	0	0	0	10	8	22	0	0	0	18	145	3	0	0	0	1	138	11	0	0
15:00	0	5	1	3	0	0	0	15	6	24	0	0	0	32	170	7	0	0	0	0	193	12	0	0
16:00	0	7	2	0	0	0	0	19	6	24	0	0	0	38	127	11	0	0	0	2	179	18	0	0
17:00	0	7	4	2	0	0	0	12	3	25	0	0	0	29	153	7	0	0	0	2	171	13	0	0
18:00	0	1	1	0	0	0	0	3	4	5	0	0	0	7	68	4	0	0	0	0	62	5	0	0
19:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix B: Vehicular Level of Service (VLOS) Results – Existing

HCS Two-Way Stop-Control Report

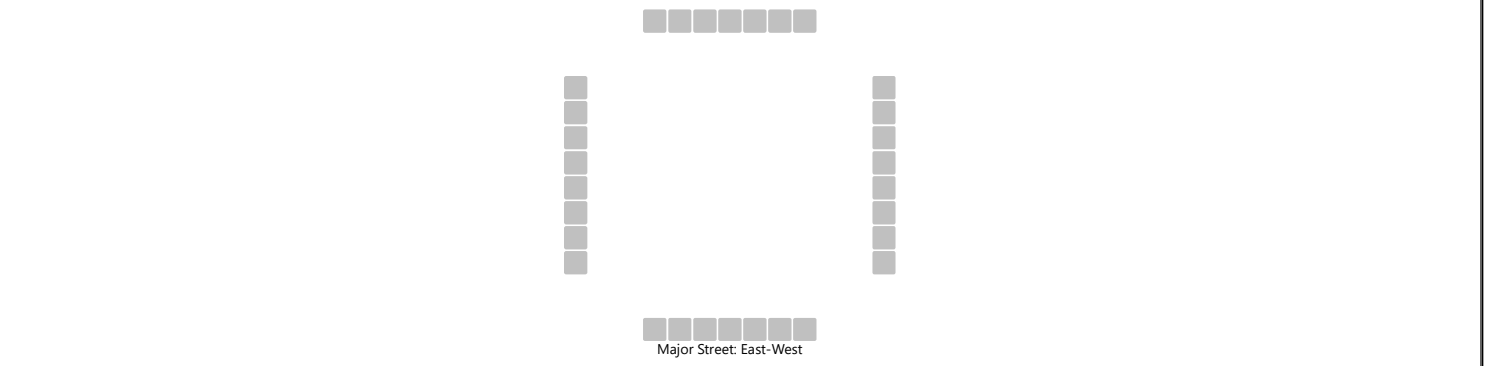
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/2/2023
Analysis Year	2023
Time Analyzed	AM peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and 151st Ave
Jurisdiction	Box Elder SD
East/West Street	Highway 1416
North/South Street	151st Ave
Peak Hour Factor	0.76
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		7	38				94	8						5		34
Percent Heavy Vehicles (%)		9												16		16
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage					Undivided											

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.19												6.56		6.36
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.28												3.64		3.44

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		9													51	
Capacity, c (veh/h)		1409													866	
v/c Ratio		0.01													0.06	
95% Queue Length, Q_{95} (veh)		0.0													0.2	
Control Delay (s/veh)		7.6	0.1												9.4	
Level of Service (LOS)		A	A												A	
Approach Delay (s/veh)		1.2												9.4		
Approach LOS		A												A		

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HCS Two-Way Stop-Control Report

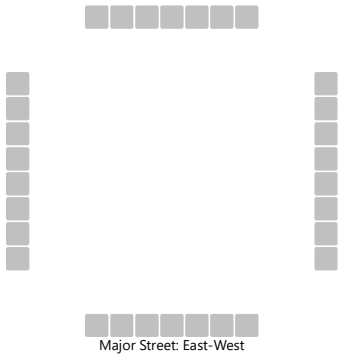
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/2/2023
Analysis Year	2023
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and 151st Ave
Jurisdiction	Box Elder SD
East/West Street	Highway 1416
North/South Street	151st Ave
Peak Hour Factor	0.83
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		36	84				50	1						3		15
Percent Heavy Vehicles (%)		9												16		16
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.19												6.56		6.36
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.28												3.64		3.44

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		43													22	
Capacity, c (veh/h)		1498													905	
v/c Ratio		0.03													0.02	
95% Queue Length, Q_{95} (veh)		0.1													0.1	
Control Delay (s/veh)		7.5	0.2												9.1	
Level of Service (LOS)		A	A												A	
Approach Delay (s/veh)		2.4												9.1		
Approach LOS		A												A		

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HCS Two-Way Stop-Control Report

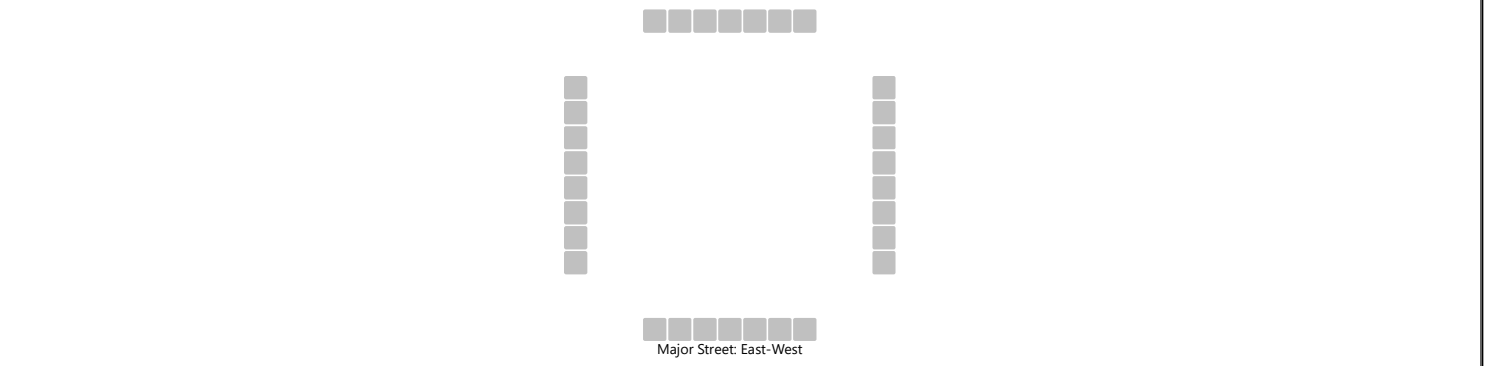
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/2/2023
Analysis Year	2023
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and Liberty Blvd
Jurisdiction	Box Elder SD
East/West Street	Highway 1416
North/South Street	Liberty Blvd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	1	0	0	0	1	0		0	1	0		0	1	1
Configuration		L		TR			LTR				LTR			LT		R
Volume (veh/h)		134	23	2		1	15	139		3	32	2		20	8	28
Percent Heavy Vehicles (%)		8				7				2	2	2		9	9	9
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized														Yes		
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.1	6.5	6.2		7.1	6.5	6.2
Critical Headway (sec)		4.18				4.17				7.12	6.52	6.22		7.19	6.59	6.29
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.27				2.26				3.52	4.02	3.32		3.58	4.08	3.38

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		160				1					44			33		33
Capacity, c (veh/h)		1356				1551					414			406		936
v/c Ratio		0.12				0.00					0.11			0.08		0.04
95% Queue Length, Q_{95} (veh)		0.4				0.0					0.4			0.3		0.1
Control Delay (s/veh)		8.0	0.1	0.1		7.3	0.0	0.0			14.7			14.7		9.0
Level of Service (LOS)		A	A	A		A	A	A			B			B		A
Approach Delay (s/veh)	6.8				0.1				14.7				11.8			
Approach LOS	A				A				B				B			

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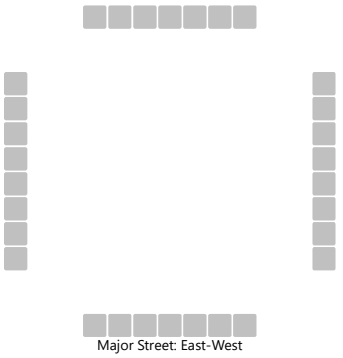
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/2/2023
Analysis Year	2023
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and Liberty Blvd
Jurisdiction	Box Elder SD
East/West Street	Highway 1416
North/South Street	Liberty Blvd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	1	0	0	0	1	0		0	1	0		0	1	1
Configuration		L		TR			LTR				LTR			LT		R
Volume (veh/h)		37	42	12		3	27	54		7	10	0		110	20	54
Percent Heavy Vehicles (%)		8				7				2	2	2		9	9	9
Proportion Time Blocked																
Percent Grade (%)									0				0			
Right Turn Channelized													Yes			
Median Type | Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.1	6.5	6.2		7.1	6.5	6.2
Critical Headway (sec)		4.18				4.17				7.12	6.52	6.22		7.19	6.59	6.29
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.27				2.26				3.52	4.02	3.32		3.58	4.08	3.38

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		44				4					20			155		64
Capacity, c (veh/h)		1460				1507					620			676		981
v/c Ratio		0.03				0.00					0.03			0.23		0.07
95% Queue Length, Q_{95} (veh)		0.1				0.0					0.1			0.9		0.2
Control Delay (s/veh)		7.5	0.1	0.1		7.4	0.0	0.0			11.0			11.9		8.9
Level of Service (LOS)		A	A	A		A	A	A			B			B		A
Approach Delay (s/veh)	3.1				0.3				11.0				11.0			
Approach LOS	A				A				B				B			

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HCS Two-Way Stop-Control Report

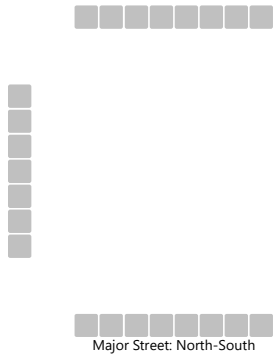
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/12/2023
Analysis Year	2023
Time Analyzed	AM Peak
Intersection Orientation	North-South
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		0	2	0	0	0	1	0	0	0	1	1
Configuration						LT		TR		LT					T	R
Volume (veh/h)						0	44	13		86	674				26	194
Percent Heavy Vehicles (%)						10	10	10		1						
Proportion Time Blocked																
Percent Grade (%)						0										
Right Turn Channelized														Yes		
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						7.1	6.5	6.2		4.1						
Critical Headway (sec)						7.20	6.60	6.30		4.11						
Base Follow-Up Headway (sec)						3.5	4.0	3.3		2.2						
Follow-Up Headway (sec)						3.59	4.09	3.39		2.21						

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						26		42		102						
Capacity, c (veh/h)						197		239		1588						
v/c Ratio						0.13		0.17		0.06						
95% Queue Length, Q_{95} (veh)						0.5		0.6		0.2						
Control Delay (s/veh)						26.1		23.3		7.4	0.9					
Level of Service (LOS)						D		C		A	A					
Approach Delay (s/veh)						24.4				1.6						
Approach LOS						C				A						

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HCS Two-Way Stop-Control Report

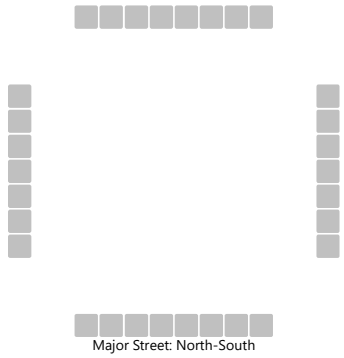
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/12/2023
Analysis Year	2023
Time Analyzed	PM Peak
Intersection Orientation	North-South
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		0	2	0	0	0	1	0	0	0	1	1
Configuration						LT		TR		LT					T	R
Volume (veh/h)						14	71	6		36	328				65	256
Percent Heavy Vehicles (%)						10	10	10		1						
Proportion Time Blocked																
Percent Grade (%)						0										
Right Turn Channelized														Yes		
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						7.1	6.5	6.2		4.1						
Critical Headway (sec)						7.20	6.60	6.30		4.11						
Base Follow-Up Headway (sec)						3.5	4.0	3.3		2.2						
Follow-Up Headway (sec)						3.59	4.09	3.39		2.21						

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						55		46		40						
Capacity, c (veh/h)						438		459		1534						
v/c Ratio						0.13		0.10		0.03						
95% Queue Length, Q_{95} (veh)						0.4		0.3		0.1						
Control Delay (s/veh)						14.4		13.7		7.4	0.2					
Level of Service (LOS)						B		B		A	A					
Approach Delay (s/veh)						14.1				1.0						
Approach LOS						B				A						

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HCS Two-Way Stop-Control Report

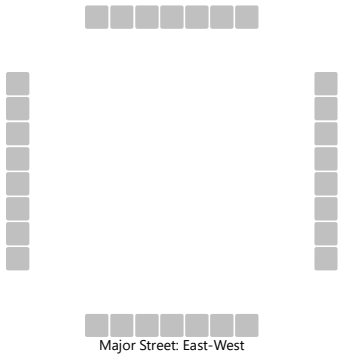
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	2	0	0	0	0	0		0	1	0		0	1	0
Configuration		LT		TR								TR		LT		
Volume (veh/h)		618	115	15							142	7		10	16	
Percent Heavy Vehicles (%)		4									1	1		5	5	
Proportion Time Blocked																
Percent Grade (%)									0				0			
Right Turn Channelized																
Median Type | Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)		5.3									6.5	6.9		7.5	6.5	
Critical Headway (sec)		5.38									6.52	6.92		7.60	6.60	
Base Follow-Up Headway (sec)		3.1									4.0	3.3		3.5	4.0	
Follow-Up Headway (sec)		3.14									4.01	3.31		3.55	4.05	

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		736										177		31		
Capacity, c (veh/h)		1146										36		34		
v/c Ratio		0.64										4.98		0.92		
95% Queue Length, Q_{95} (veh)		5.2										74.4		6.2		
Control Delay (s/veh)		13.7	0.8									7390.1		468.7		
Level of Service (LOS)		B	A									F		F		
Approach Delay (s/veh)	11.5								7390.1				468.7			
Approach LOS	B								F				F			

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HCS Two-Way Stop-Control Report

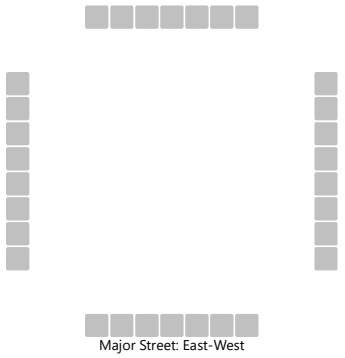
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	2	0	0	0	0	0		0	1	0		0	1	0
Configuration		LT		TR								TR		LT		
Volume (veh/h)		291	79	143							73	6		6	73	
Percent Heavy Vehicles (%)		4									1	1		5	5	
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		5.3									6.5	6.9		7.5	6.5	
Critical Headway (sec)		5.38									6.52	6.92		7.60	6.60	
Base Follow-Up Headway (sec)		3.1									4.0	3.3		3.5	4.0	
Follow-Up Headway (sec)		3.14									4.01	3.31		3.55	4.05	

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		323										88		88		
Capacity, c (veh/h)		1146										231		184		
v/c Ratio		0.28										0.38		0.48		
95% Queue Length, Q_{95} (veh)		1.2										1.8		2.6		
Control Delay (s/veh)		9.4	0.3									30.0		42.0		
Level of Service (LOS)		A	A									D		E		
Approach Delay (s/veh)	5.4								30.0				42.0			
Approach LOS	A								D				E			

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HCS Two-Way Stop-Control Report

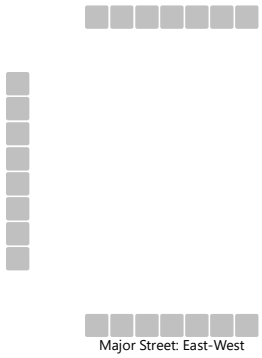
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	0	0	0	0	2	0		0	1	0		0	1	0
Configuration						LT		TR		LT						TR
Volume (veh/h)						79	334	5		167	5				17	16
Percent Heavy Vehicles (%)						5				4	4				3	3
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						5.3				7.5	6.5				6.5	6.9
Critical Headway (sec)						5.40				7.58	6.58				6.56	6.96
Base Follow-Up Headway (sec)						3.1				3.5	4.0				4.0	3.3
Follow-Up Headway (sec)						3.15				3.54	4.04				4.03	3.33

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						90				195						38
Capacity, c (veh/h)						1143				462						525
v/c Ratio						0.08				0.42						0.07
95% Queue Length, Q_{95} (veh)						0.3				2.2						0.2
Control Delay (s/veh)						8.4	0.5			18.5						12.4
Level of Service (LOS)						A	A			C						B
Approach Delay (s/veh)						2.0				18.5				12.4		
Approach LOS						A				C				B		

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HCS Two-Way Stop-Control Report

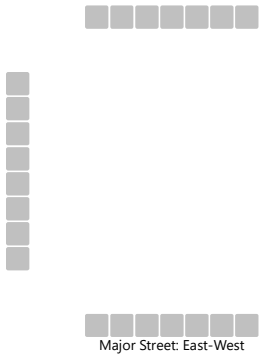
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	0	0	0	0	2	0		0	1	0		0	1	0
Configuration						LT		TR		LT						TR
Volume (veh/h)						184	531	3		112	28				13	10
Percent Heavy Vehicles (%)						5				4	4				3	3
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						5.3				7.5	6.5				6.5	6.9
Critical Headway (sec)						5.40				7.58	6.58				6.56	6.96
Base Follow-Up Headway (sec)						3.1				3.5	4.0				4.0	3.3
Follow-Up Headway (sec)						3.15				3.54	4.04				4.03	3.33

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						196				149						24
Capacity, c (veh/h)						1143				235						293
v/c Ratio						0.17				0.63						0.08
95% Queue Length, Q_{95} (veh)						0.6				4.7						0.3
Control Delay (s/veh)						8.8	1.1			45.8						18.4
Level of Service (LOS)						A	A			E						C
Approach Delay (s/veh)						3.0				45.8				18.4		
Approach LOS						A				E				C		

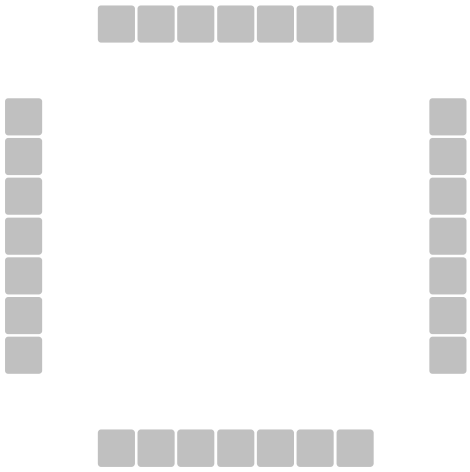
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	4	527	55					168	236	8	88	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	304	362					459			109		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.270	0.322					0.408			0.097		
Final Departure Headway, h_d (s)	6.19	6.06					5.39			6.36		
Final Degree of Utilization, x	0.523	0.609					0.688			0.193		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.89	3.76					3.39			4.36		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	304	362					459			109		
Capacity (veh/h)	582	594					667			566		
95% Queue Length, Q_{95} (veh)	3.2	4.5					6.2			0.7		
Control Delay (s/veh)	15.6	18.1					20.0			10.9		
Level of Service, LOS	C	C					C			B		
Approach Delay (s/veh) | LOS	17.0	C					20.0	C		10.9	B	
Intersection Delay (s/veh) | LOS	17.6						C					

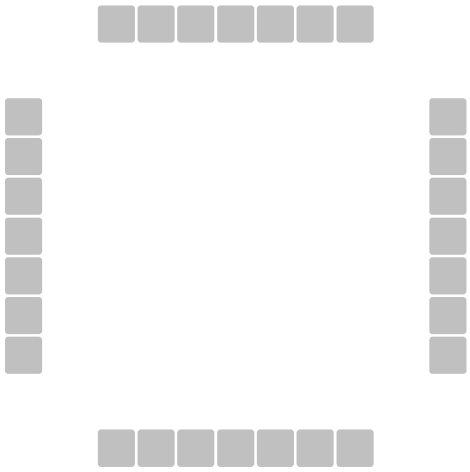
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	19	401	193					121	116	4	193	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	234	419					252			210		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.208	0.372					0.224			0.186		
Final Departure Headway, h_d (s)	5.94	5.55					5.57			5.91		
Final Degree of Utilization, x	0.385	0.645					0.390			0.344		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.64	3.25					3.57			3.91		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	234	419					252			210		
Capacity (veh/h)	606	649					646			609		
95% Queue Length, Q_{95} (veh)	1.9	5.2					1.9			1.6		
Control Delay (s/veh)	12.3	18.2					12.1			12.0		
Level of Service, LOS	B	C					B			B		
Approach Delay (s/veh) | LOS	16.1	C					12.1	B		12.0	B	
Intersection Delay (s/veh) | LOS	14.4						B					

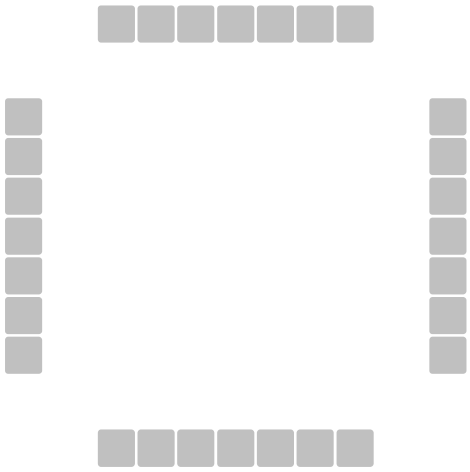
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	Radar Hill Rd and Long View Rd
Jurisdiction	Box Elder SD
East/West Street	Long View Rd
North/South Street	Radar Hill Rd
Peak Hour Factor	0.90

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	70	6	1	5	16	9	1	24	3	3	38	102
% Thrus in Shared Lane												

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	78	8		6	28		1	30		3	156	
Percent Heavy Vehicles	3	3		49	49		14	14		5	5	
Initial Departure Headway, h_d (s)	3.20	3.20		3.20	3.20		3.20	3.20		3.20	3.20	
Initial Degree of Utilization, x	0.069	0.007		0.005	0.025		0.001	0.027		0.003	0.138	
Final Departure Headway, h_d (s)	5.52	4.92		6.35	5.60		5.69	5.11		5.44	4.43	
Final Degree of Utilization, x	0.119	0.011		0.010	0.043		0.002	0.043		0.005	0.191	
Move-Up Time, m (s)	2.3	2.3		2.3	2.3		2.3	2.3		2.3	2.3	
Service Time, t_s (s)	3.22	2.62		4.05	3.30		3.39	2.81		3.14	2.13	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	78	8		6	28		1	30		3	156	
Capacity (veh/h)	652	732		567	643		633	705		662	812	
95% Queue Length, Q_{95} (veh)	0.4	0.0		0.0	0.1		0.0	0.1		0.0	0.7	
Control Delay (s/veh)	9.0	7.7		9.1	8.6		8.4	8.0		8.2	8.2	
Level of Service, LOS	A	A		A	A		A	A		A	A	
Approach Delay (s/veh) | LOS	8.8	A		8.6	A		8.0	A		8.2	A	
Intersection Delay (s/veh) | LOS	8.4						A					

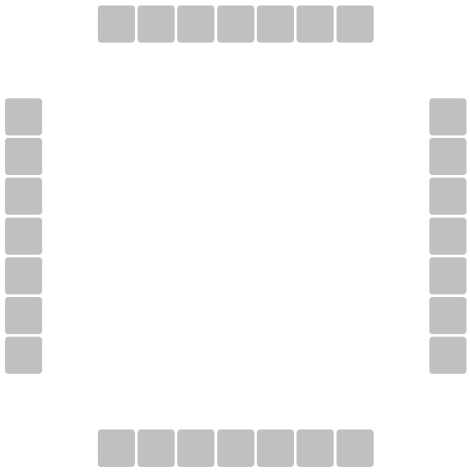
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	Radar Hill Rd and Long View Rd
Jurisdiction	Box Elder SD
East/West Street	Long View Rd
North/South Street	Radar Hill Rd
Peak Hour Factor	0.95

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	127	10	1	2	6	4	1	46	4	7	37	107
% Thrus in Shared Lane												

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	134	12		2	11		1	53		7	152	
Percent Heavy Vehicles	3	3		49	49		14	14		5	5	
Initial Departure Headway, h_d (s)	3.20	3.20		3.20	3.20		3.20	3.20		3.20	3.20	
Initial Degree of Utilization, x	0.119	0.010		0.002	0.009		0.001	0.047		0.007	0.135	
Final Departure Headway, h_d (s)	5.57	5.00		6.48	5.70		5.81	5.25		5.57	4.55	
Final Degree of Utilization, x	0.207	0.016		0.004	0.017		0.002	0.077		0.011	0.192	
Move-Up Time, m (s)	2.3	2.3		2.3	2.3		2.3	2.3		2.3	2.3	
Service Time, t_s (s)	3.27	2.70		4.18	3.40		3.51	2.95		3.27	2.25	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	134	12		2	11		1	53		7	152	
Capacity (veh/h)	647	719		555	631		620	686		646	790	
95% Queue Length, Q_{95} (veh)	0.8	0.0		0.0	0.1		0.0	0.2		0.0	0.7	
Control Delay (s/veh)	9.7	7.8		9.2	8.5		8.5	8.4		8.3	8.3	
Level of Service, LOS	A	A		A	A		A	A		A	A	
Approach Delay (s/veh) | LOS	9.6	A		8.6	A		8.4	A		8.3	A	
Intersection Delay (s/veh) | LOS	8.8						A					

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HCS Two-Way Stop-Control Report

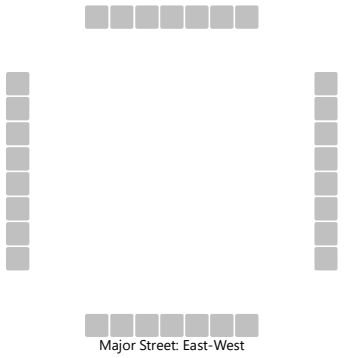
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Radar Hill Rd and Highway 44
Jurisdiction	Box Elder SD
East/West Street	Highway 44
North/South Street	Radar Hill Rd
Peak Hour Factor	0.86
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	2	0	0	1	2	0		0	1	0		0	1	0
Configuration		L	T	TR		L	T	TR			LTR				LTR	
Volume (veh/h)	0	15	217	5	0	2	207	17		4	0	1		19	2	10
Percent Heavy Vehicles (%)	5	5			3	3				6	6	6		10	10	10
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.5	6.5	6.9		7.5	6.5	6.9
Critical Headway (sec)		4.20				4.16				7.62	6.62	7.02		7.70	6.70	7.10
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.25				2.23				3.56	4.06	3.36		3.60	4.10	3.40

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		17				2					6				36	
Capacity, c (veh/h)		1279				1296					534				564	
v/c Ratio		0.01				0.00					0.01				0.06	
95% Queue Length, Q_{95} (veh)		0.0				0.0					0.0				0.2	
Control Delay (s/veh)		7.9				7.8					11.8				11.8	
Level of Service (LOS)		A				A					B				B	
Approach Delay (s/veh)	0.5				0.1				11.8				11.8			
Approach LOS	A				A				B				B			

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HCS Two-Way Stop-Control Report

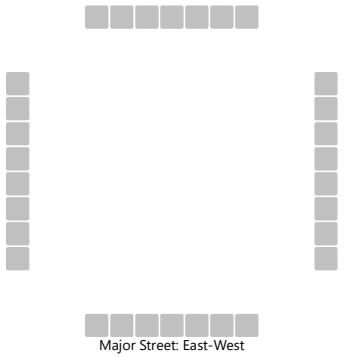
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/4/2023
Analysis Year	2023
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Radar Hill Rd and Highway 44
Jurisdiction	Box Elder SD
East/West Street	Highway 44
North/South Street	Radar Hill Rd
Peak Hour Factor	0.85
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	2	0	0	1	2	0		0	1	0		0	1	0
Configuration		L	T	TR		L	T	TR			LTR				LTR	
Volume (veh/h)	0	39	132	12	0	1	221	24		6	1	0		23	7	24
Percent Heavy Vehicles (%)	5	5			3	3				6	6	6		10	10	10
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.5	6.5	6.9		7.5	6.5	6.9
Critical Headway (sec)		4.20				4.16				7.62	6.62	7.02		7.70	6.70	7.10
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.25				2.23				3.56	4.06	3.36		3.60	4.10	3.40

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		46				1					8				64	
Capacity, c (veh/h)		1249				1398					467				564	
v/c Ratio		0.04				0.00					0.02				0.11	
95% Queue Length, Q_{95} (veh)		0.1				0.0					0.1				0.4	
Control Delay (s/veh)		8.0				7.6					12.9				12.2	
Level of Service (LOS)		A				A					B				B	
Approach Delay (s/veh)	1.7				0.0				12.9				12.2			
Approach LOS	A				A				B				B			

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Appendix C: Pedestrian Level of Service (PLOS) and Bicycle Level of Service (BLOS) Results

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	12 ft
Paved shoulder/bike lane/marked parking width:	0 ft
Bidirectional ADT traffic volume:	3943 (veh/day)
Posted speed limit:	65 mph
Heavy vehicle percentage:	3%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	4.2	D (3.51-4.50)	Moderately Low
PLOS:	4.92	E (4.51-5.50)	Very Low

Highway 1416
151st Avenue to Liberty Blvd

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	12 ft
Paved shoulder/bike lane/marked parking width:	0 ft
Bidirectional ADT traffic volume:	1469 (veh/day)
Posted speed limit:	50 mph
Heavy vehicle percentage:	5%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	4.08	D (3.51-4.50)	Moderately Low
PLOS:	4.08	D (3.51-4.50)	Moderately Low

WB Highway 1416
Liberty Blvd to S Ellsworth Rd

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	12 ft
Paved shoulder/bike lane/marked parking width:	0 ft
Bidirectional ADT traffic volume:	5878 (veh/day)
Posted speed limit:	55 mph
Heavy vehicle percentage:	5%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	4.87	E (4.51-5.50)	Very Low
PLOS:	4.55	E (4.51-5.50)	Very Low

WB Highway 1416
S Ellsworth Rd to W Gate Rd

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	12 ft
Paved shoulder/bike lane/marked parking width:	0 ft
Bidirectional ADT traffic volume:	1080 (veh/day)
Posted speed limit:	50 mph
Heavy vehicle percentage:	8%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	4.89	E (4.51-5.50)	Very Low
PLOS:	4.06	D (3.51-4.50)	Moderately Low

EB Highway 1416
Liberty Blvd to S Ellsworth Rd

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	12 ft
Paved shoulder/bike lane/marked parking width:	0 ft
Bidirectional ADT traffic volume:	6290 (veh/day)
Posted speed limit:	55 mph
Heavy vehicle percentage:	5%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	4.9	E (4.51-5.50)	Very Low
PLOS:	4.57	E (4.51-5.50)	Very Low

EB Highway 1416
S Ellsworth Rd to W Gate Rd

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	13 ft
Paved shoulder/bike lane/marked parking width:	0 ft
Bidirectional ADT traffic volume:	5385 (veh/day)
Posted speed limit:	45 mph
Heavy vehicle percentage:	4%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	4.26	D (3.51-4.50)	Moderately Low
PLOS:	4.02	D (3.51-4.50)	Moderately Low

Radar Hill Rd
Highway 1416 to 228th St

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	13 ft
Paved shoulder/bike lane/marked parking width:	10 ft
Bidirectional ADT traffic volume:	1052 (veh/day)
Posted speed limit:	45 mph
Heavy vehicle percentage:	12%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	1.5	A (below 1.50)	Extremely High
PLOS:	3.07	C (2.51-3.50)	Moderately High

Radar Hill Rd
228th St to 229th St

BLOS and PLOS for the following road segment

Lanes per direction:	2
Outside lane width:	13 ft
Paved shoulder/bike lane/marked parking width:	0 ft
Bidirectional ADT traffic volume:	320 (veh/day)
Posted speed limit:	50 mph
Heavy vehicle percentage:	7%
FHWA's pavement condition rating:	3
% of segment with occupied parking:	0%
% of segment with sidewalks:	0%

	Score	Level-of-service	Compatibility Level
BLOS:	3.81	D (3.51-4.50)	Moderately Low
PLOS:	3.92	D (3.51-4.50)	Moderately Low

Radar Hill Rd
229th St to Highway 44

Appendix D: Vehicular Level of Service (VLOS) Results - Future No-Build

HCS Two-Way Stop-Control Report

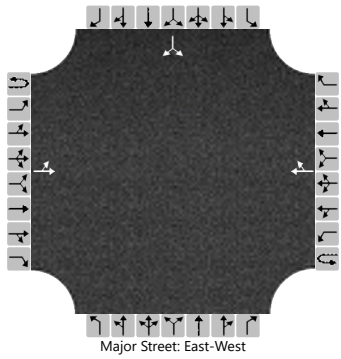
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and 151st Ave
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	151st Ave
Peak Hour Factor	0.76
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		179	41				99	19						11		146
Percent Heavy Vehicles (%)		9												16		16
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.19												6.56		6.36
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.28												3.64		3.44

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		236													207	
Capacity, c (veh/h)		1383													780	
v/c Ratio		0.17													0.26	
95% Queue Length, Q_{95} (veh)		0.6													1.1	
Control Delay (s/veh)		8.1	1.4												11.3	
Level of Service (LOS)		A	A												B	
Approach Delay (s/veh)		6.9												11.3		
Approach LOS		A												B		

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HCS Two-Way Stop-Control Report

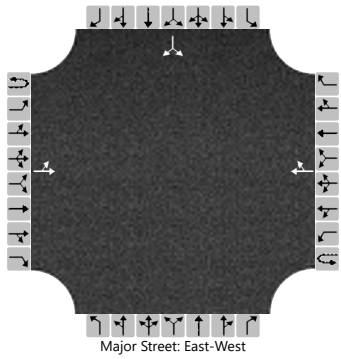
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and 151st Ave
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	151st Ave
Peak Hour Factor	0.83
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		92	87				52	5						6		65
Percent Heavy Vehicles (%)		9												16		16
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.19												6.56		6.36
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.28												3.64		3.44

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		111													86	
Capacity, c (veh/h)		1489													901	
v/c Ratio		0.07													0.09	
95% Queue Length, Q_{95} (veh)		0.2													0.3	
Control Delay (s/veh)		7.6	0.6												9.4	
Level of Service (LOS)		A	A												A	
Approach Delay (s/veh)		4.2												9.4		
Approach LOS		A												A		

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HCS Two-Way Stop-Control Report

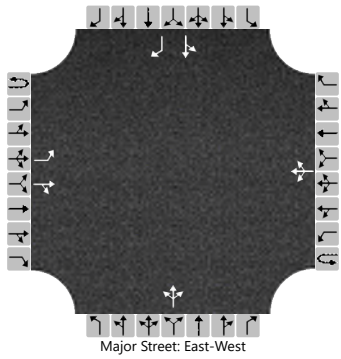
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and Liberty Blvd
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	Liberty Blvd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	1	0	0	0	1	0		0	1	0		0	1	1
Configuration		L		TR			LTR				LTR			LT		R
Volume (veh/h)		326	150	3		7	90	171		4	51	10		60	19	141
Percent Heavy Vehicles (%)		8				7				2	2	2		9	9	9
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized														Yes		
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.1	6.5	6.2		7.1	6.5	6.2
Critical Headway (sec)		4.18				4.17				7.12	6.52	6.22		7.19	6.59	6.29
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.27				2.26				3.52	4.02	3.32		3.58	4.08	3.38

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		388				8					77			94		168
Capacity, c (veh/h)		1216				1363					123			65		814
v/c Ratio		0.32				0.01					0.63			1.46		0.21
95% Queue Length, Q_{95} (veh)		1.4				0.0					4.3			21.3		0.8
Control Delay (s/veh)		9.3				7.7	0.1	0.1			81.0			1032.9		10.6
Level of Service (LOS)		A				A	A	A			F			F		B
Approach Delay (s/veh)	6.4				0.3				81.0				377.7			
Approach LOS	A				A				F				F			

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HCS Two-Way Stop-Control Report

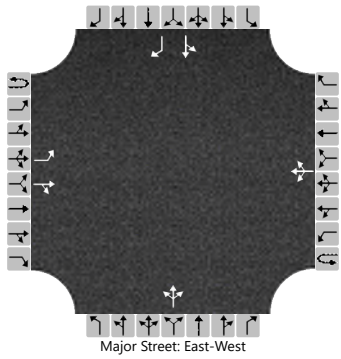
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and Liberty Blvd
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	Liberty Blvd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	1	0	0	0	1	0		0	1	0		0	1	1
Configuration		L		TR			LTR				LTR			LT		R
Volume (veh/h)		97	83	13		7	64	66		8	16	2		125	26	107
Percent Heavy Vehicles (%)		8				7				2	2	2		9	9	9
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized														Yes		
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.1	6.5	6.2		7.1	6.5	6.2
Critical Headway (sec)		4.18				4.17				7.12	6.52	6.22		7.19	6.59	6.29
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.27				2.26				3.52	4.02	3.32		3.58	4.08	3.38

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		115				8					31			180		127
Capacity, c (veh/h)		1390				1444					405			424		918
v/c Ratio		0.08				0.01					0.08			0.42		0.14
95% Queue Length, Q_{95} (veh)		0.3				0.0					0.2			2.2		0.5
Control Delay (s/veh)		7.8				7.5	0.0	0.0			14.6			19.7		9.6
Level of Service (LOS)		A				A	A	A			B			C		A
Approach Delay (s/veh)	3.9				0.4				14.6				15.5			
Approach LOS	A				A				B				C			

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HCS Two-Way Stop-Control Report

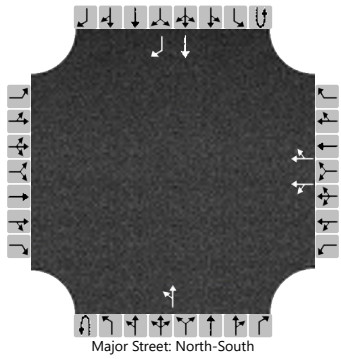
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	AM Peak
Intersection Orientation	North-South
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes


Major Street: North-South

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		0	2	0	0	0	1	0	0	0	1	1
Configuration						LT		TR		LT					T	R
Volume (veh/h)						30	173	44		90	752				128	207
Percent Heavy Vehicles (%)						10	10	10		1						
Proportion Time Blocked																
Percent Grade (%)						0										
Right Turn Channelized														Yes		
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)						7.1	6.5	6.2		4.1						
Critical Headway (sec)						7.20	6.60	6.30		4.11						
Base Follow-Up Headway (sec)						3.5	4.0	3.3		2.2						
Follow-Up Headway (sec)						3.59	4.09	3.39		2.21						

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						139		155		107						
Capacity, c (veh/h)						133		172		1434						
v/c Ratio						1.04		0.90		0.07						
95% Queue Length, Q_{95} (veh)						15.8		11.6		0.2						
Control Delay (s/veh)						295.8		141.5		7.7	1.2					
Level of Service (LOS)						F		F		A	A					
Approach Delay (s/veh)						214.3				1.9						
Approach LOS						F				A						

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HCS Two-Way Stop-Control Report

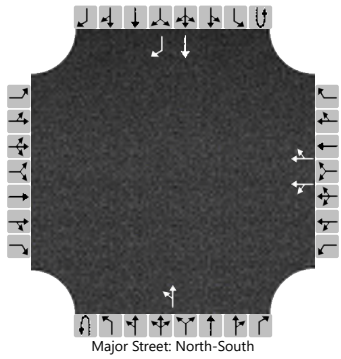
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	PM Peak
Intersection Orientation	North-South
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes


Major Street: North-South

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		0	2	0	0	0	1	0	0	0	1	1
Configuration						LT		TR		LT					T	R
Volume (veh/h)						29	135	21		38	356				93	273
Percent Heavy Vehicles (%)						10	10	10		1						
Proportion Time Blocked																
Percent Grade (%)						0										
Right Turn Channelized														Yes		
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						7.1	6.5	6.2		4.1						
Critical Headway (sec)						7.20	6.60	6.30		4.11						
Base Follow-Up Headway (sec)						3.5	4.0	3.3		2.2						
Follow-Up Headway (sec)						3.59	4.09	3.39		2.21						

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						115		105		45						
Capacity, c (veh/h)						374		413		1486						
v/c Ratio						0.31		0.25		0.03						
95% Queue Length, Q_{95} (veh)						1.3		1.0		0.1						
Control Delay (s/veh)						18.9		16.7		7.5	0.3					
Level of Service (LOS)						C		C		A	A					
Approach Delay (s/veh)						17.8				1.0						
Approach LOS						C				A						

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HCS Two-Way Stop-Control Report

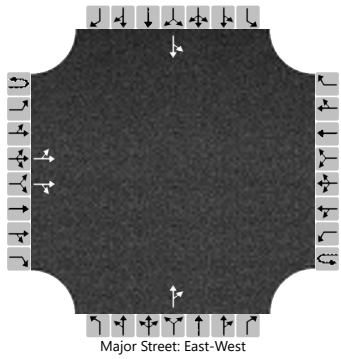
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes


Major Street: East-West

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	2	0	0	0	0	0		0	1	0		0	1	0
Configuration		LT		TR								TR		LT		
Volume (veh/h)		650	335	16							190	59		62	96	
Percent Heavy Vehicles (%)		4									1	1		5	5	
Proportion Time Blocked																
Percent Grade (%)									0				0			
Right Turn Channelized																
Median Type | Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)		5.3									6.5	6.9		7.5	6.5	
Critical Headway (sec)		5.38									6.52	6.92		7.60	6.60	
Base Follow-Up Headway (sec)		3.1									4.0	3.3		3.5	4.0	
Follow-Up Headway (sec)		3.14									4.01	3.31		3.55	4.05	

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		774										296		188		
Capacity, c (veh/h)		1146										19		13		
v/c Ratio		0.67										15.26		14.20		
95% Queue Length, Q_{95} (veh)		6.0										141.6		90.5		
Control Delay (s/veh)		14.6	2.3									26052.6		24320.7		
Level of Service (LOS)		B	A									F		F		
Approach Delay (s/veh)	10.2								26052.6				24320.7			
Approach LOS	B								F				F			

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HCS Two-Way Stop-Control Report

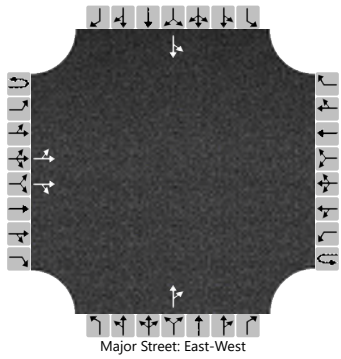
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	2	0	0	0	0	0		0	1	0		0	1	0
Configuration		LT		TR								TR		LT		
Volume (veh/h)		306	150	152							87	22		22	100	
Percent Heavy Vehicles (%)		4									1	1		5	5	
Proportion Time Blocked																
Percent Grade (%)											0				0	
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		5.3									6.5	6.9		7.5	6.5	
Critical Headway (sec)		5.38									6.52	6.92		7.60	6.60	
Base Follow-Up Headway (sec)		3.1									4.0	3.3		3.5	4.0	
Follow-Up Headway (sec)		3.14									4.01	3.31		3.55	4.05	

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		364										130		145		
Capacity, c (veh/h)		1146										189		109		
v/c Ratio		0.32										0.69		1.33		
95% Queue Length, Q_{95} (veh)		1.4										5.6		26.4		
Control Delay (s/veh)		9.6	0.7									63.5		747.2		
Level of Service (LOS)		A	A									F		F		
Approach Delay (s/veh)		5.0								63.5				747.2		
Approach LOS		A								F				F		

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HCS Two-Way Stop-Control Report

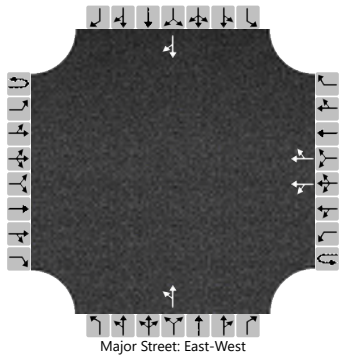
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	0	0	0	0	2	0		0	1	0		0	1	0
Configuration						LT		TR		LT						TR
Volume (veh/h)						107	454	7		179	28				37	17
Percent Heavy Vehicles (%)						5				4	4				3	3
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						5.3				7.5	6.5				6.5	6.9
Critical Headway (sec)						5.40				7.58	6.58				6.56	6.96
Base Follow-Up Headway (sec)						3.1				3.5	4.0				4.0	3.3
Follow-Up Headway (sec)						3.15				3.54	4.04				4.03	3.33

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						122				235						61
Capacity, c (veh/h)						1143				314						358
v/c Ratio						0.11				0.75						0.17
95% Queue Length, Q_{95} (veh)						0.4				7.5						0.6
Control Delay (s/veh)						8.5	0.7			48.4						17.2
Level of Service (LOS)						A	A			E						C
Approach Delay (s/veh)						2.2				48.4				17.2		
Approach LOS						A				E				C		

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HCS Two-Way Stop-Control Report

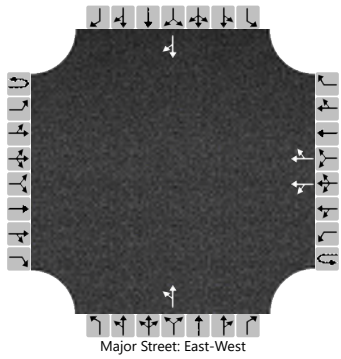
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	0	0	0	0	2	0		0	1	0		0	1	0
Configuration						LT		TR		LT						TR
Volume (veh/h)						209	605	4		118	34				18	11
Percent Heavy Vehicles (%)						5				4	4				3	3
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)						5.3				7.5	6.5				6.5	6.9
Critical Headway (sec)						5.40				7.58	6.58				6.56	6.96
Base Follow-Up Headway (sec)						3.1				3.5	4.0				4.0	3.3
Follow-Up Headway (sec)						3.15				3.54	4.04				4.03	3.33

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						222				162						31
Capacity, c (veh/h)						1143				184						227
v/c Ratio						0.19				0.88						0.14
95% Queue Length, Q_{95} (veh)						0.7				11.0						0.5
Control Delay (s/veh)						8.9	1.3			123.8						23.4
Level of Service (LOS)						A	A			F						C
Approach Delay (s/veh)					3.2				123.8				23.4			
Approach LOS					A				F				C			

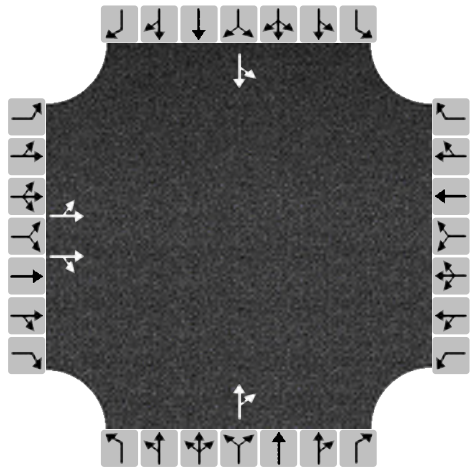
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	5	702	64					197	314	12	111	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	405	472					581			140		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.360	0.419					0.516			0.124		
Final Departure Headway, h_d (s)	6.73	6.61					5.79			7.02		
Final Degree of Utilization, x	0.756	0.866					0.934			0.273		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	4.43	4.31					3.79			5.02		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	405	472					581			140		
Capacity (veh/h)	535	544					622			513		
95% Queue Length, Q_{95} (veh)	8.3	14.0					20.9			1.1		
Control Delay (s/veh)	29.4	46.4					64.3			12.7		
Level of Service, LOS	D	E					F			B		
Approach Delay (s/veh) | LOS	38.6	E					64.3	F		12.7	B	
Intersection Delay (s/veh) | LOS	45.7						E					

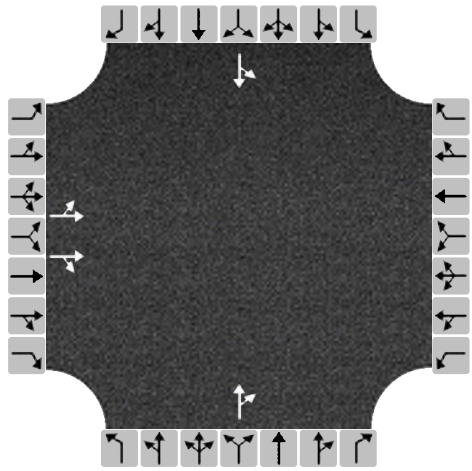
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	20	475	205					132	138	5	206	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	274	471					287			224		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.243	0.418					0.255			0.200		
Final Departure Headway, h_d (s)	6.12	5.75					5.79			6.18		
Final Degree of Utilization, x	0.466	0.752					0.462			0.385		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.82	3.45					3.79			4.18		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	274	471					287			224		
Capacity (veh/h)	588	626					622			582		
95% Queue Length, Q_{95} (veh)	2.6	8.2					2.5			1.9		
Control Delay (s/veh)	14.1	25.3					13.7			13.0		
Level of Service, LOS	B	D					B			B		
Approach Delay (s/veh) | LOS	21.2	C					13.7	B		13.0	B	
Intersection Delay (s/veh) | LOS	18.0						C					

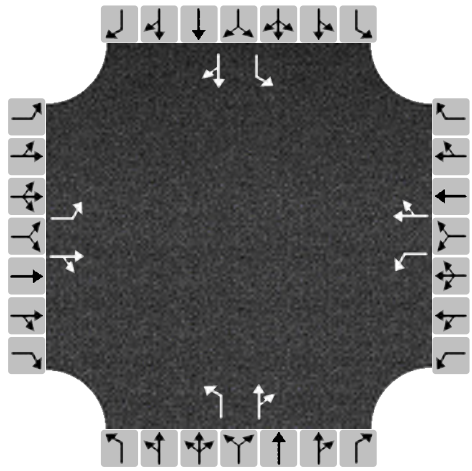
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	Radar Hill Rd and Long View Dr
Jurisdiction	Box Elder, SD
East/West Street	Radar Hill Rd
North/South Street	Long View Dr
Peak Hour Factor	0.90

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	80	7	2	6	18	10	2	26	4	4	41	116
% Thrus in Shared Lane												

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	89	10		7	31		2	33		4	174	
Percent Heavy Vehicles	3	3		49	49		14	14		5	5	
Initial Departure Headway, h_d (s)	3.20	3.20		3.20	3.20		3.20	3.20		3.20	3.20	
Initial Degree of Utilization, x	0.079	0.009		0.006	0.028		0.002	0.030		0.004	0.155	
Final Departure Headway, h_d (s)	5.59	4.93		6.43	5.68		5.76	5.16		5.50	4.48	
Final Degree of Utilization, x	0.138	0.014		0.012	0.049		0.004	0.048		0.007	0.217	
Move-Up Time, m (s)	2.3	2.3		2.3	2.3		2.3	2.3		2.3	2.3	
Service Time, t_s (s)	3.29	2.63		4.13	3.38		3.46	2.86		3.20	2.18	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	89	10		7	31		2	33		4	174	
Capacity (veh/h)	644	730		560	634		625	697		655	803	
95% Queue Length, Q_{95} (veh)	0.5	0.0		0.0	0.2		0.0	0.2		0.0	0.8	
Control Delay (s/veh)	9.2	7.7		9.2	8.7		8.5	8.1		8.2	8.4	
Level of Service, LOS	A	A		A	A		A	A		A	A	
Approach Delay (s/veh) | LOS	9.0	A		8.8	A		8.1	A		8.4	A	
Intersection Delay (s/veh) | LOS	8.6						A					

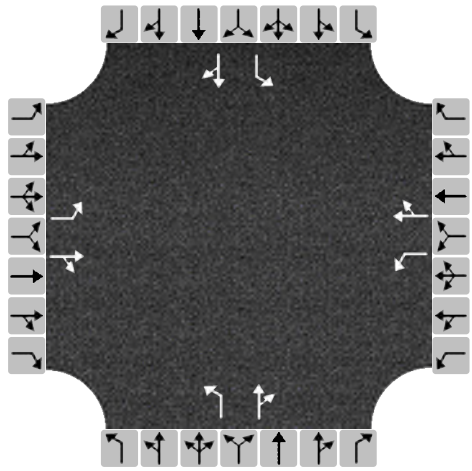
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	Radar Hill Rd and Long View Dr
Jurisdiction	Box Elder, SD
East/West Street	Radar Hill Rd
North/South Street	Long View Dr
Peak Hour Factor	0.95

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	145	12	2	3	7	5	2	50	5	8	40	122
% Thrus in Shared Lane												

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	153	15		3	13		2	58		8	171	
Percent Heavy Vehicles	3	3		49	49		14	14		5	5	
Initial Departure Headway, h_d (s)	3.20	3.20		3.20	3.20		3.20	3.20		3.20	3.20	
Initial Degree of Utilization, x	0.136	0.013		0.003	0.011		0.002	0.051		0.007	0.152	
Final Departure Headway, h_d (s)	5.64	5.04		6.58	5.79		5.91	5.34		5.66	4.63	
Final Degree of Utilization, x	0.239	0.021		0.006	0.020		0.003	0.086		0.013	0.219	
Move-Up Time, m (s)	2.3	2.3		2.3	2.3		2.3	2.3		2.3	2.3	
Service Time, t_s (s)	3.34	2.74		4.28	3.49		3.61	3.04		3.36	2.33	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	153	15		3	13		2	58		8	171	
Capacity (veh/h)	638	714		547	622		610	674		636	777	
95% Queue Length, Q_{95} (veh)	0.9	0.1		0.0	0.1		0.0	0.3		0.0	0.8	
Control Delay (s/veh)	10.1	7.8		9.3	8.6		8.6	8.5		8.4	8.6	
Level of Service, LOS	B	A		A	A		A	A		A	A	
Approach Delay (s/veh) | LOS	9.9	A		8.8	A		8.5	A		8.6	A	
Intersection Delay (s/veh) | LOS	9.1						A					

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HCS Two-Way Stop-Control Report

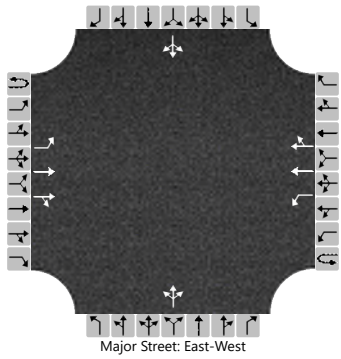
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Radar Hill Rd and Highway 44
Jurisdiction	Box Elder, SD
East/West Street	Highway 44
North/South Street	Radar Hill Rd
Peak Hour Factor	0.86
Analysis Time Period (hrs)	1.00

Lanes


Major Street: East-West

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	2	0	0	1	2	0		0	1	0		0	1	0
Configuration		L	T	TR		L	T	TR			LTR				LTR	
Volume (veh/h)	0	16	232	6	0	3	221	19		5	2	2		21	3	11
Percent Heavy Vehicles (%)	5	5			3	3				6	6	6		10	10	10
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.5	6.5	6.9		7.5	6.5	6.9
Critical Headway (sec)		4.20				4.16				7.62	6.62	7.02		7.70	6.70	7.10
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.25				2.23				3.56	4.06	3.36		3.60	4.10	3.40

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		19				3					10				41	
Capacity, c (veh/h)		1259				1276					494				531	
v/c Ratio		0.01				0.00					0.02				0.08	
95% Queue Length, Q_{95} (veh)		0.0				0.0					0.1				0.2	
Control Delay (s/veh)		7.9				7.8					12.5				12.3	
Level of Service (LOS)		A				A					B				B	
Approach Delay (s/veh)	0.5				0.1				12.5				12.3			
Approach LOS	A				A				B				B			

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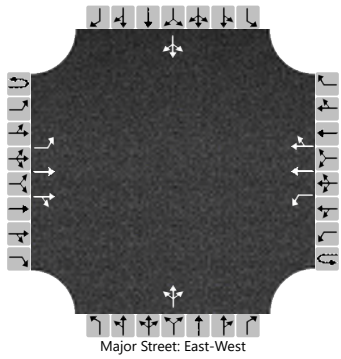
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/28/2023
Analysis Year	2030
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Radar Hill Rd and Highway 44
Jurisdiction	Box Elder, SD
East/West Street	Highway 44
North/South Street	Radar Hill Rd
Peak Hour Factor	0.85
Analysis Time Period (hrs)	1.00

Lanes


Major Street: East-West

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	2	0	0	1	2	0		0	1	0		0	1	0
Configuration		L	T	TR		L	T	TR			LTR				LTR	
Volume (veh/h)	0	42	141	13	0	2	236	26		7	2	2		25	8	26
Percent Heavy Vehicles (%)	5	5			3	3				6	6	6		10	10	10
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.5	6.5	6.9		7.5	6.5	6.9
Critical Headway (sec)		4.20				4.16				7.62	6.62	7.02		7.70	6.70	7.10
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.25				2.23				3.56	4.06	3.36		3.60	4.10	3.40

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		49				2					13				69	
Capacity, c (veh/h)		1228				1384					481				534	
v/c Ratio		0.04				0.00					0.03				0.13	
95% Queue Length, Q_{95} (veh)		0.1				0.0					0.1				0.4	
Control Delay (s/veh)		8.1				7.6					12.7				12.8	
Level of Service (LOS)		A				A					B				B	
Approach Delay (s/veh)	1.7				0.1				12.7				12.8			
Approach LOS	A				A				B				B			

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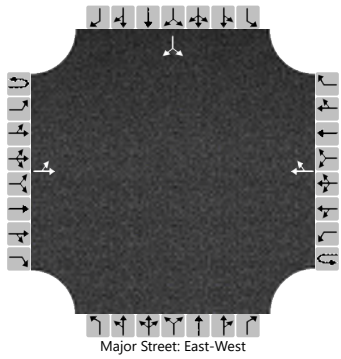
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and 151st Ave
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	151st Ave
Peak Hour Factor	0.76
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		180	44				108	20						11		151
Percent Heavy Vehicles (%)		9												16		16
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.19												6.56		6.36
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.28												3.64		3.44

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		237													213	
Capacity, c (veh/h)		1368													769	
v/c Ratio		0.17													0.28	
95% Queue Length, Q_{95} (veh)		0.6													1.1	
Control Delay (s/veh)		8.2	1.5												11.5	
Level of Service (LOS)		A	A												B	
Approach Delay (s/veh)		6.9												11.5		
Approach LOS		A												B		

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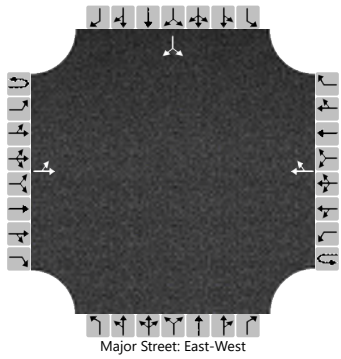
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and 151st Ave
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	151st Ave
Peak Hour Factor	0.83
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	1	0	0	0	1	0		0	0	0		0	1	0
Configuration		LT						TR							LR	
Volume (veh/h)		97	95				57	5						6		67
Percent Heavy Vehicles (%)		9												16		16
Proportion Time Blocked																
Percent Grade (%)														0		
Right Turn Channelized																
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1												7.1		6.2
Critical Headway (sec)		4.19												6.56		6.36
Base Follow-Up Headway (sec)		2.2												3.5		3.3
Follow-Up Headway (sec)		2.28												3.64		3.44

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		117													88	
Capacity, c (veh/h)		1481													891	
v/c Ratio		0.08													0.10	
95% Queue Length, Q_{95} (veh)		0.3													0.3	
Control Delay (s/veh)		7.6	0.6												9.5	
Level of Service (LOS)		A	A												A	
Approach Delay (s/veh)		4.2												9.5		
Approach LOS		A												A		

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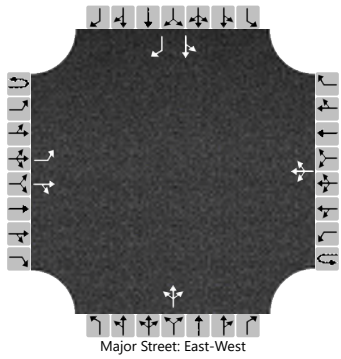
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and Liberty Blvd
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	Liberty Blvd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes


Major Street: East-West

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	1	0	0	0	1	0		0	1	0		0	1	1
Configuration		L		TR			LTR				LTR			LT		R
Volume (veh/h)		333	151	3		7	91	178		4	52	10		61	19	142
Percent Heavy Vehicles (%)		8				7				2	2	2		9	9	9
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized														Yes		
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.1	6.5	6.2		7.1	6.5	6.2
Critical Headway (sec)		4.18				4.17				7.12	6.52	6.22		7.19	6.59	6.29
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.27				2.26				3.52	4.02	3.32		3.58	4.08	3.38

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		396				8					79			95		169
Capacity, c (veh/h)		1207				1362					116			58		808
v/c Ratio		0.33				0.01					0.67			1.65		0.21
95% Queue Length, Q_{95} (veh)		1.5				0.0					4.9			24.6		0.8
Control Delay (s/veh)		9.4				7.7	0.1	0.1			94.3			1387.3		10.6
Level of Service (LOS)		A				A	A	A			F			F		B
Approach Delay (s/veh)	6.5				0.3				94.3				506.7			
Approach LOS	A				A				F				F			

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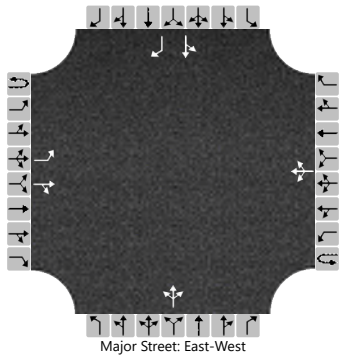
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Highway 1416 and Liberty Blvd
Jurisdiction	Box Elder, SD
East/West Street	Highway 1416
North/South Street	Liberty Blvd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes


Major Street: East-West

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	1	0	0	0	1	0		0	1	0		0	1	1
Configuration		L		TR			LTR				LTR			LT		R
Volume (veh/h)		99	86	13		7	66	69		8	16	2		131	27	110
Percent Heavy Vehicles (%)		8				7				2	2	2		9	9	9
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized														Yes		
Median Type | Storage		Undivided														

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.1	6.5	6.2		7.1	6.5	6.2
Critical Headway (sec)		4.18				4.17				7.12	6.52	6.22		7.19	6.59	6.29
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.27				2.26				3.52	4.02	3.32		3.58	4.08	3.38

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		118				8					31			188		131
Capacity, c (veh/h)		1383				1440					395			415		913
v/c Ratio		0.09				0.01					0.08			0.45		0.14
95% Queue Length, Q_{95} (veh)		0.3				0.0					0.3			2.4		0.5
Control Delay (s/veh)		7.8				7.5	0.0	0.0			14.9			20.8		9.6
Level of Service (LOS)		A				A	A	A			B			C		A
Approach Delay (s/veh)	3.9				0.4				14.9				16.2			
Approach LOS	A				A				B				C			

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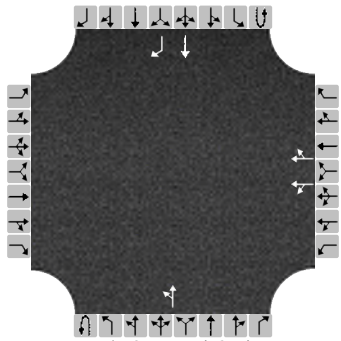
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	AM Peak
Intersection Orientation	North-South
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes


Major Street: North-South

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		0	2	0	0	0	1	0	0	0	1	1
Configuration						LT		TR		LT					T	R
Volume (veh/h)						30	182	47		102	868				132	248
Percent Heavy Vehicles (%)						10	10	10		1						
Proportion Time Blocked																
Percent Grade (%)						0										
Right Turn Channelized														Yes		
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						7.1	6.5	6.2		4.1						
Critical Headway (sec)						7.20	6.60	6.30		4.11						
Base Follow-Up Headway (sec)						3.5	4.0	3.3		2.2						
Follow-Up Headway (sec)						3.59	4.09	3.39		2.21						

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						144		164		121						
Capacity, c (veh/h)						97		130		1429						
v/c Ratio						1.48		1.27		0.08						
95% Queue Length, Q_{95} (veh)						30.5		26.6		0.3						
Control Delay (s/veh)						1010.7		620.4		7.8	1.6					
Level of Service (LOS)						F		F		A	A					
Approach Delay (s/veh)						802.8				2.3						
Approach LOS						F				A						

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HCS Two-Way Stop-Control Report

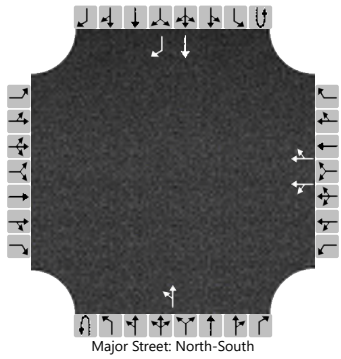
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	PM Peak
Intersection Orientation	North-South
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90
Analysis Time Period (hrs)	1.00

Lanes



Major Street: North-South

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6
Number of Lanes		0	0	0		0	2	0	0	0	1	0	0	0	1	1
Configuration						LT		TR		LT					T	R
Volume (veh/h)						32	150	22		43	413				104	327
Percent Heavy Vehicles (%)						10	10	10		1						
Proportion Time Blocked																
Percent Grade (%)						0										
Right Turn Channelized														Yes		
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)						7.1	6.5	6.2		4.1						
Critical Headway (sec)						7.20	6.60	6.30		4.11						
Base Follow-Up Headway (sec)						3.5	4.0	3.3		2.2						
Follow-Up Headway (sec)						3.59	4.09	3.39		2.21						

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						119		108		48						
Capacity, c (veh/h)						350		387		1480						
v/c Ratio						0.34		0.28		0.03						
95% Queue Length, Q_{95} (veh)						1.5		1.1		0.1						
Control Delay (s/veh)						20.6		17.9		7.5	0.3					
Level of Service (LOS)						C		C		A	A					
Approach Delay (s/veh)						19.3				1.0						
Approach LOS						C				A						

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HCS Two-Way Stop-Control Report

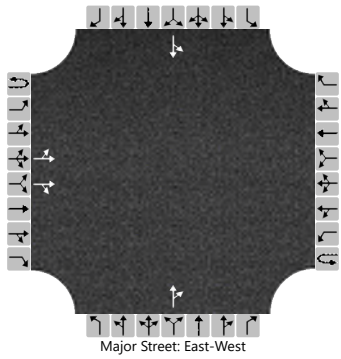
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	2	0	0	0	0	0		0	1	0		0	1	0
Configuration		LT		TR								TR		LT		
Volume (veh/h)		748	356	19							209	60		63	98	
Percent Heavy Vehicles (%)		4									1	1		5	5	
Proportion Time Blocked																
Percent Grade (%)											0				0	
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		5.3									6.5	6.9		7.5	6.5	
Critical Headway (sec)		5.38									6.52	6.92		7.60	6.60	
Base Follow-Up Headway (sec)		3.1									4.0	3.3		3.5	4.0	
Follow-Up Headway (sec)		3.14									4.01	3.31		3.55	4.05	

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		890										320		192		
Capacity, c (veh/h)		1146										6		4		
v/c Ratio		0.78										51.91		50.64		
95% Queue Length, Q_{95} (veh)		9.7										160.0		96.9		
Control Delay (s/veh)		18.8	3.2									92815.6		91259.1		
Level of Service (LOS)		C	A									F		F		
Approach Delay (s/veh)		13.5								92815.6				91259.1		
Approach LOS		B								F				F		

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HCS Two-Way Stop-Control Report

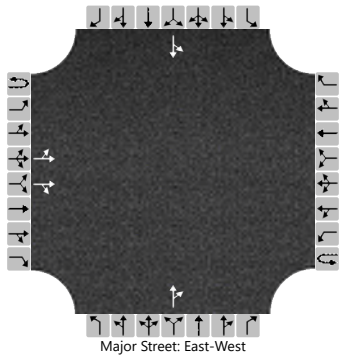
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	2	0	0	0	0	0		0	1	0		0	1	0
Configuration		LT		TR								TR		LT		
Volume (veh/h)		352	165	178							96	23		23	109	
Percent Heavy Vehicles (%)		4									1	1		5	5	
Proportion Time Blocked																
Percent Grade (%)											0				0	
Right Turn Channelized																
Median Type | Storage				Undivided												

Critical and Follow-up Headways

Base Critical Headway (sec)		5.3									6.5	6.9		7.5	6.5	
Critical Headway (sec)		5.38									6.52	6.92		7.60	6.60	
Base Follow-Up Headway (sec)		3.1									4.0	3.3		3.5	4.0	
Follow-Up Headway (sec)		3.14									4.01	3.31		3.55	4.05	

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		391										132		147		
Capacity, c (veh/h)		1146										164		83		
v/c Ratio		0.34										0.81		1.76		
95% Queue Length, Q_{95} (veh)		1.5										8.2		37.6		
Control Delay (s/veh)		9.8	0.7									102.1		1513.9		
Level of Service (LOS)		A	A									F		F		
Approach Delay (s/veh)		5.1									102.1			1513.9		
Approach LOS		A									F			F		

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HCS Two-Way Stop-Control Report

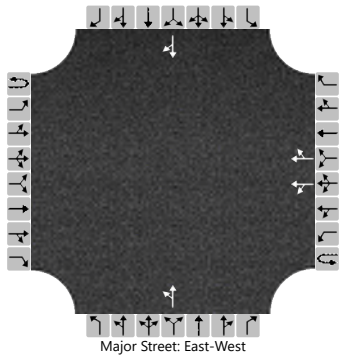
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	0	0	0	0	2	0		0	1	0		0	1	0
Configuration						LT		TR		LT						TR
Volume (veh/h)						120	512	8		202	28				40	19
Percent Heavy Vehicles (%)						5				4	4				3	3
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						5.3				7.5	6.5				6.5	6.9
Critical Headway (sec)						5.40				7.58	6.58				6.56	6.96
Base Follow-Up Headway (sec)						3.1				3.5	4.0				4.0	3.3
Follow-Up Headway (sec)						3.15				3.54	4.04				4.03	3.33

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						136				261						67
Capacity, c (veh/h)						1143				266						314
v/c Ratio						0.12				0.98						0.21
95% Queue Length, Q_{95} (veh)						0.4				18.6						0.8
Control Delay (s/veh)						8.6	0.8			158.0						19.6
Level of Service (LOS)						A	A			F						C
Approach Delay (s/veh)					2.3				158.0				19.6			
Approach LOS					A				F				C			

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HCS Two-Way Stop-Control Report

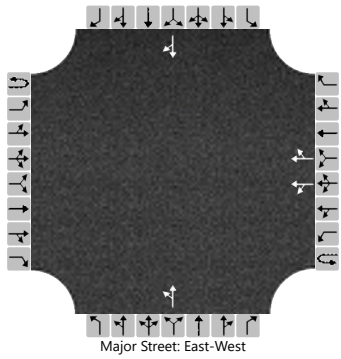
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	0	0	0	0	0	2	0		0	1	0		0	1	0
Configuration						LT		TR		LT						TR
Volume (veh/h)						237	697	4		134	38				20	12
Percent Heavy Vehicles (%)						5				4	4				3	3
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage						Undivided										

Critical and Follow-up Headways

Base Critical Headway (sec)						5.3				7.5	6.5				6.5	6.9
Critical Headway (sec)						5.40				7.58	6.58				6.56	6.96
Base Follow-Up Headway (sec)						3.1				3.5	4.0				4.0	3.3
Follow-Up Headway (sec)						3.15				3.54	4.04				4.03	3.33

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)						252				183						34
Capacity, c (veh/h)						1143				138						176
v/c Ratio						0.22				1.32						0.19
95% Queue Length, Q_{95} (veh)						0.8				31.1						0.7
Control Delay (s/veh)						9.0	1.5			703.8						30.4
Level of Service (LOS)						A	A			F						D
Approach Delay (s/veh)					3.4				703.8				30.4			
Approach LOS					A				F				D			

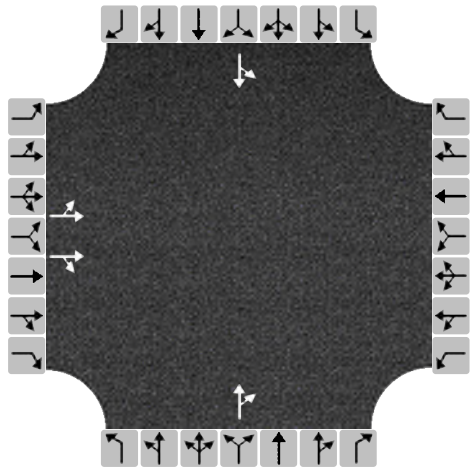
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.86

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	5	794	73					220	356	13	123	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	467	547					670			158		
Percent Heavy Vehicles	3	3					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.416	0.486					0.595			0.141		
Final Departure Headway, h_d (s)	6.81	6.69					5.83			7.04		
Final Degree of Utilization, x	0.884	1.016					1.084			0.309		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	4.51	4.39					3.83			5.04		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	467	547					670			158		
Capacity (veh/h)	529	538					618			511		
95% Queue Length, Q_{95} (veh)	15.2	30.8					47.3			1.3		
Control Delay (s/veh)	52.4	135.1					215.6			13.2		
Level of Service, LOS	F	F					F			B		
Approach Delay (s/veh) | LOS	97.0	F					215.6	F		13.2	B	
Intersection Delay (s/veh) | LOS	132.9						F					

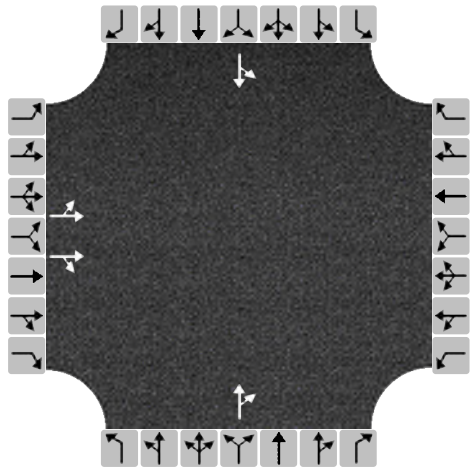
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.85

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	23	545	239					148	158	5	232	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	348	602					360			279		
Percent Heavy Vehicles	3	3					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.309	0.535					0.320			0.248		
Final Departure Headway, h_d (s)	6.58	6.21					6.14			6.57		
Final Degree of Utilization, x	0.636	1.038					0.614			0.509		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	4.28	3.91					4.14			4.57		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	348	602					360			279		
Capacity (veh/h)	547	579					586			548		
95% Queue Length, Q_{95} (veh)	5.0	36.1					4.6			3.0		
Control Delay (s/veh)	20.6	156.7					18.8			16.3		
Level of Service, LOS	C	F					C			C		
Approach Delay (s/veh) | LOS	106.9	F					18.8	C		16.3	C	
Intersection Delay (s/veh) | LOS	71.0						F					

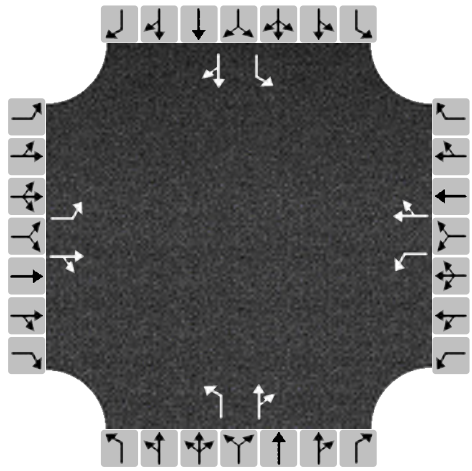
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	Radar Hill Rd and Long View Dr
Jurisdiction	Box Elder, SD
East/West Street	Long View Dr
North/South Street	Radar Hill Rd
Peak Hour Factor	0.90

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	114	10	2	7	25	12	2	32	4	4	50	166
% Thrus in Shared Lane												

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	127	13		8	41		2	40		4	240	
Percent Heavy Vehicles	3	3		49	49		14	14		5	5	
Initial Departure Headway, h_d (s)	3.20	3.20		3.20	3.20		3.20	3.20		3.20	3.20	
Initial Degree of Utilization, x	0.113	0.012		0.007	0.037		0.002	0.036		0.004	0.213	
Final Departure Headway, h_d (s)	5.79	5.17		6.67	5.94		5.99	5.41		5.67	4.63	
Final Degree of Utilization, x	0.204	0.019		0.014	0.068		0.004	0.060		0.007	0.309	
Move-Up Time, m (s)	2.3	2.3		2.3	2.3		2.3	2.3		2.3	2.3	
Service Time, t_s (s)	3.49	2.87		4.37	3.64		3.69	3.11		3.37	2.33	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	127	13		8	41		2	40		4	240	
Capacity (veh/h)	622	696		540	606		601	665		635	778	
95% Queue Length, Q_{95} (veh)	0.8	0.1		0.0	0.2		0.0	0.2		0.0	1.3	
Control Delay (s/veh)	10.0	8.0		9.5	9.1		8.7	8.5		8.4	9.4	
Level of Service, LOS	A	A		A	A		A	A		A	A	
Approach Delay (s/veh) | LOS	9.8	A		9.1	A		8.5	A		9.4	A	
Intersection Delay (s/veh) | LOS	9.4						A					

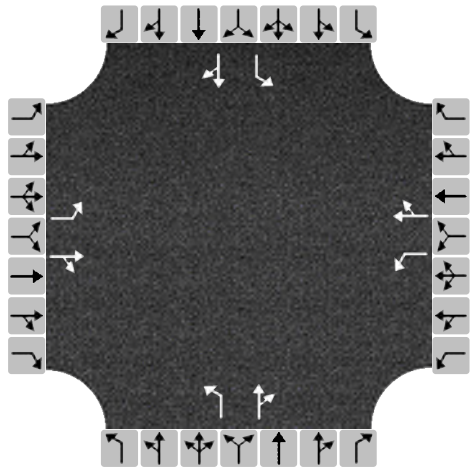
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study
Intersection	Radar Hill Rd and Long View Dr
Jurisdiction	Box Elder, SD
East/West Street	Long View Dr
North/South Street	Radar Hill Rd
Peak Hour Factor	0.85

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	50	169	16	2	283	31	8	2	2	30	9	31
% Thrus in Shared Lane												

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	59	218		2	369		9	5		35	47	
Percent Heavy Vehicles	3	3		49	49		14	14		5	5	
Initial Departure Headway, h_d (s)	3.20	3.20		3.20	3.20		3.20	3.20		3.20	3.20	
Initial Degree of Utilization, x	0.052	0.193		0.002	0.328		0.008	0.004		0.031	0.042	
Final Departure Headway, h_d (s)	5.70	5.14		6.38	5.81		7.01	6.16		6.74	5.70	
Final Degree of Utilization, x	0.093	0.311		0.004	0.596		0.018	0.008		0.066	0.074	
Move-Up Time, m (s)	2.3	2.3		2.3	2.3		2.3	2.3		2.3	2.3	
Service Time, t_s (s)	3.40	2.84		4.08	3.51		4.71	3.86		4.44	3.40	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	L	TR		L	TR		L	TR		L	TR	
Flow Rate, v (veh/h)	59	218		2	369		9	5		35	47	
Capacity (veh/h)	632	701		565	620		513	584		534	632	
95% Queue Length, Q_{95} (veh)	0.3	1.3		0.0	4.3		0.1	0.0		0.2	0.2	
Control Delay (s/veh)	9.0	10.1		9.1	17.0		9.8	8.9		9.9	8.9	
Level of Service, LOS	A	B		A	C		A	A		A	A	
Approach Delay (s/veh) | LOS	9.9	A		16.9	C		9.5	A		9.3	A	
Intersection Delay (s/veh) | LOS	13.3						B					

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HCS Two-Way Stop-Control Report

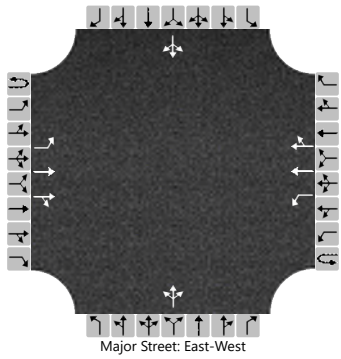
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	AM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Radar Hill Rd and Highway 44
Jurisdiction	Box Elder, SD
East/West Street	Highway 44
North/South Street	Radar Hill Rd
Peak Hour Factor	0.86
Analysis Time Period (hrs)	1.00

Lanes


Major Street: East-West

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	2	0	0	1	2	0		0	1	0		0	1	0
Configuration		L	T	TR		L	T	TR			LTR				LTR	
Volume (veh/h)	0	20	278	7	0	3	265	22		6	2	2		25	3	13
Percent Heavy Vehicles (%)	5	5			3	3				6	6	6		10	10	10
Proportion Time Blocked																
Percent Grade (%)										0				0		
Right Turn Channelized																
Median Type | Storage			Undivided													

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.5	6.5	6.9		7.5	6.5	6.9
Critical Headway (sec)		4.20				4.16				7.62	6.62	7.02		7.70	6.70	7.10
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.25				2.23				3.56	4.06	3.36		3.60	4.10	3.40

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		23				3					12				48	
Capacity, c (veh/h)		1201				1218					422				465	
v/c Ratio		0.02				0.00					0.03				0.10	
95% Queue Length, Q_{95} (veh)		0.1				0.0					0.1				0.3	
Control Delay (s/veh)		8.1				8.0					13.8				13.6	
Level of Service (LOS)		A				A					B				B	
Approach Delay (s/veh)	0.5				0.1				13.8				13.6			
Approach LOS	A				A				B				B			

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HCS Two-Way Stop-Control Report

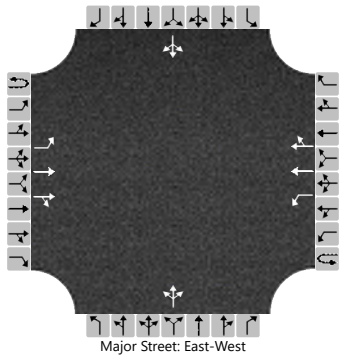
General Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	7/30/2023
Analysis Year	2050
Time Analyzed	PM Peak
Intersection Orientation	East-West
Project Description	Radar Hill 1416 Corridor Study

Site Information

Intersection	Radar Hill Rd and Highway 44
Jurisdiction	Box Elder, SD
East/West Street	Highway 44
North/South Street	Radar Hill Rd
Peak Hour Factor	0.85
Analysis Time Period (hrs)	1.00

Lanes



Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Priority	1U	1	2	3	4U	4	5	6		7	8	9		10	11	12
Number of Lanes	0	1	2	0	0	1	2	0		0	1	0		0	1	0
Configuration		L	T	TR		L	T	TR			LTR				LTR	
Volume (veh/h)	0	50	169	16	0	2	283	31		8	2	2		30	9	31
Percent Heavy Vehicles (%)	5	5			3	3				6	6	6		10	10	10
Proportion Time Blocked																
Percent Grade (%)									0				0			
Right Turn Channelized																
Median Type | Storage	Undivided															

Critical and Follow-up Headways

Base Critical Headway (sec)		4.1				4.1				7.5	6.5	6.9		7.5	6.5	6.9
Critical Headway (sec)		4.20				4.16				7.62	6.62	7.02		7.70	6.70	7.10
Base Follow-Up Headway (sec)		2.2				2.2				3.5	4.0	3.3		3.5	4.0	3.3
Follow-Up Headway (sec)		2.25				2.23				3.56	4.06	3.36		3.60	4.10	3.40

Delay, Queue Length, and Level of Service

Flow Rate, v (veh/h)		59				2					14				82	
Capacity, c (veh/h)		1164				1342					409				466	
v/c Ratio		0.05				0.00					0.03				0.18	
95% Queue Length, Q_{95} (veh)		0.2				0.0					0.1				0.6	
Control Delay (s/veh)		8.3				7.7					14.1				14.4	
Level of Service (LOS)		A				A					B				B	
Approach Delay (s/veh)	1.8				0.0				14.1				14.4			
Approach LOS	A				A				B				B			

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Appendix E: Signal Warrant Analysis Results

Radar Hill 1416 Corridor Study **No-Build (2030)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Liberty Blvd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	50	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB Liberty Blvd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB Liberty Blvd	45	2	100%

Warrants Analysis

Time of Day	Major #1	Major #3	Total 1+3	Major 1A/1B 420/630	Minor #2	Minor #2 1A/1B 140/070	Minor #4	Minor #4 1A/1B 140/070	Both Met 1A/1B	Crash Warrant	MWSA Warrant
6:00 - 7:00	89	117	206	/	20	/	50	/	/		
7:00 - 8:00	485	247	732	X/X	68	/	213	X/X	**X/X**	**X**	**X**
8:00 - 9:00	66	89	155	/	17	/	60	/	**/**		
9:00 - 10:00	70	57	127	/	19	/	63	/	**/**		
10:00 - 11:00	46	33	79	/	12	/	47	/	**/**		
11:00 - 12:00	82	62	144	/	15	/	70	/	**/**		
12:00 - 1:00	100	64	164	/	12	/	74	/X	**/**		
1:00 - 2:00	91	65	156	/	21	/	108	/X	**/**		
2:00 - 3:00	94	66	160	/	24	/	92	/X	**/**		
3:00 - 4:00	177	119	296	/	31	/	217	X/X	**/**		**X**
4:00 - 5:00	134	85	219	/	18	/	163	X/X	**/**		**X**
5:00 - 6:00	132	96	228	/	26	/	179	X/X	**/**		**X**
6:00 - 7:00	63	34	97	/	14	/	53	/	**/**		
7:00 - 8:00	66	52	118	/	14	/	60	/	**/**		
8:00 - 9:00	48	37	85	/	10	/	43	/	**/**		
9:00 - 10:00	31	24	55	/	7	/	28	/	**/**		

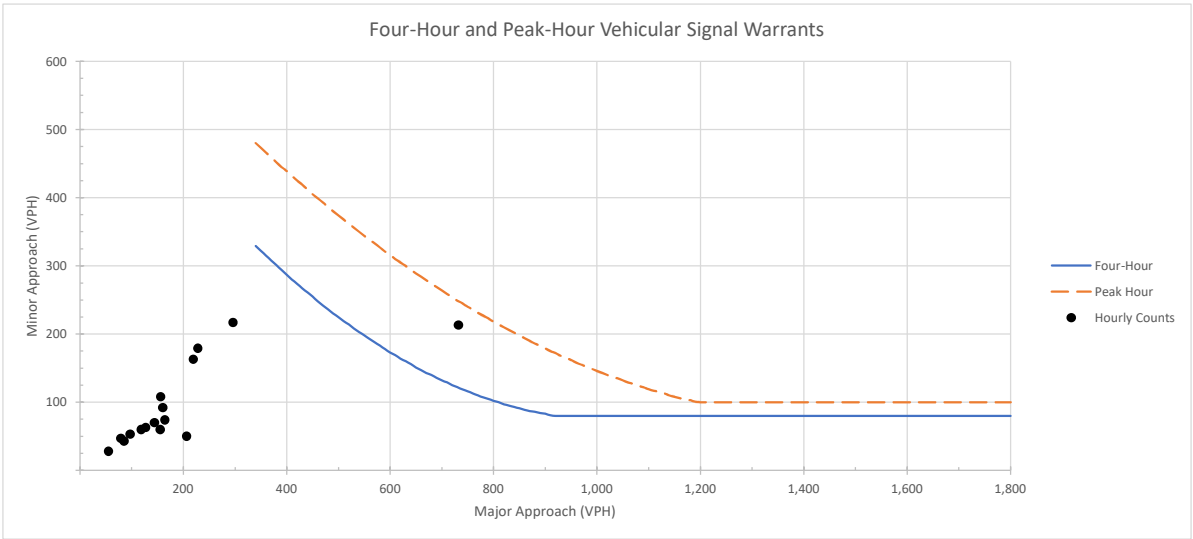
Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 1a: Minimum Vehicular Volume	1	8	Not Met
Warrant 1b: Interruption of Continuous Traffic	1	8	Not Met
Warrant 2: Four-Hour Vehicular Volume	1	4	Not Met
Warrant 7: Crash Experience	1	8	Not Met
Multi-way Stop Applications (MWSA)	4	8	Not Met

Radar Hill 1416 Corridor Study **No-Build (2030)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Liberty Blvd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	50	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB Liberty Blvd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB Liberty Blvd	45	2	100%



*Note: For data outside of the graph range, check the minor street volume against the lower thresholds

Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 2: Four-Hour Vehicular Volume	1	4	Not Met
Warrant 3: Peak Hour	0	1	Not Met

Radar Hill 1416 Corridor Study **No-Build (2050)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Liberty Blvd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	50	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB Liberty Blvd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB Liberty Blvd	45	2	100%

Warrants Analysis

Time of Day	Major #1	Major #3	Total 1+3	Major 1A/1B 420/630	Minor #2	Minor #2 1A/1B 140/070	Minor #4	Minor #4 1A/1B 140/070	Both Met 1A/1B	Crash Warrant	MWSA Warrant
6:00 - 7:00	93	123	216	/	21	/	52	/	/		
7:00 - 8:00	493	254	747	X/X	70	/	217	X/X	**X/X**	**X**	**X**
8:00 - 9:00	68	94	162	/	18	/	63	/	/		
9:00 - 10:00	73	59	132	/	20	/	66	/	/		
10:00 - 11:00	48	35	83	/	13	/	49	/	/		
11:00 - 12:00	85	65	150	/	16	/	74	/X	/		
12:00 - 1:00	104	67	171	/	13	/	78	/X	/		
1:00 - 2:00	95	68	163	/	22	/	113	/X	/		
2:00 - 3:00	97	69	166	/	26	/	96	/X	/		
3:00 - 4:00	182	123	305	/	33	/	225	X/X	/		**X**
4:00 - 5:00	139	89	228	/	19	/	171	X/X	/		**X**
5:00 - 6:00	137	101	238	/	28	/	188	X/X	/		**X**
6:00 - 7:00	64	36	100	/	15	/	55	/	/		
7:00 - 8:00	68	55	123	/	14	/	63	/	/		
8:00 - 9:00	49	39	88	/	11	/	45	/	/		
9:00 - 10:00	33	25	58	/	7	/	30	/	/		

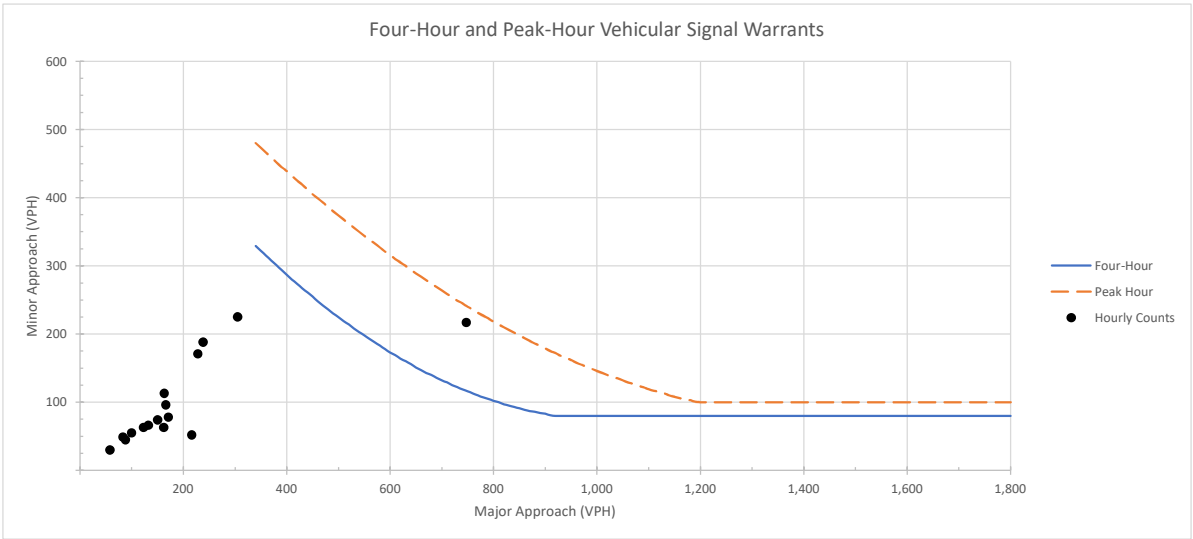
Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 1a: Minimum Vehicular Volume	1	8	Not Met
Warrant 1b: Interruption of Continuous Traffic	1	8	Not Met
Warrant 2: Four-Hour Vehicular Volume	1	4	Not Met
Warrant 7: Crash Experience	1	8	Not Met
Multi-way Stop Applications (MWSA)	4	8	Not Met

Radar Hill 1416 Corridor Study **No-Build (2050)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Liberty Blvd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	50	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB Liberty Blvd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB Liberty Blvd	45	2	100%



*Note: For data outside of the graph range, check the minor street volume against the lower thresholds

Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 2: Four-Hour Vehicular Volume	1	4	Not Met
Warrant 3: Peak Hour	0	1	Not Met

Radar Hill 1416 Corridor Study **No-Build (2030)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and S Ellsworth Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB S Ellsworth Rd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB S Ellsworth Rd	35	1	100%

Warrants Analysis

Time of Day	Major #1	Major #3	Total 1+3	Major 1A/1B 420/630	Minor #2	Minor #2 1A/1B 105/053	Minor #4	Minor #4 1A/1B 105/053	Both Met 1A/1B	Crash Warrant	MWSA Warrant
6:00 - 7:00	741	39	780	X/X	93	/X	101	/X	**/X**	**X**	**X**
7:00 - 8:00	1013	236	1249	X/X	247	X/X	364	X/X	**X/X**	**X**	**X**
8:00 - 9:00	336	67	403	/	59	/X	158	X/X	**/**		**X**
9:00 - 10:00	294	52	346	/	46	/	170	X/X	**/**		**X**
10:00 - 11:00	281	67	348	/	38	/	177	X/X	**/**		**X**
11:00 - 12:00	324	62	386	/	36	/	196	X/X	**/**		**X**
12:00 - 1:00	407	78	485	X/	46	/	233	X/X	**X/**	**X**	**X**
1:00 - 2:00	366	76	442	X/	56	/X	179	X/X	**X/**		**X**
2:00 - 3:00	410	92	502	X/	48	/	217	X/X	**X/**	**X**	**X**
3:00 - 4:00	454	178	632	X/X	78	/X	450	X/X	**X/X**	**X**	**X**
4:00 - 5:00	484	109	593	X/	65	/X	383	X/X	**X/**	**X**	**X**
5:00 - 6:00	541	119	660	X/X	82	/X	343	X/X	**X/X**	**X**	**X**
6:00 - 7:00	186	41	227	/	35	/	139	X/X	**/**		**X**
7:00 - 8:00	285	52	337	/	41	/	148	X/X	**/**		**X**
8:00 - 9:00	204	37	241	/	30	/	106	X/X	**/**		
9:00 - 10:00	134	25	159	/	19	/	69	/X	**/**		

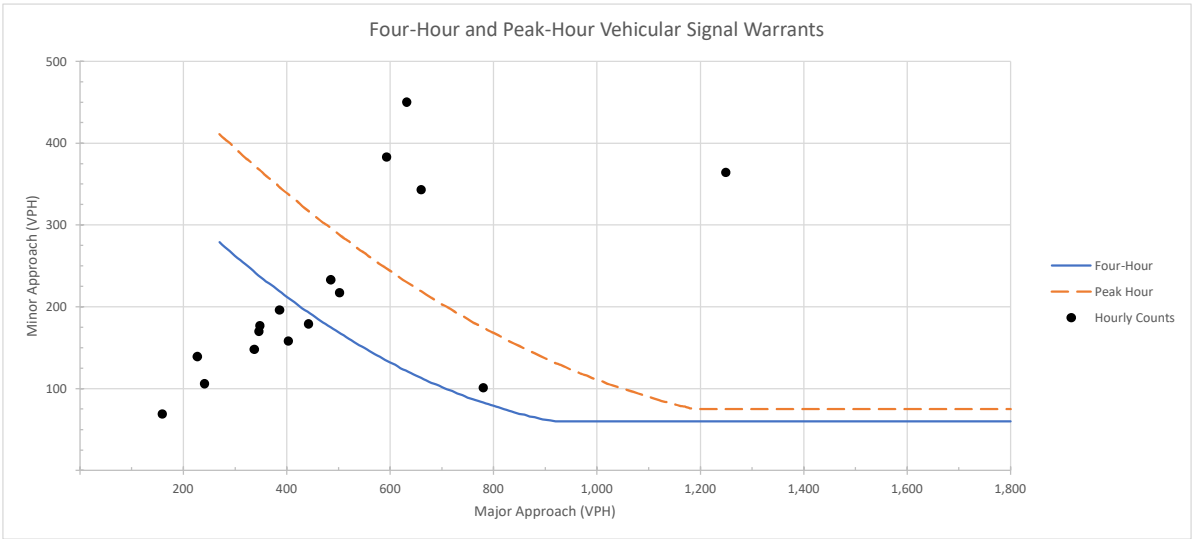
Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 1a: Minimum Vehicular Volume	7	8	Not Met
Warrant 1b: Interruption of Continuous Traffic	4	8	Not Met
Warrant 2: Four-Hour Vehicular Volume	7	4	Met
Warrant 7: Crash Experience	7	8	Not Met
Multi-way Stop Applications (MWSA)	14	8	Met

Radar Hill 1416 Corridor Study **No-Build (2030)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and S Ellsworth Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB S Ellsworth Rd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB S Ellsworth Rd	35	1	100%



*Note: For data outside of the graph range, check the minor street volume against the lower thresholds

Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 2: Four-Hour Vehicular Volume	7	4	Met
Warrant 3: Peak Hour	4	1	Met

Radar Hill 1416 Corridor Study **No-Build (2050)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and S Ellsworth Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB S Ellsworth Rd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB S Ellsworth Rd	35	1	100%

Warrants Analysis

Time of Day	Major #1	Major #3	Total 1+3	Major 1A/1B 420/630	Minor #2	Minor #2 1A/1B 105/053	Minor #4	Minor #4 1A/1B 105/053	Both Met 1A/1B	Crash Warrant	MWSA Warrant
6:00 - 7:00	853	43	896	X/X	107	X/X	115	X/X	**X/X**	**X**	**X**
7:00 - 8:00	1134	245	1379	X/X	271	X/X	400	X/X	**X/X**	**X**	**X**
8:00 - 9:00	384	74	458	X/	68	/X	181	X/X	**X/**		**X**
9:00 - 10:00	337	57	394	/	53	/	195	X/X	**/**		**X**
10:00 - 11:00	322	75	397	/	44	/	203	X/X	**/**		**X**
11:00 - 12:00	371	68	439	X/	41	/	225	X/X	**X/**		**X**
12:00 - 1:00	466	86	552	X/	53	/	267	X/X	**X/**	**X**	**X**
1:00 - 2:00	419	84	503	X/	64	/X	206	X/X	**X/**	**X**	**X**
2:00 - 3:00	470	102	572	X/	56	/X	249	X/X	**X/**	**X**	**X**
3:00 - 4:00	514	191	705	X/X	87	/X	513	X/X	**X/X**	**X**	**X**
4:00 - 5:00	555	121	676	X/X	75	/X	440	X/X	**X/X**	**X**	**X**
5:00 - 6:00	620	133	753	X/X	95	/X	394	X/X	**X/X**	**X**	**X**
6:00 - 7:00	212	44	256	/	40	/	159	X/X	**/**		**X**
7:00 - 8:00	327	58	385	/	48	/	170	X/X	**/**		**X**
8:00 - 9:00	233	41	274	/	34	/	121	X/X	**/**		**X**
9:00 - 10:00	154	27	181	/	22	/	79	/X	**/**		

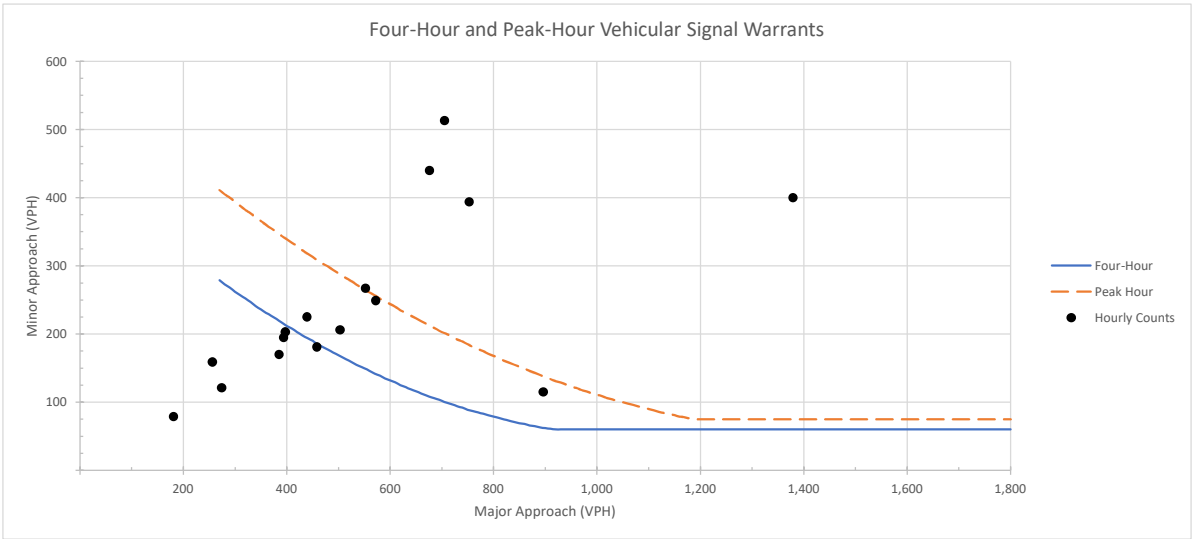
Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 1a: Minimum Vehicular Volume	10	8	Met
Warrant 1b: Interruption of Continuous Traffic	5	8	Not Met
Warrant 2: Four-Hour Vehicular Volume	9	4	Met
Warrant 7: Crash Experience	8	8	Met - Check Crash Rate
Multi-way Stop Applications (MWSA)	15	8	Met

Radar Hill 1416 Corridor Study **No-Build (2050)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and S Ellsworth Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	50	2	100%
0.70 Factor Used:	Yes	Minor 2: NB S Ellsworth Rd	25	1	100%
0.80 Factor Used:	No	Minor 4: SB S Ellsworth Rd	35	1	100%



*Note: For data outside of the graph range, check the minor street volume against the lower thresholds

Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 2: Four-Hour Vehicular Volume	9	4	Met
Warrant 3: Peak Hour	5	1	Met

Radar Hill 1416 Corridor Study **No-Build (2030)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Radar Hill Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	55	2	100%
0.70 Factor Used:	Yes	Minor 2: NB Radar Hill Rd	45	1	100%
0.80 Factor Used:	No	Minor 4: SB Gumbo Dr	25	1	100%

Warrants Analysis

Time of Day	Major #1	Major #3	Total 1+3	Major 1A/1B 420/630	Minor #2	Minor #2 1A/1B 105/053	Minor #4	Minor #4 1A/1B 105/053	Both Met 1A/1B	Crash Warrant	MWSA Warrant
6:00 - 7:00	591	192	783	X/X	299	X/X	19	/	**X/X**	**X**	**X**
7:00 - 8:00	774	560	1334	X/X	512	X/X	56	/X	**X/X**	**X**	**X**
8:00 - 9:00	328	289	617	X/	151	X/X	40	/	**X/**		**X**
9:00 - 10:00	307	268	575	X/	141	X/X	21	/	**X/**		
10:00 - 11:00	288	320	608	X/	135	X/X	15	/	**X/**		
11:00 - 12:00	363	407	770	X/X	115	X/X	18	/	**X/X**	**X**	
12:00 - 1:00	413	328	741	X/X	160	X/X	31	/	**X/X**	**X**	
1:00 - 2:00	408	330	738	X/X	141	X/X	28	/	**X/X**	**X**	
2:00 - 3:00	436	438	874	X/X	162	X/X	31	/	**X/X**	**X**	
3:00 - 4:00	480	809	1289	X/X	179	X/X	21	/	**X/X**	**X**	**X**
4:00 - 5:00	580	877	1457	X/X	208	X/X	22	/	**X/X**	**X**	**X**
5:00 - 6:00	631	626	1257	X/X	262	X/X	21	/	**X/X**	**X**	**X**
6:00 - 7:00	232	183	415	/	63	/X	12	/	**/**		
7:00 - 8:00	287	274	561	X/	123	X/X	16	/	**X/**		
8:00 - 9:00	205	196	401	/	88	/X	11	/	**/**		
9:00 - 10:00	135	128	263	/	58	/X	7	/	**/**		

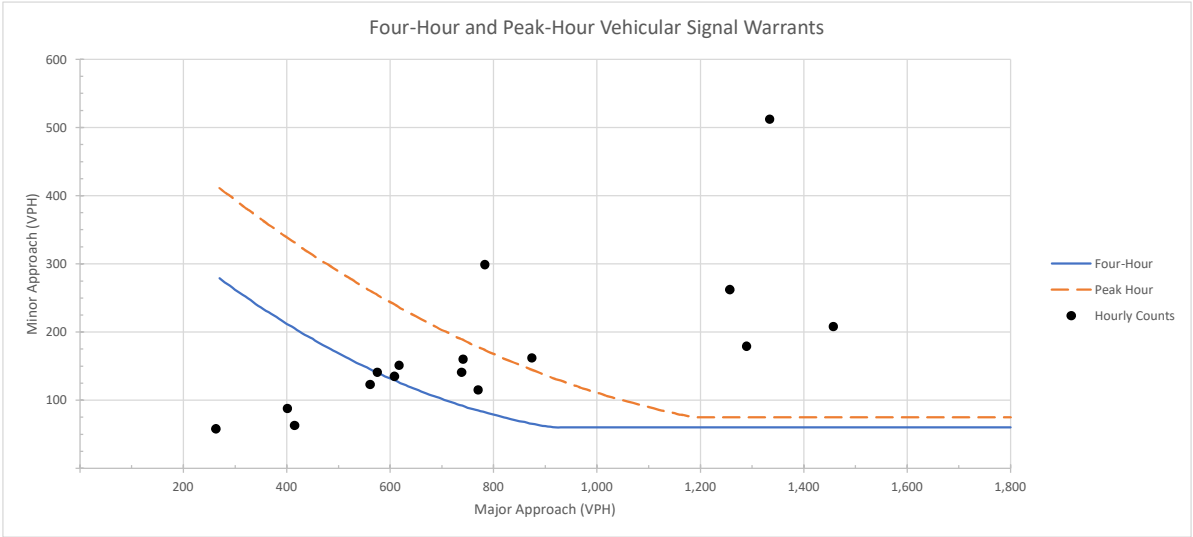
Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 1a: Minimum Vehicular Volume	13	8	Met
Warrant 1b: Interruption of Continuous Traffic	9	8	Met
Warrant 2: Four-Hour Vehicular Volume	11	4	Met
Warrant 7: Crash Experience	9	8	Met - Check Crash Rate
Multi-way Stop Applications (MWSA)	6	8	Not Met

Radar Hill 1416 Corridor Study **No-Build (2030)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Radar Hill Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	55	2	100%
0.70 Factor Used:	Yes	Minor 2: NB Radar Hill Rd	45	1	100%
0.80 Factor Used:	No	Minor 4: SB Gumbo Dr	25	1	100%



*Note: For data outside of the graph range, check the minor street volume against the lower thresholds

Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 2: Four-Hour Vehicular Volume	11	4	Met
Warrant 3: Peak Hour	6	1	Met

Radar Hill 1416 Corridor Study **No-Build (2050)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Radar Hill Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
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Warrants Analysis

Time of Day	Major #1	Major #3	Total 1+3	Major 1A/1B 420/630	Minor #2	Minor #2 1A/1B 105/053	Minor #4	Minor #4 1A/1B 105/053	Both Met 1A/1B	Crash Warrant	MWSA Warrant
6:00 - 7:00	672	217	889	X/X	341	X/X	21	/	**X/X**	**X**	**X**
7:00 - 8:00	860	620	1480	X/X	571	X/X	60	/X	**X/X**	**X**	**X**
8:00 - 9:00	372	327	699	X/X	172	X/X	45	/	**X/X**	**X**	**X**
9:00 - 10:00	349	304	653	X/X	161	X/X	24	/	**X/X**	**X**	
10:00 - 11:00	327	362	689	X/X	154	X/X	17	/	**X/X**		
11:00 - 12:00	411	462	873	X/X	131	X/X	20	/	**X/X**	**X**	
12:00 - 1:00	468	371	839	X/X	182	X/X	36	/	**X/X**	**X**	**X**
1:00 - 2:00	463	374	837	X/X	161	X/X	32	/	**X/X**	**X**	
2:00 - 3:00	494	496	990	X/X	185	X/X	36	/	**X/X**	**X**	**X**
3:00 - 4:00	540	912	1452	X/X	202	X/X	23	/	**X/X**	**X**	**X**
4:00 - 5:00	658	996	1654	X/X	237	X/X	25	/	**X/X**	**X**	**X**
5:00 - 6:00	717	710	1427	X/X	298	X/X	24	/	**X/X**	**X**	**X**
6:00 - 7:00	262	206	468	X/	72	/X	13	/	**/**		
7:00 - 8:00	325	310	635	X/X	140	X/X	18	/	**X/X**		**X**
8:00 - 9:00	232	222	454	X/	100	/X	13	/	**/**		
9:00 - 10:00	153	145	298	/	66	/X	8	/	**/**		

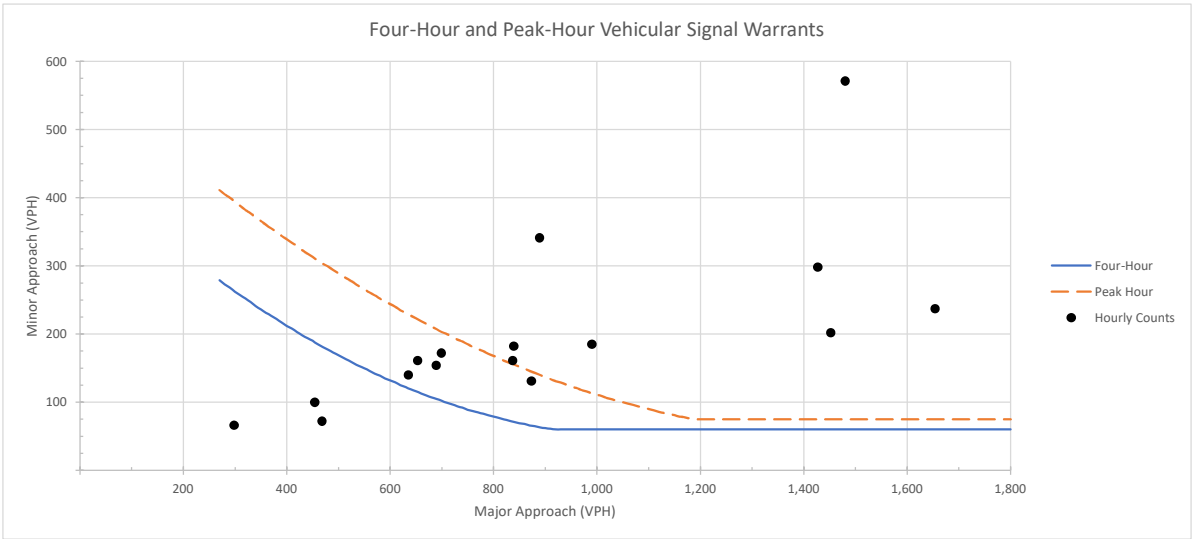
Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 1a: Minimum Vehicular Volume	13	8	Met
Warrant 1b: Interruption of Continuous Traffic	13	8	Met
Warrant 2: Four-Hour Vehicular Volume	13	4	Met
Warrant 7: Crash Experience	11	8	Met - Check Crash Rate
Multi-way Stop Applications (MWSA)	9	8	Met

Radar Hill 1416 Corridor Study **No-Build (2050)**

City/County: Box Elder, SD
Intersection: Hwy 1416 and Radar Hill Rd

Study Data						
Date:	8/25/2023	Approach	Speed	Lanes	RT %
Population < 10,000:	No	Major 1: EB Highway 1416	55	2	100%
Existing Signal:	No	Major 3: WB Highway 1416	55	2	100%
0.70 Factor Used:	Yes	Minor 2: NB Radar Hill Rd	45	1	100%
0.80 Factor Used:	No	Minor 4: SB Gumbo Dr	25	1	100%

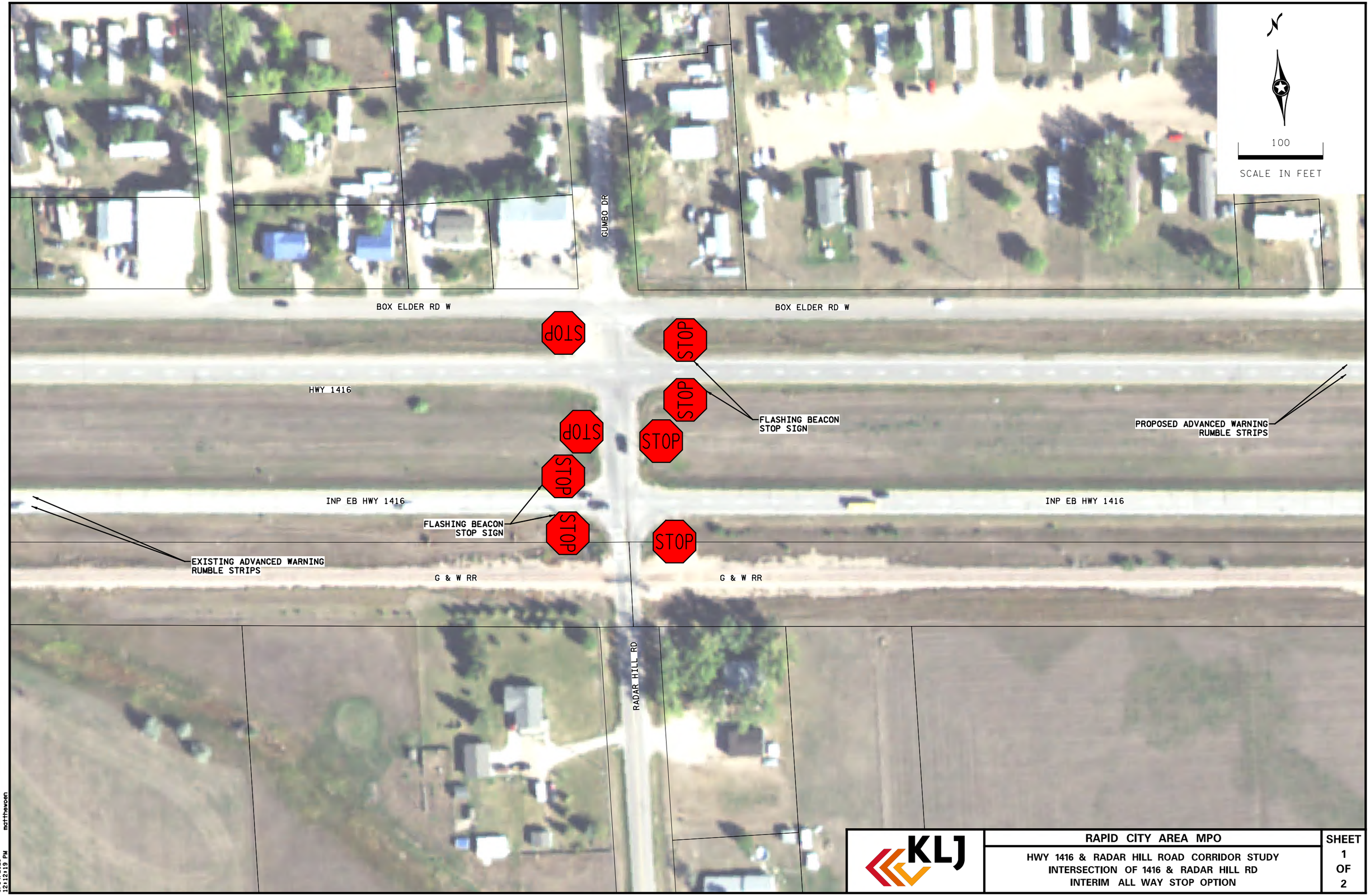


*Note: For data outside of the graph range, check the minor street volume against the lower thresholds

Results

Criteria	Hours Met	Hours Required	Warrants Met
Warrant 2: Four-Hour Vehicular Volume	13	4	Met
Warrant 3: Peak Hour	8	1	Met

Appendix F: Alternative Concepts



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matthewoen

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RAPID CITY AREA MPO

HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
INTERSECTION OF 1416 & RADAR HILL RD
INTERIM ALL WAY STOP OPTION

SHEET
1
OF
2

MELODY LN

S ELLSWORTH RD

HILLVIEW DR

MELODY LN

BOX ELDER RD W

HWY 1416

INP EB HWY 1416

STOP

FLASHING BEACON
STOP SIGN

PPROPOSED ADVANCED WARNING
RUMBLE STRIPS

G & W RR

OAK ST

N

100

SCALE IN FEET

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RAPID CITY AREA MPO

HWY 1416 & RADAR HILL ROAD CORRDIOR STUDY
INTERSECTION OF 1416 & ELLSWORTH RD
INTERIM ALL WAY STOP OPTION

SHEET
2
OF
2

HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
HWY 1416 ROUNDABOUT ALTERNATIVES







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HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
RADAR HILL ROAD 3 LANE SECTION ALTERNATIVE



HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY

COMBINING OF BOX ELDER ROAD AND HWY 1416 WAS STUDIED WITH FUTURE CONDITIONS, BASED ON STUDY RESULTS, THIS CONCEPT WILL BE REMOVED FROM FUTURE CONSIDERATION







LEGEND
WALK
MEDIAN
PAVEMENT
CURB & GUTTER
BRIDGE
TRUCK APRON
PAVEMENT REMOVAL

N

100

SCALE IN FEET

BOX ELDER RD W

GUMBO DR

BOX ELDER RD W

10' TRAIL

10' TRAIL

PED CROSSING WITH
RECTANGULAR RAPID
FLASHING BEACON

14' EXIT

14' EXIT

HWY 1416

18' ENTRY

16' ENTRY

16' ENTRY

14' EXIT

14' EXIT

PED CROSSING WITH
RECTANGULAR RAPID
FLASHING BEACON

INP EB HWY 1416

INP EB HWY 1416

20' EXIT

20' ENTRY

G & W RR

G & W RR

14' FREE RIGHT

6' WALK

RADAR HILL RD

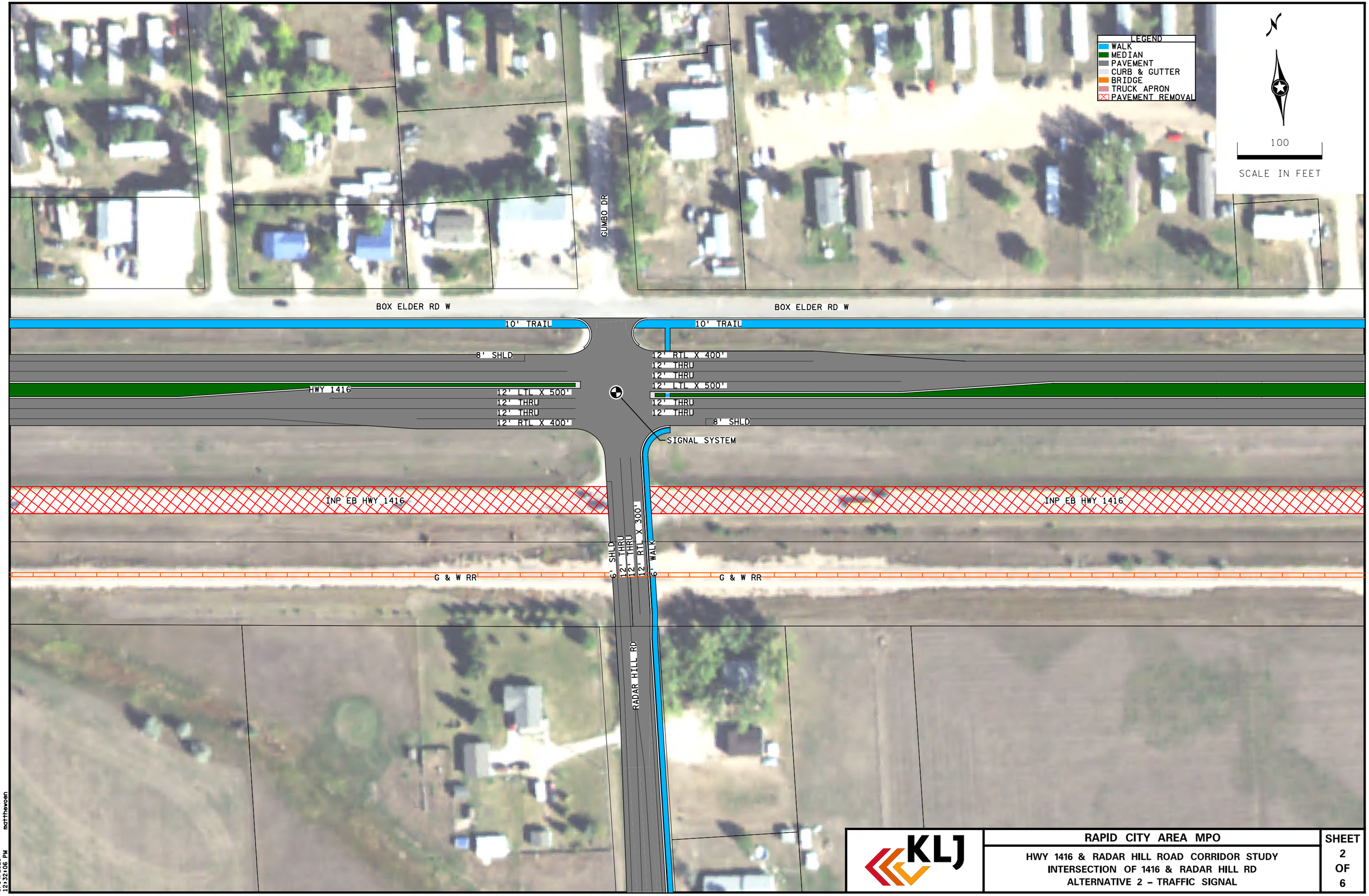
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RAPID CITY AREA MPO

HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
INTERSECTION OF 1416 & RADAR HILL RD
ALTERNATVE 1 – 2 X 1 ROUNDABOUT W/ EB FREE RIGHT

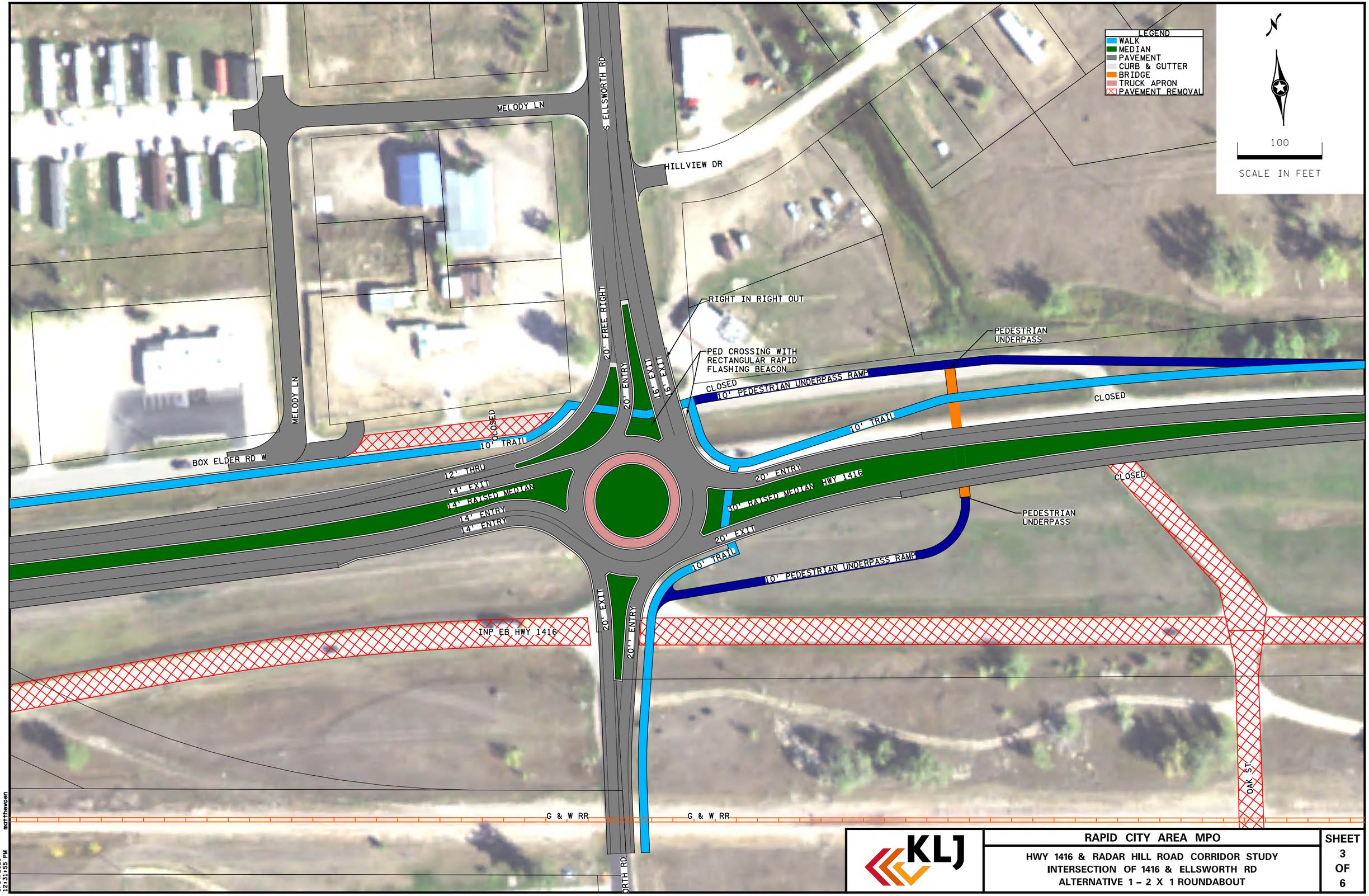
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6



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RAPID CITY AREA MPO	SHEET 2 OF 6
HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY INTERSECTION OF 1416 & RADAR HILL RD ALTERNATIVE 2 – TRAFFIC SIGNAL	



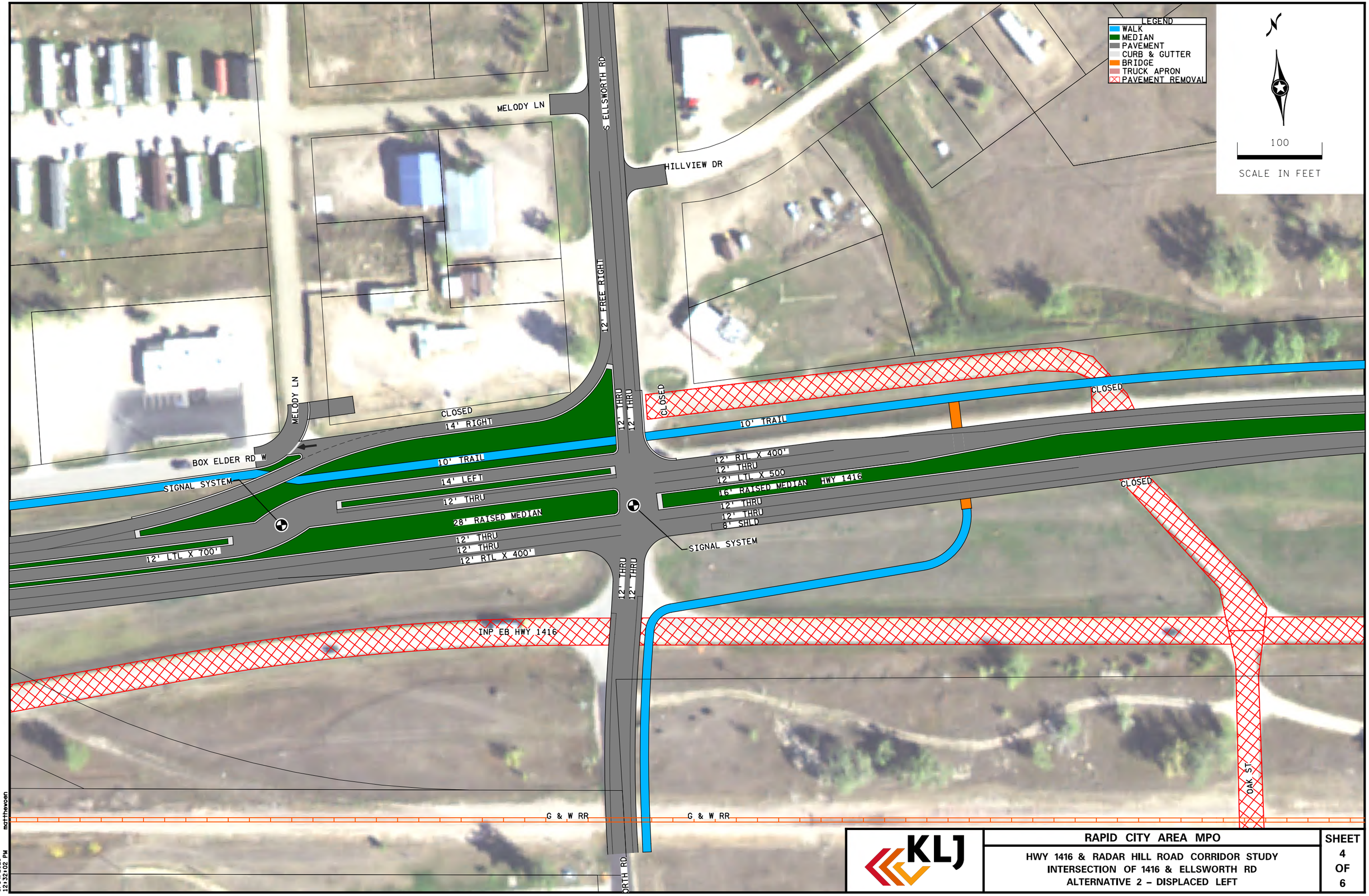
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RAPID CITY AREA MPO

HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
INTERSECTION OF 1416 & ELLSWORTH RD
ALTERNATIVE 1 – 2 X 1 ROUNDABOUT

SHEET 3 OF 6



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RAPID CITY AREA MPO

HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
INTERSECTION OF 1416 & ELLSWORTH RD
ALTERNATIVE 2 – DISPLACED LEFT

SHEET 4 OF 6

LEGEND
WALK
MEDIAN
PAVEMENT
CURB & GUTTER
BRIDGE
TRUCK APRON
PAVEMENT REMOVAL

N

100

SCALE IN FEET

MELODY LN

S ELLSWORTH RD

HILLVIEW DR

MELODY LN

1000' AUXILLARY NEEDED FOR 2ND RECIEVING LANE FROM DUAL LEFT TURNS.
LENGTH PROVIDED TO REMOVE MERGE FROM INTERSECTION OPERATION.

12' FREE RIGHT

12' THRU
12' THRU
12' AUX X 1000'

CLOSED

10' TRAIL

CLOSED

BOX ELDER RD W

12' RTL X 400'
12' THRU
12' LTL X 500
16' RAISED MEDIAN
12' THRU

HWY 1416

12' THRU
12' THRU
4' RAISED MEDIAN
12' LTL X 700'
12' LTL DROP LANE
12' THRU
12' RTL X 400'

SIGNAL SYSTEM

CLOSED

12' THRU
12' THRU

INP EB HWY 1416

OAK ST

G & W RR

G & W RR

ELLSWORTH RD

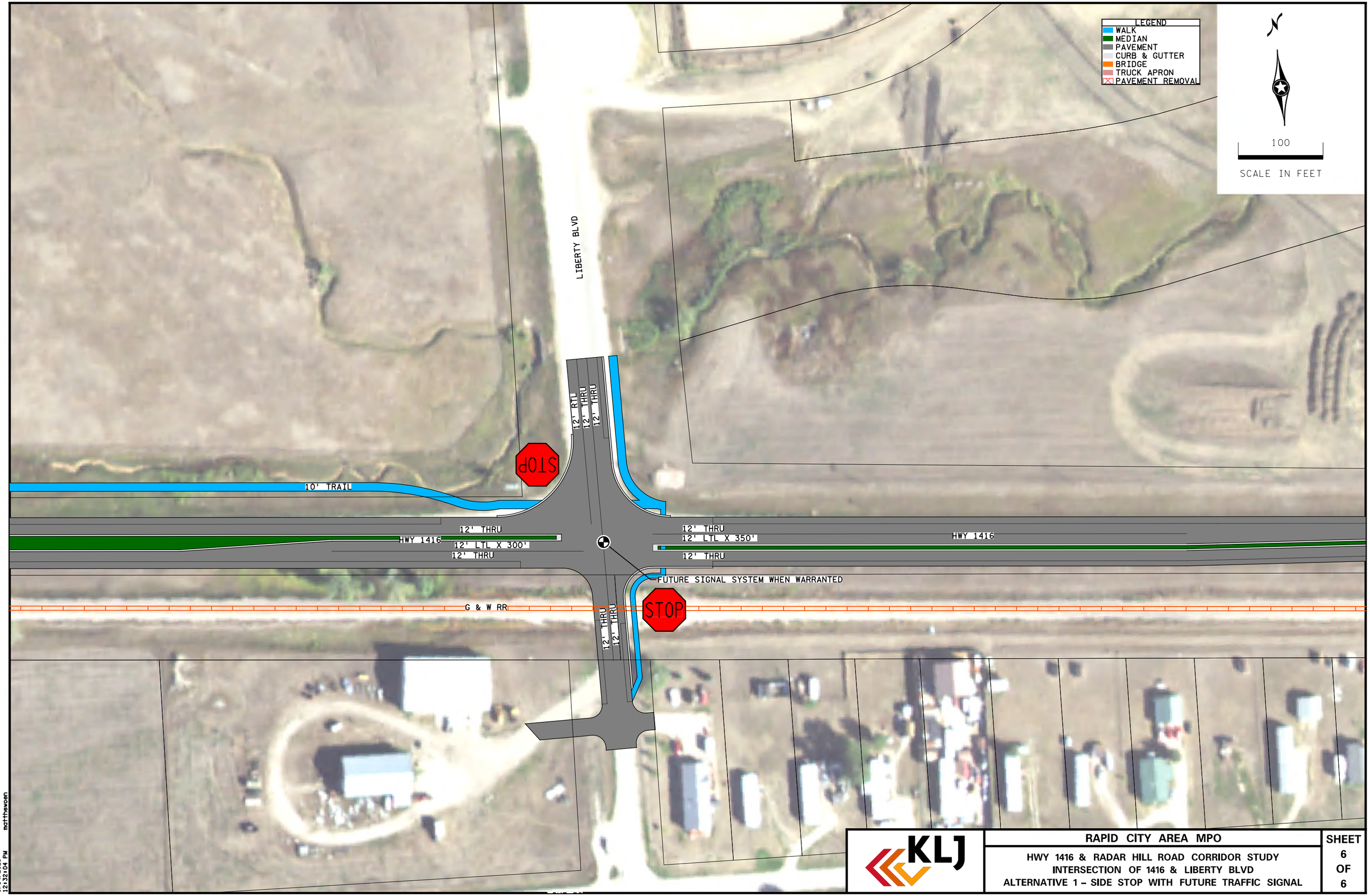
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RAPID CITY AREA MPO

HWY 1416 & RADAR HILL ROAD CORRDIOR STUDY
INTERSECTION OF 1416 & ELLSWORTH RD
ALTERNATIVE 3 – TRAFFIC SIGNAL

SHEET
5
OF
6



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RAPID CITY AREA MPO

HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
INTERSECTION OF 1416 & LIBERTY BLVD
ALTERNATIVE 1 – SIDE STOP WITH FUTURE TRAFFIC SIGNAL

SHEET 6 OF 6

Rapid City Area Metropolitan Planning Organization

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HWY 1416 & RADAR HILL ROAD CORRIDOR STUDY
RADAR HILL ROAD 3 LANE SECTION ALTERNATIVE



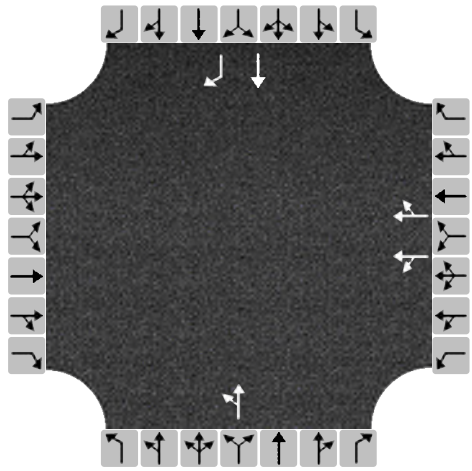
Appendix G: Vehicular Level of Service (VLOS) Results – Alternatives

HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	WB Highway 1416 and S Ellsworth Road
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				0	44	13	86	674			26	194
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				26	42		905			31	231	
Percent Heavy Vehicles				10	10		1			5	5	
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20	3.20	
Initial Degree of Utilization, x				0.023	0.037		0.804			0.028	0.205	
Final Departure Headway, h_d (s)				6.94	6.68		4.86			5.39	4.69	
Final Degree of Utilization, x				0.050	0.077		1.222			0.046	0.301	
Move-Up Time, m (s)				2.3	2.3		2.0			2.3	2.3	
Service Time, t_s (s)				4.64	4.38		2.86			3.09	2.39	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				26	42		905			31	231	
Capacity (veh/h)				519	539		740			668	767	
95% Queue Length, Q_{95} (veh)				0.2	0.3		96.3			0.1	1.3	
Control Delay (s/veh)				10.0	9.9		432.7			8.4	9.4	
Level of Service, LOS				B	A		F			A	A	
Approach Delay (s/veh) | LOS				10.0	A		432.7	F		9.3	A	
Intersection Delay (s/veh) | LOS	319.7						F					

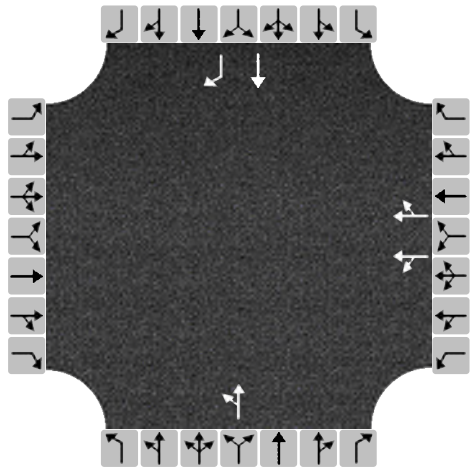
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				14	71	6	36	328			65	256
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				55	46		404			72	284	
Percent Heavy Vehicles				10	10		1			5	5	
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20	3.20	
Initial Degree of Utilization, x				0.049	0.041		0.360			0.064	0.253	
Final Departure Headway, h_d (s)				6.55	6.30		5.04			5.29	4.58	
Final Degree of Utilization, x				0.100	0.081		0.566			0.106	0.362	
Move-Up Time, m (s)				2.3	2.3		2.0			2.3	2.3	
Service Time, t_s (s)				4.25	4.00		3.04			2.99	2.28	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				55	46		404			72	284	
Capacity (veh/h)				550	571		714			681	785	
95% Queue Length, Q_{95} (veh)				0.3	0.3		3.8			0.4	1.7	
Control Delay (s/veh)				10.0	9.6		14.6			8.6	9.9	
Level of Service, LOS				A	A		B			A	A	
Approach Delay (s/veh) | LOS				9.8		A	14.6		B	9.6		A
Intersection Delay (s/veh) | LOS	12.0						B					

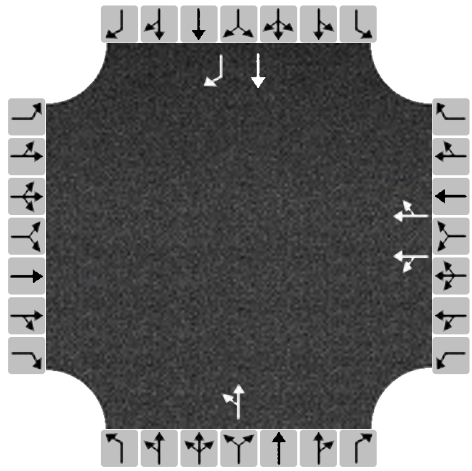
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	WB Highway 1416 and S Ellsworth Road
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				30	173	44	90	752			128	207
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				139	155		1002			152	246	
Percent Heavy Vehicles				10	10		1			5	5	
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20	3.20	
Initial Degree of Utilization, x				0.123	0.138		0.891			0.135	0.219	
Final Departure Headway, h_d (s)				7.34	6.98		5.87			6.37	5.67	
Final Degree of Utilization, x				0.283	0.301		1.633			0.270	0.388	
Move-Up Time, m (s)				2.3	2.3		2.0			2.3	2.3	
Service Time, t_s (s)				5.04	4.68		3.87			4.07	3.37	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				139	155		1002			152	246	
Capacity (veh/h)				490	516		614			565	635	
95% Queue Length, Q_{95} (veh)				1.2	1.3		201.8			1.1	1.9	
Control Delay (s/veh)				12.9	12.7		1163.9			11.4	12.0	
Level of Service, LOS				B	B		F			B	B	
Approach Delay (s/veh) | LOS				12.8	B		1163.9	F		11.8	B	
Intersection Delay (s/veh) | LOS	693.2						F					

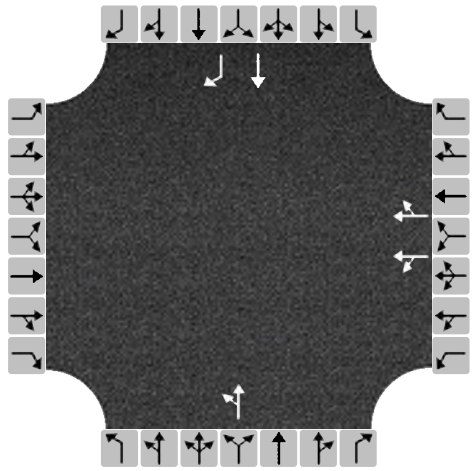
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HCS All-Way Stop Control Report

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Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	WB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				29	135	21	38	356			93	273
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				107	98		438			103	303	
Percent Heavy Vehicles				10	10		1			5	5	
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20	3.20	
Initial Degree of Utilization, x				0.095	0.087		0.389			0.092	0.270	
Final Departure Headway, h_d (s)				6.90	6.58		5.51			5.80	5.09	
Final Degree of Utilization, x				0.205	0.180		0.670			0.167	0.429	
Move-Up Time, m (s)				2.3	2.3		2.0			2.3	2.3	
Service Time, t_s (s)				4.60	4.28		3.51			3.50	2.79	

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			T	R	
Flow Rate, v (veh/h)				107	98		438			103	303	
Capacity (veh/h)				522	547		653			620	707	
95% Queue Length, Q_{95} (veh)				0.8	0.7		5.8			0.6	2.2	
Control Delay (s/veh)				11.4	10.7		19.5			9.7	11.6	
Level of Service, LOS				B	B		C			A	B	
Approach Delay (s/veh) | LOS				11.1	B		19.5	C		11.1	B	
Intersection Delay (s/veh) | LOS	14.6						B					

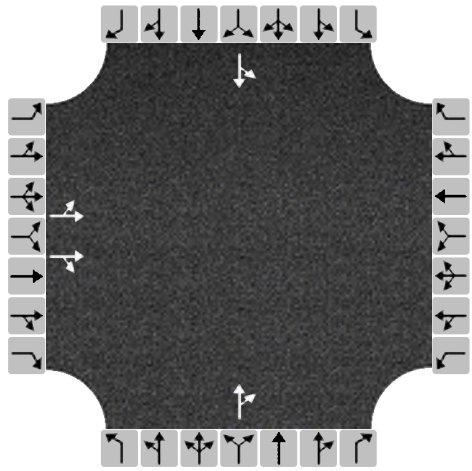
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HCS All-Way Stop Control Report

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Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	618	115	15					142	7	10	16	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	804	86					177			31		
Percent Heavy Vehicles	4	4					1			5		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.715	0.077					0.158			0.028		
Final Departure Headway, h_d (s)	5.67	5.07					5.80			6.26		
Final Degree of Utilization, x	1.267	0.121					0.286			0.054		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.37	2.77					3.80			4.26		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	804	86					177			31		
Capacity (veh/h)	635	711					621			575		
95% Queue Length, Q_{95} (veh)	97.1	0.4					1.2			0.2		
Control Delay (s/veh)	514.0	8.5					11.1			9.6		
Level of Service, LOS	F	A					B			A		
Approach Delay (s/veh) | LOS	465.0	F					11.1	B		9.6	A	
Intersection Delay (s/veh) | LOS	378.9						F					

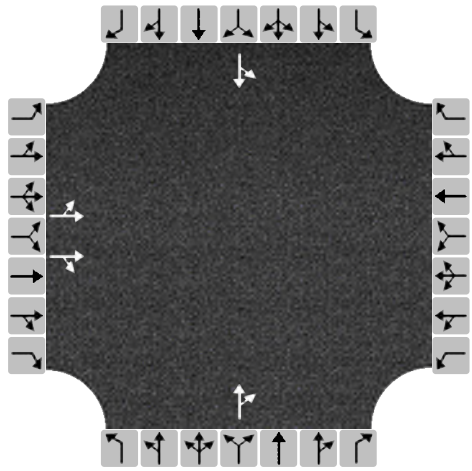
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	291	79	143					73	6	6	73	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	367	203					88			88		
Percent Heavy Vehicles	4	4					1			5		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.326	0.180					0.078			0.078		
Final Departure Headway, h_d (s)	5.50	4.51					5.30			5.42		
Final Degree of Utilization, x	0.561	0.254					0.129			0.132		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.20	2.21					3.30			3.42		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	367	203					88			88		
Capacity (veh/h)	655	799					680			664		
95% Queue Length, Q_{95} (veh)	3.7	1.0					0.4			0.5		
Control Delay (s/veh)	15.2	8.7					9.1			9.2		
Level of Service, LOS	C	A					A			A		
Approach Delay (s/veh) | LOS	12.9	B					9.1	A		9.2	A	
Intersection Delay (s/veh) | LOS	12.0						B					

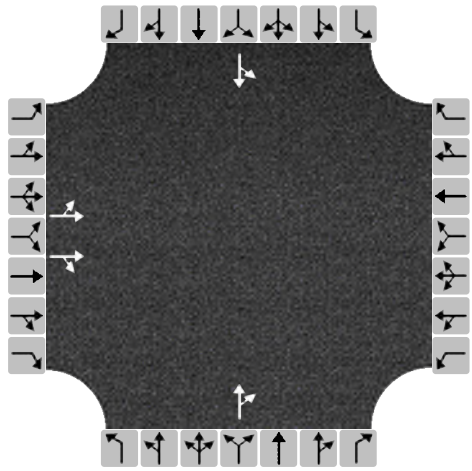
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Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.84

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	650	335	16					190	59	62	96	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	973	218					296			188		
Percent Heavy Vehicles	4	4					1			5		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.865	0.194					0.263			0.167		
Final Departure Headway, h_d (s)	6.47	6.01					6.04			6.52		
Final Degree of Utilization, x	1.750	0.365					0.497			0.341		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	4.17	3.71					4.04			4.52		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	973	218					296			188		
Capacity (veh/h)	556	599					596			552		
95% Queue Length, Q_{95} (veh)	215.4	1.7					2.9			1.5		
Control Delay (s/veh)	1374.5	12.2					15.0			12.9		
Level of Service, LOS	F	B					B			B		
Approach Delay (s/veh) | LOS	1124.8	F					15.0	B		12.9	B	
Intersection Delay (s/veh) | LOS	803.7						F					

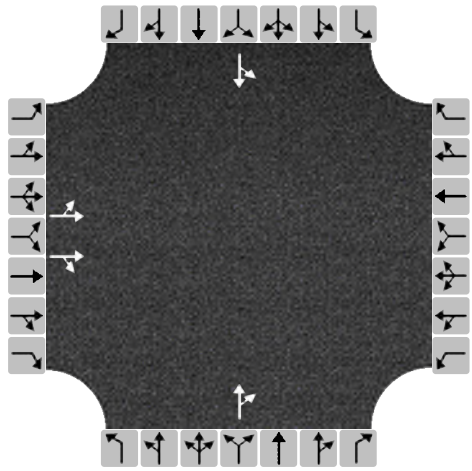
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Intersection	EB Highway 1416 and S Ellsworth Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	S Ellsworth Rd
Peak Hour Factor	0.90

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	306	150	152					87	22	22	100	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	423	252					121			136		
Percent Heavy Vehicles	4	4					1			5		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.376	0.224					0.108			0.120		
Final Departure Headway, h_d (s)	5.71	4.84					5.53			5.72		
Final Degree of Utilization, x	0.672	0.339					0.186			0.216		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.41	2.54					3.53			3.72		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	423	252					121			136		
Capacity (veh/h)	630	744					651			629		
95% Queue Length, Q_{95} (veh)	5.8	1.5					0.7			0.8		
Control Delay (s/veh)	19.9	10.0					9.8			10.3		
Level of Service, LOS	C	B					A			B		
Approach Delay (s/veh) | LOS	16.2	C					9.8	A		10.3	B	
Intersection Delay (s/veh) | LOS	14.5						B					

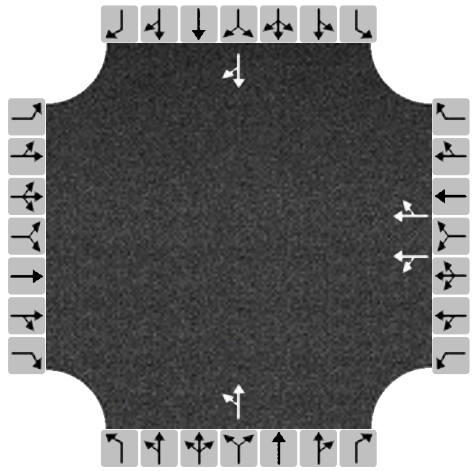
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HCS All-Way Stop Control Report

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Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				79	334	5	167	5			17	16
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				280	195		195			38		
Percent Heavy Vehicles				5	5		4			3		
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20		
Initial Degree of Utilization, x				0.248	0.174		0.174			0.033		
Final Departure Headway, h_d (s)				5.39	5.21		5.33			5.08		
Final Degree of Utilization, x				0.419	0.283		0.289			0.053		
Move-Up Time, m (s)				2.3	2.3		2.0			2.0		
Service Time, t_s (s)				3.09	2.91		3.33			3.08		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				280	195		195			38		
Capacity (veh/h)				668	691		676			709		
95% Queue Length, Q_{95} (veh)				2.1	1.2		1.2			0.2		
Control Delay (s/veh)				12.0	10.0		10.5			8.4		
Level of Service, LOS				B	A		B			A		
Approach Delay (s/veh) | LOS				11.1	B		10.5	B		8.4	A	
Intersection Delay (s/veh) | LOS	10.8						B					

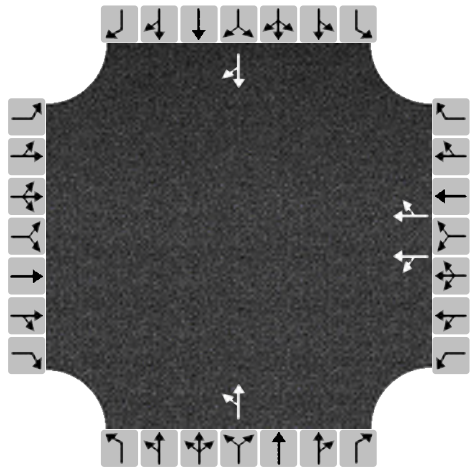
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HCS All-Way Stop Control Report

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Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				184	531	3	112	28			13	10
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				478	286		149			24		
Percent Heavy Vehicles				5	5		4			3		
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20		
Initial Degree of Utilization, x				0.425	0.254		0.132			0.022		
Final Departure Headway, h_d (s)				5.31	5.10		5.74			5.54		
Final Degree of Utilization, x				0.705	0.404		0.237			0.038		
Move-Up Time, m (s)				2.3	2.3		2.0			2.0		
Service Time, t_s (s)				3.01	2.80		3.74			3.54		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				478	286		149			24		
Capacity (veh/h)				678	706		627			650		
95% Queue Length, Q_{95} (veh)				6.7	2.0		0.9			0.1		
Control Delay (s/veh)				20.4	11.2		10.5			8.8		
Level of Service, LOS				C	B		B			A		
Approach Delay (s/veh) | LOS				17.0	C		10.5	B		8.8	A	
Intersection Delay (s/veh) | LOS	15.8						C					

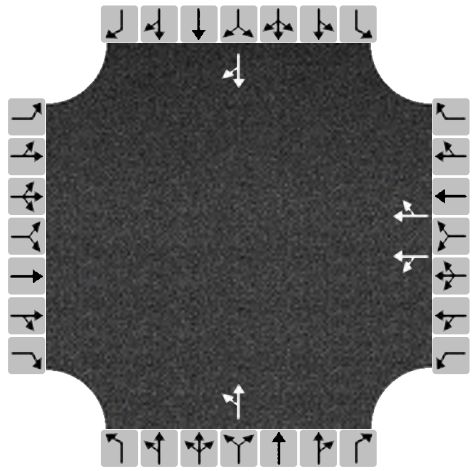
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Intersection	WB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	WB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				107	454	7	179	28			37	17
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				380	266		235			61		
Percent Heavy Vehicles				5	5		4			3		
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20		
Initial Degree of Utilization, x				0.337	0.236		0.209			0.055		
Final Departure Headway, h_d (s)				5.61	5.43		5.68			5.63		
Final Degree of Utilization, x				0.592	0.401		0.371			0.096		
Move-Up Time, m (s)				2.3	2.3		2.0			2.0		
Service Time, t_s (s)				3.31	3.13		3.68			3.63		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				380	266		235			61		
Capacity (veh/h)				641	663		633			640		
95% Queue Length, Q_{95} (veh)				4.2	2.0		1.8			0.3		
Control Delay (s/veh)				16.4	11.8		12.0			9.2		
Level of Service, LOS				C	B		B			A		
Approach Delay (s/veh) | LOS				14.5	B		12.0	B		9.2	A	
Intersection Delay (s/veh) | LOS	13.5						B					

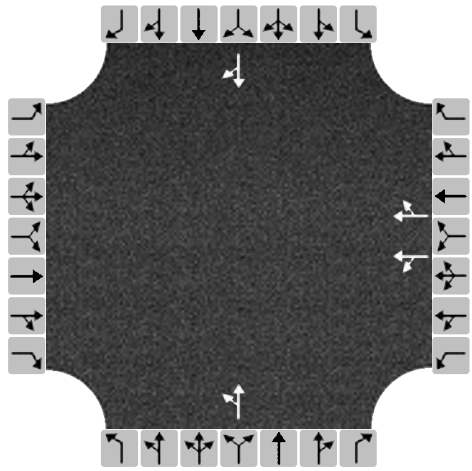
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North/South Street	Radar Hill Rd
Peak Hour Factor	0.94

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)				209	605	4	118	34			18	11
% Thrus in Shared Lane				50		50						

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				544	326		162			31		
Percent Heavy Vehicles				5	5		4			3		
Initial Departure Headway, h_d (s)				3.20	3.20		3.20			3.20		
Initial Degree of Utilization, x				0.484	0.290		0.144			0.027		
Final Departure Headway, h_d (s)				5.38	5.17		5.90			5.76		
Final Degree of Utilization, x				0.814	0.468		0.265			0.049		
Move-Up Time, m (s)				2.3	2.3		2.0			2.0		
Service Time, t_s (s)				3.08	2.87		3.90			3.76		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration				LT	TR		LT			TR		
Flow Rate, v (veh/h)				544	326		162			31		
Capacity (veh/h)				669	697		611			625		
95% Queue Length, Q_{95} (veh)				11.1	2.6		1.1			0.2		
Control Delay (s/veh)				30.1	12.4		11.0			9.1		
Level of Service, LOS				D	B		B			A		
Approach Delay (s/veh) | LOS				23.5	C		11.0	B		9.1	A	
Intersection Delay (s/veh) | LOS	21.2						C					

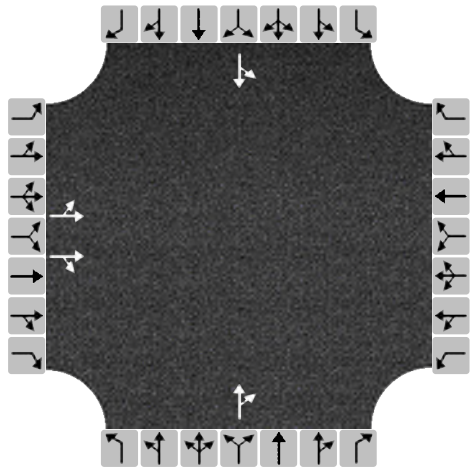
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North/South Street	Radar Hill Rd
Peak Hour Factor	0.88

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	4	527	55					168	236	8	88	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	304	362					459			109		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.270	0.322					0.408			0.097		
Final Departure Headway, h_d (s)	6.19	6.06					5.39			6.36		
Final Degree of Utilization, x	0.523	0.609					0.688			0.193		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.89	3.76					3.39			4.36		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	304	362					459			109		
Capacity (veh/h)	582	594					667			566		
95% Queue Length, Q_{95} (veh)	3.2	4.5					6.2			0.7		
Control Delay (s/veh)	15.6	18.1					20.0			10.9		
Level of Service, LOS	C	C					C			B		
Approach Delay (s/veh) | LOS	17.0	C					20.0	C		10.9	B	
Intersection Delay (s/veh) | LOS	17.6						C					

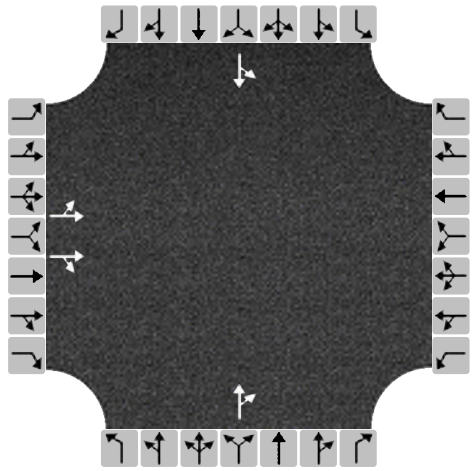
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2023
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	19	401	193					121	116	4	193	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	234	419					252			210		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.208	0.372					0.224			0.186		
Final Departure Headway, h_d (s)	5.94	5.55					5.57			5.91		
Final Degree of Utilization, x	0.385	0.645					0.390			0.344		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.64	3.25					3.57			3.91		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	234	419					252			210		
Capacity (veh/h)	606	649					646			609		
95% Queue Length, Q_{95} (veh)	1.9	5.2					1.9			1.6		
Control Delay (s/veh)	12.3	18.2					12.1			12.0		
Level of Service, LOS	B	C					B			B		
Approach Delay (s/veh) | LOS	16.1	C					12.1	B		12.0	B	
Intersection Delay (s/veh) | LOS	14.4						B					

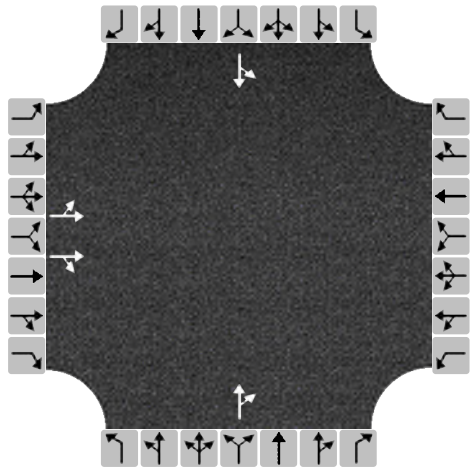
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.88

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	5	702	64					197	314	12	111	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	405	472					581			140		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.360	0.419					0.516			0.124		
Final Departure Headway, h_d (s)	6.73	6.61					5.79			7.02		
Final Degree of Utilization, x	0.756	0.866					0.934			0.273		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	4.43	4.31					3.79			5.02		

Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	405	472					581			140		
Capacity (veh/h)	535	544					622			513		
95% Queue Length, Q_{95} (veh)	8.3	14.0					20.9			1.1		
Control Delay (s/veh)	29.4	46.4					64.3			12.7		
Level of Service, LOS	D	E					F			B		
Approach Delay (s/veh) | LOS	38.6	E					64.3	F		12.7	B	
Intersection Delay (s/veh) | LOS	45.7						E					

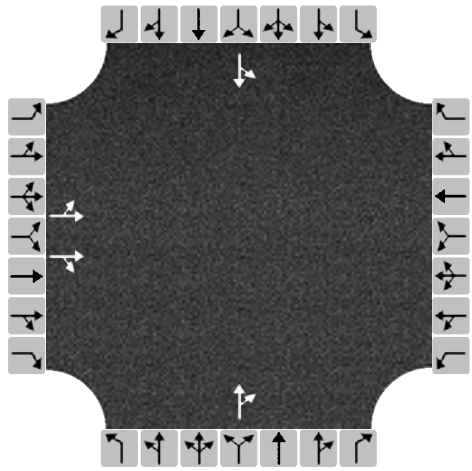
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HCS All-Way Stop Control Report

General and Site Information

Analyst	Emma Myers-Verhage
Agency/Co.	
Date Performed	6/26/2023
Analysis Year	2030
Analysis Time Period (hrs)	1.00
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study - Interim
Intersection	EB Highway 1416 and Radar Hill Rd
Jurisdiction	Box Elder, SD
East/West Street	EB Highway 1416
North/South Street	Radar Hill Rd
Peak Hour Factor	0.94

Lanes



Turning Movement Demand Volumes

Approach	Eastbound			Westbound			Northbound			Southbound		
Movement	L	T	R	L	T	R	L	T	R	L	T	R
Volume (veh/h)	20	475	205					132	138	5	206	
% Thrus in Shared Lane	50		50									

Lane Flow Rate and Adjustments

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	274	471					287			224		
Percent Heavy Vehicles	4	4					4			3		
Initial Departure Headway, h_d (s)	3.20	3.20					3.20			3.20		
Initial Degree of Utilization, x	0.243	0.418					0.255			0.200		
Final Departure Headway, h_d (s)	6.12	5.75					5.79			6.18		
Final Degree of Utilization, x	0.466	0.752					0.462			0.385		
Move-Up Time, m (s)	2.3	2.3					2.0			2.0		
Service Time, t_s (s)	3.82	3.45					3.79			4.18		

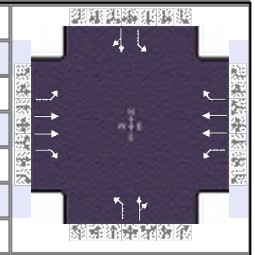
Capacity, Delay and Level of Service

Approach	Eastbound			Westbound			Northbound			Southbound		
Lane	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
Configuration	LT	TR					TR			LT		
Flow Rate, v (veh/h)	274	471					287			224		
Capacity (veh/h)	588	626					622			582		
95% Queue Length, Q_{95} (veh)	2.6	8.2					2.5			1.9		
Control Delay (s/veh)	14.1	25.3					13.7			13.0		
Level of Service, LOS	B	D					B			B		
Approach Delay (s/veh) | LOS	21.2	C					13.7	B		13.0	B	
Intersection Delay (s/veh) | LOS	18.0						C					

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HCS Signalized Intersection Results Summary

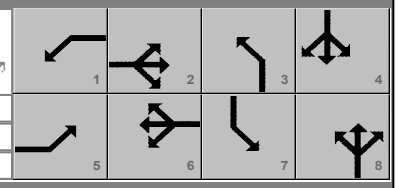
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/14/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2030	Analysis Period	1> 7:00
Intersection	Hwy 1416 and Radar Hil…	File Name	Hwy1416-RadarHill_Alt1_AMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	5	697	64	102	433	7	179	18	312	11	26	17

Signal Information			
Cycle, s	61.1	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	0.4	3.7	15.0	0.9	4.2	18.9						
Yellow	3.5	0.0	3.5	3.5	0.0	3.5						
Red	1.0	0.0	1.0	1.0	0.0	1.0						



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	3.0	1.1	3.0	1.1	4.0	1.1	4.0
Phase Duration, s	4.9	19.5	8.6	23.2	9.6	27.6	5.4	23.4
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	2.9	2.9	2.9	3.0	3.3	3.3	3.3
Queue Clearance Time (g_s), s	2.1	14.2	4.7	8.3	6.3	12.8	2.3	3.1
Green Extension Time (g_e), s	0.0	0.8	0.0	2.1	0.0	0.5	0.0	0.7
Phase Call Probability	0.08	1.00	0.82	1.00	0.95	1.00	0.17	1.00
Max Out Probability	1.00	0.70	1.00	0.08	1.00	0.14	1.00	0.00

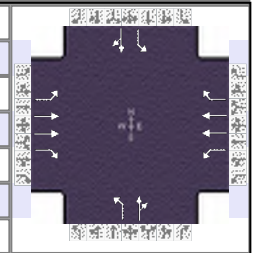
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	5	697	64	102	433	7	179	330		11	43	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1667	1666	1483	1667	1666	1483	1667	1495		1667	1634	
Queue Service Time (g_s), s	0.1	12.2	2.1	2.7	6.3	0.2	4.3	10.8		0.3	1.1	
Cycle Queue Clearance Time (g_c), s	0.1	12.2	2.1	2.7	6.3	0.2	4.3	10.8		0.3	1.1	
Green Ratio (*g/C*)	0.25	0.25	0.25	0.33	0.31	0.31	0.42	0.38		0.32	0.31	
Capacity (*c*), veh/h	294	819	365	265	1021	455	659	566		322	505	
Volume-to-Capacity Ratio (*X*)	0.017	0.851	0.176	0.385	0.424	0.015	0.272	0.583		0.034	0.085	
Back of Queue (*Q*), ft/ln (95 th percentile)	2	200.7	26.8	36.8	87.5	2.5	57.1	164.5		4.5	20.1	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.1	8.0	1.1	1.5	3.5	0.1	2.3	6.6		0.2	0.8	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	17.3	22.0	18.2	16.2	16.9	14.8	11.6	15.2		14.7	15.0	
Incremental Delay (d_2), s/veh	0.0	5.7	0.1	0.3	0.1	0.0	0.1	4.4		0.0	0.3	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	17.3	27.7	18.3	16.5	17.0	14.8	11.6	19.6		14.7	15.3	
Level of Service (LOS)	B	C	B	B	B	B	B	B		B	B	
Approach Delay, s/veh / LOS	26.9	C		16.9	B		16.8	B		15.2	B	
Intersection Delay, s/veh / LOS	20.9						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.91	B	1.91	B	2.41	B	2.42	B
Bicycle LOS Score / LOS	1.12	A	0.93	A	1.33	A	0.58	A

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HCS Signalized Intersection Results Summary

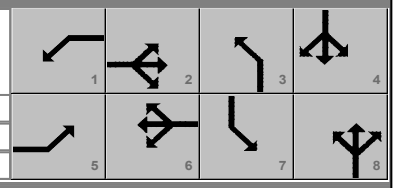
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/17/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 and Radar Hil…	File Name	Hwy1416-RadarHill_Alt1_AMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	5	789	73	115	491	8	202	18	354	12	28	19

Signal Information			
Cycle, s	66.6	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	0.4	4.2	18.5	5.1	20.4	0.0	
Yellow	3.5	0.0	3.5	3.5	3.5	0.0	
Red	1.0	0.0	1.0	1.0	1.0	0.0	



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	3.0	1.1	3.0	1.1	4.0	1.1	4.0
Phase Duration, s	4.9	23.0	9.1	27.2	9.6	25.0	9.5	24.9
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	2.9	2.9	2.9	3.0	3.3	3.3	3.3
Queue Clearance Time (g_s), s	2.1	17.6	5.2	10.0	7.1	17.9	2.3	3.4
Green Extension Time (g_e), s	0.0	0.9	0.0	2.6	0.0	0.3	0.0	0.8
Phase Call Probability	0.09	1.00	0.88	1.00	0.98	1.00	1.00	1.00
Max Out Probability	1.00	0.71	1.00	0.06	1.00	1.00	1.00	0.00

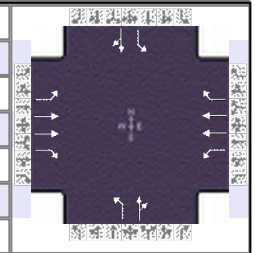
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	5	789	73	115	491	8	202	372		12	47	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614	1437	1602	1601	1425	1615	1447		1628	1593	
Queue Service Time (g_s), s	0.1	15.6	2.6	3.2	8.0	0.2	5.1	15.9		0.3	1.4	
Cycle Queue Clearance Time (g_c), s	0.1	15.6	2.6	3.2	8.0	0.2	5.1	15.9		0.3	1.4	
Green Ratio (*g/C*)	0.28	0.28	0.28	0.37	0.34	0.34	0.38	0.31		0.38	0.31	
Capacity (*c*), veh/h	289	896	399	249	1090	485	613	445		269	488	
Volume-to-Capacity Ratio (*X*)	0.017	0.880	0.183	0.463	0.451	0.016	0.330	0.835		0.045	0.096	
Back of Queue (*Q*), ft/ln (95 th percentile)	2.2	253.9	33.8	45.6	111.8	3.1	85.1	292.8		6	25.2	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.1	9.8	1.3	1.8	4.3	0.1	3.3	11.3		0.2	1.0	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	17.4	23.0	18.3	16.8	17.1	14.6	14.7	21.5		15.3	16.5	
Incremental Delay (d_2), s/veh	0.0	7.9	0.1	0.5	0.1	0.0	0.1	19.2		0.3	0.4	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	17.4	30.9	18.4	17.3	17.2	14.6	14.8	40.7		15.6	16.9	
Level of Service (LOS)	B	C	B	B	B	B	B	D		B	B	
Approach Delay, s/veh / LOS	29.7	C		17.2	B		31.6	C		16.6	B	
Intersection Delay, s/veh / LOS	26.2						C					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.91	B	1.90	B	2.42	B	2.42	B
Bicycle LOS Score / LOS	1.20	A	0.99	A	1.43	A	0.58	A

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HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/14/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2030	Analysis Period	1> 16:45
Intersection	Hwy 1416 and Radar Hil…	File Name	Hwy1416-RadarHill_Alt1_PMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	20	424	204	194	561	4	117	10	123	5	9	11

Signal Information			
Cycle, s	57.8	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

								1	2	3	4	
Green	1.4	4.1	11.6	0.4	3.9	18.5						
Yellow	3.5	0.0	3.5	3.5	0.0	3.5						
Red	1.0	0.0	1.0	1.0	0.0	1.0						
							5	6	7	8		

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	3.0	1.1	3.0	1.1	4.0	1.1	4.0
Phase Duration, s	5.9	16.1	10.0	20.2	8.7	26.9	4.9	23.0
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	2.9	2.9	2.9	3.0	3.3	3.3	3.3
Queue Clearance Time (g_s), s	2.6	9.7	7.4	10.9	4.6	5.6	2.1	2.5
Green Extension Time (g_e), s	0.0	2.0	0.0	1.9	0.0	0.2	0.0	0.2
Phase Call Probability	0.27	1.00	0.96	1.00	0.85	1.00	0.08	1.00
Max Out Probability	1.00	0.14	1.00	0.18	1.00	0.00	1.00	0.00

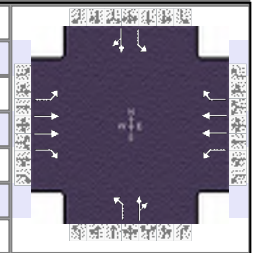
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	20	424	204	194	561	4	117	133		5	20	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614	1437	1602	1601	1425	1615	1453		1628	1555	
Queue Service Time (g_s), s	0.6	7.0	7.7	5.4	8.9	0.1	2.6	3.6		0.1	0.5	
Cycle Queue Clearance Time (g_c), s	0.6	7.0	7.7	5.4	8.9	0.1	2.6	3.6		0.1	0.5	
Green Ratio (*g/C*)	0.22	0.20	0.20	0.32	0.27	0.27	0.42	0.39		0.33	0.32	
Capacity (*c*), veh/h	232	648	288	352	871	388	669	562		497	497	
Volume-to-Capacity Ratio (*X*)	0.086	0.655	0.708	0.551	0.644	0.010	0.175	0.237		0.010	0.040	
Back of Queue (*Q*), ft/ln (95 th percentile)	8.1	101.9	101.6	75.4	126.1	1.5	34.4	49.7		1.9	8.7	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.3	3.9	3.9	2.9	4.8	0.1	1.3	1.9		0.1	0.3	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	18.0	21.3	21.5	15.9	18.6	15.4	10.7	12.0		13.2	13.6	
Incremental Delay (d_2), s/veh	0.1	0.4	1.2	1.1	0.6	0.0	0.0	1.0		0.0	0.2	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	18.1	21.7	22.7	17.0	19.2	15.4	10.7	13.0		13.2	13.7	
Level of Service (LOS)	B	C	C	B	B	B	B	B		B	B	
Approach Delay, s/veh / LOS	21.9	C		18.6	B		11.9	B		13.6	B	
Intersection Delay, s/veh / LOS	18.8						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.91	B	1.91	B	2.41	B	2.41	B
Bicycle LOS Score / LOS	1.02	A	1.11	A	0.90	A	0.53	A

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HCS Signalized Intersection Results Summary

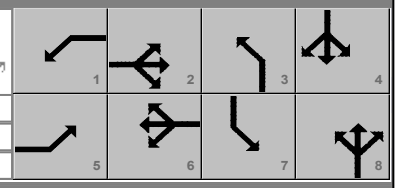
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/17/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2050	Analysis Period	1> 16:30
Intersection	Hwy 1416 and Radar Hil…	File Name	Hwy1416-RadarHill_Alt1_PMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	23	494	238	222	653	4	133	10	143	5	11	12

Signal Information			
Cycle, s	60.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	1.6	4.3	13.3	0.4	4.2	18.1						
Yellow	3.5	0.0	3.5	3.5	0.0	3.5						
Red	1.0	0.0	1.0	1.0	0.0	1.0						



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	3.0	1.1	3.0	1.1	4.0	1.1	4.0
Phase Duration, s	6.1	17.8	10.4	22.1	9.1	26.8	4.9	22.6
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	2.9	2.9	2.9	3.0	3.3	3.3	3.3
Queue Clearance Time (g_s), s	2.7	11.3	7.9	12.8	5.2	6.4	2.1	2.6
Green Extension Time (g_e), s	0.0	2.1	0.0	2.0	0.0	0.3	0.0	0.3
Phase Call Probability	0.32	1.00	0.98	1.00	0.89	1.00	0.08	1.00
Max Out Probability	1.00	0.31	1.00	0.38	1.00	0.00	1.00	0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	23	494	238	222	653	4	133	153		5	23	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614	1437	1602	1601	1425	1615	1451		1628	1562	
Queue Service Time (g_s), s	0.7	8.4	9.3	5.9	10.8	0.1	3.2	4.4		0.1	0.6	
Cycle Queue Clearance Time (g_c), s	0.7	8.4	9.3	5.9	10.8	0.1	3.2	4.4		0.1	0.6	
Green Ratio (*g/C*)	0.25	0.22	0.22	0.35	0.29	0.29	0.41	0.37		0.31	0.30	
Capacity (*c*), veh/h	224	718	320	350	942	419	643	540		455	472	
Volume-to-Capacity Ratio (*X*)	0.102	0.688	0.745	0.634	0.693	0.010	0.207	0.283		0.011	0.049	
Back of Queue (*Q*), ft/ln (95 th percentile)	9.4	123.6	129.7	94.9	157.8	1.5	42.7	63.8		2.1	10.8	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.4	4.8	5.0	3.7	6.1	0.1	1.7	2.5		0.1	0.4	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	17.8	21.4	21.7	16.3	18.8	15.0	11.5	13.2		14.4	14.8	
Incremental Delay (d_2), s/veh	0.1	0.5	2.9	2.9	1.5	0.0	0.1	1.3		0.0	0.2	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	17.9	21.9	24.6	19.3	20.3	15.0	11.6	14.5		14.4	15.0	
Level of Service (LOS)	B	C	C	B	C	B	B	B		B	B	
Approach Delay, s/veh / LOS	22.7	C		20.0	B		13.1	B		14.9	B	
Intersection Delay, s/veh / LOS	19.9						B					

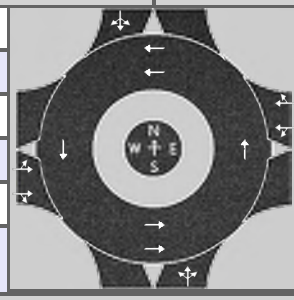
Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.91	B	1.91	B	2.41	B	2.42	B
Bicycle LOS Score / LOS	1.11	A	1.21	A	0.96	A	0.53	A

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2030
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.88
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LTR				LTR	
Volume (V), veh/h	0	5	702	64	0	107	454	7	0	179	18	314	0	12	25	17
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	6	830	76	0	128	542	8	0	212	21	371	0	14	29	20
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276			4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352			2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	429	483		319	359			604			63	
Entry Volume, veh/h	412	465		303	342			581			61	
Circulating Flow (v_c), pc/h	171			239			850			882		
Exiting Flow (v_{ex}), pc/h	1215			774			35			233		
Capacity (c_{pce}), pc/h	1215	1215		1142	1142			689			671	
Capacity (c), veh/h	1169	1169		1088	1088			663			651	
v/c Ratio (x)	0.35	0.40		0.28	0.31			0.88			0.09	

Delay and Level of Service

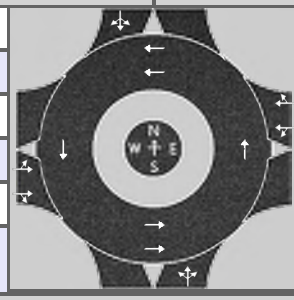
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	6.5	7.1		6.0	6.4			43.2			6.6	
Lane LOS	A	A		A	A			E			A	
95% Queue, veh	1.6	2.0		1.2	1.4			15.4			0.3	
Approach Delay, s/veh | LOS	6.8	A		6.2	A		43.2	E		6.6	A	
Intersection Delay, s/veh | LOS	16.4						C					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2050
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.88
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LTR				LTR	
Volume (V), veh/h	0	5	794	73	0	120	512	8	0	202	18	356	0	13	27	19
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	6	938	86	0	143	611	10	0	239	21	421	0	15	32	22
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276			4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352			2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	484	546		359	405			681			69	
Entry Volume, veh/h	465	525		342	386			655			67	
Circulating Flow (v_c), pc/h	190			266			959			993		
Exiting Flow (v_{ex}), pc/h	1374			872			37			261		
Capacity (c_{pce}), pc/h	1195	1195		1115	1115			628			611	
Capacity (c), veh/h	1149	1149		1062	1062			604			593	
v/c Ratio (x)	0.41	0.46		0.32	0.36			1.08			0.11	

Delay and Level of Service

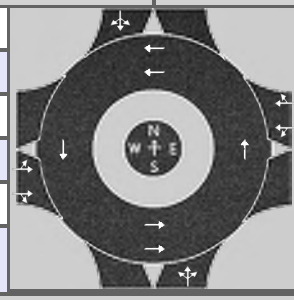
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	7.3	8.0		6.6	7.1			217.7			7.4	
Lane LOS	A	A		A	A			F			A	
95% Queue, veh	2.0	2.5		1.4	1.7			46.4			0.4	
Approach Delay, s/veh | LOS	7.7	A		6.9	A		217.7	F		7.4	A	
Intersection Delay, s/veh | LOS	63.8						F					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2030
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.94
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LTR				LTR	
Volume (V), veh/h	0	20	475	205	0	209	605	4	0	118	14	138	0	5	13	11
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	22	526	227	0	233	676	4	0	131	15	153	0	5	14	12
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276			4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352			2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	364	411		429	484			299			31	
Entry Volume, veh/h	350	395		409	461			288			30	
Circulating Flow (v_c), pc/h	252			168			553			1040		
Exiting Flow (v_{ex}), pc/h	684			819			41			474		
Capacity (c_{pce}), pc/h	1129	1129		1219	1219			887			587	
Capacity (c), veh/h	1086	1086		1161	1161			853			570	
v/c Ratio (x)	0.32	0.36		0.35	0.40			0.34			0.05	

Delay and Level of Service

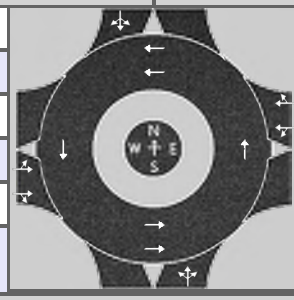
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	6.5	7.0		6.5	7.1			8.0			6.9	
Lane LOS	A	A		A	A			A			A	
95% Queue, veh	1.4	1.7		1.6	2.0			1.5			0.2	
Approach Delay, s/veh | LOS	6.8	A		6.9	A		8.0	A		6.9	A	
Intersection Delay, s/veh | LOS	7.0						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2050
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.94
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LTR				LTR	
Volume (V), veh/h	0	23	545	239	0	237	697	4	0	134	14	158	0	5	15	12
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	25	603	264	0	265	779	4	0	148	15	175	0	5	16	13
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276			4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352			2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	419	473		493	555			338			34	
Entry Volume, veh/h	403	455		469	529			325			33	
Circulating Flow (v_c), pc/h	286			188			633			1192		
Exiting Flow (v_{ex}), pc/h	783			940			44			545		
Capacity (c_{pce}), pc/h	1095	1095		1197	1197			829			516	
Capacity (c), veh/h	1053	1053		1140	1140			797			501	
v/c Ratio (x)	0.38	0.43		0.41	0.46			0.41			0.07	

Delay and Level of Service

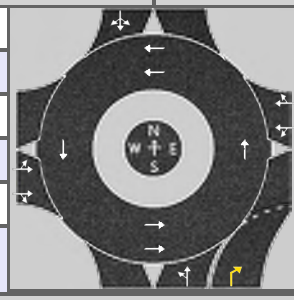
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	7.5	8.2		7.4	8.2			9.7			8.0	
Lane LOS	A	A		A	A			A			A	
95% Queue, veh	1.9	2.3		2.1	2.6			2.0			0.2	
Approach Delay, s/veh | LOS	7.8	A		7.8	A		9.7	A		8.0	A	
Intersection Delay, s/veh | LOS	8.1						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2030
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.88
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LT				LTR	
Volume (V), veh/h	0	5	702	64	0	107	454	7	0	179	18	314	0	12	25	17
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	6	830	76	0	128	542	8	0	212	21	371	0	14	29	20
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	429	483		319	359			233	371		63	
Entry Volume, veh/h	412	465		303	342			224	357		61	
Circulating Flow (v_c), pc/h	171			239			850			882		
Exiting Flow (v_{ex}), pc/h	844			774			35			233		
Capacity (c_{pce}), pc/h	1215	1215		1142	1142			689	583		671	
Capacity (c), veh/h	1169	1169		1088	1088			663	561		651	
v/c Ratio (x)	0.35	0.40		0.28	0.31			0.34	0.64		0.09	

Delay and Level of Service

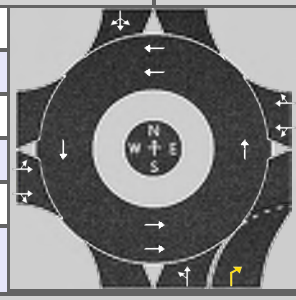
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	6.5	7.1		6.0	6.4			9.9	20.6		6.6	
Lane LOS	A	A		A	A			A	C		A	
95% Queue, veh	1.6	2.0		1.2	1.4			1.5	5.0		0.3	
Approach Delay, s/veh | LOS	6.8	A		6.2	A		16.5	C		6.6	A	
Intersection Delay, s/veh | LOS	9.2						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2050
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.88
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LT				LTR	
Volume (V), veh/h	0	5	794	73	0	120	512	8	0	202	18	356	0	13	27	19
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	6	938	86	0	143	611	10	0	239	21	421	0	15	32	22
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	484	546		359	405			260	421		69	
Entry Volume, veh/h	465	525		342	386			250	405		67	
Circulating Flow (v_c), pc/h	190			266			959			993		
Exiting Flow (v_{ex}), pc/h	953			872			37			261		
Capacity (c_{pce}), pc/h	1195	1195		1115	1115			628	522		611	
Capacity (c), veh/h	1149	1149		1062	1062			604	502		593	
v/c Ratio (x)	0.41	0.46		0.32	0.36			0.41	0.81		0.11	

Delay and Level of Service

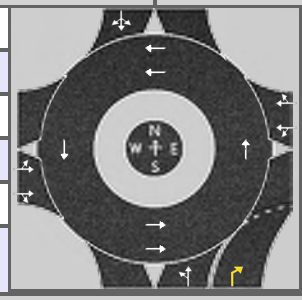
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	7.3	8.0		6.6	7.1			12.2	38.9		7.4	
Lane LOS	A	A		A	A			B	E		A	
95% Queue, veh	2.0	2.5		1.4	1.7			2.1	10.3		0.4	
Approach Delay, s/veh | LOS	7.7	A		6.9	A		28.7	D		7.4	A	
Intersection Delay, s/veh | LOS	13.1						B					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2030
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.94
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LT				LTR	
Volume (V), veh/h	0	20	475	205	0	209	605	4	0	118	14	138	0	5	13	11
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	22	526	227	0	233	676	4	0	131	15	153	0	5	14	12
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	364	411		429	484			146	153		31	
Entry Volume, veh/h	350	395		409	461			140	147		30	
Circulating Flow (v_c), pc/h	252			168			553			1040		
Exiting Flow (v_{ex}), pc/h	531			819			41			474		
Capacity (c_{pce}), pc/h	1129	1129		1219	1219			887	803		587	
Capacity (c), veh/h	1086	1086		1161	1161			853	772		570	
v/c Ratio (x)	0.32	0.36		0.35	0.40			0.16	0.19		0.05	

Delay and Level of Service

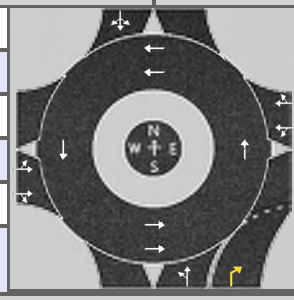
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	6.5	7.0		6.5	7.1			5.9	6.7		6.9	
Lane LOS	A	A		A	A			A	A		A	
95% Queue, veh	1.4	1.7		1.6	2.0			0.6	0.7		0.2	
Approach Delay, s/veh | LOS	6.8	A		6.9	A		6.3	A		6.9	A	
Intersection Delay, s/veh | LOS	6.7						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2050
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.94
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	2	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment	LT		TR		LT		TR				LT				LTR	
Volume (V), veh/h	0	23	545	239	0	237	697	4	0	134	14	158	0	5	15	12
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	25	603	264	0	265	779	4	0	148	15	175	0	5	16	13
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s	2.5352	2.5352		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	419	473		493	555			163	175		34	
Entry Volume, veh/h	403	455		469	529			157	168		33	
Circulating Flow (v_c), pc/h	286			188			633			1192		
Exiting Flow (v_{ex}), pc/h	608			940			44			545		
Capacity (c_{pce}), pc/h	1095	1095		1197	1197			829	742		516	
Capacity (c), veh/h	1053	1053		1140	1140			797	714		501	
v/c Ratio (x)	0.38	0.43		0.41	0.46			0.20	0.24		0.07	

Delay and Level of Service

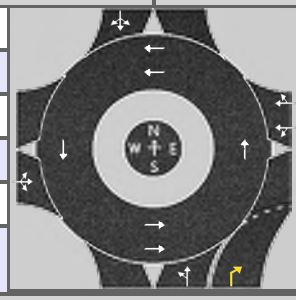
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	7.5	8.2		7.4	8.2			6.6	7.8		8.0	
Lane LOS	A	A		A	A			A	A		A	
95% Queue, veh	1.9	2.3		2.1	2.6			0.7	0.9		0.2	
Approach Delay, s/veh | LOS	7.8	A		7.8	A		7.2	A		8.0	A	
Intersection Delay, s/veh | LOS	7.7						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2030
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.88
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR		LT		TR				LT				LTR	
Volume (V), veh/h	0	5	702	64	0	107	454	7	0	179	18	314	0	12	25	17
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	6	830	76	0	128	542	8	0	212	21	371	0	14	29	20
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s		2.6087		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		912		319	359			233	371		63	
Entry Volume, veh/h		877		303	342			224	357		61	
Circulating Flow (v_c), pc/h	171			239			850			882		
Exiting Flow (v_{ex}), pc/h	844			774			35			233		
Capacity (c_{pce}), pc/h		1159		1142	1142			689	583		671	
Capacity (c), veh/h		1115		1088	1088			663	561		651	
v/c Ratio (x)		0.79		0.28	0.31			0.34	0.64		0.09	

Delay and Level of Service

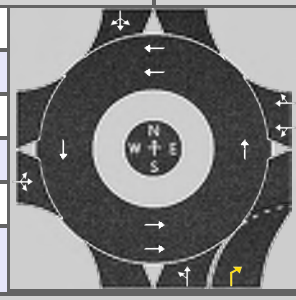
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		18.7		6.0	6.4			9.9	20.6		6.6	
Lane LOS		C		A	A			A	C		A	
95% Queue, veh		10.2		1.2	1.4			1.5	5.0		0.3	
Approach Delay, s/veh | LOS	18.7	C		6.2	A		16.5	C		6.6	A	
Intersection Delay, s/veh | LOS	14.0						B					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2050
Time Analyzed	AM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.88
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR		LT		TR				LT				LTR	
Volume (V), veh/h	0	5	794	73	0	120	512	8	0	202	18	356	0	13	27	19
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	6	938	86	0	143	611	10	0	239	21	421	0	15	32	22
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s		2.6087		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		1030		359	405			260	421		69	
Entry Volume, veh/h		990		342	386			250	405		67	
Circulating Flow (v_c), pc/h	190			266			959			993		
Exiting Flow (v_{ex}), pc/h	953			872			37			261		
Capacity (c_{pce}), pc/h		1137		1115	1115			628	522		611	
Capacity (c), veh/h		1093		1062	1062			604	502		593	
v/c Ratio (x)		0.91		0.32	0.36			0.41	0.81		0.11	

Delay and Level of Service

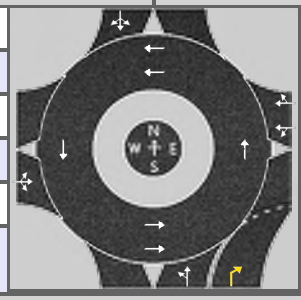
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		35.1		6.6	7.1			12.2	38.9		7.4	
Lane LOS		E		A	A			B	E		A	
95% Queue, veh		20.6		1.4	1.7			2.1	10.3		0.4	
Approach Delay, s/veh | LOS	35.1	E		6.9	A		28.7	D		7.4	A	
Intersection Delay, s/veh | LOS	24.2						C					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2030
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.94
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR		LT		TR				LT				LTR	
Volume (V), veh/h	0	20	475	205	0	209	605	4	0	118	14	138	0	5	13	11
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	22	526	227	0	233	676	4	0	131	15	153	0	5	14	12
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s		2.6087		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		775		429	484			146	153		31	
Entry Volume, veh/h		745		409	461			140	147		30	
Circulating Flow (v_c), pc/h	252			168			553			1040		
Exiting Flow (v_{ex}), pc/h	531			819			41			474		
Capacity (c_{pce}), pc/h		1067		1219	1219			887	803		587	
Capacity (c), veh/h		1026		1161	1161			853	772		570	
v/c Ratio (x)		0.73		0.35	0.40			0.16	0.19		0.05	

Delay and Level of Service

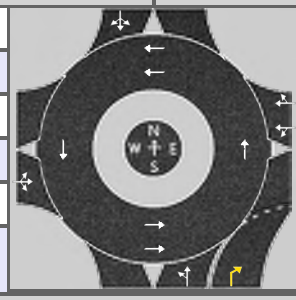
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		16.3		6.5	7.1			5.9	6.7		6.9	
Lane LOS		C		A	A			A	A		A	
95% Queue, veh		7.6		1.6	2.0			0.6	0.7		0.2	
Approach Delay, s/veh | LOS	16.3	C		6.9	A		6.3	A		6.9	A	
Intersection Delay, s/veh | LOS	10.4						B					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/17/2023
Analysis Year	2050
Time Analyzed	PM Peak
Project Description	Radar Hill 1416 Corridor Study



Site Information

Intersection	Highway 1416 and Radar Hil...
E/W Street Name	Highway 1416
N/S Street Name	Radar Hill Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.94
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	2	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR		LT		TR				LT				LTR	
Volume (V), veh/h	0	23	545	239	0	237	697	4	0	134	14	158	0	5	15	12
Percent Heavy Vehicles, %	4	4	4	4	5	5	5	5	4	4	4	4	3	3	3	3
Flow Rate (v_{PCE}), pc/h	0	25	603	264	0	265	779	4	0	148	15	175	0	5	16	13
Right-Turn Bypass	None				None				Yielding				None			
Conflicting Lanes	1				1				2				2			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763		4.5436	4.5436			4.3276	4.9763		4.3276	
Follow-Up Headway, s		2.6087		2.5352	2.5352			2.5352	2.6087		2.5352	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		892		493	555			163	175		34	
Entry Volume, veh/h		858		469	529			157	168		33	
Circulating Flow (v_c), pc/h	286			188			633			1192		
Exiting Flow (v_{ex}), pc/h	608			940			44			545		
Capacity (c_{pce}), pc/h		1031		1197	1197			829	742		516	
Capacity (c), veh/h		991		1140	1140			797	714		501	
v/c Ratio (x)		0.87		0.41	0.46			0.20	0.24		0.07	

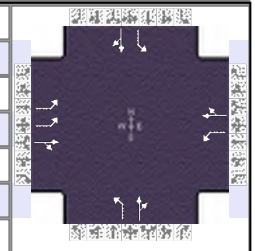
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		29.4		7.4	8.2			6.6	7.8		8.0	
Lane LOS		D		A	A			A	A		A	
95% Queue, veh		15.6		2.1	2.6			0.7	0.9		0.2	
Approach Delay, s/veh | LOS	29.4	D		7.8	A		7.2	A		8.0	A	
Intersection Delay, s/veh | LOS	16.1						C					

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HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 8, 2023	Area Type	Other
Jurisdiction		Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2030	Analysis Period	1> 7:00
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt1_AMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	650	327	16	24	147	38	90	100	57	60	66	207

Signal Information			
Cycle, s	61.1	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	1.7	4.3	9.1	3.9	1.1	18.5	1	2	3	4		
Yellow	3.5	3.5	3.5	3.5	0.0	3.5	5	6	7	8		
Red	1.0	1.0	1.0	1.0	0.0	1.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	4.0	1.1	4.0	1.1	4.0	1.1	4.0
Phase Duration, s	15.0	22.4	6.2	13.6	8.4	23.0	9.5	24.1
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	2.9	2.9	2.9	2.9	3.1	2.9	3.1
Queue Clearance Time (g_s), s	11.9	12.6	2.7	8.4	4.2	6.5	3.4	10.9
Green Extension Time (g_e), s	0.0	0.7	0.0	0.7	0.0	0.7	0.0	0.5
Phase Call Probability	1.00	1.00	0.33	1.00	0.78	1.00	1.00	1.00
Max Out Probability	1.00	0.01	1.00	0.01	1.00	0.00	1.00	0.05

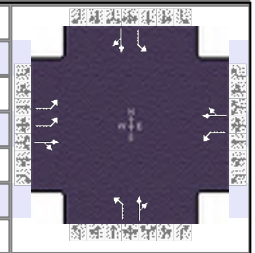
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	650	343		24	185		90	157		60	273	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1618	1735		1667	1688		1667	1643		1667	1540	
Queue Service Time (g_s), s	9.9	10.6		0.7	6.4		2.2	4.5		1.4	8.9	
Cycle Queue Clearance Time (g_c), s	9.9	10.6		0.7	6.4		2.2	4.5		1.4	8.9	
Green Ratio (*g/C*)	0.35	0.29		0.18	0.15		0.37	0.30		0.38	0.32	
Capacity (*c*), veh/h	899	509		255	251		384	498		541	494	
Volume-to-Capacity Ratio (*X*)	0.723	0.674		0.094	0.737		0.235	0.316		0.111	0.553	
Back of Queue (*Q*), ft/ln (95 th percentile)	141.1	158		11.1	102.4		29.2	71.2		20.7	139.6	
Back of Queue (*Q*), veh/ln (95 th percentile)	5.6	6.3		0.4	4.1		1.2	2.8		0.8	5.6	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	16.8	19.0		21.2	24.9		13.8	16.4		12.2	17.1	
Incremental Delay (d_2), s/veh	2.5	0.8		0.1	1.6		0.1	1.7		0.4	4.5	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	19.3	19.8		21.2	26.5		13.9	18.1		12.6	21.6	
Level of Service (LOS)	B	B		C	C		B	B		B	C	
Approach Delay, s/veh / LOS	19.5	B		25.9	C		16.6	B		20.0	B	
Intersection Delay, s/veh / LOS	19.9						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.91	B	2.11	B	1.91	B	2.09	B
Bicycle LOS Score / LOS	2.13	B	0.83	A	0.90	A	1.04	A

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HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 8, 2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt1_AMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	748	348	19	24	156	41	102	107	58	61	69	248

Signal Information			
Cycle, s	83.4	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	2.1	11.1	11.7	18.0	18.0	0.0	1	2	3	4		
Yellow	3.5	3.5	3.5	3.5	3.5	0.0	5	6	7	8		
Red	1.0	1.0	1.0	1.0	1.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	4.0	1.1	4.0	1.1	4.0	1.1	4.0
Phase Duration, s	22.2	31.8	6.6	16.2	22.5	22.5	22.5	22.5
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	2.9	2.9	2.9	2.9	3.1	2.9	3.1
Queue Clearance Time (g_s), s	17.6	17.1	3.0	11.5	5.1	9.3	3.8	19.0
Green Extension Time (g_e), s	0.1	0.1	0.0	0.2	0.1	0.7	0.1	0.0
Phase Call Probability	1.00	1.00	0.43	1.00	1.00	1.00	1.00	1.00
Max Out Probability	1.00	1.00	0.00	0.10	0.00	0.03	0.00	1.00

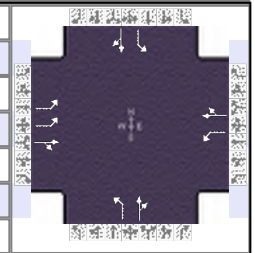
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	748	367		24	197		102	165		61	317	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1618	1734		1667	1687		1667	1646		1667	1534	
Queue Service Time (g_s), s	15.6	15.1		1.0	9.5		3.1	7.3		1.8	17.0	
Cycle Queue Clearance Time (g_c), s	15.6	15.1		1.0	9.5		3.1	7.3		1.8	17.0	
Green Ratio (*g/C*)	0.38	0.33		0.17	0.14		0.43	0.22		0.43	0.22	
Capacity (*c*), veh/h	924	567		255	236		446	355		575	331	
Volume-to-Capacity Ratio (*X*)	0.809	0.647		0.094	0.833		0.229	0.465		0.106	0.958	
Back of Queue (*Q*), ft/ln (95 th percentile)	241	240.8		17	176.8		51.4	136.2		28.7	433.7	
Back of Queue (*Q*), veh/ln (95 th percentile)	9.6	9.6		0.7	7.1		2.1	5.4		1.1	17.3	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	22.1	24.0		29.5	34.9		16.3	28.5		14.5	32.3	
Incremental Delay (d_2), s/veh	5.1	2.0		0.1	5.8		1.2	4.4		0.4	66.0	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	27.2	26.0		29.5	40.7		17.5	32.9		14.9	98.4	
Level of Service (LOS)	C	C		C	D		B	C		B	F	
Approach Delay, s/veh / LOS	26.8	C		39.5	D		27.0	C		84.9	F	
Intersection Delay, s/veh / LOS	39.4						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.92	B	2.13	B	1.93	B	2.12	B
Bicycle LOS Score / LOS	2.33	B	0.85	A	0.93	A	1.11	A

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HCS Signalized Intersection Results Summary

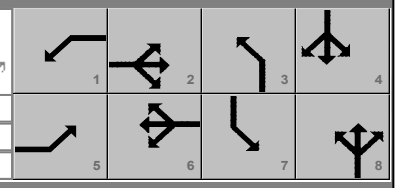
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 8, 2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2030	Analysis Period	1> 16:45
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt1_PMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	306	84	152	15	76	7	38	39	7	7	62	273

Signal Information			
Cycle, s	52.4	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	1.0	4.1	5.8	2.1	2.9	18.5	
Yellow	3.5	0.0	3.5	3.5	0.0	3.5	
Red	1.0	0.0	1.0	1.0	0.0	1.0	



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	4.0	1.1	4.0	1.1	4.0	1.1	4.0
Phase Duration, s	9.6	14.4	5.5	10.3	6.6	23.0	9.5	25.9
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	3.0	3.0	3.0	3.3	3.4	3.3	3.4
Queue Clearance Time (g_s), s	6.2	9.5	2.4	4.4	2.7	2.9	2.1	10.7
Green Extension Time (g_e), s	0.0	0.4	0.0	0.5	0.0	0.8	0.0	0.6
Phase Call Probability	0.99	1.00	0.20	0.99	0.42	1.00	1.00	1.00
Max Out Probability	1.00	0.01	1.00	0.00	1.00	0.00	1.00	0.07

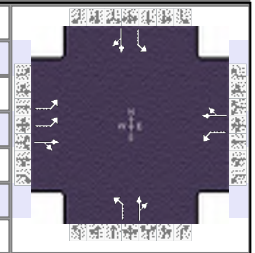
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	306	236		15	83		38	46		7	335	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1618	1568		1667	1724		1667	1703		1667	1526	
Queue Service Time (g_s), s	4.2	7.5		0.4	2.4		0.7	0.9		0.1	8.7	
Cycle Queue Clearance Time (g_c), s	4.2	7.5		0.4	2.4		0.7	0.9		0.1	8.7	
Green Ratio (*g/C*)	0.24	0.19		0.13	0.11		0.39	0.35		0.46	0.41	
Capacity (*c*), veh/h	766	297		178	191		421	601		759	622	
Volume-to-Capacity Ratio (*X*)	0.399	0.795		0.084	0.434		0.090	0.077		0.009	0.538	
Back of Queue (*Q*), ft/ln (95 th percentile)	54.2	104		6.2	37.3		10.9	16.2		1.9	141.3	
Back of Queue (*Q*), veh/ln (95 th percentile)	2.2	4.2		0.2	1.5		0.4	0.6		0.1	5.7	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	16.9	20.3		20.3	21.8		10.5	11.3		7.8	11.8	
Incremental Delay (d_2), s/veh	0.1	1.9		0.1	0.6		0.0	0.2		0.0	3.4	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	17.1	22.1		20.4	22.3		10.5	11.5		7.8	15.1	
Level of Service (LOS)	B	C		C	C		B	B		A	B	
Approach Delay, s/veh / LOS	19.3	B		22.0	C		11.1	B		15.0	B	
Intersection Delay, s/veh / LOS	17.5						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.91	B	2.11	B	1.89	B	2.08	B
Bicycle LOS Score / LOS	1.38	A	0.65	A	0.63	A	1.05	A

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HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 10, 2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2050	Analysis Period	1> 16:45
Intersection	Highway 1416 and S Ell…	File Name	Hwy1416-EllsworthRd_Alt1_PMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	352	99	178	18	91	8	43	43	8	8	72	327

Signal Information			
Cycle, s	54.6	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	1.2	3.9	8.0	2.4	2.6	18.5	1	2	3	4		
Yellow	3.5	0.0	3.5	3.5	0.0	3.5	5	6	7	8		
Red	1.0	0.0	1.0	1.0	0.0	1.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	4.0	1.1	4.0	1.1	4.0	1.1	4.0
Phase Duration, s	9.6	16.5	5.7	12.5	6.9	23.0	9.5	25.6
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	2.9	3.0	3.0	3.0	3.3	3.4	3.3	3.4
Queue Clearance Time (g_s), s	7.1	11.5	2.5	5.1	2.9	3.1	2.2	14.5
Green Extension Time (g_e), s	0.0	0.4	0.0	0.6	0.0	1.0	0.0	0.5
Phase Call Probability	1.00	1.00	0.24	1.00	0.48	1.00	1.00	1.00
Max Out Probability	1.00	0.05	1.00	0.00	1.00	0.00	1.00	0.75

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	352	277		18	99		43	51		8	399	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1568	1520		1537	1590		1654	1689		1602	1466	
Queue Service Time (g_s), s	5.1	9.5		0.5	3.1		0.9	1.1		0.2	12.5	
Cycle Queue Clearance Time (g_c), s	5.1	9.5		0.5	3.1		0.9	1.1		0.2	12.5	
Green Ratio (*g/C*)	0.27	0.22		0.17	0.15		0.38	0.34		0.43	0.39	
Capacity (*c*), veh/h	788	332		174	234		323	572		698	566	
Volume-to-Capacity Ratio (*X*)	0.447	0.833		0.104	0.423		0.133	0.089		0.011	0.705	
Back of Queue (*Q*), ft/ln (95 th percentile)	66.1	140.6		8	48.3		13.7	19.8		2.5	219.1	
Back of Queue (*Q*), veh/ln (95 th percentile)	2.6	5.4		0.3	1.8		0.5	0.8		0.1	8.4	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00		0.00	0.00		0.00	0.00		0.00	0.00	
Uniform Delay (d_1), s/veh	16.8	20.4		19.6	21.2		12.1	12.3		8.9	14.1	
Incremental Delay (d_2), s/veh	0.1	4.0		0.1	0.5		0.1	0.3		0.0	7.5	
Initial Queue Delay (d_3), s/veh	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	16.9	24.4		19.7	21.6		12.1	12.6		8.9	21.6	
Level of Service (LOS)	B	C		B	C		B	B		A	C	
Approach Delay, s/veh / LOS	20.2	C		21.3	C		12.4	B		21.4	C	
Intersection Delay, s/veh / LOS	20.1						C					

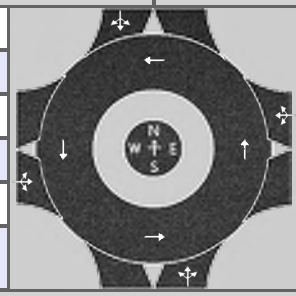
Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.91	B	2.11	B	1.90	B	2.08	B
Bicycle LOS Score / LOS	1.53	B	0.68	A	0.64	A	1.16	A

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/7/2023
Analysis Year	2030
Time Analyzed	AM Peak
Project Description	Alternative 2



Site Information

Intersection	Highway 1416 and S Ellswor...
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	650	335	16	0	30	173	44	0	90	100	59	0	62	66	207
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	805	415	20	0	39	227	58	0	108	120	71	0	78	82	259
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		1240			324			299			419	
Entry Volume, veh/h		1192			295			296			399	
Circulating Flow (v_c), pc/h	199			1033			1298			374		
Exiting Flow (v_{ex}), pc/h	564			594			983			141		
Capacity (c_{pce}), pc/h		1126			481			367			942	
Capacity (c), veh/h		1083			437			364			897	
v/c Ratio (x)		1.10			0.67			0.81			0.44	

Delay and Level of Service

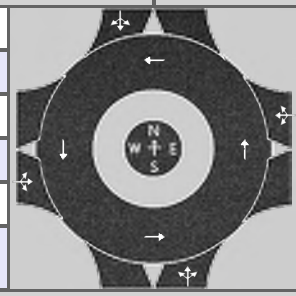
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		220.7			28.1			52.9			9.4	
Lane LOS		F			D			F			A	
95% Queue, veh		77.6			5.7			10.1			2.4	
Approach Delay, s/veh | LOS	220.7	F		28.1	D		52.9	F		9.4	A	
Intersection Delay, s/veh | LOS	133.3						F					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/7/2023
Analysis Year	2050
Time Analyzed	AM Peak
Project Description	Alternative 2



Site Information

Intersection	Highway 1416 and S Ellswor...
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	748	356	19	0	30	182	47	0	102	107	60	0	63	69	248
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	926	441	24	0	39	238	62	0	123	129	72	0	79	86	310
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		1391			339			324			475	
Entry Volume, veh/h		1338			308			321			452	
Circulating Flow (v_c), pc/h	204			1178			1446			400		
Exiting Flow (v_{ex}), pc/h	592			671			1117			149		
Capacity (c_{pce}), pc/h		1121			415			316			918	
Capacity (c), veh/h		1078			377			313			874	
v/c Ratio (x)		1.24			0.82			1.03			0.52	

Delay and Level of Service

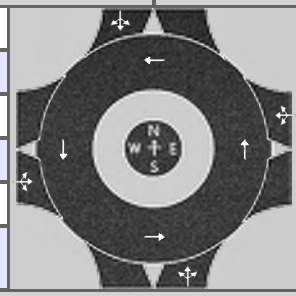
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		458.9			51.8			187.8			11.1	
Lane LOS		F			F			F			B	
95% Queue, veh		143.9			10.3			24.1			3.2	
Approach Delay, s/veh | LOS	458.9	F		51.8	F		187.8	F		11.1	B	
Intersection Delay, s/veh | LOS	287.3						F					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/7/2023
Analysis Year	2030
Time Analyzed	PM Peak
Project Description	Alternative 2



Site Information

Intersection	Highway 1416 and S Ellswor...
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.90
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	306	150	152	0	29	135	21	0	38	49	22	0	22	71	273
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	354	173	176	0	35	165	26	0	43	55	25	0	26	83	318
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		703			226			123			427	
Entry Volume, veh/h		676			205			122			407	
Circulating Flow (v_c), pc/h	144			452			553			243		
Exiting Flow (v_{ex}), pc/h	224			526			435			294		
Capacity (c_{pce}), pc/h		1191			870			785			1077	
Capacity (c), veh/h		1146			791			777			1026	
v/c Ratio (x)		0.59			0.26			0.16			0.40	

Delay and Level of Service

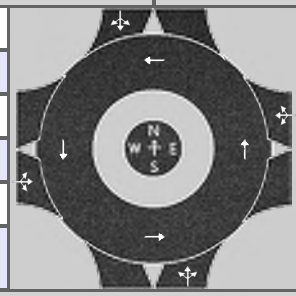
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		10.6			7.4			6.3			7.8	
Lane LOS		B			A			A			A	
95% Queue, veh		4.2			1.0			0.6			2.0	
Approach Delay, s/veh | LOS	10.6	B		7.4	A		6.3	A		7.8	A	
Intersection Delay, s/veh | LOS	9.0						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/7/2023
Analysis Year	2050
Time Analyzed	PM Peak
Project Description	Alternative 2



Site Information

Intersection	Highway 1416 and S Ellswor...
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.90
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	352	165	178	0	32	150	22	0	43	53	23	0	23	81	327
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	407	191	206	0	39	183	27	0	48	59	26	0	27	94	382
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		804			249			133			503	
Entry Volume, veh/h		773			226			132			479	
Circulating Flow (v_c), pc/h	160			514			625			270		
Exiting Flow (v_{ex}), pc/h	244			613			493			339		
Capacity (c_{pce}), pc/h		1172			817			729			1048	
Capacity (c), veh/h		1127			743			722			998	
v/c Ratio (x)		0.69			0.30			0.18			0.48	

Delay and Level of Service

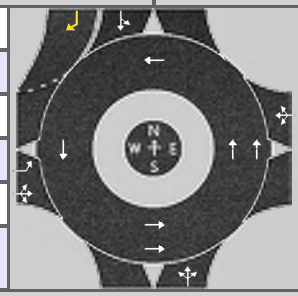
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		13.5			8.5			7.0			9.3	
Lane LOS		B			A			A			A	
95% Queue, veh		6.3			1.3			0.7			2.7	
Approach Delay, s/veh | LOS	13.5	B		8.5	A		7.0	A		9.3	A	
Intersection Delay, s/veh | LOS	11.0						B					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/4/2023
Analysis Year	2030
Time Analyzed	AM Peak
Project Description	Alternative 3



Site Information

Intersection	Hwy 1416 and S Ellsworth Rd
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	1	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment	L		LTR				LTR				LTR				LT	
Volume (V), veh/h	0	650	335	16	0	30	173	44	0	90	100	59	0	62	66	207
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	805	415	20	0	39	227	58	0	108	120	71	0	78	82	259
Right-Turn Bypass	None				None				None				Yielding			
Conflicting Lanes	1				2				2				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	1															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436			4.3276			4.3276			4.9763	4.9763
Follow-Up Headway, s	2.5352	2.5352			2.5352			2.5352			2.6087	2.6087

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	657	583			324			299			160	259
Entry Volume, veh/h	632	560			295			296			152	247
Circulating Flow (v_c), pc/h	199			1033			1298			374		
Exiting Flow (v_{ex}), pc/h	564			335			983			141		
Capacity ($c_{adj,pce}$), pc/h	1187	1187			591			472			944	981
Capacity (c), veh/h	1142	1142			537			467			899	934
v/c Ratio (x)	0.55	0.49			0.55			0.63			0.17	0.26

Delay and Level of Service

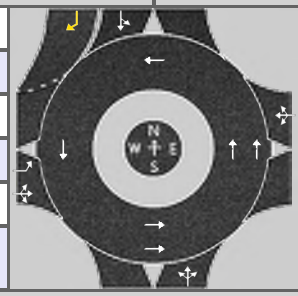
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	9.8	8.6			17.5			23.9			5.7	6.6
Lane LOS	A	A			C			C			A	A
95% Queue, veh	3.7	2.9			3.5			4.9			0.6	1.1
Approach Delay, s/veh | LOS	9.3	A		17.5	C		23.9	C		6.2	A	
Intersection Delay, s/veh | LOS	11.8						B					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/4/2023
Analysis Year	2050
Time Analyzed	AM Peak
Project Description	Alternative 3



Site Information

Intersection	Hwy 1416 and S Ellsworth Rd
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	1	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment	L		LTR				LTR				LTR				LT	
Volume (V), veh/h	0	748	356	19	0	30	182	47	0	102	107	60	0	63	69	248
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	926	441	24	0	39	238	62	0	123	129	72	0	79	86	310
Right-Turn Bypass	None				None				None				Yielding			
Conflicting Lanes	1				2				2				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	1															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436			4.3276			4.3276			4.9763	4.9763
Follow-Up Headway, s	2.5352	2.5352			2.5352			2.5352			2.6087	2.6087

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	737	654			339			324			165	310
Entry Volume, veh/h	709	629			308			321			157	295
Circulating Flow (v_c), pc/h	204			1178			1446			400		
Exiting Flow (v_{ex}), pc/h	592			361			1117			149		
Capacity ($c_{adj,pce}$), pc/h	1182	1182			523			416			920	955
Capacity (c), veh/h	1137	1137			475			412			876	909
v/c Ratio (x)	0.62	0.55			0.65			0.78			0.18	0.32

Delay and Level of Service

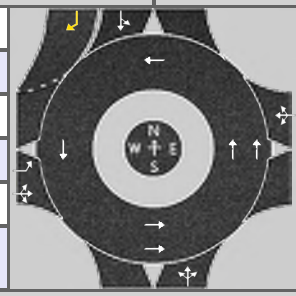
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	11.5	9.8			24.5			41.3			5.9	7.5
Lane LOS	B	A			C			E			A	A
95% Queue, veh	4.9	3.7			5.2			8.8			0.7	1.4
Approach Delay, s/veh | LOS	10.7	B		24.5	C		41.3	E		6.9	A	
Intersection Delay, s/veh | LOS	15.8						C					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/4/2023
Analysis Year	2030
Time Analyzed	PM Peak
Project Description	Alternative 3



Site Information

Intersection	Hwy 1416 and S Ellsworth Rd
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.90
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	1	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment	L		LTR				LTR				LTR				LT	
Volume (V), veh/h	0	306	150	152	0	29	135	21	0	38	49	22	0	22	71	273
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	354	173	176	0	35	165	26	0	43	55	25	0	26	83	318
Right-Turn Bypass	None				None				None				Yielding			
Conflicting Lanes	1				2				2				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	1															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436			4.3276			4.3276			4.9763	4.9763
Follow-Up Headway, s	2.5352	2.5352			2.5352			2.5352			2.6087	2.6087

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	373	330			226			123			109	318
Entry Volume, veh/h	358	318			205			122			104	303
Circulating Flow (v_c), pc/h	144			452			553			243		
Exiting Flow (v_{ex}), pc/h	224			208			435			294		
Capacity ($c_{adj,pce}$), pc/h	1248	1248			968			889			1079	1116
Capacity (c), veh/h	1200	1200			880			880			1028	1063
v/c Ratio (x)	0.30	0.26			0.23			0.14			0.10	0.28

Delay and Level of Service

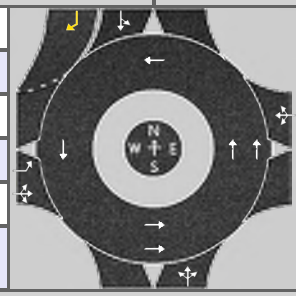
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	5.8	5.4			6.5			5.4			4.4	6.2
Lane LOS	A	A			A			A			A	A
95% Queue, veh	1.3	1.1			0.9			0.5			0.3	1.2
Approach Delay, s/veh | LOS	5.6	A		6.5	A		5.4	A		5.7	A	
Intersection Delay, s/veh | LOS	5.7						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/4/2023
Analysis Year	2050
Time Analyzed	PM Peak
Project Description	Alternative 3



Site Information

Intersection	Hwy 1416 and S Ellsworth Rd
E/W Street Name	Highway 1416
N/S Street Name	S Ellsworth Rd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.90
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	1	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment	L		LTR				LTR				LTR				LT	
Volume (V), veh/h	0	352	165	178	0	32	150	22	0	43	53	23	0	23	81	327
Percent Heavy Vehicles, %	4	4	4	4	10	10	10	10	1	1	1	1	5	5	5	5
Flow Rate (v_{PCE}), pc/h	0	407	191	206	0	39	183	27	0	48	59	26	0	27	94	382
Right-Turn Bypass	None				None				None				Yielding			
Conflicting Lanes	1				2				2				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	1															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s	4.5436	4.5436			4.3276			4.3276			4.9763	4.9763
Follow-Up Headway, s	2.5352	2.5352			2.5352			2.5352			2.6087	2.6087

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h	426	378			249			133			121	382
Entry Volume, veh/h	410	363			226			132			115	364
Circulating Flow (v_c), pc/h	160			514			625			270		
Exiting Flow (v_{ex}), pc/h	244			231			493			339		
Capacity ($c_{adj,pce}$), pc/h	1230	1230			919			836			1050	1090
Capacity (c), veh/h	1183	1183			835			828			1000	1038
v/c Ratio (x)	0.35	0.31			0.27			0.16			0.12	0.35

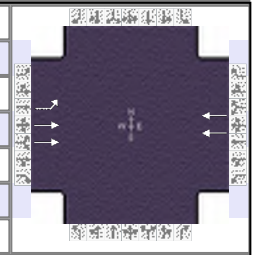
Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh	6.4	5.9			7.3			6.0			4.6	7.1
Lane LOS	A	A			A			A			A	A
95% Queue, veh	1.6	1.3			1.1			0.6			0.4	1.6
Approach Delay, s/veh | LOS	6.2	A		7.3	A		6.0	A		6.5	A	
Intersection Delay, s/veh | LOS	6.4						A					

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HCS Signalized Intersection Results Summary

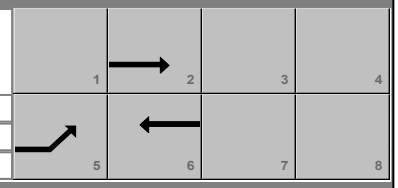
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2030	Analysis Period	1> 7:00
Intersection	Hwy 1416 Displaced EBL	File Name	Hwy1416-EllsworthRd_Alt4.1_AMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	650	343			237							

Signal Information			
Cycle, s	30.5	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	14.2	7.4	0.0	0.0	0.0	0.0	
Yellow	3.5	3.5	0.0	0.0	0.0	0.0	
Red	1.0	1.0	0.0	0.0	0.0	0.0	



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6				
Case Number	2.0	4.0		8.3				
Phase Duration, s	18.7	30.5		11.9				
Change Period, ($Y+R_c$), s	4.5	4.5		4.5				
Max Allow Headway (*MAH*), s	2.9	2.8		2.8				
Queue Clearance Time (g_s), s	13.0	2.5		5.9				
Green Extension Time (g_e), s	1.2	1.6		1.4				
Phase Call Probability	1.00	1.00		1.00				
Max Out Probability	0.00	0.00		0.00				

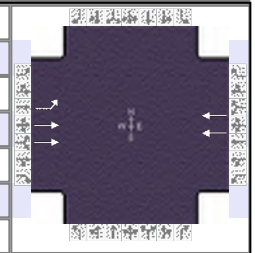
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2			6							
Adjusted Flow Rate (*v*), veh/h	650	343			444							
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614			1536							
Queue Service Time (g_s), s	11.0	0.5			3.9							
Cycle Queue Clearance Time (g_c), s	11.0	0.5			3.9							
Green Ratio (*g/C*)	0.46	0.85			0.24							
Capacity (*c*), veh/h	750	2753			740							
Volume-to-Capacity Ratio (*X*)	0.866	0.125			0.600							
Back of Queue (*Q*), ft/ln (95 th percentile)	38.8	0.1			32.3							
Back of Queue (*Q*), veh/ln (95 th percentile)	1.5	0.0			1.2							
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00							
Uniform Delay (d_1), s/veh	7.3	0.4			10.3							
Incremental Delay (d_2), s/veh	1.2	0.0			0.3							
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0							
Control Delay (*d*), s/veh	8.6	0.4			10.6							
Level of Service (LOS)	A	A			B							
Approach Delay, s/veh / LOS	5.7	A		10.6	B		0.0			0.0		
Intersection Delay, s/veh / LOS	7.2						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	0.60	A	1.37	A	2.10	B	2.27	B
Bicycle LOS Score / LOS	1.31	A	0.68	A				

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HCS Signalized Intersection Results Summary

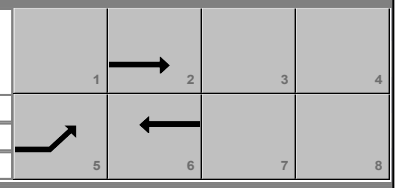
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 Displaced EBL	File Name	Hwy1416-EllsworthRd_Alt4.1_AMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	748	367			258							

Signal Information			
Cycle, s	35.6	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	18.4	8.2	0.0	0.0	0.0	0.0	
Yellow	3.5	3.5	0.0	0.0	0.0	0.0	
Red	1.0	1.0	0.0	0.0	0.0	0.0	



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6				
Case Number	2.0	4.0		8.3				
Phase Duration, s	22.9	35.6		12.7				
Change Period, ($Y+R_c$), s	4.5	4.5		4.5				
Max Allow Headway (*MAH*), s	2.9	2.8		2.8				
Queue Clearance Time (g_s), s	16.9	2.6		6.7				
Green Extension Time (g_e), s	1.5	1.7		1.5				
Phase Call Probability	1.00	1.00		1.00				
Max Out Probability	0.00	0.00		0.01				

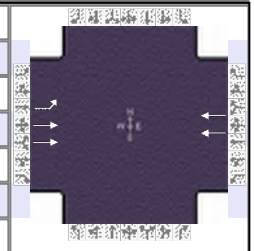
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2			6							
Adjusted Flow Rate (*v*), veh/h	748	367			453							
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614			1536							
Queue Service Time (g_s), s	14.9	0.6			4.7							
Cycle Queue Clearance Time (g_c), s	14.9	0.6			4.7							
Green Ratio (*g/C*)	0.52	0.87			0.23							
Capacity (*c*), veh/h	834	2821			710							
Volume-to-Capacity Ratio (*X*)	0.897	0.130			0.638							
Back of Queue (*Q*), ft/ln (95 th percentile)	68	0.1			48.4							
Back of Queue (*Q*), veh/ln (95 th percentile)	2.6	0.0			1.8							
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00							
Uniform Delay (d_1), s/veh	7.8	0.3			12.4							
Incremental Delay (d_2), s/veh	1.5	0.0			0.3							
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0							
Control Delay (*d*), s/veh	9.3	0.3			12.7							
Level of Service (LOS)	A	A			B							
Approach Delay, s/veh / LOS	6.3	A		12.7	B		0.0			0.0		
Intersection Delay, s/veh / LOS	8.2						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	0.60	A	1.38	A	2.10	B	2.27	B
Bicycle LOS Score / LOS	1.41	A	0.70	A				

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HCS Signalized Intersection Results Summary

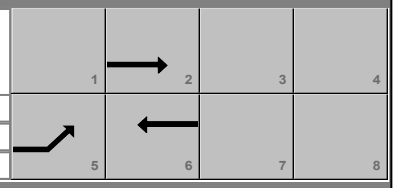
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2030	Analysis Period	1> 16:45
Intersection	Hwy 1416 Displaced EBL	File Name	Hwy1416-EllsworthRd_Alt4.1_PMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	306	236			114							

Signal Information			
Cycle, s	18.5	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	4.5	5.1	0.0	0.0	0.0	0.0	
Yellow	3.5	3.5	0.0	0.0	0.0	0.0	
Red	1.0	1.0	0.0	0.0	0.0	0.0	



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6				
Case Number	2.0	4.0		8.3				
Phase Duration, s	9.0	18.5		9.6				
Change Period, ($Y+R_c$), s	4.5	4.5		4.5				
Max Allow Headway (*MAH*), s	2.9	2.8		2.8				
Queue Clearance Time (g_s), s	5.3	2.4		3.9				
Green Extension Time (g_e), s	0.3	1.2		1.1				
Phase Call Probability	0.79	1.00		1.00				
Max Out Probability	0.02	0.00		0.00				

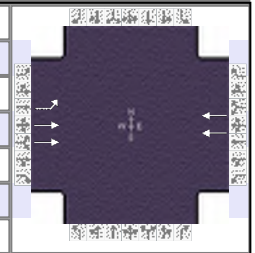
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2			6							
Adjusted Flow Rate (*v*), veh/h	306	236			387							
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614			1536							
Queue Service Time (g_s), s	3.3	0.4			1.9							
Cycle Queue Clearance Time (g_c), s	3.3	0.4			1.9							
Green Ratio (*g/C*)	0.24	0.76			0.27							
Capacity (*c*), veh/h	389	2445			842							
Volume-to-Capacity Ratio (*X*)	0.786	0.097			0.460							
Back of Queue (*Q*), ft/ln (95 th percentile)	6.8	0.1			0.8							
Back of Queue (*Q*), veh/ln (95 th percentile)	0.3	0.0			0.0							
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00							
Uniform Delay (d_1), s/veh	6.6	0.6			5.6							
Incremental Delay (d_2), s/veh	1.4	0.0			0.1							
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0							
Control Delay (*d*), s/veh	8.0	0.6			5.7							
Level of Service (LOS)	A	A			A							
Approach Delay, s/veh / LOS	4.8	A		5.7	A		0.0			0.0		
Intersection Delay, s/veh / LOS	5.2						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	0.60	A	1.34	A	2.08	B	2.25	B
Bicycle LOS Score / LOS	0.93	A	0.58	A				

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HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2050	Analysis Period	1> 16:45
Intersection	Hwy 1416 Displaced EBL	File Name	Hwy1416-EllsworthRd_Alt4.1_PMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	352	277			134							

Signal Information			
Cycle, s	20.7	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

								1	2	3	4	
Green	5.8	5.9	0.0	0.0	0.0	0.0						
Yellow	3.5	3.5	0.0	0.0	0.0	0.0						
Red	1.0	1.0	0.0	0.0	0.0	0.0	5	6	7	8		

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2		6				
Case Number	2.0	4.0		8.3				
Phase Duration, s	10.3	20.7		10.4				
Change Period, ($Y+R_c$), s	4.5	4.5		4.5				
Max Allow Headway (*MAH*), s	2.9	2.8		2.8				
Queue Clearance Time (g_s), s	6.2	2.4		4.6				
Green Extension Time (g_e), s	0.5	1.5		1.4				
Phase Call Probability	0.87	1.00		0.99				
Max Out Probability	0.00	0.00		0.00				

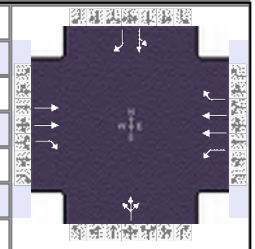
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2			6							
Adjusted Flow Rate (*v*), veh/h	352	277			461							
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614			1536							
Queue Service Time (g_s), s	4.2	0.4			2.6							
Cycle Queue Clearance Time (g_c), s	4.2	0.4			2.6							
Green Ratio (*g/C*)	0.28	0.78			0.29							
Capacity (*c*), veh/h	451	2525			876							
Volume-to-Capacity Ratio (*X*)	0.780	0.110			0.526							
Back of Queue (*Q*), ft/ln (95 th percentile)	8.9	0.1			1.9							
Back of Queue (*Q*), veh/ln (95 th percentile)	0.3	0.0			0.1							
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00							
Uniform Delay (d_1), s/veh	6.9	0.5			6.2							
Incremental Delay (d_2), s/veh	1.1	0.0			0.2							
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0							
Control Delay (*d*), s/veh	8.0	0.5			6.4							
Level of Service (LOS)	A	A			A							
Approach Delay, s/veh / LOS	4.7	A		6.4	A		0.0			0.0		
Intersection Delay, s/veh / LOS	5.4						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	0.60	A	1.35	A	2.08	B	2.25	B
Bicycle LOS Score / LOS	1.01	A	0.60	A				

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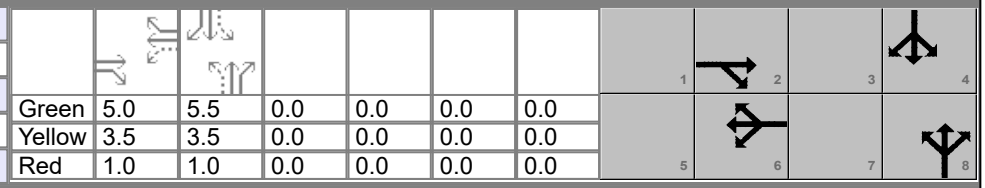
HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2030	Analysis Period	1> 7:00
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.1_AMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h		327	16	24	147	38	90	100	57	60	66	207

Signal Information			
Cycle, s	19.5	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	5.0	5.5	0.0	0.0	0.0	0.0						
Yellow	3.5	3.5	0.0	0.0	0.0	0.0						
Red	1.0	1.0	0.0	0.0	0.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		7.0		5.0		8.0		7.0
Phase Duration, s		9.5		9.5		10.0		10.0
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		2.9		2.9		3.3		3.3
Queue Clearance Time (g_s), s		3.6		4.0		4.6		4.4
Green Extension Time (g_e), s		1.0		1.0		1.1		1.1
Phase Call Probability		1.00		1.00		0.96		0.96
Max Out Probability		0.00		0.00		0.01		0.01

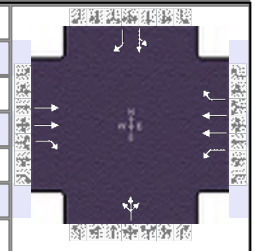
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		327	16	24	147	38		247			126	207
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1614	1437	986	1536	1367		1546			1495	
Queue Service Time (g_s), s		1.6	0.2	0.4	0.7	0.4		1.4			0.0	
Cycle Queue Clearance Time (g_c), s		1.6	0.2	2.0	0.7	0.4		2.6			1.1	
Green Ratio (*g/C*)		0.26	0.26	0.26	0.26	0.26		0.28			0.28	
Capacity (*c*), veh/h		833	371	541	793	353		685			691	
Volume-to-Capacity Ratio (*X*)		0.392	0.043	0.044	0.185	0.108		0.361			0.182	
Back of Queue (*Q*), ft/ln (95 th percentile)		0.8	0.1	0.9	1.1	0.7		5.7			8.3	
Back of Queue (*Q*), veh/ln (95 th percentile)		0.0	0.0	0.0	0.0	0.0		0.2			0.3	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00	0.00	0.00	0.00	0.00		0.00			0.00	
Uniform Delay (d_1), s/veh		6.0	5.4	6.8	5.6	5.5		6.0			5.5	
Incremental Delay (d_2), s/veh		0.1	0.0	0.0	0.0	0.0		0.1			0.0	
Initial Queue Delay (d_3), s/veh		0.0	0.0	0.0	0.0	0.0		0.0			0.0	
Control Delay (*d*), s/veh		6.1	5.4	6.8	5.7	5.6		6.1			5.5	0.0
Level of Service (LOS)		A	A	A	A	A		A			A	A
Approach Delay, s/veh / LOS	6.0	A		5.8	A		6.1	A		2.1	A	
Intersection Delay, s/veh / LOS	4.8						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.64	B	1.86	B	2.38	B	2.22	B
Bicycle LOS Score / LOS	0.77	A	0.66	A	0.90	A	1.04	A

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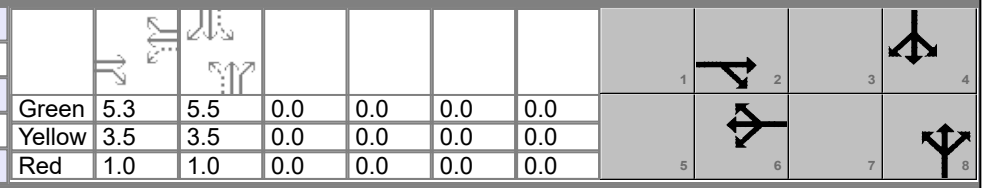
HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.1_AMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h		348	19	24	156	41	90	100	57	60	66	207

Signal Information			
Cycle, s	19.8	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	5.3	5.5	0.0	0.0	0.0	0.0						
Yellow	3.5	3.5	0.0	0.0	0.0	0.0						
Red	1.0	1.0	0.0	0.0	0.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		7.0		5.0		8.0		7.0
Phase Duration, s		9.8		9.8		10.0		10.0
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		2.9		2.9		3.3		3.3
Queue Clearance Time (g_s), s		3.8		4.2		4.6		4.4
Green Extension Time (g_e), s		1.1		1.1		1.1		1.1
Phase Call Probability		1.00		1.00		0.96		0.96
Max Out Probability		0.00		0.00		0.01		0.01

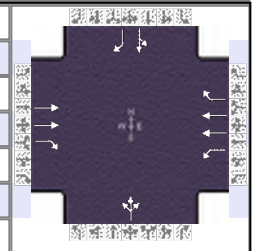
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		348	19	24	156	41		247			126	207
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1614	1437	967	1536	1367		1546			1495	
Queue Service Time (g_s), s		1.8	0.2	0.4	0.8	0.4		1.5			0.0	
Cycle Queue Clearance Time (g_c), s		1.8	0.2	2.2	0.8	0.4		2.6			1.2	
Green Ratio (*g/C*)		0.27	0.27	0.27	0.27	0.27		0.28			0.28	
Capacity (*c*), veh/h		860	383	535	818	364		679			685	
Volume-to-Capacity Ratio (*X*)		0.405	0.050	0.045	0.191	0.113		0.364			0.184	
Back of Queue (*Q*), ft/ln (95 th percentile)		0.9	0.1	0.9	1.2	0.7		6			8.6	
Back of Queue (*Q*), veh/ln (95 th percentile)		0.0	0.0	0.0	0.0	0.0		0.2			0.3	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00	0.00	0.00	0.00	0.00		0.00			0.00	
Uniform Delay (d_1), s/veh		6.0	5.4	6.9	5.6	5.5		6.1			5.6	
Incremental Delay (d_2), s/veh		0.1	0.0	0.0	0.0	0.1		0.1			0.0	
Initial Queue Delay (d_3), s/veh		0.0	0.0	0.0	0.0	0.0		0.0			0.0	
Control Delay (*d*), s/veh		6.1	5.4	6.9	5.6	5.5		6.2			5.6	0.0
Level of Service (LOS)		A	A	A	A	A		A			A	A
Approach Delay, s/veh / LOS	6.0	A		5.8	A		6.2	A		2.1	A	
Intersection Delay, s/veh / LOS	4.9						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.64	B	1.86	B	2.38	B	2.22	B
Bicycle LOS Score / LOS	0.79	A	0.67	A	0.90	A	1.04	A

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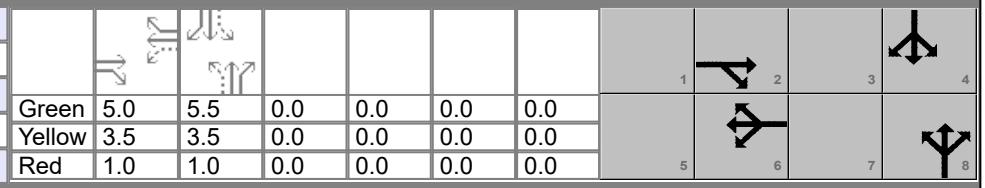
HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2030	Analysis Period	1> 16:45
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.1_PMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h		84	152	15	76	7	38	39	7	7	62	273

Signal Information			
Cycle, s	19.5	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	5.0	5.5	0.0	0.0	0.0	0.0						
Yellow	3.5	3.5	0.0	0.0	0.0	0.0						
Red	1.0	1.0	0.0	0.0	0.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		7.0		5.0		8.0		7.0
Phase Duration, s		9.5		9.5		10.0		10.0
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		3.0		3.0		3.4		3.4
Queue Clearance Time (g_s), s		3.7		2.6		2.7		5.3
Green Extension Time (g_e), s		0.6		0.6		0.9		0.8
Phase Call Probability		1.00		1.00		0.90		0.90
Max Out Probability		0.00		0.00		0.00		0.00

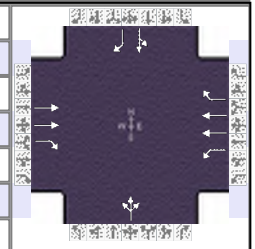
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		84	152	15	76	7		84			69	273
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1614	1437	1231	1536	1367		1586			1662	
Queue Service Time (g_s), s		0.4	1.7	0.2	0.4	0.1		0.0			0.0	
Cycle Queue Clearance Time (g_c), s		0.4	1.7	0.6	0.4	0.1		0.7			0.6	
Green Ratio (*g/C*)		0.26	0.26	0.26	0.26	0.26		0.28			0.28	
Capacity (*c*), veh/h		826	368	659	786	350		717			674	
Volume-to-Capacity Ratio (*X*)		0.102	0.413	0.023	0.097	0.020		0.117			0.102	
Back of Queue (*Q*), ft/ln (95 th percentile)		0.2	1.5	0.3	0.6	0.1		1.5			4.3	
Back of Queue (*Q*), veh/ln (95 th percentile)		0.0	0.1	0.0	0.0	0.0		0.1			0.2	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00	0.00	0.00	0.00	0.00		0.00			0.00	
Uniform Delay (d_1), s/veh		5.6	6.0	5.8	5.5	5.4		5.3			5.2	
Incremental Delay (d_2), s/veh		0.0	0.3	0.0	0.0	0.0		0.0			0.0	
Initial Queue Delay (d_3), s/veh		0.0	0.0	0.0	0.0	0.0		0.0			0.0	
Control Delay (*d*), s/veh		5.6	6.3	5.8	5.6	5.4		5.3			5.3	0.0
Level of Service (LOS)		A	A	A	A	A		A			A	A
Approach Delay, s/veh / LOS	6.1	A		5.6	A		5.3	A		1.1	A	
Intersection Delay, s/veh / LOS	3.7						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.64	B	1.87	B	2.37	B	2.22	B
Bicycle LOS Score / LOS	0.68	A	0.57	A	0.63	A	1.05	A

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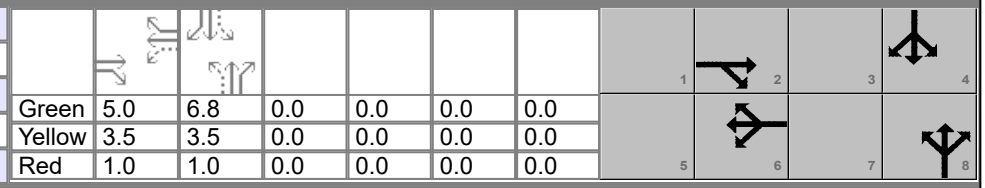
HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 4.1 - no EBL	Analysis Year	2050	Analysis Period	1> 16:45
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.1_PMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h		99	178	18	91	8	43	43	8	8	72	327

Signal Information			
Cycle, s	20.8	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	5.0	6.8	0.0	0.0	0.0	0.0						
Yellow	3.5	3.5	0.0	0.0	0.0	0.0						
Red	1.0	1.0	0.0	0.0	0.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		7.0		5.0		8.0		7.0
Phase Duration, s		9.5		9.5		11.3		11.3
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		3.0		3.0		3.4		3.4
Queue Clearance Time (g_s), s		4.2		2.7		2.8		6.2
Green Extension Time (g_e), s		0.7		0.7		1.1		1.0
Phase Call Probability		1.00		1.00		0.94		0.94
Max Out Probability		0.00		0.00		0.00		0.01

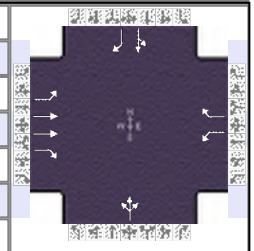
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement		2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h		99	178	18	91	8		94			80	327
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1614	1437	1214	1536	1367		1570			1664	
Queue Service Time (g_s), s		0.5	2.2	0.2	0.5	0.1		0.0			0.0	
Cycle Queue Clearance Time (g_c), s		0.5	2.2	0.7	0.5	0.1		0.8			0.7	
Green Ratio (*g/C*)		0.24	0.24	0.24	0.24	0.24		0.33			0.33	
Capacity (*c*), veh/h		778	346	611	740	329		764			733	
Volume-to-Capacity Ratio (*X*)		0.127	0.514	0.029	0.123	0.024		0.123			0.109	
Back of Queue (*Q*), ft/ln (95 th percentile)		1	5.2	0.7	1.4	0.3		1.7			5.1	
Back of Queue (*Q*), veh/ln (95 th percentile)		0.0	0.2	0.0	0.1	0.0		0.1			0.2	
Queue Storage Ratio (*RQ*) (95 th percentile)		0.00	0.00	0.00	0.00	0.00		0.00			0.00	
Uniform Delay (d_1), s/veh		6.2	6.8	6.5	6.2	6.0		5.0			5.0	
Incremental Delay (d_2), s/veh		0.0	0.4	0.0	0.0	0.0		0.0			0.0	
Initial Queue Delay (d_3), s/veh		0.0	0.0	0.0	0.0	0.0		0.0			0.0	
Control Delay (*d*), s/veh		6.2	7.3	6.5	6.2	6.0		5.0			5.0	0.0
Level of Service (LOS)		A	A	A	A	A		A			A	A
Approach Delay, s/veh / LOS	6.9	A		6.2	A		5.0	A		1.0	A	
Intersection Delay, s/veh / LOS	3.9						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.64	B	1.87	B	2.37	B	2.22	B
Bicycle LOS Score / LOS	0.72	A	0.58	A	0.64	A	1.16	A

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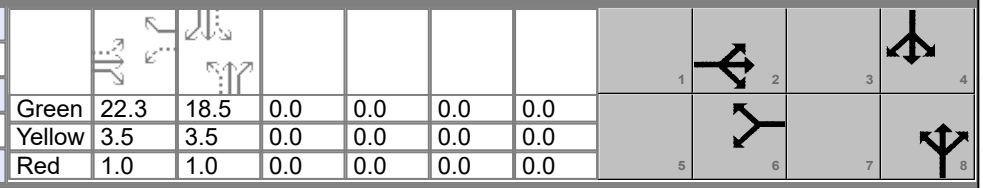
HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 4.2 - no WBT	Analysis Year	2030	Analysis Period	1> 7:00
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.2_AMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	650	327	16	24		38	90	100	57	60	66	207

Signal Information			
Cycle, s	49.8	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	22.3	18.5	0.0	0.0	0.0	0.0						
Yellow	3.5	3.5	0.0	0.0	0.0	0.0						
Red	1.0	1.0	0.0	0.0	0.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		5.0		5.0		8.0		7.0
Phase Duration, s		26.8		26.8		23.0		23.0
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		2.9		2.9		3.3		3.3
Queue Clearance Time (g_s), s		20.5		5.9		7.7		7.3
Green Extension Time (g_e), s		1.8		2.0		1.0		1.0
Phase Call Probability		1.00		1.00		1.00		1.00
Max Out Probability		0.03		0.00		0.02		0.02

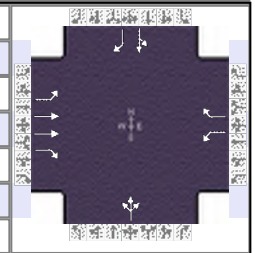
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1		16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	650	327	16	24		38		247			126	207
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614	1437	986		1367		1542			1444	
Queue Service Time (g_s), s	18.5	3.1	0.3	0.8		0.8		2.3			0.0	
Cycle Queue Clearance Time (g_c), s	18.5	3.1	0.3	3.9		0.8		5.7			2.6	
Green Ratio (*g/C*)	0.45	0.45	0.45	0.45		0.45		0.37			0.37	
Capacity (*c*), veh/h	868	1446	644	525		613		671			643	
Volume-to-Capacity Ratio (*X*)	0.749	0.226	0.025	0.046		0.062		0.368			0.196	
Back of Queue (*Q*), ft/ln (95 th percentile)	193.8	30.6	2.8	5.7		7.4		80.7			44.2	
Back of Queue (*Q*), veh/ln (95 th percentile)	7.5	1.2	0.1	0.2		0.3		3.2			1.7	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00		0.00		0.00			0.00	
Uniform Delay (d_1), s/veh	12.7	8.4	7.7	9.6		7.8		11.6			10.6	
Incremental Delay (d_2), s/veh	1.0	0.0	0.0	0.0		0.0		1.6			0.7	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0		0.0		0.0			0.0	
Control Delay (*d*), s/veh	13.7	8.5	7.7	9.6		7.8		13.1			11.3	0.0
Level of Service (LOS)	B	A	A	A		A		B			B	A
Approach Delay, s/veh / LOS	11.9	B		8.5	A		13.1	B		4.3	A	
Intersection Delay, s/veh / LOS	10.4						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.65	B	1.88	B	2.08	B	2.25	B
Bicycle LOS Score / LOS	1.31	A		F	0.90	A	1.04	A

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HCS Signalized Intersection Results Summary

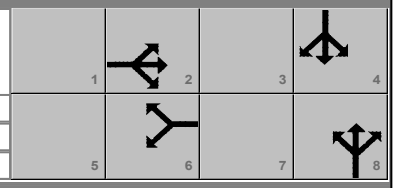
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 4.2 - no WBT	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.2_AMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	748	348	19	27		41	102	107	58	61	69	248

Signal Information			
Cycle, s	38.9	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	20.4	9.5	0.0	0.0	0.0	0.0	
Yellow	3.5	3.5	0.0	0.0	0.0	0.0	
Red	1.0	1.0	0.0	0.0	0.0	0.0	



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		5.0		5.0		8.0		7.0
Phase Duration, s		24.9		24.9		14.0		14.0
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		2.9		2.9		3.3		3.3
Queue Clearance Time (g_s), s		18.0		4.7		8.1		8.2
Green Extension Time (g_e), s		2.3		2.3		1.3		1.3
Phase Call Probability		1.00		1.00		1.00		1.00
Max Out Probability		0.00		0.00		0.01		0.01

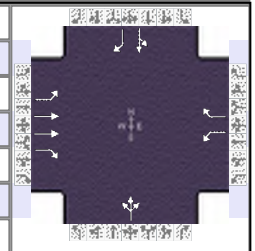
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1		16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	748	348	19	27		41		267			130	248
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614	1437	967		1367		1543			1471	
Queue Service Time (g_s), s	16.0	2.2	0.2	0.6		0.6		3.6			0.0	
Cycle Queue Clearance Time (g_c), s	16.0	2.2	0.2	2.7		0.6		6.1			2.5	
Green Ratio (*g/C*)	0.52	0.52	0.52	0.52		0.52		0.24			0.24	
Capacity (*c*), veh/h	1031	1693	753	640		717		505			496	
Volume-to-Capacity Ratio (*X*)	0.725	0.206	0.025	0.042		0.057		0.528			0.262	
Back of Queue (*Q*), ft/ln (95 th percentile)	79.2	10.6	1.1	2.7		2.9		69.3			37	
Back of Queue (*Q*), veh/ln (95 th percentile)	3.1	0.4	0.0	0.1		0.1		2.7			1.4	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00		0.00		0.00			0.00	
Uniform Delay (d_1), s/veh	8.2	4.9	4.5	5.6		4.5		13.3			12.1	
Incremental Delay (d_2), s/veh	0.4	0.0	0.0	0.0		0.0		0.3			0.1	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0		0.0		0.0			0.0	
Control Delay (*d*), s/veh	8.6	5.0	4.5	5.6		4.6		13.7			12.2	0.0
Level of Service (LOS)	A	A	A	A		A		B			B	A
Approach Delay, s/veh / LOS	7.4	A		5.0	A		13.7	B		4.2	A	
Intersection Delay, s/veh / LOS	7.6						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.63	B	1.86	B	2.08	B	2.25	B
Bicycle LOS Score / LOS	1.41	A		F	0.93	A	1.11	A

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HCS Signalized Intersection Results Summary

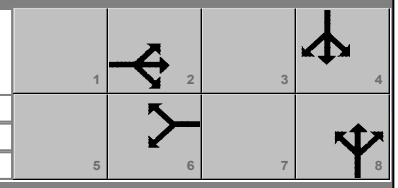
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 4.2 - no WBT	Analysis Year	2030	Analysis Period	1> 16:45
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.2_PMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	306	84	142	15		7	38	39	7	7	62	273

Signal Information			
Cycle, s	21.3	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	6.3	5.9	0.0	0.0	0.0	0.0	
Yellow	3.5	3.5	0.0	0.0	0.0	0.0	
Red	1.0	1.0	0.0	0.0	0.0	0.0	



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		5.0		5.0		8.0		7.0
Phase Duration, s		10.8		10.8		10.4		10.4
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		2.9		2.9		3.4		3.4
Queue Clearance Time (g_s), s		5.5		2.6		2.8		5.6
Green Extension Time (g_e), s		0.8		0.9		0.9		0.8
Phase Call Probability		1.00		1.00		0.92		0.92
Max Out Probability		0.00		0.00		0.00		0.00

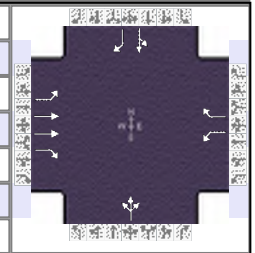
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1		16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	306	84	142	15		7		84			69	273
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614	1437	1231		1231		1583			1663	
Queue Service Time (g_s), s	3.5	0.4	1.6	0.2		0.1		0.0			0.0	
Cycle Queue Clearance Time (g_c), s	3.5	0.4	1.6	0.6		0.1		0.8			0.7	
Green Ratio (*g/C*)	0.30	0.30	0.30	0.30		0.30		0.28			0.28	
Capacity (*c*), veh/h	820	963	428	683		367		688			651	
Volume-to-Capacity Ratio (*X*)	0.373	0.087	0.331	0.022		0.019		0.122			0.106	
Back of Queue (*Q*), ft/ln (95 th percentile)	3.5	0.4	1.8	0.4		0.2		3			5.6	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.1	0.0	0.1	0.0		0.0		0.1			0.2	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00		0.00		0.00			0.00	
Uniform Delay (d_1), s/veh	6.5	5.4	5.8	5.6		5.3		5.8			5.8	
Incremental Delay (d_2), s/veh	0.1	0.0	0.2	0.0		0.0		0.0			0.0	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0		0.0		0.0			0.0	
Control Delay (*d*), s/veh	6.6	5.4	6.0	5.6		5.3		5.8			5.8	0.0
Level of Service (LOS)	A	A	A	A		A		A			A	A
Approach Delay, s/veh / LOS	6.2	A		5.5	A		5.8	A		1.2	A	
Intersection Delay, s/veh / LOS	4.4						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.64	B	1.86	B	2.06	B	2.23	B
Bicycle LOS Score / LOS	0.93	A		F	0.63	A	1.05	A

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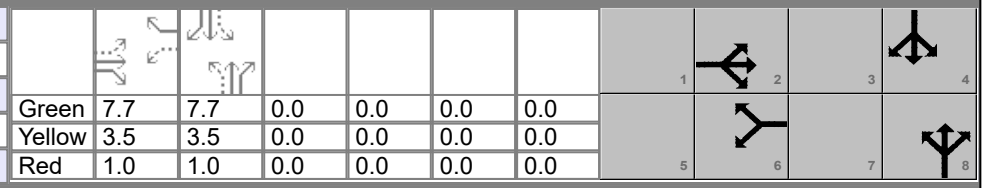
HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	8/16/2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 4.2 - no WBT	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 and S Ellswor…	File Name	Hwy1416-EllsworthRd_Alt4.2_PMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	352	99	178	18		8	43	43	8	8	72	327

Signal Information			
Cycle, s	24.3	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On



Green	7.7	7.7	0.0	0.0	0.0	0.0						
Yellow	3.5	3.5	0.0	0.0	0.0	0.0						
Red	1.0	1.0	0.0	0.0	0.0	0.0						

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase		2		6		8		4
Case Number		5.0		5.0		8.0		7.0
Phase Duration, s		12.2		12.2		12.2		12.2
Change Period, ($Y+R_c$), s		4.5		4.5		4.5		4.5
Max Allow Headway (*MAH*), s		3.0		3.0		3.4		3.4
Queue Clearance Time (g_s), s		6.6		2.8		3.0		7.0
Green Extension Time (g_e), s		1.0		1.1		1.1		1.0
Phase Call Probability		1.00		1.00		0.97		0.97
Max Out Probability		0.01		0.00		0.00		0.02

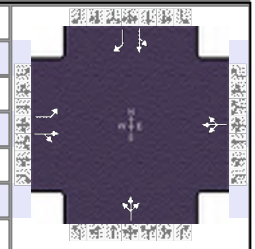
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1		16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	352	99	178	18		8		94			80	327
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1614	1437	1214		1367		1565			1666	
Queue Service Time (g_s), s	4.6	0.5	2.4	0.3		0.1		0.0			0.0	
Cycle Queue Clearance Time (g_c), s	4.6	0.5	2.4	0.8		0.1		1.0			0.8	
Green Ratio (*g/C*)	0.31	0.31	0.31	0.31		0.31		0.31			0.31	
Capacity (*c*), veh/h	805	1017	453	653		431		709			688	
Volume-to-Capacity Ratio (*X*)	0.438	0.097	0.393	0.028		0.019		0.133			0.116	
Back of Queue (*Q*), ft/ln (95 th percentile)	14.2	1.5	6.9	0.9		0.4		5			7.9	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.5	0.1	0.3	0.0		0.0		0.2			0.3	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00	0.00	0.00		0.00		0.00			0.00	
Uniform Delay (d_1), s/veh	7.3	5.9	6.5	6.1		5.7		6.0			6.0	
Incremental Delay (d_2), s/veh	0.1	0.0	0.2	0.0		0.0		0.0			0.0	
Initial Queue Delay (d_3), s/veh	0.0	0.0	0.0	0.0		0.0		0.0			0.0	
Control Delay (*d*), s/veh	7.4	5.9	6.7	6.2		5.7		6.1			6.0	0.0
Level of Service (LOS)	A	A	A	A		A		A			A	A
Approach Delay, s/veh / LOS	7.0	A		6.0	A		6.1	A		1.2	A	
Intersection Delay, s/veh / LOS	4.9						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.64	B	1.87	B	2.06	B	2.23	B
Bicycle LOS Score / LOS	1.01	A		F	0.64	A	1.16	A

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HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 8, 2023	Area Type	Other
Jurisdiction	Box Elder, Sd	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2030	Analysis Period	1> 7:00
Intersection	Hwy 1416 and Liberty Blvd	File Name	Hwy1416-Liberty_Alt1_AMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	326	150	3	7	90	171	4	51	10	60	19	141

Signal Information			
Cycle, s	58.0	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

							1	2	3	4
Green	9.5	12.5	22.5	0.0	0.0	0.0	5	6	7	8
Yellow	3.5	3.5	3.5	0.0	0.0	0.0				
Red	1.0	1.0	1.0	0.0	0.0	0.0				

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6		4		8
Case Number	1.1	4.0	0.0	14.0		8.0		7.0
Phase Duration, s	14.0	31.0	0.0	17.0		27.0		27.0
Change Period, ($Y+R_c$), s	4.5	4.5	3.5	4.5		4.5		4.5
Max Allow Headway (*MAH*), s	3.0	3.0	0.0	3.0		3.2		3.2
Queue Clearance Time (g_s), s	10.6	5.1		11.8		3.5		5.8
Green Extension Time (g_e), s	0.0	0.7	0.0	0.7		0.5		0.5
Phase Call Probability	0.99	1.00		1.00		1.00		1.00
Max Out Probability	1.00	0.00		0.00		0.00		0.00

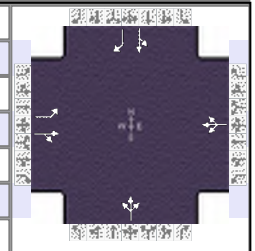
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	7	4	14	3	8	18
Adjusted Flow Rate (*v*), veh/h	326	153			268			65			79	141
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1615	1689			1508			1643			1414	1448
Queue Service Time (g_s), s	8.6	3.1			5.0			0.0			0.5	3.8
Cycle Queue Clearance Time (g_c), s	8.6	3.1			9.8			1.5			2.0	3.8
Green Ratio (*g/C*)	0.41	0.46			0.22			0.39			0.39	0.39
Capacity (*c*), veh/h	440	772			426			703			658	562
Volume-to-Capacity Ratio (*X*)	0.742	0.198			0.629			0.092			0.120	0.251
Back of Queue (*Q*), ft/ln (95 th percentile)	141.4	39.1			137.3			25			27.3	53
Back of Queue (*Q*), veh/ln (95 th percentile)	5.5	1.5			5.3			1.0			1.1	2.1
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00			0.00			0.00	0.00
Uniform Delay (d_1), s/veh	14.1	9.4			21.7			11.3			11.4	12.0
Incremental Delay (d_2), s/veh	6.1	0.0			0.6			0.3			0.4	1.1
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0			0.0			0.0	0.0
Control Delay (*d*), s/veh	20.2	9.4			22.3			11.6			11.8	13.1
Level of Service (LOS)	C	A			C			B			B	B
Approach Delay, s/veh / LOS	16.8	B		22.3	C		11.6	B		12.7	B	
Intersection Delay, s/veh / LOS	17.0						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.66	B	1.91	B	1.67	B	1.89	B
Bicycle LOS Score / LOS	1.28	A	0.93	A	0.59	A	0.85	A

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HCS Signalized Intersection Results Summary

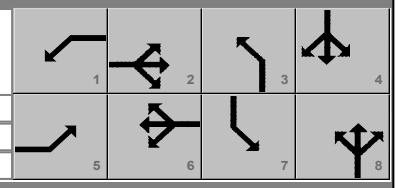
General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 8, 2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	AM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 and Liberty Blvd	File Name	Hwy1416-Liberty_Alt1_AMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	326	146	3	6	76	173	4	51	10	59	17	119

Signal Information			
Cycle, s	60.9	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

Green	9.9	18.1	19.4	0.0	0.0	0.0
Yellow	3.5	3.5	3.5	0.0	0.0	0.0
Red	1.0	1.0	1.0	0.0	0.0	0.0



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	4.0	0.0	14.0	11.0	14.2	14.0	13.3
Phase Duration, s	14.4	37.0	0.0	22.6	0.0	23.9	0.0	23.9
Change Period, ($Y+R_c$), s	4.5	4.5	4.0	4.5	4.0	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	3.0	3.0	0.0	3.0	0.0	3.2	0.0	3.2
Queue Clearance Time (g_s), s	9.5	4.7		20.1		3.7		8.2
Green Extension Time (g_e), s	0.4	0.6	0.0	0.0	0.0	0.1	0.0	0.3
Phase Call Probability	1.00	1.00		1.00		1.00		1.00
Max Out Probability	0.00	0.00		1.00		0.00		0.00

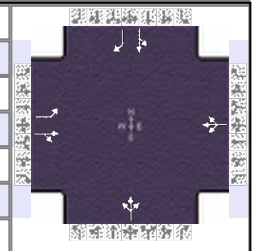
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	326	149			255			65			76	119
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1667	1744			757			1698			508	
Queue Service Time (g_s), s	7.5	2.7			5.0			1.7			0.0	
Cycle Queue Clearance Time (g_c), s	7.5	2.7			18.1			1.7			6.2	
Green Ratio (*g/C*)	0.49	0.53			0.30			0.32			0.32	
Capacity (*c*), veh/h	389	931			313			615			267	
Volume-to-Capacity Ratio (*X*)	0.837	0.160			0.816			0.106			0.285	
Back of Queue (*Q*), ft/ln (95 th percentile)	96	30.3			173.8			29.4			39.9	
Back of Queue (*Q*), veh/ln (95 th percentile)	3.8	1.2			7.0			1.2			1.6	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh	13.1	7.2			18.7			14.7			15.8	
Incremental Delay (d_2), s/veh	1.9	0.0			16.1			0.3			2.7	
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh	15.0	7.3			34.8			15.0			18.5	0.0
Level of Service (LOS)	B	A			C			B			B	A
Approach Delay, s/veh / LOS	12.5	B		34.8	C		15.0	B		7.2	A	
Intersection Delay, s/veh / LOS	17.4						B					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.65	B	1.91	B	1.71	B	1.90	B
Bicycle LOS Score / LOS	1.27	A	0.91	A	0.59	A	0.81	A

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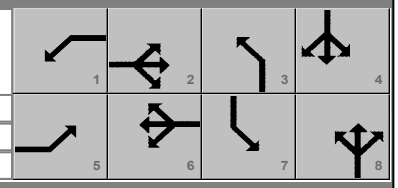
HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 8, 2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2030	Analysis Period	1> 16:30
Intersection	Hwy 1416 and Liberty Blvd	File Name	Hwy1416-Liberty_Alt1_PMPeak2030.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	38	43	13	4	28	55	8	11	2	112	21	55

Signal Information												
Cycle, s	37.5	Reference Phase	2									
Offset, s	0	Reference Point	End									
Uncoordinated	Yes	Simult. Gap E/W	On	Green	1.6	3.9	18.5	0.0	0.0	0.0		
Force Mode	Fixed	Simult. Gap N/S	On	Yellow	3.5	3.5	3.5	0.0	0.0	0.0		
				Red	1.0	1.0	1.0	0.0	0.0	0.0		



Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	4.0	0.0	14.0	11.0	14.2	14.0	13.3
Phase Duration, s	6.1	14.5	0.0	8.4	0.0	23.0	0.0	23.0
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	3.0	3.1	0.0	3.1	0.0	3.2	0.0	3.0
Queue Clearance Time (g_s), s	2.7	2.9		4.0		2.2		5.2
Green Extension Time (g_e), s	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.2
Phase Call Probability	0.33	0.85		0.77		1.00		1.00
Max Out Probability	1.00	0.00		0.00		0.00		0.00

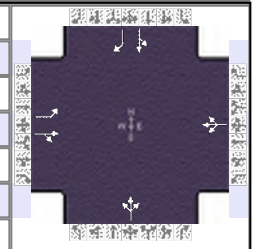
Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	38	56			87			21			133	55
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1667	1680			1571			1605			831	
Queue Service Time (g_s), s	0.7	0.9			2.0			0.2			0.0	
Cycle Queue Clearance Time (g_c), s	0.7	0.9			2.0			0.2			3.2	
Green Ratio (*g/C*)	0.20	0.27			0.10			0.49			0.49	
Capacity (*c*), veh/h	333	448			281			926			587	
Volume-to-Capacity Ratio (*X*)	0.114	0.125			0.310			0.023			0.227	
Back of Queue (*Q*), ft/ln (95 th percentile)	8.1	10.3			23.6			3			18.2	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.3	0.4			0.9			0.1			0.7	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh	12.5	10.4			16.0			4.9			5.5	
Incremental Delay (d_2), s/veh	0.1	0.0			0.2			0.0			0.9	
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh	12.5	10.5			16.2			4.9			6.4	0.0
Level of Service (LOS)	B	B			B			A			A	A
Approach Delay, s/veh / LOS	11.3	B		16.2	B		4.9	A		4.6	A	
Intersection Delay, s/veh / LOS	8.8						A					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.66	B	1.91	B	1.69	B	1.86	B
Bicycle LOS Score / LOS	0.64	A	0.63	A	0.52	A	0.80	A

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HCS Signalized Intersection Results Summary

General Information				Intersection Information	
Agency				Duration, h	1.000
Analyst	Emma Myers-Verhage	Analysis Date	Aug 8, 2023	Area Type	Other
Jurisdiction	Box Elder, SD	Time Period	PM Peak	PHF	1.00
Urban Street	Alternative 1	Analysis Year	2050	Analysis Period	1> 7:00
Intersection	Hwy 1416 and Liberty Blvd	File Name	Hwy1416-Liberty_Alt1_PMPeak2050.xus		
Project Description	Radar Hill 1416 Corridor Study				



Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	40	46	13	4	30	58	8	11	2	118	22	58

Signal Information			
Cycle, s	42.5	Reference Phase	2
Offset, s	0	Reference Point	End
Uncoordinated	Yes	Simult. Gap E/W	On
Force Mode	Fixed	Simult. Gap N/S	On

							1	2	3	4
Green	1.9	4.2	23.0	0.0	0.0	0.0	5	6	7	8
Yellow	3.5	3.5	3.5	0.0	0.0	0.0				
Red	1.0	1.0	1.0	0.0	0.0	0.0				

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.1	4.0	0.0	14.0	11.0	14.2	0.0	13.3
Phase Duration, s	6.4	15.0	0.0	8.7	0.0	27.5	0.0	27.5
Change Period, ($Y+R_c$), s	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Max Allow Headway (*MAH*), s	3.0	3.1	0.0	3.1	0.0	3.2	0.0	3.0
Queue Clearance Time (g_s), s	2.8	3.2		4.4		2.2		5.7
Green Extension Time (g_e), s	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.3
Phase Call Probability	0.38	0.90		0.83		1.00		1.00
Max Out Probability	1.00	0.00		0.00		0.00		0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5	2	12	1	6	16	3	8	18	7	4	14
Adjusted Flow Rate (*v*), veh/h	40	59			92			21			140	58
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1667	1683			1572			1600			794	
Queue Service Time (g_s), s	0.8	1.2			2.4			0.2			0.0	
Cycle Queue Clearance Time (g_c), s	0.8	1.2			2.4			0.2			3.7	
Green Ratio (*g/C*)	0.19	0.25			0.10			0.54			0.54	
Capacity (*c*), veh/h	299	417			259			984			585	
Volume-to-Capacity Ratio (*X*)	0.134	0.141			0.355			0.021			0.239	
Back of Queue (*Q*), ft/ln (95 th percentile)	10.9	14.3			31			3.1			20.2	
Back of Queue (*Q*), veh/ln (95 th percentile)	0.4	0.6			1.2			0.1			0.8	
Queue Storage Ratio (*RQ*) (95 th percentile)	0.00	0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh	14.6	12.5			18.4			4.5			5.2	
Incremental Delay (d_2), s/veh	0.1	0.1			0.3			0.0			1.0	
Initial Queue Delay (d_3), s/veh	0.0	0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh	14.6	12.5			18.7			4.6			6.2	0.0
Level of Service (LOS)	B	B			B			A			A	A
Approach Delay, s/veh / LOS	13.4	B		18.7	B		4.6	A		4.4	A	
Intersection Delay, s/veh / LOS	9.8						A					

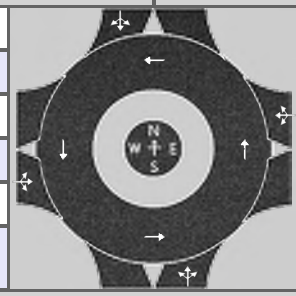
Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	1.67	B	1.91	B	1.69	B	1.86	B
Bicycle LOS Score / LOS	0.65	A	0.64	A	0.52	A	0.81	A

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/3/2023
Analysis Year	2030
Time Analyzed	AM Peak
Project Description	Alternative 1



Site Information

Intersection	Highway 1416 and Liberty Bl...
E/W Street Name	Highway 1416
N/S Street Name	Liberty Blvd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	326	150	3	0	7	90	171	0	4	51	10	0	60	19	141
Percent Heavy Vehicles, %	8	8	8	8	7	7	7	7	2	2	2	2	9	9	9	9
Flow Rate (v_{PCE}), pc/h	0	419	193	4	0	9	115	218	0	5	62	12	0	78	25	183
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		616			342			79			286	
Entry Volume, veh/h		570			320			77			262	
Circulating Flow (v_c), pc/h	112			486			690			129		
Exiting Flow (v_{ex}), pc/h	283			303			699			38		
Capacity (c_{pce}), pc/h		1231			841			683			1210	
Capacity (c), veh/h		1140			786			669			1110	
v/c Ratio (x)		0.50			0.41			0.12			0.24	

Delay and Level of Service

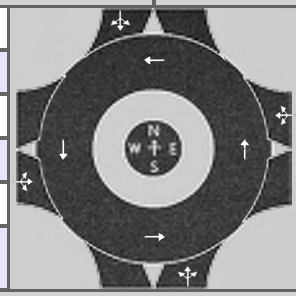
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		8.8			9.8			6.7			5.4	
Lane LOS		A			A			A			A	
95% Queue, veh		3.0			2.0			0.4			0.9	
Approach Delay, s/veh | LOS	8.8	A		9.8	A		6.7	A		5.4	A	
Intersection Delay, s/veh | LOS	8.2						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/3/2023
Analysis Year	2050
Time Analyzed	AM Peak
Project Description	Alternative 1



Site Information

Intersection	Highway 1416 and Liberty Bl...
E/W Street Name	Highway 1416
N/S Street Name	Liberty Blvd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	333	151	3	0	7	91	178	0	4	52	10	0	61	19	142
Percent Heavy Vehicles, %	8	8	8	8	7	7	7	7	2	2	2	2	9	9	9	9
Flow Rate (v_{PCE}), pc/h	0	428	194	4	0	9	116	227	0	5	63	12	0	79	25	184
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		626			352			80			288	
Entry Volume, veh/h		580			329			78			264	
Circulating Flow (v_c), pc/h	113			496			701			130		
Exiting Flow (v_{ex}), pc/h	285			305			718			38		
Capacity (c_{pce}), pc/h		1230			832			675			1209	
Capacity (c), veh/h		1139			778			662			1109	
v/c Ratio (x)		0.51			0.42			0.12			0.24	

Delay and Level of Service

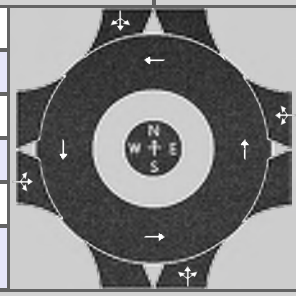
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		9.0			10.1			6.8			5.5	
Lane LOS		A			B			A			A	
95% Queue, veh		3.1			2.2			0.4			0.9	
Approach Delay, s/veh | LOS	9.0	A		10.1	B		6.8	A		5.5	A	
Intersection Delay, s/veh | LOS	8.4						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/3/2023
Analysis Year	2030
Time Analyzed	PM Peak
Project Description	Alternative 1



Site Information

Intersection	Highway 1416 and Liberty Bl...
E/W Street Name	Highway 1416
N/S Street Name	Liberty Blvd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	97	83	13	0	7	64	66	0	8	16	2	0	125	26	107
Percent Heavy Vehicles, %	8	8	8	8	7	7	7	7	2	2	2	2	9	9	9	9
Flow Rate (v_{PCE}), pc/h	0	125	107	17	0	9	82	84	0	10	19	2	0	162	34	139
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		249			175			31			335	
Entry Volume, veh/h		231			164			30			307	
Circulating Flow (v_c), pc/h	205			154			394			101		
Exiting Flow (v_{ex}), pc/h	271			231			228			60		
Capacity (c_{pce}), pc/h		1120			1179			923			1245	
Capacity (c), veh/h		1037			1102			905			1142	
v/c Ratio (x)		0.22			0.15			0.03			0.27	

Delay and Level of Service

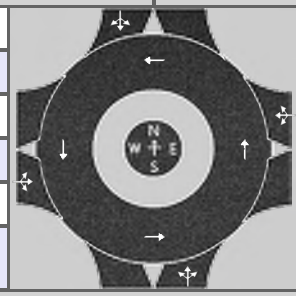
Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		5.6			4.6			4.3			5.7	
Lane LOS		A			A			A			A	
95% Queue, veh		0.9			0.5			0.1			1.1	
Approach Delay, s/veh | LOS	5.6	A		4.6	A		4.3	A		5.7	A	
Intersection Delay, s/veh | LOS	5.3						A					

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HCS Roundabouts Report

General Information

Analyst	Emma Myers-Verhage
Agency or Co.	
Date Performed	8/3/2023
Analysis Year	2050
Time Analyzed	PM Peak
Project Description	Alternative 1



Site Information

Intersection	Highway 1416 and Liberty Bl...
E/W Street Name	Highway 1416
N/S Street Name	Liberty Blvd
Analysis Time Period, hrs	1.00
Peak Hour Factor	0.84
Jurisdiction	Box Elder, SD

Volume Adjustments and Site Characteristics

Approach	EB				WB				NB				SB			
Movement	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Number of Lanes (N)	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0
Lane Assignment			LTR				LTR				LTR				LTR	
Volume (V), veh/h	0	99	86	13	0	7	66	69	0	8	16	2	0	131	27	110
Percent Heavy Vehicles, %	8	8	8	8	7	7	7	7	2	2	2	2	9	9	9	9
Flow Rate (v_{PCE}), pc/h	0	127	111	17	0	9	84	88	0	10	19	2	0	170	35	143
Right-Turn Bypass	None				None				None				None			
Conflicting Lanes	1				1				1				1			
Pedestrians Crossing, p/h	0				0				0				0			
Proportion of CAVs	0															

Critical and Follow-Up Headway Adjustment

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Critical Headway, s		4.9763			4.9763			4.9763			4.9763	
Follow-Up Headway, s		2.6087			2.6087			2.6087			2.6087	

Flow Computations, Capacity and v/c Ratios

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Entry Flow (v_e), pc/h		255			181			31			348	
Entry Volume, veh/h		236			169			30			319	
Circulating Flow (v_c), pc/h	214			156			408			103		
Exiting Flow (v_{ex}), pc/h	283			237			234			61		
Capacity (c_{pce}), pc/h		1109			1177			910			1242	
Capacity (c), veh/h		1027			1100			892			1140	
v/c Ratio (x)		0.23			0.15			0.03			0.28	

Delay and Level of Service

Approach	EB			WB			NB			SB		
Lane	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		5.7			4.6			4.3			5.8	
Lane LOS		A			A			A			A	
95% Queue, veh		0.9			0.5			0.1			1.2	
Approach Delay, s/veh | LOS	5.7	A		4.6	A		4.3	A		5.8	A	
Intersection Delay, s/veh | LOS	5.4						A					

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Appendix H: Public Input Meeting Summaries

Radar Hill Road & Highway 1416 Corridor Study
Public Input Meeting #1
Box Elder Community Center
June 20, 2023
5:30 – 8:00 P.M. MST

Meeting Discussion Points

Meeting Attendees

- See attached

- **Welcome & Presentation**
  - Steve Grabill welcomed attendees to the meeting.
  - Steve Grabill provided a PowerPoint presentation that included bullets and graphics highlighting the corridor study area, as well as data that had been collected and analyzed to date.
  - Steve Grabill reviewed the schedule for the project, noting that another public meeting is scheduled for September to present preliminary design concepts intended to address corridor needs. This meeting will receive further input on needs and public response to the design concepts. He also noted that a Study Advisory Team comprised of FHWA, State, Metropolitan Planning Organization (MPO), Pennington County and Box Elder officials and staff were providing key direction for the study.
  - The presentation covered study objectives, known issues, currently planned improvements, traffic volume and crash data, existing conditions traffic operations and pedestrian/bicycle analysis results.
  - Attendees were asked to provide comments verbally, through a printed comments sheet, via email, and through the website.

- **Public Comments**
  - An open house opportunity was offered prior to and after the formal presentation. Board displays and roll plots of the two corridors were available for viewing and discussion. Staff were available to discuss specific concerns attendees had during, prior to and after the formal presentation.
  - Following the presentation, Steve Grabill led a discussion of corridor needs and issues.
  - Attendee comment: How is the study being paid for? Mr. Grabill responded that it was paid with approximately 80% federal dollars through the MPO, with the local match split between Pennington County and Box Elder.

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- Attendee comment: Concern was raised regarding overall traffic capacity of the corridors.
- Attendee comment: Some crashes are not reported, so actual safety issue could be worse.
- Attendee comment: Concern with detours during Exit 63 construction.
- Attendee comment: I prefer Hwy 1416 and Box Elder Road be combined into a 5-lane and removing the divided highway. Highway 1416 turn movements are not intuitive.
- Attendee comment: Coordination needs to happen between the Hwy 1416 improvements and the Exit 63 project.
- Attendee comment: Traffic control along Hwy 1416 is confusing. Non-intuitive turns where yield for one direction and not the opposite direction.
- Attendee comment: Comments were made that Hwy 1416 was originally built to facilitate Ellsworth Air Base traffic more than traffic for local use.
- Attendee comment: Radar Hill Road is not safe for use by pedestrians or bicyclists.
- Attendee comment: Crash analysis should investigate run-off-the-road crashes. This is particularly a problem in winter with icy conditions along Hwy 1416.
- Attendee comment: Truck traffic has increased and is causing excessive road damage and requires wider turns.
- Attendee comment: Corridor improvements need to take into account growth, impacts to rural residents. Impacts to agricultural land and irrigation should be considered. Urban development occurring in rural areas needs to be better planned and the impacts need to be better considered.
- Attendee comment: High speeds have been observed along Radar Hill Road. Corridor improvements should include pull-offs for law enforcement.
- Attendee comment: Access to Box Elder parks should be provided for pedestrians and bicyclists.
- Attendee comment: The traffic peak for Ellsworth Air Base occurs at 6:30 and not 7:00. Mr. Grabill responded that the 7:00 traffic peak came from actual collected data, but that he would verify that there was not a mistake.
- Attendee comment: A stop sign or signal on westbound Hwy 1416 should be added to promote use of Liberty Boulevard by Air Base traffic.
- Attendee comment: Add an acceleration lane on Hwy 1416 for traffic heading east from Radar Hill Road.
- Attendee comment: Add a stop sign to Hwy 1416 as a short-term improvement at Ellsworth Road. The Ellsworth intersection should be a 4 way stop.
- Attendee comment: Concern about runoff along Hwy 1416 during a large storm event. This was also a problem on Radar Hill Road where they had to detour traffic so they couldn't drive on Radar Hill Road.
- Attendee comment: Concern about irrigation ditches being used for runoff.
- Attendee comment: Are Twilight Drive and Cheyenne Boulevard being studied as part of this project?

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- Attendee comment: Are new schools considered as part of this project? Mr. Miller responded that the study area was extended further east to account for the new school at Liberty Boulevard. Mr. Grabill said the new school along Creekside Drive was being considered as well.
- Attendee comment: Roundabouts should be considered as a viable traffic control alternative along Hwy 1416.
- Attendee comment: Unique solutions used in other states (such as Colorado) should be considered to address traffic problems here.
- Attendee comment: Disappointment was expressed that more people didn't attend the meeting. Other methods to advertise the next public meeting should be undertaken.

After the formal presentation was completed, members of the public joined staff and informally discussed the project. The meeting adjourned at 8:00 p.m.

ATTENDANCE LIST

Tuesday, June 20, 2023
Box Elder, SD

Pennington County Highway 1416 and Radar Hill Road

NAME	ORGANIZATION/BUSINESS ADDRESS/EMAIL
Jay Schwarzenbach	315 Ruth Ln, Box Elder
Travis Lusseter	Penn. Co. BOC.
Jason Thompson	Penn. Co. Planning
Mike Gubka	City of Box Elder cme2set@yahoo.com
Tom Blair	Realtor - Homeowner Anderson Rd

ATTENDANCE LIST

Tuesday, June 20, 2023
Box Elder, SD

Pennington County Highway 1416 and Radar Hill Road

NAME	ORGANIZATION/BUSINESS ADDRESS/EMAIL
Steve Grabill	KLJ
Dana Foreman	KLJ
Mimi Dieball	waz0029@hotmail.com
Ray + Stacy Campbell	
Jim Hayward	7866 Long View Rd
Jay Wickham	19791 Moonlight Drive
Tim Trueblood	ttrueblood@1791.com
Marie Trueblood	october@gci.net
Tim Pike	SDDOT
Tina Mulally	Dist 35 State Representative
Sherrie Nuhsen	6600 Longview Rd / hnuhsen@msn.com
Joe Muller	Renco Group

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Radar Hill Road & Highway 1416 Corridor Study
Public Input Meeting #2
Box Elder Community Center
September 19, 2023
5:30 – 8:00 P.M. MST

Meeting Discussion Points

Meeting Attendees

- See attached

- **Welcome & Presentation**
  - Steve Grabill welcomed attendees to the meeting. He said that the Study was being completed on behalf of the SDDOT, Metropolitan Planning Organization (MPO), Pennington County and Box Elder.
  - Steve Grabill provided a PowerPoint presentation that included bullets and graphics highlighting the study process and schedule, future conditions, interim corridor options and analysis, and conceptual corridor design options and analysis.
  - Steve Grabill noted that a concept to build Highway 1416 in the current location of Box Elder Road was eliminated due to the many accesses along Box Elder Road, noise, safety, and traffic engineering reasons.
  - A variety of intersection improvement concepts were shown for the Radar Hill Road and Ellsworth intersections along Highway 1416. Radar Hill Road Concept 1(Signals) & Concept 3 (Roundabout) were compared, with most staff support for the roundabout concept. This concept included cross arms to prevent cars from stopping on the railroad tracks. Since a roundabout splitter island would cut off through traffic from using Box Elder Road, this concept eliminated access to Gumbo (north extension of Radar Hill Road. All concepts improved pedestrian/bicycle crossings across Highway 1416.
  - Steve Grabill noted that another public meeting is tentatively scheduled for March 2024 to present the draft Corridor Study Report. Attendees were asked to provide comments verbally, through a printed comments sheet, via email, and through the website. Attendees were also encouraged to offer feedback during the presentation.

- **Public Comments**
  - An open house opportunity was offered prior to and after the formal presentation. Board displays and roll plots of the design options for Highway 1416 and Radar Hill

Road were available for viewing and discussion. Staff were available to discuss specific concerns attendees had during, prior to and after the formal presentation.

- Attendee comment: Joe Miller said for the interim stop signs that they plan on rubble strips, message boards, control signs for the intersections, but waiting to see the input from this public meeting. He also said it may take some time to implement the interim improvements.
- Attendee comment: Roundabouts may create problems for trucks. A tow truck driver said he can be towing a full semi with trailer, and he didn't think the roundabouts would allow him to pass through. Joe Miller noted that the severity of impact and number of conflict points are less in roundabout alternatives.
- Attendee comment: Concern in ability of roundabouts to handle trucks (with triples) turning, consider emergency response times and consult with the fire department.
- Attendee comment: Concern was raised that some semi-trucks are triples from freight company Old Dominion. Skyburg also has centipede trucks.
- Attendee comment: There is potential for a railroad crossing being added at West Gate Drive.
- Attendee comment: Ellsworth Road should have stop signs at Box Elder Road. Also, signing and striping should prohibit vehicles from blocking Box Elder Road.
- Attendee comment: Property owners along Radar Hill Road were concerned about their property being acquired for the wider road and sidewalk. Mr. Grabill said he didn't think additional property would be acquired along Radar Hill Road but that he would need to confirm that.
- Attendee comment: Concern was raised about how trucks would be accommodated if Box Elder Road does not connect directly onto Ellsworth Road.
- Attendee comment: Concerns were raised regarding the Displaced Left Turn option. Statements were received that it wouldn't work well if pavement markings are covered by snow. Also, there was concern if signals were not properly coordinated. A comment was also made that the option would be confusing to drive through.
- Attendee comment: A comment was made that trucks on Liberty find out they are going the wrong way and end up making a U-turn at the Highway 1416 intersection. Perhaps some signing can provide better direction or other accommodations can be made.
- Attendee comment: What will be the speed limit along Highway 1416? Mr. Grabill responded that the speed limit has not been determined yet. He added that if roundabouts are chosen as a preferred option, they generally have an impact of slowing traffic down. Joe Miller added that enforcement is important. The county tries to stay within 85% of the present corridor speeds.
- Attendee comment: Concern was raised regarding fire department access with roundabouts.
- Attendee comment: Comments both for sidewalks and against sidewalks were received. A resident was concerned about undesirable situations on a sidewalk that would be abutting his property. Another attendee responded that life safety is

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important, he was in favor of sidewalks and added that street lighting would be another important improvement.

- Attendee comment: What improvements will be made at Commercial Gate Drive? Mr. Grabill responded that the current layout shows southbound left turns being prohibited. However, he said that he hadn't met with Ellsworth Air Force Base yet, and they would likely have project needs that have not yet been considered.
- Attendee comment: There needs to be coordination with the Exit 63 project.
- Attendee comment: Questions were raised concerning how quickly improvements might be made, and what locations might be prioritized first. County staff said interim options could be implemented soon, but that would depend on availability of contractors, especially for rumble strip installations. Mr. Grabill said that other, more expensive improvements are needed now, but implementation will be subject to available funding.

After the formal presentation and joint comment period was completed, members of the public joined staff and informally discussed the project. Attendees were told they could continue to comment through the website, and that another meeting was tentatively scheduled for March 2024 to present the draft corridor study report. The meeting adjourned at 8:00 p.m.

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Radar Hill Road & Highway 1416 Corridor Study
Public Input Meeting #3
Box Elder Community Center
February 29, 2024
5:30 – 7:00 P.M. MST

Meeting Discussion Points

Meeting Attendees

- See attached

- **Welcome & Presentation**
  - Steve Grabill welcomed attendees to the meeting. He said that the Study was being completed on behalf of the SDDOT, FHWA, Metropolitan Planning Organization (MPO), Pennington County and Box Elder.
  - Steve Grabill provided a PowerPoint presentation that included bullets and graphics highlighting the study process and schedule, recommended corridor and intersection alternatives, and next steps in the report approval process.
  - Estimated costs for the recommended alternatives were included as a table in the PowerPoint presentation.
  - Copies of the draft Corridor Study Report were available at the meeting. Attendees were asked to provide comments verbally, through a printed comments sheet, via email, and through the website. Attendees were also encouraged to offer feedback during the presentation.

- **Public Comments**
  - Concern was raised that the project eliminates access onto 1416 and no left turns off 1416 - will affect fire truck access.
  - Roundabouts to function as turnaround "U-turn" ? Mr. Grabill responded that was correct.
  - How are traffic crossings for pedestrians handled and questions about whether signal lights can address pedestrian crossings. Mr. Grabill showed on the displays how pedestrian crossings along 1416 were being addressed. He said it is possible, especially for pedestrian crossings across a multi-lane roundabout, to signalize the crossing. These decisions would be made during design.
  - A traffic signal at Gumbo Drive is better. Still close Gumbo but install Signal.
  - After questions were raised about corridor speed, Mr. Grabill said the design speed on each roundabout is 20 mph and on 1416 is 45 mph.

- Are you planning an Asphalt or Concrete Road surface? Mr. Grabill said asphalt.
- Question About removing people from floodplain. Mr. Grabill said the expectation is that no additional fill material would be placed in the floodplain, and perhaps some can be removed. He didn't know whether the result could be that some people would be removed from the floodplain.
- More discussion about fire department access @ Commercial Gate. City staff responded that the fire department would be involved in reviewing design proposals.
- There was general discussion about U-turns for semi-trucks at 1416 & Liberty.
- A comment was received about the proposed 151st Ave left turn lane. Mr. Grabill said the project would also hopefully straighten out the intersection skew.
- Roundabout at Commercial Gate? Can a roundabout be added? Mr. Grabill responded that it may be possible but was not evaluated.
- Thank you for Stop Signs that were added.
- Concerns controlling the speed down in the roundabouts.
- Concerns about turning left or right in the roundabout. Mr. Grabill said the curvilinear design helps to facilitate proper use of the roundabouts.
- Sidewalks safe in the roundabouts, pedestrians push button cross. Mr. Grabill said crossing one lane, not multiple lanes for pedestrians helps pedestrian safety in the roundabouts.
- Close off Gumbo Road concern, why can't you put signals. Mr. Grabill said the roundabouts were a safer alternative from a crash severity standpoint.

After the formal presentation and joint comment period was completed, members of the public joined staff and informally discussed the project. Attendees were told they could continue to comment through the website. The meeting adjourned at 7:00 p.m.

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ATTENDANCE LIST

Thursday, February 29, 2024
Box Elder, SD

Pennington County
Highway 1416 and Radar Hill Road

NAME	ORGANIZATION/ADDRESS/EMAIL (Optional)
Steve Grabill	KLJ / Rapid City
Eileen Krengle	Box Elder, SD.
Joe Miller	Penco
Danny & Smith	Radar Hills Dr
Larry Larson	City of BE
Ken & Traci Gethers	Box Elder Rd, Box Elder
Dick Holzer	Box Elder, RADAR Hills DR.
Mike & Amanda Brown	Box Elder Radar Hill Rd
Jay & Amanda Schoneenbach	Box Elder
Justin Taylor	BEPD
Dan Brown	Box Elder, Radar Hills Rd.
Gary Walton	301 Crocus Ct, Box Elda

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ATTENDANCE LIST

Thursday, February 29, 2024
Box Elder, SD

Pennington County Highway 1416 and Radar Hill Road

NAME	ORGANIZATION/ADDRESS/EMAIL (Optional)
CARMLYN ZIERKE	234 MOCKINGBIRD DR 605 430-6323 Sue.a.2e@yahoo.com
Lucille Smith	Box Elder
Curt & Sandee Meier	428 Box Elder Rd W Box Elder
Matt Schwahl	West River Electric
Dustin Hall	[illegible] Rapid City, SD
Jerald Maine	607 W Sunnydale Rd. Box Elder
Dana Framan	DLR 1313 E. St Nt St.
Matt Corcoran	KLJ
Sarah Gilkerson	SDDOT
Julie Rieder	KLJ
Tim Hartman	KLJ
Tim Thompson	

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ATTENDANCE LIST

Thursday, February 29, 2024
Box Elder, SD

Pennington County
Highway 1416 and Radar Hill Road

NAME	ORGANIZATION/ADDRESS/EMAIL (Optional)
Kelsie Burkhard	SDDOT 700 E. Broadway Pierre, SD 57501
Tara Sirles	308 Box Elder Rd W. B.E. 57719
Brenda Degen-Whiting	11000 N. Elk Vale Rd RC SD 57701

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18 East Main Street, STE. 229
Rapid City, SD 57701-2949
605-721-5553
KLJENG.COM

Memorandum

Date: 4/5/24
To: Hwy 1416/Radar Hill Project Team (Joe Miller, Sarah Gilkerson, Doug Curry, Cassie Furchner, Mike Carlson, Michael Gubka, Jennica Wilcox, Kip Harrington, Eric Radke)
Copy to: Steve Grabill, PE, PTOE
From: Mark Powers, PE, PTOE
RE: Hwy 1416 Connection to W Gate Rd

Introduction

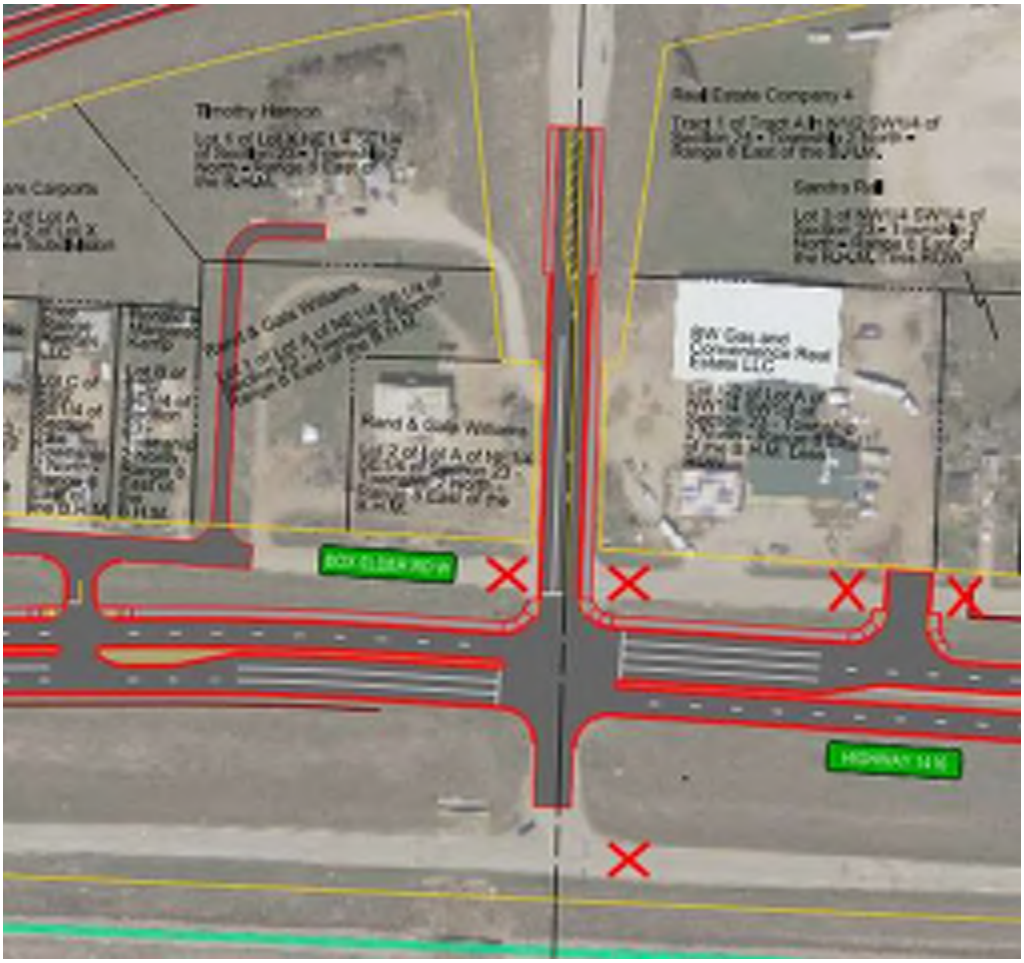
This memo was created in support of the Highway 1416/Radar Hill Road corridor study. In the public comment period following the Public Input Meeting on February 29, 2024, the project manager received an email from a citizen of Box Elder, SD. The citizen stated that they lived on Box Elder Road near the Yesway convenience store. Their expressed concern was that the proposed layout for Highway 1416 as part of this project, combined with the layout currently in development for the Exit 63/Highway 1416 and I-94 interchange project, limits the mobility for them and other citizens and businesses in the area.

Project Background

The Highway 1416/Radar Hill Road study spans from just east of the W Gate Road Intersection to 151st Avenue on Highway 1416. The design for the W Gate Road intersection is part of the Highway 1416 and I-94 interchange reconstruction project which is currently in its design phase. The current plans for the W Gate Road intersection are shown in **Figure 1**. As shown, the planned design will close access from Box Elder Road to W Gate Road to improve safety by eliminating the tight spacing between the intersections. The Yesway convenience store will have a private access on Highway 1416 that will be Right-In Right-Out (RIRO), but it will not connect to Box Elder Road.

Currently, there are two full access intersections on Highway 1416 between W Gate Road and Radar Hill Road. Radar Hill Road, Commercial Drive, and Ellsworth Road intersections are all currently full access as well. Study recommendations for the Highway 1416/Radar Hill Road project also include making the two full access intersections west of Radar Hill Road RIRO with median separation on Highway 1416. The proposed plan also recommends making the Radar Hill Road intersection a roundabout and eliminating the north leg of the intersection. The Commercial Drive intersection is proposed to be ¾ access where vehicles can enter Commercial Drive from both directions of Highway 1416 but can only exit heading westbound. The intersection at Ellsworth Drive is proposed to be a full access roundabout.

Figure 1 - West Gate Road Intersection Design



Citizen's Concern

The citizen along Box Elder, SD which contacted the Project Manager currently lives on Box Elder Road east of the Yesway convenience store. The concern raised by the citizen was that the design and concept of the two projects make traveling east on Highway 1416 or south on Radar Hill Road difficult for residents and businesses north of Highway 1416 on the west side of town.

Travel to East on Highway 1416

With the two project plans there are two ways to complete this movement:

- All vehicles can travel east on Box Elder Road to Ellsworth Road and use the roundabout at Ellsworth Drive and Highway 1416 to continue east. This route is expected to add about 1-2 minutes in travel time to what drivers are currently experiencing along the corridor.
- Personal vehicles can also use one of the RIRO intersections to travel west on Highway 1416 and make a U-turn at the W Gate Road signal to continue east. This route is expected to add 0.6-1.5 minutes in travel time to what drivers are currently experiencing on the corridor. With a 6-foot

median and two lanes of eastbound travel at the W Gate Road intersection, passenger cars are expected to be capable of making this maneuver, but larger vehicles are not expected to be able to make the tight turn.

Travel to South on Radar Hill Road

With the two project plans there are two ways to complete this movement:

- All vehicles can travel east on Box Elder Road to Commercial Gate and use the RIRO intersection to travel west on Highway 1416 to Radar Hill Road. Based on travel speed and distance, this route is expected to add 1.5 minutes in travel time to what drivers are currently experiencing on the corridor.
- Passenger car vehicles can also use one of the RIRO intersections to travel west on Highway 1416 and make a U-turn at the W Gate Road signal to continue east to Radar Hill Road. Based on travel speed and distance, this route is expected to add 0.6-1.5 minutes in travel time to what drivers are currently experiencing on the corridor. With a 6-foot median and two lanes of eastbound travel at the W Gate Road intersection personal vehicles are expected to be capable of making this maneuver, but heavy vehicles of any size are not expected to be able to make the tight turn.

Alternative Solutions

The Study Advisory Team (SAT) held a meeting on March 13, 2024 specifically to address this issue. The SAT discussed numerous potential changes to the proposed concepts that could address the concern raised. Ultimately, all the potential changes were eliminated from consideration. The discussion on conceptual solutions is summarized in **Table 1**.

Table 1 - SAT Discussion Summary

Alternative Solutions	Reasons for Consideration/Elimination
Move the Radar Hill roundabout 75’ to the south in order to fit a north leg	• Moving the roundabout would put it closer to the train tracks and create a potential conflict with the northbound queues and oncoming trains. • Adding a north leg with minimal distance between Box Elder Rd and Hwy 1416 would have a similar safety risk as it currently does.
Change the planned traffic control for W Gate Rd at Hwy 1416 to a roundabout	• With the planned additions of roundabouts on Hwy 1416 at Radar Hill Rd and Ellsworth Dr on this study, installing a roundabout at W Gate Road would create a homogenous network of intersection control on the corridor. • The roundabout control type was evaluated by the SDDOT but rejected due to operational concerns and poor level of Service.

Create a full access intersection on Hwy 1416 between W Gate Rd and Radar Hill Rd	• There are safety concerns with creating a full access intersection similar to the current issues. These issues would likely be made worse by anticipated increasing traffic volumes.
Create a limited access intersection on Hwy 1416 between W Gate Rd and Radar Hill Rd with an acceleration lane for southbound left-turning vehicles to give them added time to merge	• Historically, drivers in this area have had difficulty understanding an intersection like this and they have led to additional safety concerns.

Final Recommendation

After considering all the described alternatives listed in **Table 1**, the SAT ultimately decided to maintain the currently planned roadway designs and intersection concepts. The W Gate intersection is wide enough for personal vehicles to make a west-east U-turn movement. Travel times for all displaced vehicle trips are not expected to be increased by more than 2 minutes.