MONTANA DEPARTMENT OF TRANSPORTATION

I-90 Three Forks to Billings Road Closure Analysis

Final Report

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CDM Smith

MONTANA MDT DEPARTMENT OF TRANSPORTATION

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Abbreviations and Acronyms

AADT – Annual Average Daily Traffic

CAD – Computer-Aided Dispatch

CCTV – Closed-Circuit Television

HAR – Highway Advisory Radio

I-90 – Interstate 90

ITS – Intelligent Transportation System

MDT – Montana Department of Transportation

NCHRP – National Cooperative Highway Research Program

NDOR – Nebraska Department of Roads

P3 – Public-Private Partnership

RP – Reference Post

USDOT – United States Department of Transportation

VMS – Variable Message Signs

WYDOT – Wyoming Department of Transportation

Executive Summary

This report evaluated and analyzed potential improvements and procedural changes that will reduce delays and operational impacts for Interstate 90 (I-90) closures and weather events between Livingston and Billings, Montana. The I-90 study area is defined from the intersection of I-90 and US 287 (Reference Post [RP] 274) to Billings (RP 443), but recommendations for mitigation measures extended beyond the study corridor.

ES.1 Purpose of the Study

Weather events, especially snow and wind events during winter months, can create impassable conditions in this corridor. This is particularly true between Livingston (RP 330) and Columbus (RP 408). These events frequently require closures or detours within the corridor. To better understand the issues, CDM Smith met with Montana Department of Transportation (MDT) staff responsible for the closures. Data was obtained for the corridor, including number of closure events, traffic volumes, crash data, and an inventory of MDT assets related to the closures. Additional information was gathered through stakeholder interviews.

MDT data identified 212 closure events related to snow that occurred from 2007 to March 2018, or approximately 19 events per year. In addition, wind events that occur from late October to March require detouring I-90 traffic through Livingston. From 2012 to 2018, 97 events averaging 15 hours each were recorded.

ES.2 Summary of Existing Conditions

The corridor consists of approximately 170 miles of I-90 between the US 287 interchange west of Three Forks (RP 274) and Billings (RP 443). Five communities of note along the corridor were identified by MDT, including the cities of Bozeman, Livingston, Big Timber, Columbus, and Billings.

Figure ES-1 shows winter weather-related closures, showing the cumulative hours of road closure experienced throughout the corridor during the study period.

Wind-related closures in the Livingston area are addressed separately from the interstate closure event data. Wind events primarily occur from late October through March and result in partial or full detours between Exit 330 and Exit 337. Wind event durations last up to two days. There are two critical wind event locations that primarily impact westbound truck traffic.

Truck traffic is fairly consistent over the corridor with some seasonal variation in passenger car travel. There is a spike in crashes in the early winter months; otherwise, crashes are evenly distributed across the year.

Figure ES-1: Total Hours of Closure Events (2007–2018)

There are many existing operational assets within the corridor, primarily consisting of staff, vehicles, and traffic control devices. As a rural corridor, this area has few Intelligent Transportation System (ITS) devices. Primary ITS assets within the corridor consist of the following:

- Variable message signs (VMS)
- Highway advisory radio (HAR)
- Traffic count stations
- Weather sensors or stations
- Closed-circuit television (CCTV) cameras

There are existing wind speed gauges near RP 332 and RP 334. The existing wind speed gauge at RP 332 can be accessed by MDT Maintenance staff remotely while the gauge at RP 334 currently requires that Maintenance staff manually download data from the device.

Additional ITS assets include the MDT traveler information system. This system incorporates Montana's 511 system, which was developed and is maintained by MDT staff. The MDT traveler information system provides real-time information on closure events throughout the state. The MDT website includes pages for commercial motor carriers.

ES.3 Corridor Needs and Objectives

MDT identified a need to evaluate and mitigate operational impacts for I-90 closures and weather events between Livingston and Billings. The I-90 Three Forks to Billings Road Closure/Detour

Analysis identified the following needs and corresponding objectives to mitigate impacts during interstate closure and detour events:

Improve Safety	
	Minimizing time out of vehicle
	Improve visibility of warning messages
	Safely get traffic off the road when conditions warrant
	Get travelers to slow down in poor weather conditions when approaching road closures
	Provide parking
Improve Response Time and Operations	
	Get staff to gates more quickly
	Close gates more quickly
	Improve Inter-Agency Communication
	Improve Intra-Agency Communication
Improve Traveler Information Systems	
	Provide more accurate and timely information
	Provide information in multiple formats common to users
	Provide real-time parking information
Improve Local Traffic Operations	
	Move traffic through Livingston more efficiently
	Address ramp backups during weather events
	Build windbreak

ES.4 Improvement Options

A variety of options are proposed to address the operational issues identified in this report. They are summarized in the following categories and in **Table ES-1**.

ES 4.1 Gate Closure

Highway gates are a vital component to every highway closure plan. The ability to reduce the time required to implement closures and detours relies upon the speed, efficiency, and safety with which closure gates are deployed. The installation of automated gates will reduce the manpower and time required to close the highway.

ES 4.2 Road Closure Warning Signs

Road closure warning signs are dynamic by nature—they only apply at certain times. There are three primary ways to improve the speed and efficiency of road closure warnings. The first is to use static signs with flashing beacons. The signs may state "road closed when flashing." The beacons can be operated remotely and activated electronically without the need for crews to physically change the signs. Rotary drum changeable message signs are a second option and allow the signs to be changed remotely.

VMS are traffic control devices used to disseminate traffic information to travelers via a remotely operated electronic display board. The traveler information displayed on VMS may be generated as a result of a planned or unplanned event, as programmed by operations personnel. Information is most often displayed in real time.

ES 4.3 Physical Windbreak

Windbreaks are often natural barriers, but man-made options can be designed and constructed to be effective. The intent is to reduce the crosswind speeds across the highway that cause highway closures and detours.

ES 4.4 Highway Geometric Improvements

As traffic is removed from the highway during a closure, the efficiency of the highway interchanges and the local roadway system becomes increasingly important. The improvement options to interchange ramp configurations, intersection design, and traffic signal timings were evaluated based on stakeholder and MDT Maintenance staff input.

ES 4.5 Parking Management

Accommodation of vehicle parking, particularly trucks, was evaluated for a full closure scenario. Options are fairly limited but offered as part of this report.

ES 4.6 Traveler Information Systems

MDT has a traveler information system that is currently being upgraded with new hardware and supporting software. Additional services that can be added to the new system were identified. These include not only enhancements to existing means of informing the public but also finding ways to automate and improve accuracy and timeliness of information relative to road closure events.

ES 4.7 Maintenance and Monitoring Equipment

The safety and efficiency of the staff during a closure event is of outmost importance. The upgrade of service trucks from 2-wheel-drive (2WD) to 4WD for use during closures will increase the safety of the staff who need to respond to closure events in adverse conditions. Additional wind speed gauges near Livingston would improve MDT's ability to monitor the road conditions.

ES 4.8 Other Non-Capital Improvements

There are other improvements that could be completed by MDT maintenance forces (e.g., moving static signs) or require coordination between MDT staff and other stakeholders. An example is working with the local agencies in Livingston to improve the coordination of activities related to closures.

ES.5 Conclusions

Through the planning process and with input from MDT, local agencies, and stakeholders, a series of improvement options have been identified to help address the needs and objectives associated with road closures in this corridor. Costs vary greatly as do expected impacts, implementation will be dependent on the identification of funding. The following table summarizes the improvement options and cost estimates.

Table ES-1: Improvement Option Summary

Improvement Option #	Improvement Option Name	Construction Cost	CE/TC/Mobilization Cost Estimate	Total Estimated Cost
1	VMS - Three Forks	$125,000	$50,000	**$175,000**
2	VMS - Belgrade	$50,000	$20,000	**$70,000**
3	Road Closure Signage - Bear Canyon Road Exit 313	$38,000	$15,000	**$53,000**
4	Gates - Bear Canyon Road Exit 313	$75,000	$30,000	**$105,000**
5	Livingston EB I-90 Parking Area Expansion	$1,664,000	$666,000	**$2,330,000**
6	Road Closure Signage - Livingston Exit 330	$234,000	$94,000	**$328,000**
7	Gates - Livingston Exit 330	$75,000	$30,000	**$105,000**
8	Road Closure Signage - Livingston Exit 333 On-Ramps	$20,000	$8,000	**$28,000**
9	Gates - Livingston Exit 333 On-Ramps	$50,000	$20,000	**$70,000**
10	Livingston Windbreak	$1,300,000	$520,000	*** $2,070,000**
11	Livingston Wind Speed Gauge Upgrade	$30,000	$12,000	**$42,000**
12	Livingston Exit 337 Parking	$1,632,000	$653,000	**$2,285,000**
13	Road Closure Signage - Livingston Exit 337	$209,000	$84,000	**$293,000**
14	Gates - Livingston Exit 337	$75,000	$30,000	**$105,000**
15	Reconfigure/Reconstruct WB Off-Ramp at Livingston Exit 337	$1,500,000	$600,000	**** $2,400,000**
16	Road Closure Signage - White Sulphur Springs Exit 340	$13,000	$5,000	**$18,000**
17	Gates - White Sulphur Springs Exit 340	$25,000	$10,000	**$35,000**
18	Road Closure Signage - Big Timber Exit 367	$45,000	$18,000	**$63,000**
19	Gates - Big Timber Exit 367	$100,000	$40,000	**$140,000**
20	Road Closure Signage - Big Timber Exit 370	$45,000	$18,000	**$63,000**
21	Gates - Big Timber Exit 370	$100,000	$40,000	**$140,000**
22	Big Timber Exit 370 Parking	$998,000	$399,000	**$1,397,000**
23	Road Closure Signage - Columbus	$53,000	$21,000	**$74,000**
24	Gates - Columbus	$125,000	$50,000	**$175,000**
25	VMS - Park City	$50,000	$20,000	**$70,000**
26	VMS - Laurel	$50,000	$20,000	**$70,000**
27	VMS - Lockwood	$50,000	$20,000	**$70,000**

* Improvement Option #10 Total Cost includes $250,000 for Engineering Design

** Improvement Option #15 Total Cost includes $300,000 for Engineering Design

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Section 1
Introduction

1.1 Study Background and Approach

MDT identified a need to evaluate and mitigate operational impacts for Interstate 90 (I-90) closures and weather events between Livingston and Billings, Montana. The I-90 study area is defined from the intersection of I-90 and US 287 (Reference Post [RP] 274) to Billings (RP 443), but recommendations for mitigation measures extended beyond this study area as warranted, particularly east of Billings to the I-90/I-94 junction. See **Figure 2-1** for a depiction of the study area.

This report addresses the needs of the corridor and identifies potential improvement options that would help address the operational needs of the corridor. It describes the travel and safety characteristics of the corridor that help define the needs and objectives and inform the potential mitigation measures recommended. To address potential solutions, needs and objectives are identified, followed by potential mitigation strategies. These measures are a mix of operational, policy, and capital improvements.

Weather events, especially snow and wind events during winter months, can create impassable conditions in this corridor. This is particularly true between Livingston (RP 330) and Columbus (RP 408). These events frequently require closures or detours within the corridor. To better understand the issues, CDM Smith met with MDT staff responsible for the closures. Data was obtained for the corridor, including number of closure events, traffic volumes, crash data, and an inventory of MDT assets related to the closures. Additional information was gathered through stakeholder interviews.

MDT data identified 212 closure events that occurred from 2007 to March 2018 due to snow, or approximately 19 events per year. In addition, wind events that primarily occur from late October to March require detouring I-90 traffic through Livingston. Since 2012, there have been 97 wind events lasting an average of approximately 15 hours each.

1.2 Organization of the Report

The general characteristics of the corridor are presented in **Section 2**. This includes identifying the overall corridor and subareas of interest, an inventory of the existing Intelligent Transportation System (ITS) and operational assets available to MDT, and operational data related to the corridor. These data include closure and wind event-related information and traffic data such as Annual Average Daily Traffic (AADT) and crash history. While exploring operational concerns, interviews with involved staff and field visits were critical to the operational understanding. Anecdotal information from these sources is included in this section.

Section 3 describes the needs and objectives supported by the operational data related to the corridor.

Section 4 provides a summary of the improvement options. The improvement options encompass a range of alternatives including closure gate improvements, implementation of improved road closure warning signs and physical windbreaks, highway geometric improvements, parking management, traveler information system improvements, maintenance and monitoring equipment, and other non-capital improvements. The objectives each improvement option addresses, benefits, potential impacts, and estimated costs are defined.

Section 5 describes a potential list of funding mechanisms to consider as the improvements are planned.

Section 6 provides a study conclusion and offers recommendations for next steps.

Section 2

Existing Conditions

2.1 Overview of Corridor and Communities

The corridor consists of approximately 170 miles of I-90 between the US 287 interchange west of Three Forks (RP 274) and Billings (RP 443). The focus of the study corridor was on the rural areas and addressing needs related to generally weather-related closures. While some solutions involved the greater Billings area or addressed statewide issues, the physical corridor will remain between these two reference posts.

The roadway consists primarily of a four-lane divided interstate (two lanes in each direction). A third lane is provided in select spots, usually for acceleration lanes with entrance ramps. The inside median primarily consists of relatively level grass that provides errant vehicles with a traversable slope outside of the clear zone. Areas where the clear zone cannot be provided are protected with guardrail. The roadway typical section throughout the corridor generally consists of a 10-foot outside shoulder, two 12-foot travel lanes, and a 4-foot inside shoulder. MDT owns the interstate right-of-way along the corridor and within each interchange.

This route serves regional traffic within Montana and interstate travelers. **Figure 2-1** is a map showing the location of permanent traffic counters along the corridor. The area is subject to harsh winters with frequent, significant snow storms; closures from these storms and other weather-related events are common and are the primary concern addressed by this analysis.

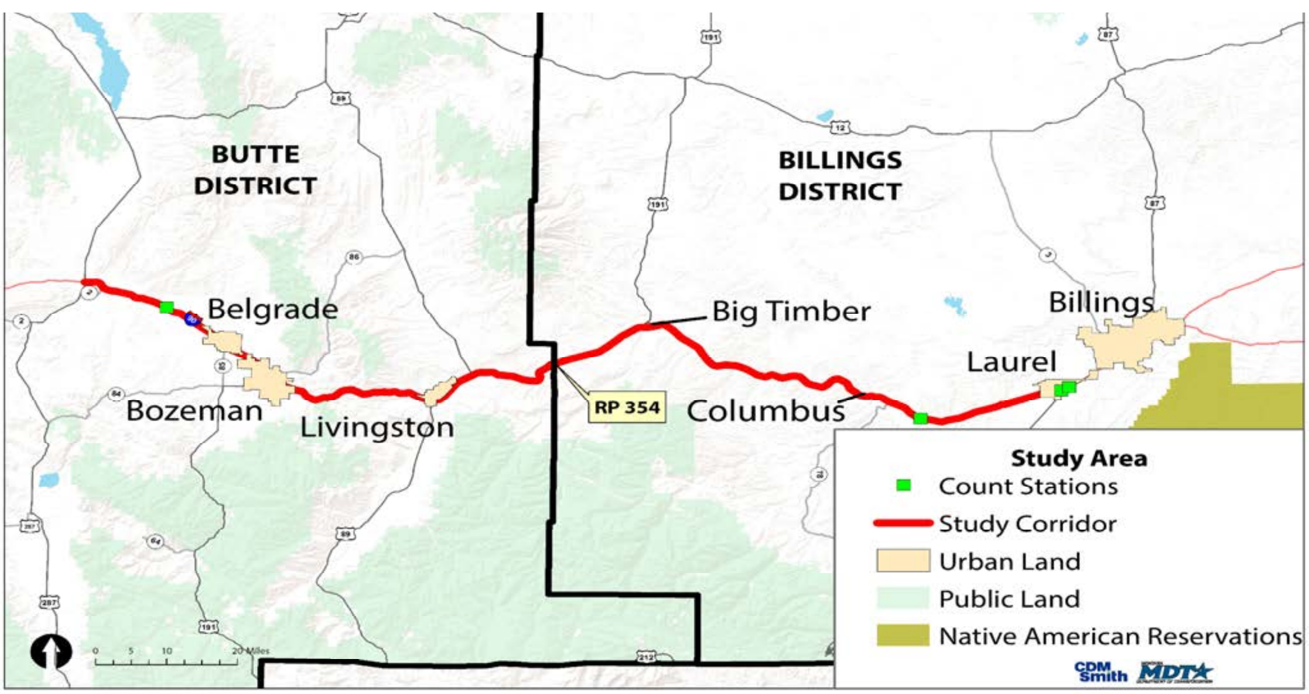

Figure 2-1: Permanent Count Station Locations

The terrain consists of rolling hills and valleys with a mountainous section within the Bozeman Pass (approximately RP 313 to RP 324). As this is primarily a rural area, there are no close alternate roads to bypass I-90. For long-distance traffic, major decision points for feasible alternate routes are typically in the Billings and Belgrade/Bozeman area and areas outside the study area in Missoula and Butte.

Rural corridors present unique operational challenges to agencies. While traffic is relatively light as compared to most urban corridors, the available assets on a per-mile basis are relatively thin in comparison. Communications and preparation are therefore important to providing the required incident management and maintenance services to minimize impacts to the facility operations.

2.1.1 Communities

Five communities of note along the corridor were identified by MDT, including the cities of Bozeman and Livingston in the Butte District and Big Timber, Columbus, and Billings in the Billings District. Columbus and Livingston were identified by MDT as field visit locations.

Bozeman

Bozeman is the county seat of Gallatin County with approximately 45,000 residents. Bozeman is the fourth largest city in Montana and located on the western edge of the study area.

Livingston

Livingston is the county seat of Park County, with roughly 7,000 residents. It is a gateway to Yellowstone National Park. It is located 26 miles east of Bozeman and 75 miles west of Columbus.

Big Timber

Big Timber is the county seat of Sweet Grass County, with 1,600 residents. It is located 61 miles east of Bozeman and 81 miles west of Billings, placing it about mid-point in the study area.

Columbus

Columbus is home to roughly 1,900 residents and is located 75 miles east of Livingston and 41 miles west of Billings. It is also the county seat of Stillwater County. Like Livingston, it serves as a gateway to the Absaroka-Beartooth Mountains and Yellowstone National Park.

Billings

Billings is the county seat of Yellowstone County, with 110,000 residents. Billings is the largest city in the state and located near the eastern edge of the study area.

2.1.2 Field Visits

CDM Smith staff met with the local MDT operations staff at two locations to complete a field review and gather information relevant to operations in the corridor. The following sections are a summary of these field visits.

Columbus – Billings District

The Columbus field visit was conducted on March 20, 2018. Minutes of the field visit are provided in **Appendix A**. There are no effective alternate routes between Columbus and Livingston where many of the road closures occur. The Columbus interchange (RP 408) is the logical turnaround location for westbound traffic, as its proximity to Billings provides long-distance traffic with an opportunity to return to the Billings area in the event of an interstate closure. From the Billings area, road users have the option to either take an alternate route for major long-term closures or to take advantage of a greater availability of parking and services. In the event of a closure, westbound traffic that has traveled beyond Columbus (RP 408) is unlikely to re-route back to Billings, exasperating traffic problems farther to the west on I-90 in Big Timber and/or Livingston.

Interviews with MDT staff indicate the following operational issues that have been observed:

- Historically, trucks frequently attempt to take US 191 at Big Timber to bypass snow events. US 191 is a two-lane road that runs in a northerly direction from Big Timber. US 191 experiences blowing snow and exposes vehicles to near-continual broadside winds and is inadvisable as an alternate route.
- Secondary Highway (HWY) 306, which heads from Columbus north toward Rapelje, has been used to bypass snow events on I-90. This route is not paved north of Rapelje, has limited traffic, and drivers can get lost on the road.
- US 212 does not typically serve as an east-west through-route for vehicles south of Red Lodge due to the nature of the roadway beyond the city. As a result, westbound travelers on US 212 are unlikely to be impacted by closures and detours occurring in the Livingston and Big Timber areas as US 212 is not a practical detour route for interstate travelers. Eastbound travelers on US 212 are generally not impacted by interstate closures in Livingston and Big Timber with the exception of vehicles that merge onto I-90 westbound at Laurel.
- The area near the twin bridges over the railroad and Yellowstone River (approximate RP 398) does not have a workable detour between Reed Point and the Springtime interchange (Exit 400) if that section of the interstate is closed.

During the field visit, locations that serve as existing truck storage during closures and additional potential parking locations were identified. The following sites were identified:

- City of Big Timber
- Greycliff rest area (RP 381)
- City of Columbus
- Columbus rest area (RP 419)

The Greycliff rest area (RP 381) was recently rebuilt to handle additional truck storage due to road closures and is used when the road is closed between Springtime and Columbus. The Greycliff rest area can serve as a storage location for westbound I-90 travelers impacted by interstate closures in Livingston and Big Timber to the west. However, it is not a good option for truck storage for eastbound I-90 travelers during wind events, as it is beyond the point where wind events typically occur. During snow events, trucks often park on the shoulder of the interstate. This practice is unsafe and generally ineffectual. Trucks on shoulders often get immobilized by snow drifts and are a hazard to plows and other motorists. The consensus of MDT staff is that historically none of these individual areas nor all of them collectively can provide for the amount of traffic that can back up in the hours it takes to implement a closure and clear the roadway. Billings was identified as the only location able to handle the potential/typical amount of trucks that back up during closures.

Livingston – Butte District

The Livingston field visit was conducted on March 21, 2018. Minutes of the field visit are provided in **Appendix A**. The Livingston area is susceptible to wind closures. The field visit and interview identified numerous issues relative to the existing conditions in the corridor.

During the interview, it was noted that the westbound off-ramp at Exit 337 has less than desirable geometry, minimal visibility, and notable lack of vehicle storage, which can back up quickly onto the interstate in detour events. Per **Figure 2-2**, the westbound exit ramp geometry is limited because the interstate width is constrained by the US 89 overpass that crosses I-90 just east of the exit ramp. This bridge blocks the exit ramp from view of westbound drivers until they arrive at the short 220-foot taper.

The deceleration length for this exit ramp is short, especially if traffic is backed up through the horizontal curve. (Note: Stopping sight distance from 70 miles-per-hour (mph) is 730 feet.) The vehicles that have exited the interstate must then enter onto US 89 westbound by making a left turn from a stop sign. This left turn can be difficult to make if there is a steady stream of detoured I-90 eastbound vehicles re-entering I-90 at Exit 337.

Figure 2-2: Livingston Exit 337 Interchange

Frequent wind events require traffic to detour through the community of Livingston. Several impacts of the detour route were discussed during the interviews and include the following:

- During full closure events, traffic quickly fills up the entirety of HWY 10 W, and Park Street/US 89.
- Passing trains during detour events cause the railroad-crossing gates at the Y-intersection between HWY 10 W and Park Street to be closed (see **Figure 2-3**).
- The traffic signals in town currently do not have the flexibility to run in a detour phase.
- During detour events, signal phasing results in delays with left-turning traffic from eastbound Park Street at the Y-intersection at HWY 10 W.
- A general lack of truck parking in Livingston was noted—especially during closure events. Local city and county staff have identified an empty parcel near Exit 337 for potential improvements that would provide increased vehicle storage capacity during closure events.
- There is a visibility issue for traffic approaching the westbound off-ramp at Exit 337. Traffic currently does not have direct visibility of MDT crews implementing a closure. Increased visibility will be a significant safety improvement for MDT staff initiating detours or closures and for the traveling public, who would have a better view of stopped traffic on the interstate in advance of the existing condition.
- Vehicles that run off the road or become stranded within the detour zone complicate the re-opening of the roadway after a closure/detour due to impacts caused by towing and recovery operations. To reduce these impacts, local stakeholders have worked with towing companies to prioritize clearing vehicles from the road and bringing stranded travelers to safety during winter weather events prior to recovering vehicles that have departed the traveled way.

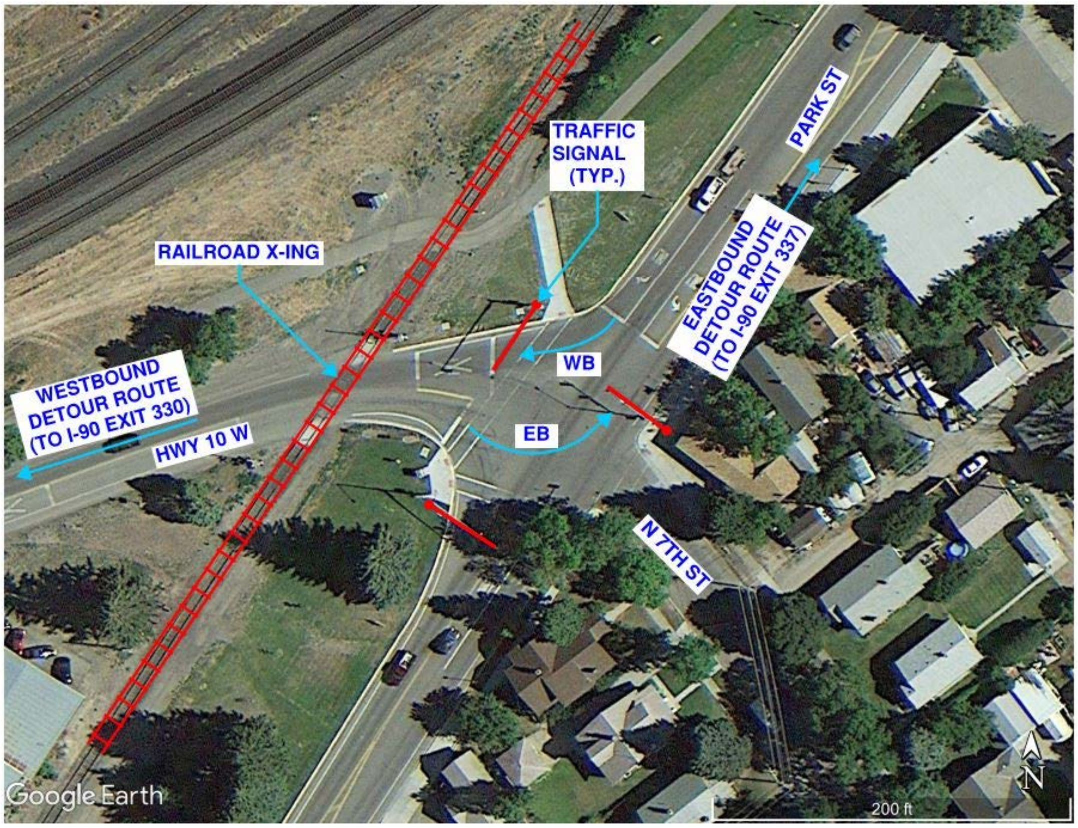

Figure 2-3: Livingston - Highway 10 W and Park Street

As previously noted, there are two specific areas with recurring wind issues. The first problem spot is near RP 332 just east of Livingston Exit 330. The second problem spot is near RP 334 just east of the bridge over the Yellowstone River. Both locations are unique for not having a natural barrier or earthen embankment on the south side of the road. The strong winds elsewhere in this corridor are generally redirected away from the road by various naturally existing means.

2.2 Inventory

There are many existing operational assets within the corridor, primarily consisting of staff, vehicles, and traffic control devices. As a rural corridor, this area has few ITS devices and no continuous power and communications to support technology throughout the corridor. The current assets are shown in **Figure 2-4**.

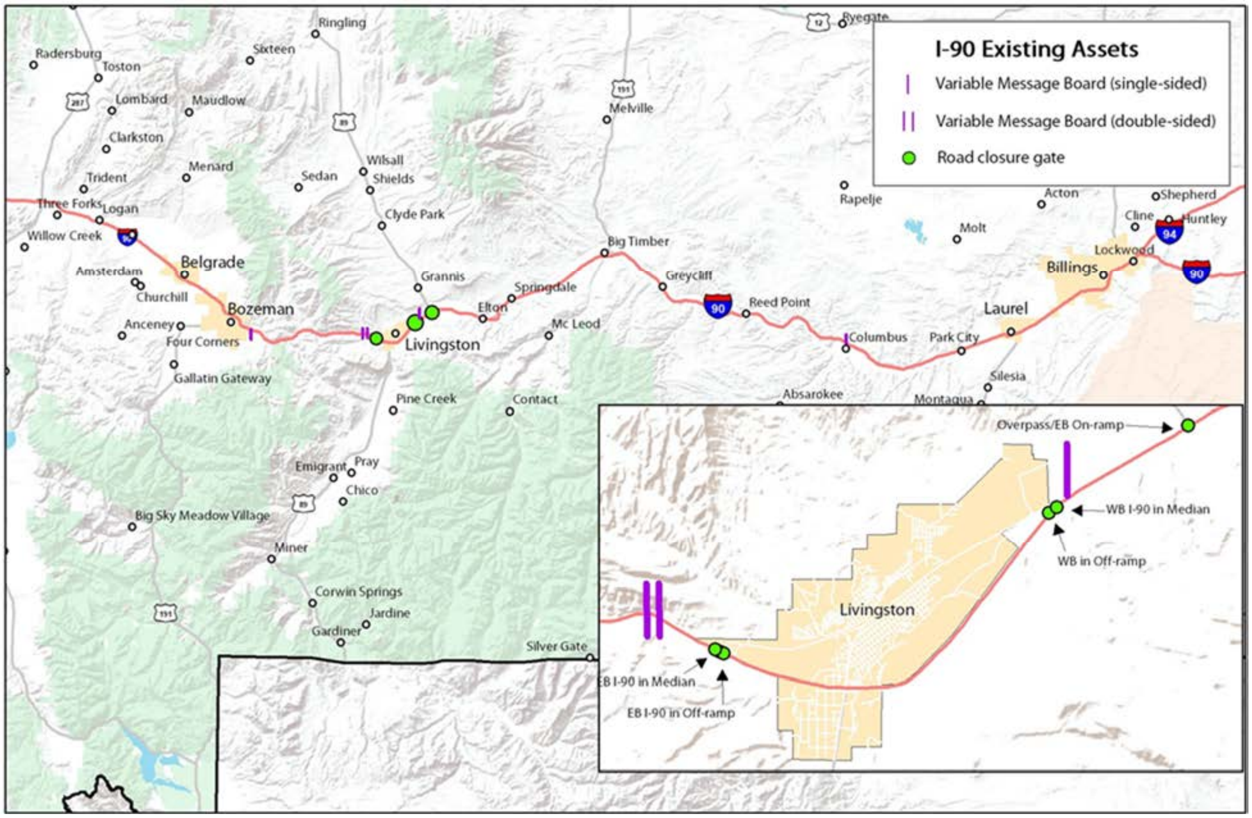

Figure 2-4: Maps of Corridor ITS and Operational Assets

2.2.1 Intelligent Transportation System

Primary ITS assets within the corridor consist of the following:

- Variable message signs (VMS)
- Highway advisory radio (HAR)
- Traffic count stations
- Weather sensors or stations
- Closed-circuit television (CCTV) cameras

MDT has a total of four existing permanent VMS boards mounted on support structures along I-90 within the study corridor. The MDT Billings Maintenance Area has one permanent VMS for westbound traffic, located approximately one-mile east of Columbus, and MDT has a total of seven portable VMS between Hardin and Big Timber, an area covering approximately 130 miles of I-90 between the cities. The MDT Bozeman Maintenance Area has one permanent VMS located on the west side of the Bozeman pass near mile marker 311 and two permanent VMS located on either side of Livingston. A double-sided VMS is located just west of the Exit 330 eastbound off-ramp, and a single-sided VMS is located just east of Exit 337, near mile marker 338. Additional resources available to the MDT Bozeman Maintenance Division include 12 portable VMS. Half of these are available for deployment during events as six are permanently devoted to warning travelers of bison between Gardiner and West Yellowstone.

There are 42 existing flip-signs between RP 328 and RP 340 that must be manually operated by the MDT Bozeman Area Maintenance staff in order to implement a detour or closure at Livingston. Flip-signs are regular static message signs that have been cut in half and hinged in the middle to allow Maintenance staff to physically open or close the signs as-needed.

MDT operates a HAR station (AM radio station 530) in the Livingston area. The HAR sign for westbound travel was noted to be within the closed detour segment of I-90, rendering it useless in a closure or detour event. The existing radio station has had performance issues, including a poor signal that grows noticeably weaker near Big Timber.

There are existing wind speed gauges near mile markers 332 and 334. The existing wind speed gauge at RP 332 can be accessed by MDT Maintenance staff remotely, while the gauge at RP 334 currently requires that Maintenance staff manually download data.

2.2.2 Operational

Operational assets include traffic control devices used to close ramps and the interstate. The assets start with field staff and their vehicles, which include snowplows and smaller 2WD pickups used for implementing traffic control. While all vehicles are equipped with standard hazard/emergency lighting (e.g., amber light bars on top, additional flashers in back), it was noted that during blizzard and white-out conditions, this emergency lighting may not be adequate.

Temporary traffic control devices may be used by MDT Maintenance staff. The range of devices include traffic barrels, traffic candlesticks, barricades, temporary signs, flashers, and other devices used to delineate and guide travelers through the intended traffic control.

There are permanent interstate closure gates at Livingston Exit 330 and Exit 337. These gates are operated by a winch with a manually operated crank. High winds acting against the gate arm require two to three people to open or close them during weather events.

2.2.3 Statewide Assets

One of the major goals of this analysis is to provide recommendations that may include improvements that can be completed along the corridor. However, there are other statewide assets that have a role in managing events within the corridor. This includes the MDT traveler information system. This system incorporates Montana's 511 system, which was developed and is maintained by MDT staff. The traveler information system provides real-time information on closure events throughout the state and provides automated notices through Twitter. The MDT's 511 website had over 10 million hits this past winter (2017–2018). The MDT website includes a motor carriers' page; however, the MDT website currently focuses primarily on permitting and restriction and not real-time traffic information specific to trucks.

Construction information is entered manually every week, and project managers are responsible for updating this information if there are any changes. During winter, snowplow drivers report conditions through their radio dispatch center. The information is not automated but is typically updated within minutes by staff. It should be noted that currently there is no central traffic management center for MDT. During the winter (typically November to the first week of April), the traveler information system is staffed 24-hours-a day/7-days-a week. Outside of winter, staff are on-call to remotely add events as needed.

MDT cooperates with other state and local transportation departments. This cooperation includes some work with the Western Transportation Institute (WTI) at Montana State University and representation with the North/West Passage Corridor Coalition. Both WTI and the coalition provide opportunities for MDT to share information and provide ideas for new ways to manage events.

Montana has a statewide maintenance communications system and private cellular networks. However, many passes and valleys have no cellular or radio coverage. Placing fiber optics cable statewide is not feasible. Crowdsource information, such as Google and Waze, are sporadic due to the lack of coverage and lack of "crowds" in a large rural state. Some of the other states in the North/West Passage coalition have citizen reporting systems that allow everyday citizens to call in or use an app to report events and conditions.

2.3 Operational Data

Part of the process of evaluating existing conditions involves noting operational issues. These issues are identified both through data analysis and anecdotal interviews with stakeholders. The issues are identified to assist with developing recommendations.

Data are available for a variety of operational concerns, including basic traffic and crash data and road closure data. These various data items are reviewed in order to better determine the corridor needs. For example, if stakeholders identified crashes as an issue, looking at the data may illustrate that the real issue is crashes at night.

2.3.1 Traffic

To examine the level of traffic impacted by the closures, AADT was determined from data gathered by the three count stations at locations shown in **Figure 2-1**. A more detailed look at AADT data in two areas in the corridor are shown in **Figure 2-5** and **Figure 2-6**. AADT is highest on the eastern end near Billings with a range between approximately 9,000 and 27,000. Large truck AADT is fairly consistent throughout the corridor at approximately 2,000. AADT vary significantly by month as shown in **Figure 2-7**, where July traffic can be nearly twice that of January.

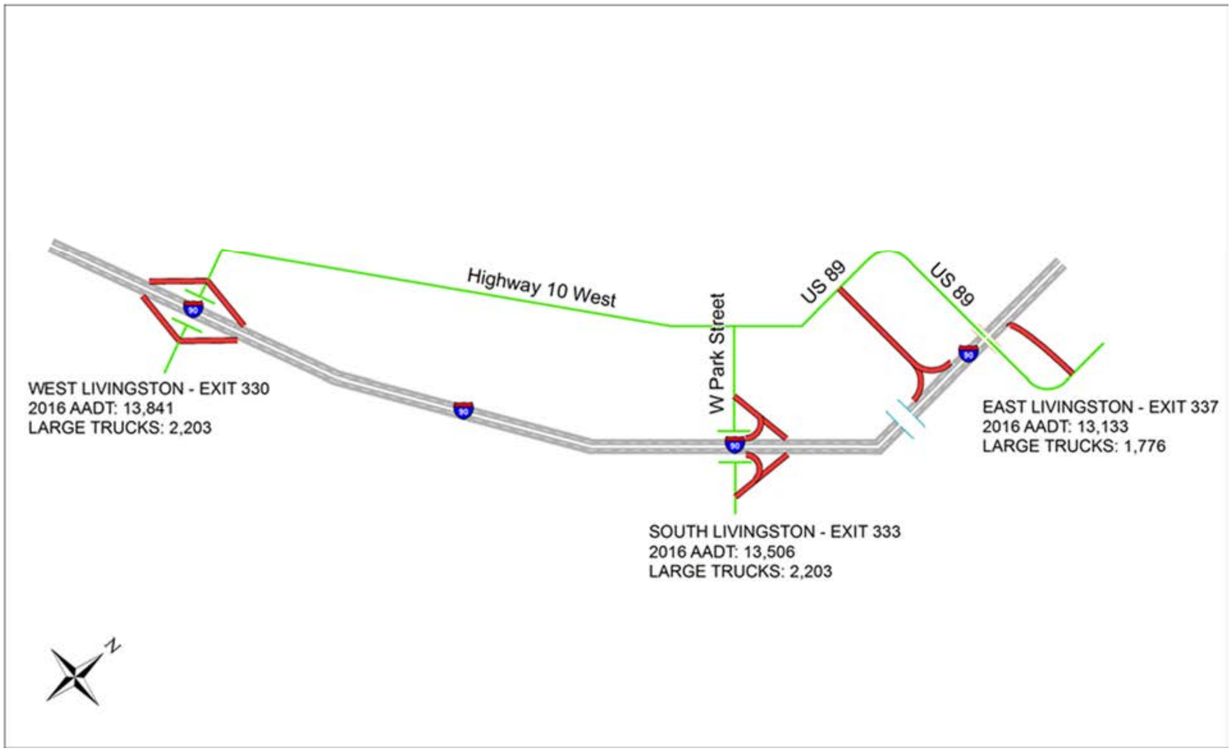

Figure 2-5: AADT Maps for Livingston

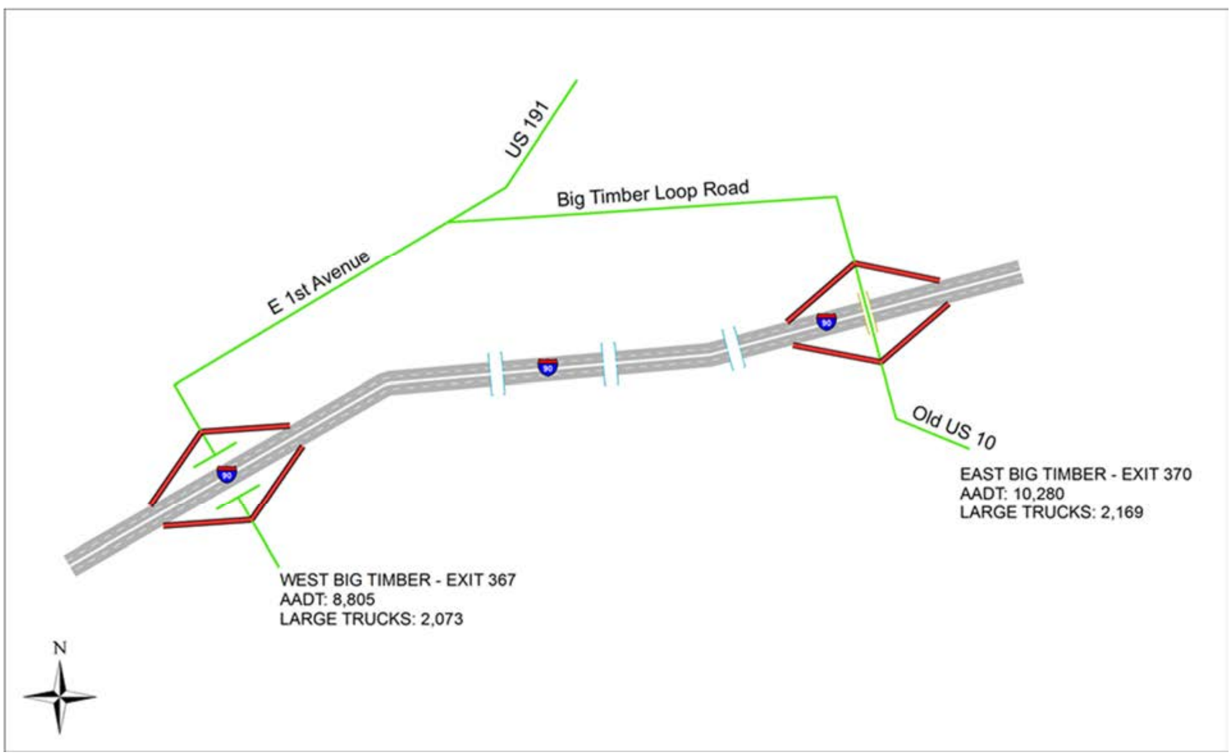

Figure 2-6: AADT Maps for Big Timber

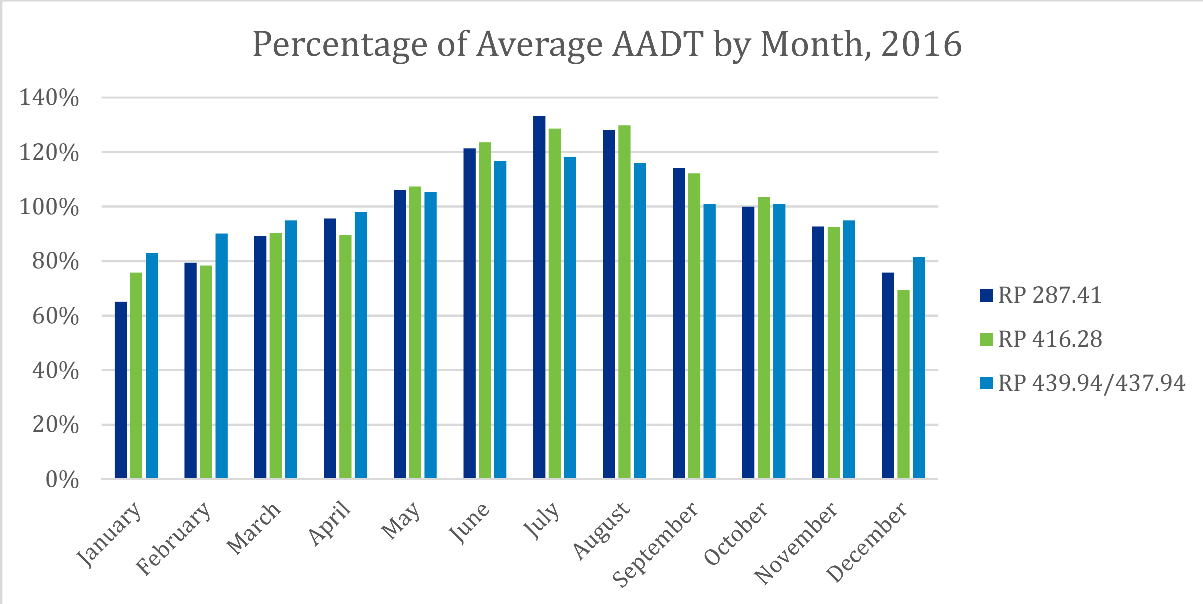

Figure 2-7: Monthly AADT Variation at Permanent Count Stations

Based on the observed traffic numbers, there are no additional needs identified. The numbers do not indicate additional problems, but they do illustrate the value of the needs and they do provide an indication of how quickly the communities fill up when the road is closed.

2.3.2 Closures

The primary concern for the corridor is full closures of the roadway. These closure events happen relatively frequently in this corridor and are almost entirely winter storm-related. For most traffic crashes, MDT is typically able to maintain at least one open lane on the roadway. Winter weather closure information was provided by MDT for the period from 2007 to 2018. **Figure 2-8** shows winter weather-related closures, showing that the majority of road closing incidents occur between November and February, with more continuing through spring. Wind-related closures in the Livingston area are addressed separately from the winter storms in **Figure 2-10**.

Closures can span a broad range of times and distances. Closing the road can take several hours, so these closures are only implemented when extreme conditions are warranted. **Table 2-1** summarizes the variation of impacts. Closures run from several hours to just over four days. The average is nearly seven hours, but the standard deviation of almost ten hours illustrates the highly variable nature of these events. Typical section lengths average 25 miles, with the minimum being 12 miles and the maximum 38 miles (see **Figure 2-9**).

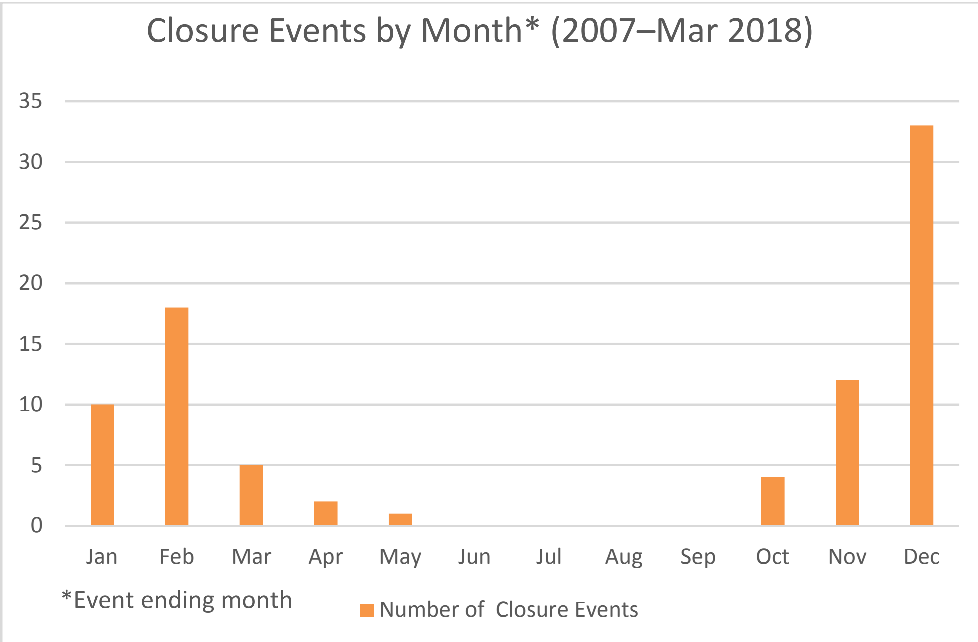

Figure 2-8: Total Winter Weather Related Closure Events by Month (2007–2018)

Table 2-1: Closure Impact Summary

Measure	Closure Duration (hours)	Closure Duration (minutes)	Closure Distance (miles)
Minimum	0.7	42	12
Maximum	50.3	3,018	38
Mean	7.6	458	24
Median	4.2	250	18
Standard Deviation	10.1	606	10

Source: MDT event closure log

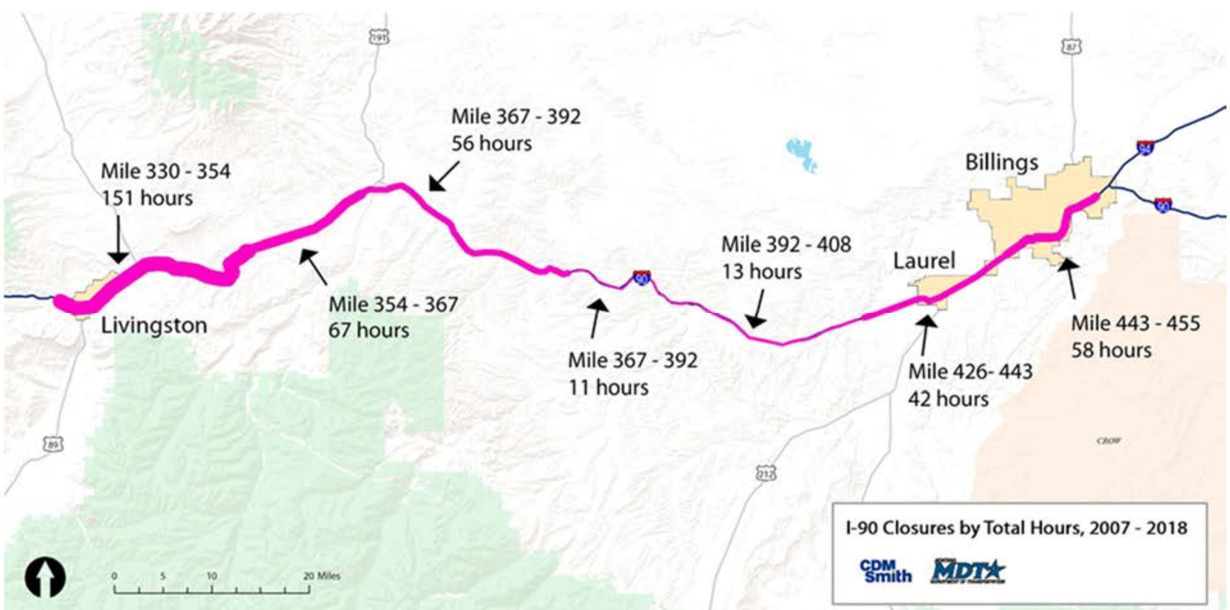

Figure 2-9: Full Closures per Segment

These events exclude the wind advisory and detour events in the Livingston area. MDT staff in Livingston noted that I-90 is frequently closed during the winter months at two specific wind event locations (see **Figure 3-1**). Wind-related closures can be for trucks only or for all traffic. Since 2012, there have been 97 wind-related events in Livingston. The total hours of delays by month is shown in **Figure 2-10**. The average duration of a wind event was approximately 15 hours, although the length varied greatly.

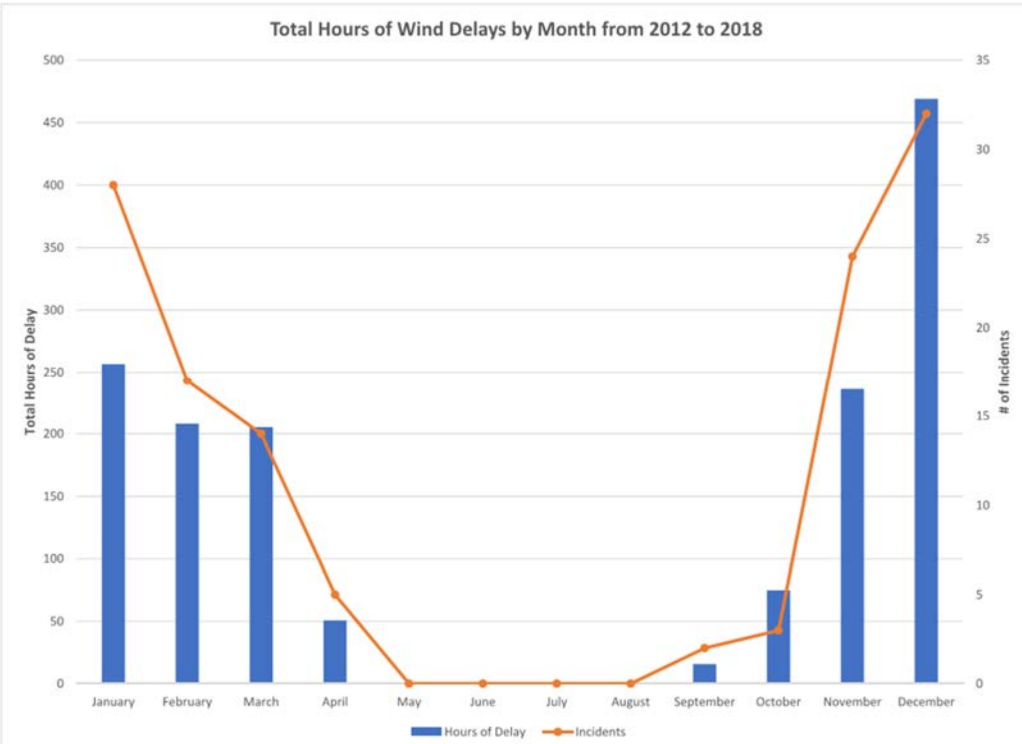

Figure 2-10: Delay Due to Winds Events

2.3.3 Crashes

While weather-related events are the primary cause of roadway closures, when addressing operational issues, it is important to look at all potential issues. Operational solutions are rarely isolated. A good solution to a weather road closure may benefit MDT in addressing other issues such as major crashes, hazmat situation, or special event traffic.

In addition, crash data often help illustrate potential operational issues, such as a curve, weaving issue, or sight distance issue. Finally, crash data serve an important role in outreach on operational efforts. Having data that illustrate issues helps to both elevate the relative importance of the analysis and educate travelers in potential solutions. For example, if the data indicate trucks are susceptible to run-off-the-road crashes in snow in a certain area, this information is important to convince truckers to use chains or abide by a variable speed limit for their own safety.

The number of crashes along the corridor is shown in **Figure 2-11**. Total crashes are indicated by the blue line, with truck-involved crashes shown by the orange line. The chart illustrates that truck-involved crashes are relatively uniform across the corridor, but car-related crashes are significantly higher between Belgrade and Livingston and from Laurel to Billings—essentially near the larger communities where there is more commuter traffic. In addition to the increased commuter traffic between Belgrade and Bozeman, the notable spike in crashes between Bozeman and Livingston may be caused by the mountainous driving conditions over the Bozeman Pass – located between the Exit 313 and Exit 324 interchanges.

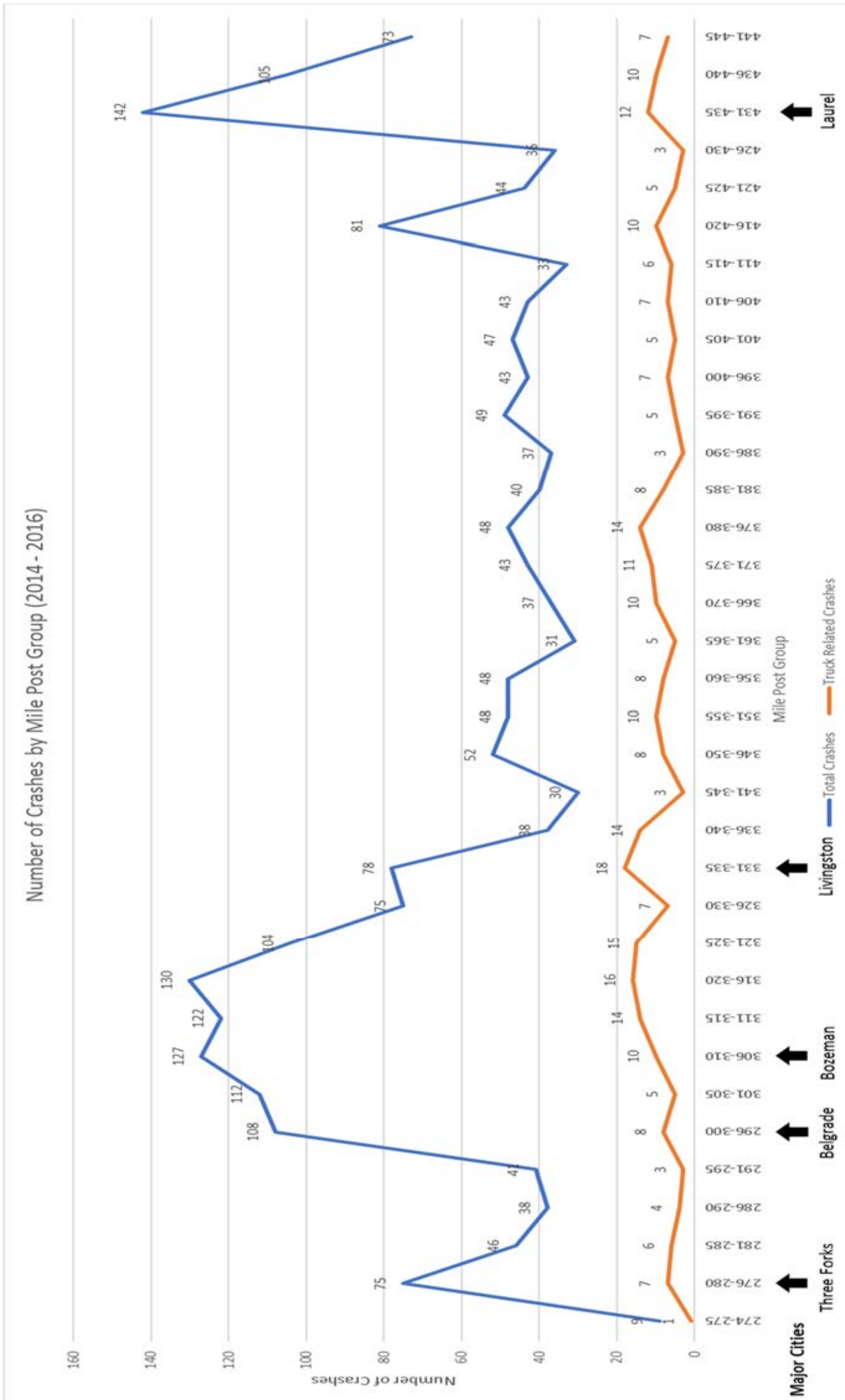

Figure 2-11: Crashes by Reference Post

Figure 2-12 shows a spike in crashes in the early winter months; otherwise, crashes are evenly distributed across the year. Similarly, **Figure 2-13** shows the crashes by hour of the day. While there is a drop in the early pre-dawn hours, the morning and afternoon peak hours are higher.

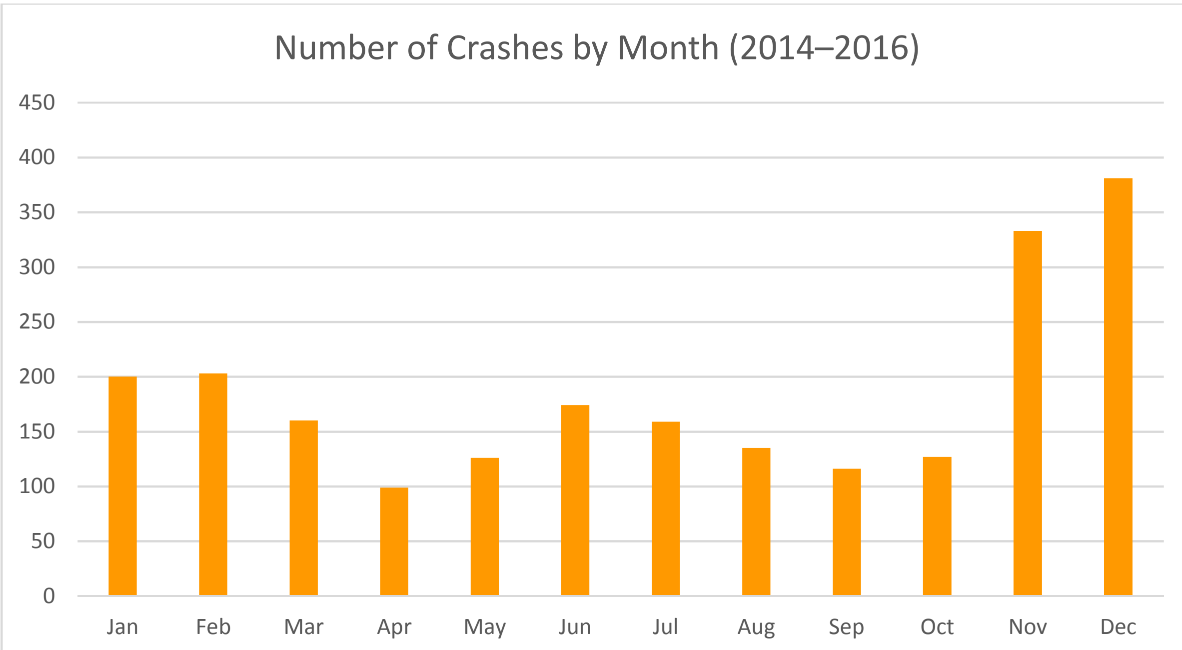

Figure 2-12: Crashes by Month

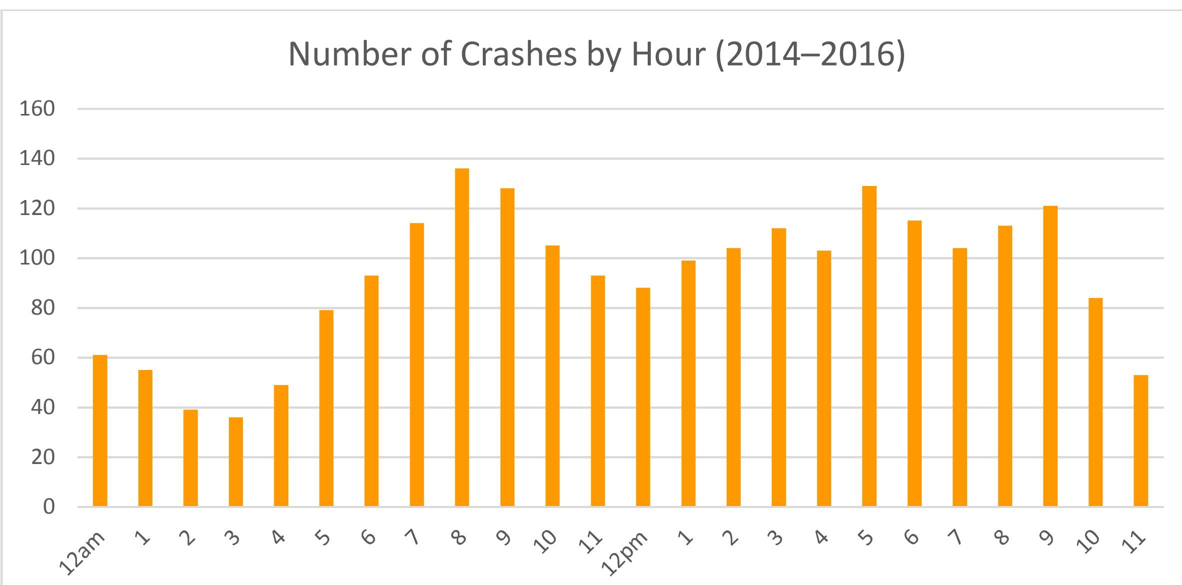

Figure 2-13: Crashes by Time of Day

Figure 2-14 is a summary of the top five collision types. These top five represent 87% of the total crashes within the corridor. Fixed object crashes on a rural interstate are typical of roadway departure crashes. Second are wild animal crashes, which are common to rural areas with dense populations of large ungulate species, including deer and elk. Wild animal crashes are typically during nighttime and often more numerous during early fall. Rollover crashes are indicative of roadway departure crashes but in this corridor may be representative of trucks and wind-related events. Rear-end and side-swipe crashes are typical of urban areas and congestion.

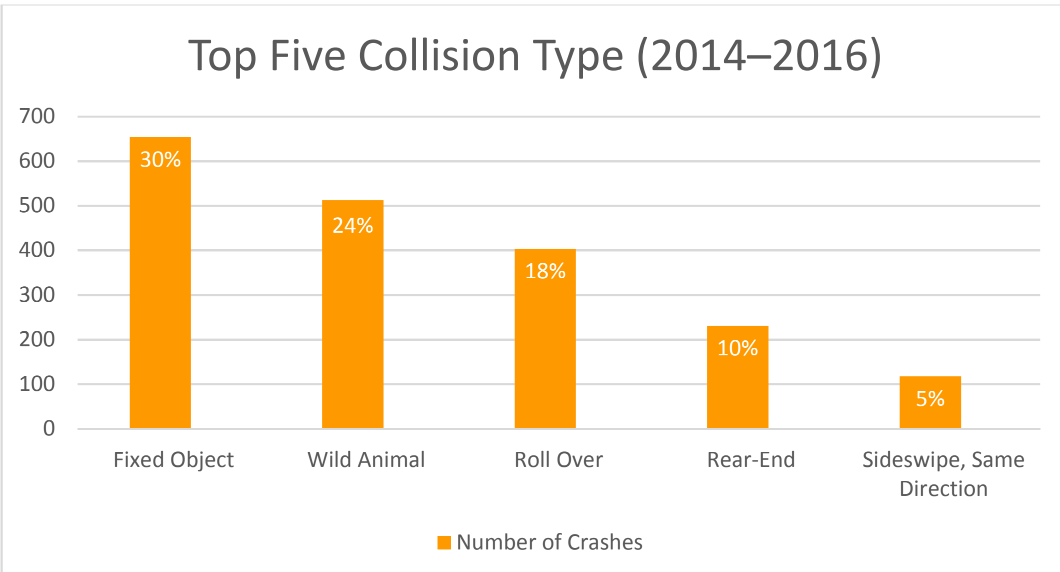

Figure 2-14: Crashes by Type

In summary, the crash and closure analysis supports the concerns over winter closure events in the corridor but did not indicate any other issues that may need to be addressed.

Section 3

Corridor Needs and Objectives

3.1 Needs Identified from the Field Visits

There were two field visits conducted in spring 2018. Discussions with MDT staff and observations from CDM Smith staff were combined to identify some corridor needs.

3.1.1 Columbus

Interviews with MDT Billings Maintenance staff noted that closure incidents within the Billings District are infrequent and primarily caused by blowing/drifting snow with low- to no-visibility conditions. The flats on either side of Big Timber are known snow drifting locations; running from approximately RP 354 to RP 381 excepting the area between the Big Timber Exit 367 and Exit 370 interchanges, this section of I-90 encompasses the most likely areas to force interstate closures within the MDT Billings Area Maintenance territory.

Additional weather-related threats include wildfires. MDT staff indicated that historically they were able to maintain at least one lane of traffic on I-90 in both the eastbound and westbound directions while closing the lane closest to the fire for firefighting operations. Interstate flooding within the area is not an issue, although maintenance staff did identify one location between Big Timber and Bridger Creek (RP 384) where the possibility of flooding exists.

The needs identified from the Columbus visit are greater visibility of closures and safety in implementing closures.

3.1.2 Livingston

Interviews with MDT Butte District staff noted the primary trigger for I-90 warnings, detours, and closures in this corridor is wind. Wind events primarily occur from late October through March. Wind events occur most weeks during the windy season, resulting in partial or full detours between Exit 330 and Exit 337. Wind event durations can last up to two days.

There are two critical wind event locations that primarily impact westbound truck traffic. The first problem area is near RP 332 just east of Livingston Exit 330. The second problem area is near RP 334 just east of the interstate bridge over the Yellowstone River. Existing wind gauges are installed near each location. A third known wind location that does not have a history of truck rollovers occurs along the flats just east of RP 336.

The four primary types of incidents in the Livingston area are as follows:

1. **Severe cross-winds warning:** Triggered when wind speed reaches 40 mph.
2. **Partial I-90 closure between Exit 330 and Exit 337:** Trucks and towing vehicles must take detour route through Livingston; triggered when wind speeds reach 50 mph.

3. **Full I-90 closure between Exit 330 and Exit 337:** All vehicles must take detour route through Livingston; triggered when wind speeds reach 60 mph or as deemed necessary by the MDT Bozeman Area Maintenance Superintendent, based on weather conditions.

4. **Full I-90 closure East (or West) of Livingston:** The interstate is closed completely east or west of Livingston; this type of incident is rare and primarily occurs when blowing snow between Livingston and Big Timber creates low-visibility conditions.

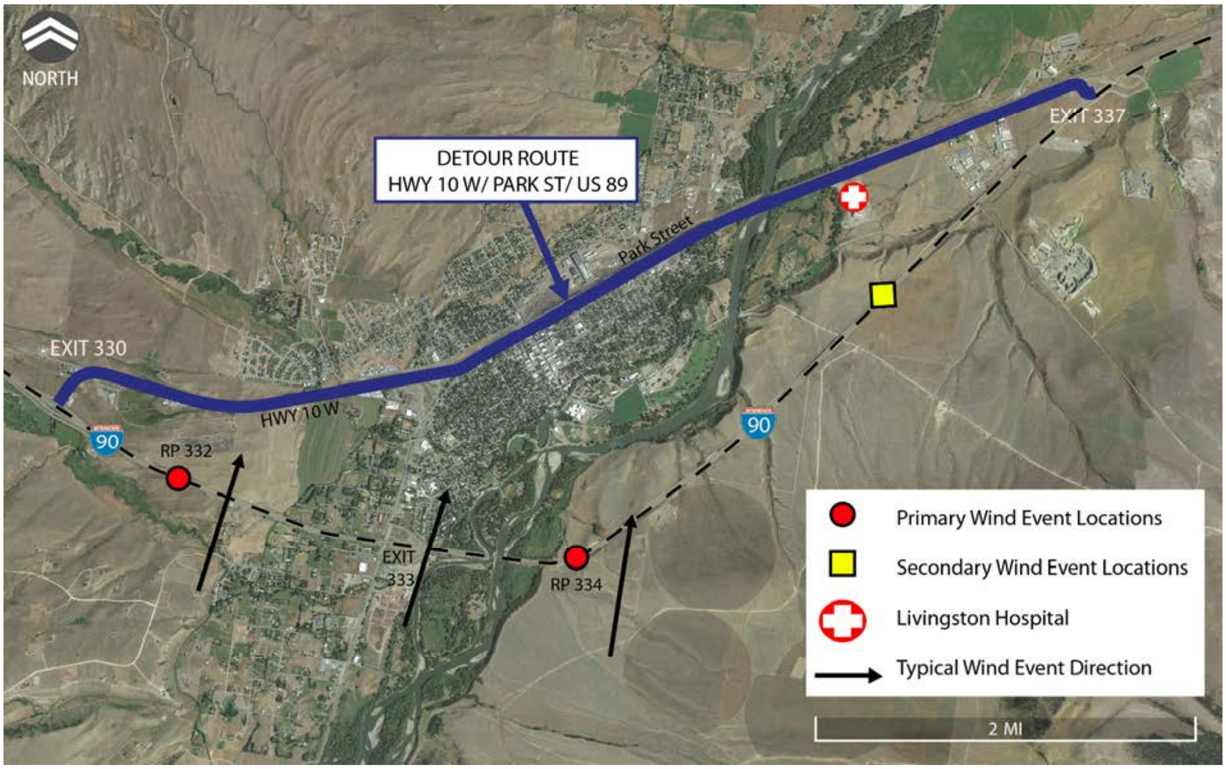

Figure 3-1: Livingston Detour Route & Wind Event Locations

During full closure events, MDT staff indicated traffic quickly fills up the entirety of HWY 10 W and Park Street/US 89. Problems created by traffic jams on the detour route through Livingston impact traffic throughout town and, critically, the ability of ambulances and other emergency service vehicles to safely and efficiently navigate through Livingston.

Several needs were identified in Livingston. These include improving traffic flow on the detour route through town, providing additional parking, and implementing safe and efficient closures. Stakeholders from both the City of Livingston and Park County expressed concern over exposure of staff to high speed traffic in poor weather conditions. These activities are necessary but expose staff to risk. Improvements in operations may limit or eliminate these exposures.

3.1.3 Traveler Information Systems

While no field visit was conducted with the traveler information system, there was a separate interview with MDT staff concerning this capability. The 511 Traveler Information System is Oracle-based and was identified as outmoded. The Maintenance Division just purchased a major system to upgrade its traveler information system.

The primary focus of MDT for the short term is replacing the current system with a more robust, reliable traveler information system. The next steps after this improvement likely would be to more fully identify the needs of the public. Many of these are identified in this report at a higher level. Reliable, timely information is critical, as is providing more ways to interact with the public. This means more ways to inform the public and more ways for the public to provide input.

3.2 Corridor Needs

The purpose or vision of this study is to identify improvement or changes that can help reduce delays and operational impacts for I-90 closures and weather events between Three Forks and Billings. To accomplish this vision, a set of four corridor needs have been developed including:

- Improve Safety
- Improve Response Time and Operations
- Improve Traveler Information Systems
- Improve Local Traffic Operations

The identified corridor needs provide the basis upon which the specific objectives to address the corridor needs are developed from.

3.3 Corridor Objectives

The purpose or vision of this study is to identify improvement or changes that can help reduce delays and operational impacts for I-90 closures and weather events between Three Forks and Billings. To accomplish this vision, a set of four objectives have been developed through examining the needs. These objectives are identified to help develop improvement options in **Section 4** that will mitigate the impacts during interstate closures and detour events.

3.3.1 Objectives to Improve Safety

The current process for closing the road requires significant manual effort that requires MDT staff to expose themselves to traffic in less than ideal conditions. Key objectives include minimizing maintenance staff time out of vehicles and exposure to traffic and improving the visibility of the warning messages.

Ultimately, the safety of the traveling public is a key responsibility of MDT. Specific to these weather events, public safety can be increased by safely getting traffic off I-90. This includes preventing traffic from entering the interstate corridor when conditions warrant and reducing the speed of traffic to appropriate levels per conditions.

The detailed objectives for the need of improving safety are as follows:

Improve Safety
Objective: Minimizing time out of vehicle
Automate sign message changes
Automate gate closures

Improve manual gate closures
Objective: Improve visibility of warning messages
Replace static retroreflective with high visibility VMS and flashers
Add lights and flashers
Objective: Safely get traffic off the road when conditions warrant
Provide information in the MDT traveler information system
Push information to travelers better
Provide accurate time estimates
Objective: Get travelers to slow down in poor weather conditions when approaching road closures
Implement variable speed limits
Objective: Provide parking
Identify vehicle storage locations during closures

3.3.2 Objectives to Improve Response Time and Operations

Related to the safety of staff and public, the more quickly closures and detours are implemented, the safer for everyone. Key objectives are to re-examine current operations for improvements that allow staff to respond more quickly and to automate the process to close the road where practical.

Those responsible for closing the road have established a process that works but is based on individual skills and experience. During the interactions with stakeholders, there were several areas where communications within agencies and between agencies could be improved. For example, person A knows a phone call to person B is sufficient to implement the subsequent action items in the closure process. However, person B may be unavailable, cell phone coverage may fail or other points of failure may occur. Automating communications and providing more details relieves each responsible party from the task of informing others and allows each responder to concentrate on other responsibilities in the field.

The detailed objectives for the goal of improving response time and operations are as follows:

Improve Response Time and Operations
Objective: Get staff to gates more quickly
Improved snow operations planning
Train more MDT staff
Provide the right vehicle with appropriate equipment
Objective: Close gates more quickly
Automate gate closures
Improve manual gate closures
Activate warning signs quickly
Objective: Improve Inter-Agency Communication

	Create a private communications network with local agencies (e.g., Twitter)
	Committee and shared list
Objective: Improve Intra-Agency Communication	
	Improve radio or other electronic communications
	Improve computers and agency communications network

3.3.3 Objectives to Improve Traveler Information Systems

A key tool in managing traffic is traveler information. Providing accurate, reliable, trusted information to travelers in the corridor allows them to make decisions. This may require some form of education. For example, providing early and accurate information about closures allows travelers to stay in Billings with readily available parking and services. Just as important is providing accurate information on when the road will open to allow travelers to time their departures more accurately.

The detailed objectives for the goal of improving traveler information systems are as follows:

Improve Traveler Information Systems		
	Objective: Provide more accurate and timely information	
		Real-time data from maintenance on closure status
		Better estimates of duration
		Use crowdsourcing to improve accuracy
	Objective: Provide information in multiple formats common to users	
		Provide information to media and third-party data users
		Push data to users
	Objective: Provide real-time parking information	
		Collect parking information
		Provide to users via electronic media
		Provide to users in the field
		Provide parking information from 10+ miles before closure
		Provide parking information at exit

3.3.4 Objectives to Improve Local Traffic Operations

There are frequent detours through the town of Livingston throughout the winter. Better management of traffic on the detour route through Livingston and improving the operations of the interchanges is important. This includes improving access to the route for local emergency services.

During the discussions with stakeholders, the frequent high wind events in Livingston are isolated to a few thousand feet of roadway—they are not major storm events, rather they are typical wind events for the area in winter that are exasperated by the specific topography at the critical wind event locations. If the high wind can be directly mitigated, most of the detours could be eliminated, having a substantial positive impact on safety, costs, and impacts to the public.

A complete closure of I-90 can result in 1,000 vehicles per hour being delayed in town(s) that lack the ability to accommodate a large number of travelers. While it is not cost-effective to build sufficient parking for all possible scenarios, there is a potential for some improvements to be made in critical locations.

The detailed objectives for the goal of improving local traffic operations are as follows:

Improve Local Traffic Operations
Objective: Move traffic through Livingston more efficiently
Upgrade signals to provide coordination
Provide an ability to implement phasing plans (for bypass events)
Objective: Address ramp backups during weather events
Reconfigure exit ramp
Geometric changes and signal at exit ramp
Objective: Build windbreak
Physical block
Natural barrier

Section 4

Improvement Options

This section describes a number of improvement options, assesses how well these options address the need and objectives of the study, highlights the benefits and potential impacts, and presents a cost estimate related to these options.

The options are discussed individually as a generic improvement. A more detailed list of potential specific improvements options is provided in **Appendix D**, which includes an improvement package data sheet that provides more specific information that could aid in decision-making. Each improvement option sheet includes a corresponding figure illustrating the proposed improvements.

4.1 Option Description

4.1.1 Gate Closure

The physical closure of a roadway requires some form of barrier. For temporary lane closure applications, work zones, cones, barrels, or smaller barricades are used. For temporary full road closures, law enforcement or maintenance vehicles often are used, but these vehicles and the staff assigned to them are frequently needed elsewhere. In locations where agencies experience frequent closures, either prepositioned larger barricades or permanent retractable gates are used.

Highway gates are a preferred method for implementing highway closure plans, as they are easier to move into place than large barricades and will typically stay fixed in place longer. The ability to reduce the time required to implement closures and detours relies on improving the process to get the gates in position. In the best of worlds, the installation of automated gates will reduce the time and staff power to get the gates deployed. Where automated gates are not implemented, improving the manual gate closing process or training additional staff to assist with closing gates could reduce the time to implement closures and detours.

Appendix C contains a technical memo on the different types of highway closure gate systems used throughout the region. Many of the states are using a railroad-style gate that was crash tested by the Wyoming Department of Transportation (WYDOT). This gate system has achieved crash worthiness testing (National Cooperative Highway Research Program [NCHRP] 350) and used by several states. The Nebraska Department of Roads (NDOR) has developed and widely deployed an automated gate system to work with the WYDOT standard gates. While the physical conditions across the region are similar, agency operations and assets are not always equal. The technical memo provides more detailed description of the system's attributes.

It is assumed that all existing gates throughout the corridor will warrant improvement—either through replacement of an updated system or modifications to speed their operation. Locations of potential improvements related to gate upgrade and installations include the following:

- Install three automated interstate closure gates at Exit 313—a pair of staggered gates to close the interstate to eastbound travel and an additional gate to close the eastbound on-ramp.
- Upgrade/install three automated interstate closure gates at Exit 330—a pair of staggered gates to close the interstate to eastbound travel and an additional gate to close the eastbound on-ramp.
- Install two automated interstate ramp closure gates at Exit 333—one gate to close the westbound on-ramp and one gate to close the eastbound on-ramp.
- Upgrade/install three automated interstate closure gates at Exit 337—a pair of staggered gates to close the interstate to westbound travel and an additional gate to close the westbound on-ramp.
- Upgrade/install an automated gate to close Highway 89 south of the westbound on-ramp at the Exit 340 overpass to prevent vehicles from entering the eastbound interstate on-ramp.
- Install three automated interstate closure gates at Exit 367—a pair of staggered gates to close the interstate to westbound travel and an additional gate to close the westbound on-ramp.
- Install an automated gate to close the frontage road to the west of Exit 367.
- Install three automated interstate closure gates at Exit 370—a pair of staggered gates to close the interstate to eastbound travel and an additional gate to close the eastbound on-ramp.
- Install an automated gate to close the frontage road to the east of Exit 370.
- Install an automated interstate closure gate on the westbound on-ramp at the Exit 400 Springtime interchange.
- Install an automated closure gate to close the frontage road between Columbus and the Springtime Interchange (Exit 400) to westbound traffic leaving the city of Columbus. The proposed gate would be installed on the western side of the intersection between Old US HWY 10 and Rapelje Road.
- Install three automated interstate closure gates at Exit 408—a pair of staggered gates to close the interstate to westbound travel and an additional gate to close the westbound on-ramp.

4.1.2 Road Closure Warning Signs

There are a variety of ways to inform the public via signage that the road is closed ahead. Currently, MDT uses static message flip-signs as shown in **Figure 4-1** to close the interstate in Livingston. These signs are hinged in the middle, so they can be "closed" (not visible) when not needed and then unhinged to be visible when needed. This system is minimal cost to implement and requires little maintenance but is labor intensive to "activate," requiring staff to physically access each sign, often in extreme weather conditions.

Figure 4-1: Flip-Sign

The Livingston area road closure warning signs must convey two different types of detours to the traveling public for 'Truck Only" and "All Traffic" detours and closures. Multiple sets of static message signs with flashers could be used to differentiate between the two detour types. The next two signage treatments are static signs with flashing beacons and VMS. A third rotary drum sign type alternative is also discussed.

The flashing beacon signs have a large static sign panel warning of a road closure when the beacons are actively flashing. The recommended signs are significantly larger than MDT's existing flip signs, improving their visibility in poor weather conditions. Flashing beacons are remotely operated, providing maintenance staff with the ability to immediately begin communicating closures or detours to the traveling public. This is a relatively low-cost option that could be implemented on an incremental basis.

VMS are electronic signs that can display a variety of messages to travelers. The information can be displayed instantaneously, as it is controlled from a remote location. The traveler information displayed on VMS may be generated as a result of a planned or unplanned event. VMS allow for custom messaging. Newer VMS can change color as required.

The third type of sign is a rotary drum changeable message sign (drum sign). Rotary drum signs have been used in conditions where a select few messages are typically required. An example is shown in **Figure 4-2** where a road may be closed, chains may be required, or some other limitation may be temporarily applied when the lights are flashing. In Livingston the drum sign could use include "Truck Only" or "All Traffic" detours. This sign type is typically less expensive than a VMS. While the drum is typically powered and operated remotely, the sign only requires power to change the message. With a loss of power, the current message remains visible.

Figure 4-2: Rotary Drum Sign

There are a range of possible alternative sign deployments. The current use of flip-signs and occasionally VMS need to be replaced as a system. In general, the recommendation is to replace the current flip-signs with static signs and flashing beacons with a series of two larger static signs with beacons or rotary drum signs. This should be supplemented with a single VMS in advance of the recommended static signs (in Livingston a total of two VMS signs are recommended). As an alternative, VMS could be used instead of the new static signs with flashers or drum signs, creating a series of three VMS approaching the road closure gates. The visibility of a VMS is much greater than the static (or drum) signs with flashers. Any of the potential signing improvements will provide a significant visibility improvement over the small reflective flip-signs currently in use.

The proposed road closure warning sign improvement locations include the following:

- Install permanent single-sided VMS west of US 287 for westbound traffic on I-90.
- Install permanent double-sided VMS east of US 287 within the interstate median to communicate messages to traffic in both directions of travel on I-90.
- Install a dedicated single-sided VMS east of the Belgrade Exit 299 Airway Blvd interchange for eastbound traffic on I-90 (portable or permanent single-sided).
- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed interstate and ramp closure gates for I-90 eastbound traffic at the Exit 313 Bear Canyon Road interchange.
- Replace existing single-sided portable VMS with a double-sided portable VMS at RP 324.5.
- Install permanent double-sided VMS at RP 328.5.
- Replace existing flip-signs with new rotary drum (or static) road closure gate warning sign(s) with flashers in conjunction with the proposed interstate and ramp closure gates for I-90 eastbound traffic at the Exit 330 Livingston interchange.
- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed interstate on-ramp closure gates at the Exit 333 Livingston/Highway 89 interchange.
- Add a dedicated portable VMS on Highway 89 south of I-90 to notify travelers when I-90 ramps at Exit 333 are closed.
- Replace existing flip-signs with new rotary drum (or static) road closure gate warning sign(s) with flashers in conjunction with the proposed interstate and ramp closure gates for I-90 westbound traffic at the Exit 337 Livingston interchange.
- Install permanent single-sided VMS for westbound I-90 traffic at RP 339.
- Add a dedicated portable VMS on Highway 89 north of I-90 to notify travelers of advisories, detours, or closures as they approach I-90.
- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed closure gate on top of the Exit 340 White Sulphur Springs/Highway 89 interchange overpass.

- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed interstate and ramp closure gates for westbound I-90 traffic at the Exit 367 Big Timber interchange.
- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed interstate and ramp closure gates for eastbound I-90 traffic at the Exit 370 Big Timber interchange.
- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed westbound interstate on-ramp closure gate at the Exit 400 Springtime interchange.
- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed road closure gate for westbound traffic departing the city of Columbus on the Old US HWY 10 frontage road.
- Install static road closure gate warning sign(s) with flashers in conjunction with the proposed interstate and ramp closure gates for westbound I-90 traffic at the Exit 408 Columbus interchange.
- Install permanent VMS east of Park City near RP 427.
- Install permanent VMS west of Laurel weigh station near RP 438.
- Install permanent VMS west of I-90/I-94 junction near RP 455.5.

Other sign upgrades include relocating the existing HAR sign(s) outside of the detoured section of I-90 through Livingston from RP 330 to RP 337.

4.1.3 Physical Windbreak

As described in **Section 3**, there are two known locations in the vicinity of Livingston where the high winds have a history of causing semi-truck and other high-profile vehicles to overturn, necessitating the road closures and detours through Livingston. The southern wind hits the east-west interstate at a critical perpendicular angle in these areas and have overturned trucks in the past. The isolation of these two areas is primarily due to the terrain and orientation of the interstate relative to the high wind direction. The adjacent areas in the vicinity are largely protected by natural hills or embankments on the south side of the interstate.

A windbreak is an effective method to decrease wind speed of the crosswinds that can cause truck rollovers and result in interstate detours or closures. Windbreaks are often used for agricultural reasons to increase crop yield, reduce erosion, and protect livestock from wind chill. Windbreaks can be a natural living windbreak in the form of trees and shrubs or man-made. Windbreaks also are used for other applications such as dust control, high-speed rail applications, or minimizing energy losses to buildings.

There are improvement options to consider for helping minimize high wind speeds in the two locations highlighted by MDT Maintenance staff. Further study and detailed design will determine feasibility.

The proposed windbreak improvements are noted below:

- Construct physical feature(s) to directly address critical wind event location near RP 332.
- Construct physical feature(s) to directly address critical wind event location near RP 334.

Generally, the horizontal wind protection zone is proportional to the height of the windbreak. Wind-speed reduction zones depend on the barrier type and height. A typical reduction in wind speed based on the barrier type is presented in **Figure 4-3**. Most researched documentation indicates significant wind speed reductions within 8 to 10 times the height of the windbreak with some impacts up to 20 times the height of the windbreak.

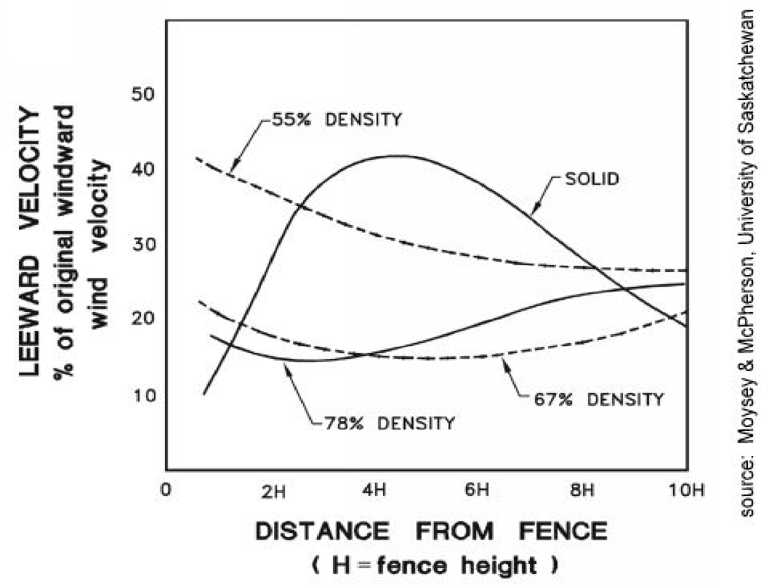

Figure 4-3: Wind Velocity Reduction from Windbreak Fences

It is important to note that the porosity (or density) of the windbreak impacts its effectiveness. According to Forman[1] (1995), the best solution that can mitigate wind is the use of a medium porous windbreak that shows the same speed reduction properties as solid windbreaks but avoids problems of turbulence beyond the wall as per **Figure 4-4**.

[1] Richard T. T. Forman, *Land Mosaics The ecology of landscapes and regions (*Cambridge University Press, Nov *9*, 1995)

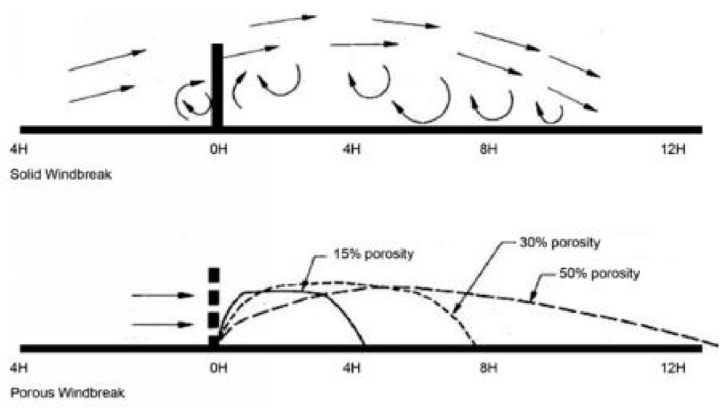

Figure 4-4: Porosity, Windbreak Protection Area

The goal of the windbreak is to decrease the number of interstate detours required through Livingston. Currently, these occur for trucks and towing vehicles when wind speeds reach 50 mph and for all traffic when wind speeds exceed 60 mph. The goal of the windbreak is to generally decrease wind speeds below 50 mph within its wind reduction zone. Limiting winds below 60 mph will decrease the most disruptive situation of an all-traffic detour.

The westbound lanes impacted by high winds are roughly 160 to 200 feet from the right-of-way line on the south side (based on existing fencing). If planning a windbreak on the southern right-of-way line to decrease wind speeds below 50 mph, a windbreak roughly 20 feet in height above the interstate would provide a decrease of 20–30% in wind speeds, depending on its design and porosity. Depending on the exact design, this would be effective for winds of roughly 62–71 mph. It also would limit the detour to trucks and towing vehicles only for extreme wind events that exceed these figures up to a potential 85 mph wind event. Under such extreme wind speeds, it is possible that other areas within the vicinity may necessitate the requirement for detours.

Placing the windbreak closer to the interstate but outside the clear zone could be even more effective but increase snow drifting near the interstate. Snow drifting should be considered regardless of the design and snow fence may be required south of the windbreak.

For this study, a concept like the aesthetic concept for a noise wall (**Figure 4-5**) is presented. However, there are numerous options from natural trees and shrubs to man-made objects, such as polymer grid fences and specific windbreak materials. All options and parameters should be studied further to optimize the design of the windbreak. What this research has found, assuming the wind events are specific to the two locations, is that a windbreak could decrease the need for detours through Livingston for many high wind events.

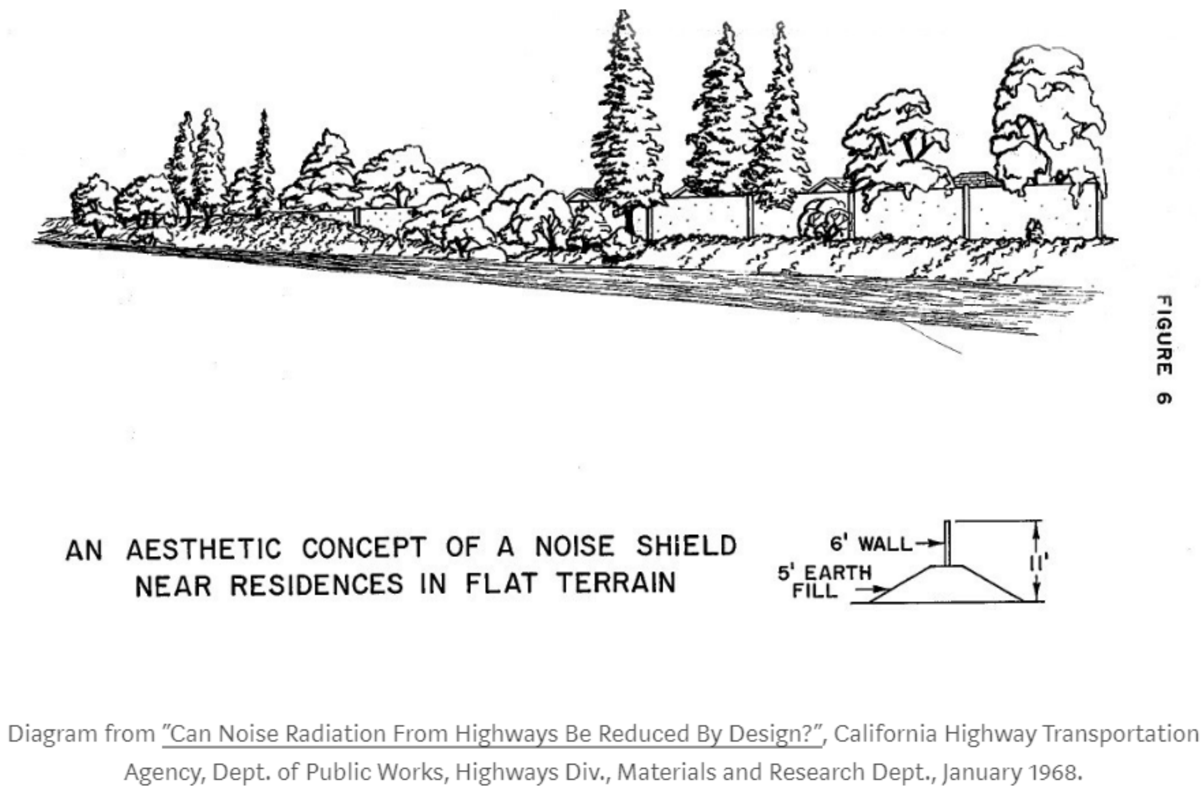

Figure 4-5: Noise Shield Concept Drawing

If earthwork is readily available, placing an embankment will be a cost-effective way to decrease the height of the windbreak required while improving the aesthetics compared to a 20-foot plus high man-made windbreak. It should be noted that for natural windbreaks "single-row tree windbreaks can provide wind reductions over as great a distance as multiple-row windbreaks" (Heisler and DeWalle[2] 1988). A natural windbreak along the edge of the right-of-way will take longer to become effective.

The locations and proposed conceptual design are shown in **Figure 4-6**.

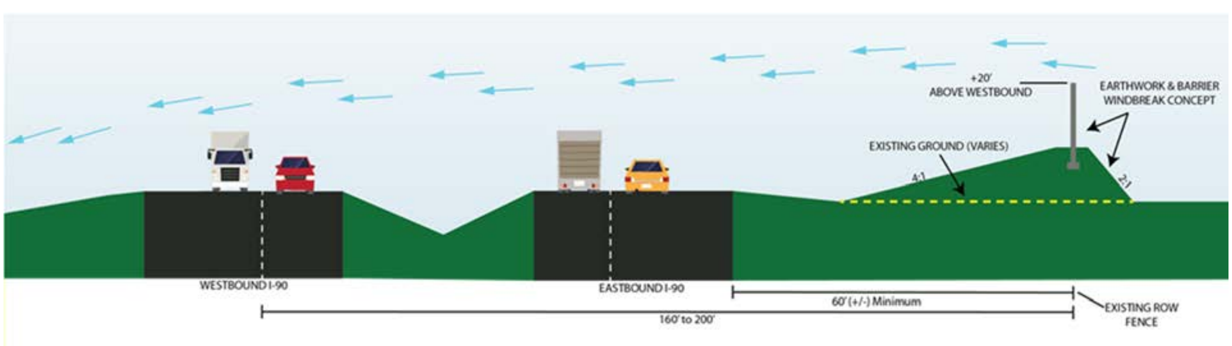

Figure 4-6: Conceptual Design of Windbreak Fence

[2] Heisler, G.M. and DeWalle, D.R., *Effects of Windbreak Structure on Wind Flow* (Agric. Ecosystems Environ., 1988), 22/23:41-69

4.1.4 Highway Geometric Improvements

The Livingston detour route was highlighted by the MDT maintenance staff and stakeholders for improvements. As traffic is detoured from the highway during a closure, the efficiency of the highway interchanges and the local roadway system becomes increasingly important. As shown in **Figure 4-7**, traffic can come to a halt along Park Street/US 89 during weather events. There are a few potential changes that could improve safety and operations in Livingston during detours.

Figure 4-7: Closure Event Traffic in Livingston

The highway geometric improvements proposed include:

- Reconfiguring I-90 WB Exit 337 off-ramp farther east to address the geometric limitations highlighted by the stakeholder needs.
- Upgrading traffic signals on the Livingston detour route to be synchronized and incorporating a detour signal phase to improve traffic operations.
- Adding dedicated turn signal phase(s) at the Y-intersection on Park Street and HWY 10 W to improve traffic operations through Livingston during detour events.

The reconfiguration of the westbound exit ramp and improvements to signal timing in the corridor could improve operations through the city during wind events. Additional geometric changes or improvements were not identified in other locations in the corridor but may be addressed at a later date.

Synchronizing the traffic signals along the Park Street/US 89 route will allow the traffic network to move traffic more efficiently and allow for a “detour” phase that could be turned on to better optimize the detour traffic when needed.

A conceptual plan for the new exit ramp is presented in **Figure 4-8**. In addition to improving the geometric deficiencies of the exit ramp, as noted in discussions with stakeholders, this concept will eliminate the left turn required of I-90 exiting westbound traffic that conflicts with eastbound traffic on the detour route. This will limit the amount of traffic that backs up into the interstate as the exit ramp will provide more storage and no conflicting left-turning movement. The concept also allows westbound interstate traffic to have the main right-of-way entering Park Street/US 89.

There is an access point that crosses the railroad tracks east of the current exit ramp intersection. During stakeholder meetings, the possibility of closing this access was discussed, but would include negotiation with the landowner. In this case, the design improvements could be simplified and improved.

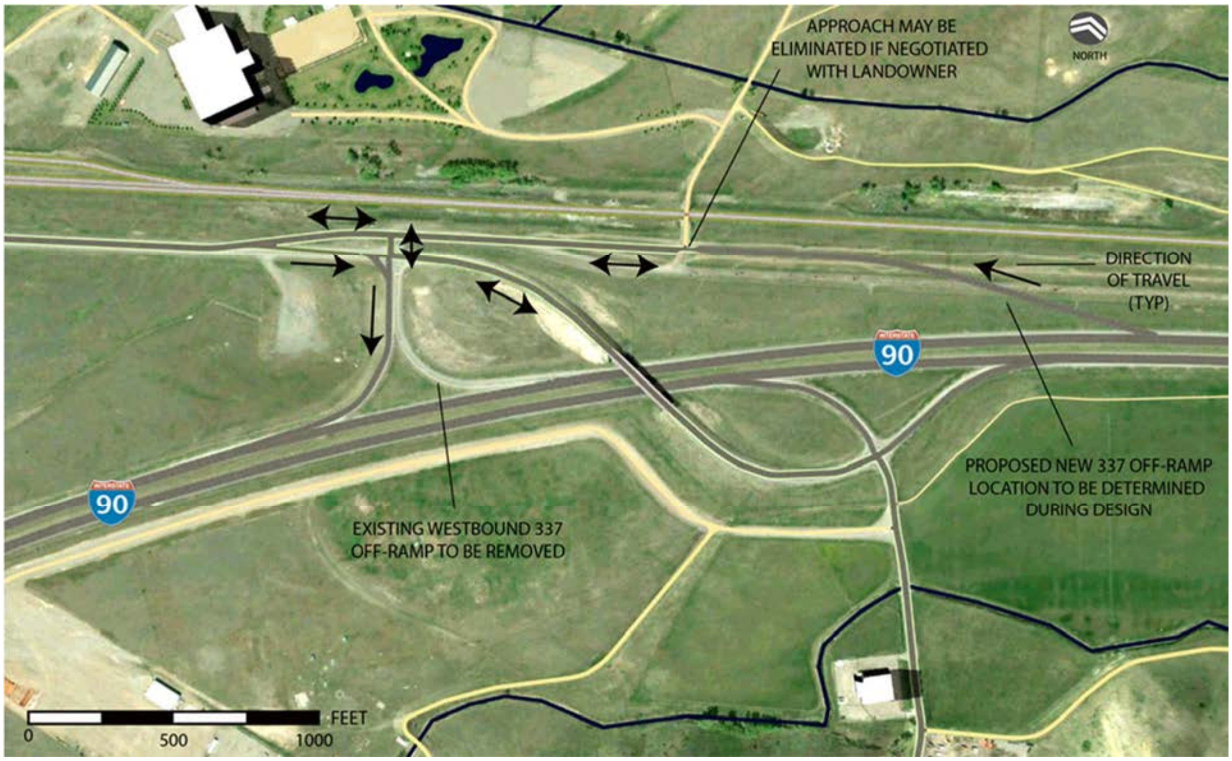

Figure 4-8: Concept for New Westbound Exit Ramp

MDT is working on a traffic signal improvement project along the detour route through Livingston. As this project will likely to be completed prior to new improvement options being nominated on the basis of this study, it is recommended that MDT Traffic staff responsible for the slated signal project work in conjunction with MDT Livingston maintenance staff to incorporate a traffic signal detour phase on the interstate detour through Livingston and add dedicated left turn signals at the Y-intersection on Park Street and HWY 10 W.

4.1.5 Parking Management

During the initial scoping of the study, discussions with MDT indicated that adding parking during weather events is a potential solution to help mitigate impacts during interstate closures. Subsequent site visits and discussions with stakeholders confirmed that during closure events traffic quickly accumulates and overwhelms the generally small towns and cities within the study corridor, with the cities of Livingston and Big Timber experiencing the worst impacts. When the main detour routes are full – Hwy 10 W/Park St/US 89 (**Figure 3-1**) in Livingston and US 191/Big Timber Loop Rd in Big Timber (**Figure 4-9**) – all traffic is turned around at the exits and forced to drive back to the previous city.

While the study stakeholders all agreed that the lack of available parking capacity during closure and detour events contributes to the operational issues experienced by the communities along the I-90 corridor, consensus among the stakeholders was that it is not feasible to increase parking capacity to the extent required to accommodate the amount of interstate traffic that accumulates during these events. As such, large-scale construction of new parking lots is not recommended with this study.

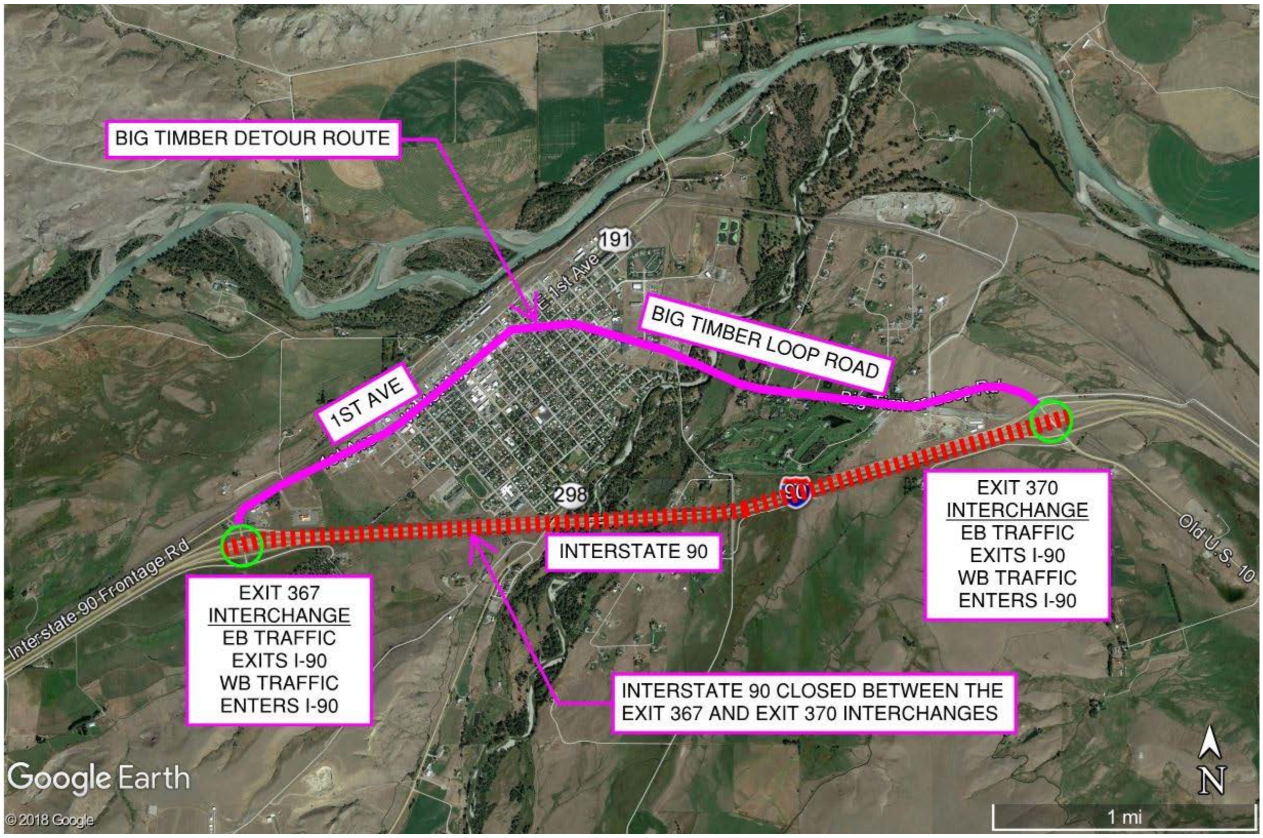

Figure 4-9: Big Timber Detour Route

The number and size of parking lots required to accommodate all projected traffic would be significant in the smaller communities and wasteful when not used. Parking lots would need to be routinely maintained and cleared of snow to ensure that they remain operational during the weather events that precipitate interstate closures. Another major concern is that vehicles quickly become immobile due to blowing snow, which would further increase the maintenance burden of MDT staff.

However, additional parking will always be helpful, and the study corridor was examined using Google Earth and Montana Cadastral to identify locations with potential to increase parking capacity. Particular attention was paid to areas within MDT right-of-way, including existing rest areas, and other publicly owned land, as it is anticipated to have a more streamlined path to constructing new parking facilities when compared to privately owned land.

There is an opportunity to work with the private sector to use existing private parking lots during closure events. Montana state law permitting, this could be done via a public-private partnership (P3), where some private facilities rent available parking to those who are willing to reserve and pay. MDT would provide signage and possibly assistance through the MDT website. Dedicated website(s) and other app-based applications could be used by travelers to reserve a spot and be guaranteed a place to park on a first-come-first-served basis.

The locations listed below have been identified as potentially feasible to expand parking capacity.

- Expand the capacity of the existing EB I-90 Livingston Parking Area near RP 326.5. Note that the recommendation is to expand the parking area without improving the facilities.
- Acquire right-of-way and construct a new gravel parking lot on the privately owned (Montana 40 Acre LLC) parcel directly adjacent to the westbound on-ramp at the eastern Livingston Interchange 337. Alternatively, a P3 with the landowner could be used to allow for the construction and use of a parking lot.
- Construct a new gravel parking lot in the undeveloped portion of the MDT Big Timber Maintenance Yard at the eastern Big Timber Exit 370 interchange.

The department also could work with private landowners in the Three Forks, Livingston, and/or Big Timber areas to determine if additional P3's are possible.

4.1.6 Traveler Information Systems

Traveler information is a key tool in addressing the objectives of this study. Comments from the steering committee and stakeholders reinforce that a considerable amount of time is lost by travelers approaching a closed section when they frequently must turn around due to the inability of the small communities along the study corridor to handle the amount of traffic that accumulates during a closure event. If travelers get reliable, accurate information on closures, they can choose to remain outside of the closed section of interstate, which would help to alleviate impacts within the closure areas.

Theoretically, with accurate information a traveler could spend time at another location with appropriate services and facilities and leave in advance of the reopening of the road to arrive as the road opens. They would not lose any more time than those at the closure while having access to facilities and services. Recognizing that storms are difficult to predict, and road clearing is not always routine, the institutional knowledge of MDT field staff is extensive, and accurate short-term estimates of road opening are possible. Automating these estimates into the traveler information system likely will require additional technology and some changes in operations. For example, snow plows fitted with computers or tablets could provide a simple one- or two-touch update on time estimates from plow operators that is automatically entered into the traveler information system.

Traveler information is accomplished through a variety of means. In the current age, there are numerous systems that most state DOTs use, including Facebook, Twitter, Instagram, emails, web pages, and other electronic means, to distribute information. Working with the local media and third-party vendors, such as Google and Waze, is common. Additionally, MDT can use direct communication methods, such as VMS and HAR, that are owned and operated by MDT.

In all of these situations, two things are required—a central computer database that collects and distributes the information and traveler confidence in the reliability of information MDT is providing. Without a database, there is no easy or automated way to share information; all communications would have to be done manually. Over time, through delivery of consistently reliable information, travelers may rely more on the information provided.

Traveler information systems are systemwide and are not isolated to a single location. They may depend on sensors at specific locations being identified during the evolution of the system.

MDT is working on an improved traveler information system. The majority of new system improvements are being implemented to improve operations and robustness of the system. New features identified in this report are in addition to those that will be provided by the new system.

4.1.7 Maintenance and Monitoring Equipment

Stakeholder interviews identified some improvements that were isolated to MDT equipment. More analysis is needed to determine more exact needs and numbers.

Two issues were noted by MDT staff during interviews. First, when the decision is made to close the road, staff would travel back to the maintenance yard and switch trucks. Unless operational changes allow for staff to stay in plow trucks, this exchange of vehicles is assumed to be required. Second, upgrading service trucks from 2WD to 4WD is needed. This upgrade was suggested for the safety of staff who have to drop signs and gates so that their vehicles could be placed farther away from the edge of the traveled lane at sign and gate sites to reduce the risk of being hit by passing traffic.

One other system mentioned was the upgrade of the wind speed gauge(s) near Livingston. The proposed equipment improvements are noted below:

- Upgrade Livingston maintenance staff pickup trucks to 4WD at the next replacement interval.
- Upgrade Columbus maintenance staff pickup trucks to 4WD at the next replacement interval.
- Upgrade wind speed gauge at RP 334 to provide real-time data to MDT.
- Increase the number of wind speed gauges to develop a more accurate wind history baseline to use in conjunction with the recommended windbreak improvement option.

4.1.8 Other Non-Capital Improvements

Several improvements identified are operational in nature. They may have a capital component but in general are focused more on changes in operational procedures and policies.

City of Livingston and Park County stakeholders specifically requested that the current official documented procedures for opening and closing I-90 be updated. Improvements in technology and local coordination have resulted in modifications to the current process. This would require some work between the various stakeholders to discuss and improve.

Stillwater County emergency service stakeholders provided feedback via the letter included within **Appendix F**. Their feedback centered around formalizing I-90 closure procedures by utilizing a tiered system for classifying incidents which could range from momentary closures to clear accident sites all the way up to longer closures lasting eight hours or more. Their concerns should be considered when MDT updates the closure procedure document contained in **Appendix E**.

Another item noted was the informal communication flow during events. This was both internal and external to MDT. While most stakeholders believed the current system was sufficient, it is still a relatively manual operation. This can result in a breakdown in communication when one person or device is not available.

Implementation of the following improvements will have a positive impact on the study corridor:

- Revisit MDT's 2004 *Procedure for Closure of I-90 between Livingston & Columbus* (**Appendix E)**. It lacks details such as re-opening procedures.
- MDT participation in North/West Passage programs including adopting citizen reporting of incidents.

4.2 Need/Objective Addressed

Section 3 outlined the needs and objectives along the I-90 corridor. Proper planning requires that proposed improvements address some identified objective, or they are not warranted. Similarly, if any objectives do not have a corresponding improvement, then new improvements must be identified to address that objective. The improvement options noted above are aligned with the objectives outlined in **Section 3**. In summary, the corridor needs are as follows:

- Improve safety
- Improve response time and operations
- Improve traveler information systems
- Improve local traffic operations

4.2.1 Gate Closure

Gate systems are intended to improve the efficiency and safety of the closures. They allow for staff to implement the closures more quickly and provide positive guidance to the traveler. The primary needs associated with the gates revolve around operational efficiency.

- Improve safety
- Improve response time and operations

4.2.2 Road Closure Warning Signs

These signs provide the most expedient way to inform and manage traffic. Many of the identified needs and objectives are addressed by these signs.

- Improve safety
- Improve response time and operations
- Improve traveler information systems

4.2.3 Physical Windbreak

If designed effectively, the windbreak can reduce the wind speeds below 50 mph for most wind events and eliminate the detours of all traffic types through Livingston. Under extreme wind events with winds in the 70 to 85 mph range, detours would be limited to trucks and towing vehicles. The reduction in wind speeds from the windbreak will eliminate most of the detours that occur roughly twice a week through Livingston from late October to March. Doing so will address the following objectives:

- Improve safety
- Improve local traffic operations

4.2.4 Highway Geometric Improvements

The geometric improvements are focused on two needs:

- Improve safety
- Improve local traffic operations

4.2.5 Parking Management

Parking management is focused on two needs by providing a safe area to get off the roads during severe weather incidents. The reality of adding and maintaining such large quantities of parking spaces limits the viability of the improvement option. But parking management could:

- Improve safety
- Improve local traffic operations

4.2.6 Traveler Information Systems

Traveler information addresses a wide range of needs, as it is a direct way of managing and informing the public.

- Improve safety
- Improve response time and operations
- Improve traveler information systems
- Improve local traffic operations

4.2.7 Maintenance and Monitoring Equipment

Maintenance and monitoring addresses many of the MDT operational needs. This will cut across safety and efficiency.

- Improve safety
- Improve response time and operations

4.2.8 Other Non-Capital Improvements

The other non-capital improvements category addresses a wide range of issues and therefore is expected to address a wide range of needs and objectives.

- Improve safety
- Improve response time and operations
- Improve traveler information systems

4.3 Benefits and Potential Impacts

With most operational improvements, benefits and impacts are often difficult to isolate, as each item is often part of a larger solution and many of the operational components work together—realizing more benefits together than as isolated systems. There are times where the benefits substantially change the needs. For example, if wind events could be eliminated altogether, then the need for interchange ramp improvements might be drastically reduced.

The following addresses the benefits and potential impacts at an improvement level. The individual improvement options are provided in **Appendix D**.

4.3.1 Gate Closure

The primary benefits involved with the improved gate closure systems are reductions in required manpower and increased speed and safety during gate deployment. The more automated a system, the more quickly it can be activated and used when maintenance staff arrive on-site. Combined with improved road closure warning signs, automated gates can improve the speed and efficiency the interstate closures and detours can be implemented. New gate installations in Big Timber and Columbus and upgrades to the gates in Livingston can be expected to increase safety by preventing travelers from continuing on a road that may no longer be safe. Fewer stranded vehicles will in turn reduce the time required to open the road, with reduction in towing and recovery operations.

The improved gate closure systems are expected to increase safety by reducing the exposure of staff to traffic and elements and may lead to other efficiencies. For example, if one less person is required, then that person could remain plowing snow.

The measurable benefits should include a long-term reduction in crashes and number of stranded vehicles. Total event closure time also may be reduced.

The impacts of an improved gate system are likely to include increased maintenance cost and exposure. Mechanical systems exposed to the elements and unused for months at a time often require maintenance. This increases the exposure of staff, as they will be required to perform maintenance on the systems. Other impacts, such as changes in procedures and policies, are expected but are difficult to define without selecting a particular gate system and reviewing policies and procedures.

4.3.2 Road Closure Warning Signs

The primary benefits of improved road closure warning signs are in expediency. By making the signs electronic, either by way of static message signs with flashing beacons, drum signs, or VMS boards, they can be remotely controlled and can be activated within minutes of deciding to close the interstate. This allows for instant notice to the public and reduces the responsibilities and exposure of maintenance staff.

Full color and HD signs provide enhanced ways to communicate with the public. For example, a road closed sign can be white text on red background. The static signs with flashing beacons are typical highway regulatory signs, consisting of either black text on a white background (or white text on a black background) with flashing amber beacons attached. Drum signs would emulate static signs, but the messages would be slightly different. While effective, the static signs do not carry the same visual impacts as a large red VMS sign. The VMS are larger than the static signs and likely more visible over a longer distance.

VMS provide the ability to customize a message unique to the circumstances. While wildfires do not typically impact interstate operations within the study corridor, any such unique event could be signed for immediately, without the need to deploy portable VMS and more quickly than deploying new static signs.

VMS require power and communications. Most are relatively close to towns where both should be readily available. As a complex system, it is important to test, maintain, and verify the messages. These all come at a cost. Additionally, it is most efficient to operate the VMS from a central location. For the interim, the VMS could be controlled locally.

4.3.3 Physical Windbreak

There are two to three wind events a week during the windy season of late October through March. If a windbreak that reduces wind speed to safe levels on I-90 can be implemented within the current problem areas, many of the other systems may not be required. Additional research is needed to design the optimum type of windbreak. Height, size, and material will be determined later in design.

The aesthetics of a barrier adjacent to the interstate may present issues. Right-of-way may be required to place earthwork, if the design follows the concept presented in this report. Additional snow fencing outside the right-of-way may be required. A natural barrier may improve the aesthetics but will take longer to grow and become efficient. The windbreak will require some maintenance and the level and frequency will depend on the design and type. Earthwork and natural barriers will minimize it, while man-made barriers will increase the maintenance required. Finally, environmental permitting considerations, depending on the windbreak type and design, may need to be addressed.

4.3.4 Highway Geometric Improvements

Similar to the windbreak, there were two noted geometric improvements that would have a large positive impact on operations during detours. Reconfiguring the westbound off-ramp at the Exit 337 interchange will improve all operations through that interchange and improve safety.

Implications are primarily cost-related. Initial indications are all improvements would be within existing right-of-way and would have minimal if any impact on the environment. Access to one property may be affected.

Improved signal timing will provide benefits to the city of Livingston and surrounding region on a daily basis. Less delays will be experienced by all travelers through the region. During detour and closure events, a simple implementation of an existing detour timing plan should free up staff and provide for the best corridor operations.

4.3.5 Parking Management

The issue with parking during closures is that there are thousands of vehicles that are forced to park alongside roads during road closure events. This creates a safety hazard for all users, impacts the environment, and reduces mobility. While it is recognized as not feasible to build enough parking for all users, any additional parking or parking management will have a positive impact.

The impacts of adding parking are cost and space. Not just initial implementation costs but ongoing maintenance. Most significantly, for lots to be useful during closures, they need to be plowed, which would divert maintenance staff from plowing operations on other facilities.

New parking facilities would need to consider engineering, construction, environmental permitting, and right-of-way acquisition costs depending upon the location.

MDT would need to assess liability of attempting to increased parking capacity while acknowledging that they cannot accommodate all vehicles.

Any potential smart parking systems would be limited in size but would likely use current technology and applications. This requires development and maintenance of websites and other applications.

4.3.6 Traveler Information Systems

Traveler information is key for managing traffic throughout the region. Accurate and reliable closure information allows travelers to choose where to wait or divert during road closures. Informing travelers will become even more important as connected and autonomous vehicle use expands. Smart vehicles make their decisions based on travel information and are more likely to act logically based on that information.

Much of the core travel information system exists within MDT. Unlike traditional traffic management centers that depend on traffic sensor data, MDT's traveler information system is more dependent on event data. While a traveler information system exists, an automated dispatch system and an automated event database are not currently available. Building both would provide a more robust data system.

Methods for distributing information are critical. Common applications are email lists, social media, news media, and web page updates. There are upcoming opportunities; for example, WYDOT is one of three United States Departments of Transportation sponsored states that have a connected vehicle pilot study. Results from this study may provide direction on future ways to communicate with rural travelers. There should be discussions with potential third-party vendors such as Waze and Google, regional entities such as North/West Passage, or larger trucking companies such as UPS and FedEx. The intent is to find new ways to provide accurate and timely information in a format friendly and useful to users. Accurate closure information is valuable to such third-party vendors and their users and may give them a competitive edge in terms of efficient routing.

The implications are not as clear. More reliable weather information and timely updates from field staff are critical data inputs. The addition of sensors is one step, but research may be needed to determine better prediction and analysis of storm data. MDT will need to determine if there are any changes in operations and policies before determining how these operations can be automated.

4.3.7 Maintenance and Monitoring Equipment

Maintenance and monitoring equipment consist primarily of new vehicles and additional wind speed monitoring systems. The benefits of 4WD vehicles are in the safety of employees and additional flexibility to respond. Having 4WD allows vehicles to be parked in better locations relative to traffic and improves staff response time.

Additional wind speed monitoring devices provide more exact information on whether it is necessary to close I-90 to truck traffic. As the high-speed winds are focused in a narrow region, improvements at one point could negatively impact another point nearby. Sufficient sensors should be deployed to ensure adequate coverage to provide an accurate assessment of the dangers presented by the winds.

The implications are primarily with additional research. For the vehicles, decisions on new procurements must go hand in hand with reviewing policies and procedures. As an extreme example, if the gate closure system were 100% automated, staff would not have to exit their vehicles at all and no new vehicles would be required. This is an extreme example and unlikely. The majority of the time, each individual objective or goal needs to be addressed until it has been solved.

4.3.8 Other Non-Capital Improvements

Other non-capital improvements include inter- and intra-agency coordination. This coordination exists at some levels and may be optimized, and in many circumstances, operations staff tend to interact well with each other. However, the same may be more complex at higher levels within organizations where other concerns and issues are addressed. Coordination is best addressed through open and honest communication at multiple levels. As groups, the stakeholders should work to more formally define the policies and procedures related to closing the road. As these are developed, opportunities for automation and change should become evident.

The only implication to this process is that it requires time—both calendar time and staff time. Increased coordination between agencies or within an agency rarely result in negative impacts to operations.

4.4 Cost

The following section identifies costs related to specific items within each category as noted in **Table ES-1** and in **Appendix D**. All costs should be considered planning level, and a basis for the costs is also provided in the appendix.

4.4.1 Gate Closure

NDOR completed a $10.8 million program installing automated gates at over 70 interchanges. NDOR's estimated cost per gate was $17,000. This estimated cost includes the cabinet and electronics, such as uninterruptible power supply, radio controllers, programmable logic controllers, and activation buttons. Costs to implement similar gates in Montana can be expected to be come at an increased cost closer to $25,000 per gate due to the smaller scale of the recommended gate improvements compared to the NDOR installation. MDT may want to consider additional research through a university or consultant to determine which gate system is best for Montana.

While designs may be readily available from both Nebraska and Wyoming, work will still be required to develop biddable plan sets for Montana.

There will be maintenance costs associated with each gate. Assuming each gate will require testing and minor repair, it can be assumed each gate requires eight hours of staff time annually. This would be on top of maintenance of traffic and replacement parts. An estimate of $1,000 per year per gate would be required in maintenance.

4.4.2 Road Closure Warning Signs

MDT has existing VMS in the corridor. Side or median pedestal mount VMS are estimated between $50,000 and $150,000 per location for construction. Costs vary significantly with size and capabilities. Design costs can be estimated at 15% of construction costs (higher than typical). Static signs with flashing beacons are estimated at $7,500 per location, including cellular connections for control and solar power. Drum signs should cost in between these two alternatives, although likely closer to the VMS. They could be solar powered.

VMS do require power and communications. Most are relatively close to towns where both should be readily available. Control of the VMS could be either from a central statewide system or locally through an interface at the MDT district office. A central location is typically preferred for two reasons. First is staffing—even if no full-time staff are dedicated to the VMS system, it is usually less of a staffing issue to consolidate these skills. Second is technical knowledge—both in operations and repair, a single person or group responsible for operations is more likely to use the system properly and efficiently and is more likely to recognize when the system is not functioning properly.

If no common vendor package is currently used by MDT, any vendor would provide software with its product.

4.4.3 Physical Windbreak

The exact type of windbreak will be established in more detail in the design phase. To accurately predict an effective solution, more detailed wind data is needed. Height, size, material, and placement will have a direct impact on the usefulness of a barrier. The cost estimate is based on the concept of an earth berm with a barrier placed on top. The construction cost is estimated at $440 per lineal foot and the overall cost is based on 3,000 total lineal feet of barrier for the two sites resulting in anticipated costs of: $1.3 million for construction, $520,000 for construction engineering/traffic control/mobilization, and $250,000 for engineering design for a total projected cost of $2.07 million.

4.4.4 Highway Geometric Improvements

The cost for the geometric ramp improvements will be dependent on many factors that will be developed in more detail with the future design. This estimate is based on 3,500 feet of new roadway as part of the ramp improvements. For planning purposes, it is estimated that the improvement option will cost in the range of $1.5 million for construction, $600,000 for construction engineering/traffic control/mobilization, and $300,000 for design, for a total of $2.4 million.

4.4.5 Parking Management

There are two basic types of smart parking systems, those based on just providing information and those based on a reservation system. Information systems provide a dynamic and real-time number of available parking spaces. This type of system would not be helpful for this corridor. When there is a road closure, the available parking is consumed within 30–45 minutes based on anecdotal reports from local stakeholders. Real-time information is not useful when the spaces are used this quickly.

A reservation system allows a traveler to pay in advance for a parking spot with a guarantee that a spot will be available for them when they arrive. This could be hours in advance. Assuming that some secure parking is available, this requires a back-office system and a user interface through a weblink or application. Costs to MDT would likely be minimal in terms of signing or advertising support. Enforcement should be addressed as part of the system operations (e.g., users need a code to enter a lot).

4.4.6 Traveler Information Systems

MDT has an existing traveler information system that is currently programmed for an upgrade. Many of the features desired for this corridor already exist, at some level. MDT should review the current scope and budget to see if additional features are warranted.

As previously stated, a traveler information system is dependent on event data. While the traveler information system exists, an automated dispatch system and an automated event database are not available. MDT could procure and integrate a computer-aided dispatch (CAD) system that would allow for better management of staff, equipment, and work orders.

Costs for a CAD system can vary greatly depending on factors such as the need for automatic vehicle location systems and the area covered – statewide or per district. To be effective for traveler information it has to be real time. Just entering the data into a spreadsheet or database for historical purposes will not help. Estimated costs for a CAD system range between $500,000 and several million dollars. The CAD system will need to be integrated into the traveler information system. Today's systems commonly have several means to share data in real time with other applications. This feature is not expected to increase the cost of the CAD system. However, it will be new work for the traveler information system.

A key input to the traveler information system is accurate weather information. This specifically is related to the impact on the opening and closing of the interstate. So, while contracted weather services may provide good information, it must be integrated with information on the status of the road conditions. Much of this is based on the knowledge and experience of the field staff. While staff information may be extremely useful and accurate, their information is not easily transferred to a computer database. There are numerous ways to help get this real-time knowledge into a database, but the best approach is dependent on current policies and procedures. A study should be completed. A consultant contract could cost an estimated $50,000 to define the system or application that best meets MDT's needs. The resulting application can cost as little as $40,000 for a smart phone app or as much as $250,000 for a centralized computer system.

4.4.7 Maintenance and Monitoring Equipment

MDT has a process in place for procuring vehicles. If the needs are as simple as acquiring 4WD, the costs will be approximately $4,000 more per vehicle procured. If more specialized vehicles are required, then specifications will have to be developed and cost will vary greatly. One key point is that the costs must be considered as differences between existing and new. The recommendations are to upgrade to 4WD as 2WD vehicles are scheduled for replacement.

Simple weather stations or wind speed monitoring sensors are minimal cost—under $1,000 for the sensor alone. Power, communications, and a system to monitor the sensors may be more expensive. Estimated cost for a network of 20 sensors divided between the two locations in Livingston is $60,000. There may be options to tie these sensors to research from regional universities. Funding to place and monitor the sensors could then come from a separate source.

4.4.8 Other Non-Capital Improvements

The majority of non-capital improvements relate to staff time and formal agreements. These do not require additional funding but will require staff time. Time spent drafting new intergovernmental agreements, policies, and procedures are time away from other responsibilities. These costs are short term, and MDT will realize long-term savings from improved operations when the work is completed.

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Section 5

Funding Mechanisms

Montana's roads and bridges are mainly funded through a combination of federal and state funding sources. Federal programs to fund the noted improvements are:

5.1 Funding Programs

MDT administers a number of programs that are funded from State and Federal sources. Each year, in accordance with 60-2-127, Montana Code Annotated (MCA), the Montana Transportation Commission allocates a portion of available Federal-aid highway funds for construction purposes and for projects located on the various systems in the state as described throughout this document.

The Fixing America's Surface Transportation Act (FAST Act) was signed into law on December 4, 2015, and authorizes federal transportation funding for federal fiscal years 2016 through 2020.

5.2 Federal Funding Sources

The following sections summarize relevant federal transportation funding categories received by the state through Titles 23 & 49 of the U.S. Code., including state developed implementation/sub-programs that may be potential sources for projects. To receive project funding under these programs, projects must be included in the STIP, where relevant.

5.2.1 National Highway Performance Program (NHPP)

The National Highway Performance Program (NHPP) funds are federally apportioned for the National Highway System roads and bridges, which includes the Interstate and non-Interstate NHS routes. The purpose of the National Highway System (NHS) is to provide an interconnected system of principal arterial routes which will serve major population centers, international border crossings, intermodal transportation facilities and other major travel destinations; meet national defense requirement; and serve interstate and interregional travel. The National Highway System includes all Interstate routes, a large percentage of urban and rural principal arterials, the defense strategic highway network, and strategic highway connectors.

Allocations and Matching Requirements

NHPP funds are Federally-apportioned to Montana and allocated to Districts by the Montana Transportation Commission. Based on system performance, the funds are allocated to three programs; Interstate Maintenance, National Highway, and NHPP Bridge (see 2.1.1 – 2.1.3).

Eligibility and Planning Considerations

Activities eligible for NH funding include construction, reconstruction, resurfacing, restoration, and rehabilitation of NH segments. Construction, replacement, rehabilitation, preservation and protection of bridges on the National Highway System; and projects or part of a program supporting national goals for improving infrastructure condition, safety, mobility, or freight movements on the National Highway System. Reconstruction, resurfacing, restoration, rehabilitation, or preservation of a bridge on a non-NHS Federal-aid highway so long as bridge condition provision requirements are satisfied. Operational improvements, projects to reduce risk of failure of critical infrastructure, as well as highway safety improvements are also eligible. Other miscellaneous activities that may qualify for NH funding include bikeways and pedestrian walkways, environmental mitigation, restoration and pollution control, infrastructure based intelligent transportation systems, vehicle-to-infrastructure communication equipment, traffic and traveler monitoring and control, and construction of intra or inter-city bus terminals serving the National Highway System. The Transportation Commission establishes priorities for the use of National Highway Performance Program funds and projects are let through a competitive bidding process.

5.2.2 Interstate Maintenance

The Commission approves and awards projects for improvements on the Interstate Highway System which are let through a competitive bidding process. The IM Program finances highway and bridge projects to rehabilitate, restore, resurface, and reconstruct the Interstate System. MDT districts are allocated IM funds by Montana's Transportation Commission based on system performance. The federal share for this program is 91.24% and the State is responsible for the remaining 8.76%. The State share is funded through the Highway State Special Revenue Account (HSSRA).

5.2.3 National Highway

The Federal share for non-Interstate NHS projects is 86.58% and the State is responsible for the remaining 13.42%. The State share is funded through the HSSRA.

5.2.4 NHPP Bridge (NHPB)

Federal funds under this program are used to finance bridge inspection, improvement, and replacement projects on Interstate and non-Interstate National Highway System routes. NHPB program funding is established at the discretion of the state. However, Title 23 U.S.C. establishes minimum standards for NHS bridge conditions. If more than 10% of the total deck area of NHS bridges in a state is on structurally deficient bridges for three consecutive years, the state must direct NHPB funds equal to 50% of the state's FY 2009 Highway Bridge Program to improve bridges each year until the state's NHS bridge condition meets the minimum standard.

5.2.5 Surface Transportation Block Grant Program (STBG)

Surface Transportation Block Grant Program (STBG) funds are federally apportioned to Montana and allocated by the Montana Transportation Commission to various programs including the Surface Transportation Program Primary Highways (STPP), Surface Transportation Program Secondary Highways (STPS), the Surface Transportation Program Urban Highways (STPU), and the Surface Transportation Program – Bridge Program (STPB), as well as set-asides for programs including Transportation Alternatives (TA) and Recreational Trails. The Federal share for these projects is 86.58% with the non-Federal share typically funded through HSSRA.

The Montana Transportation Commission establishes priorities for the use of STBG funds and projects are let through a competitive bidding process.

5.2.6 Urban Highway System (STPU)

The Federal and state funds available under this program are used to finance transportation projects on Montana's Urban Highway System, as per MCA 60-3-211. STPU allocations are based on a per capita distribution and are recalculated each decade following the census.

Allocations and Matching Requirements

State law guides the allocation of Urban funds to Montana's urban areas (population of 5,000 or greater) through a statutory formula based on each area's population compared to the total population in all urban areas. The federal share for this program is 86.58% and the State is responsible for the remaining 13.42%. The State share is funded through the HSSRA.

Eligibility and Planning Considerations

Urban funds are eligible for rehabilitation, resurfacing, new construction, reconstruction of existing facilities, operational improvements, vehicle-to-infrastructure communication equipment, bicycle facilities, pedestrian walkways, carpool projects and traffic operation projects on the 430 miles on the State-designated Urban Highway System. Priorities for the use of Urban funds are established at the local level through local planning processes with final approval by the Transportation Commission.

5.2.7 National Highway Freight Program (NHFP)

The National Highway Freight Program was created by the FAST Act to invest in freight projects on the National Highway Freight Network. This program is apportioned to States by formula and a State must have a freight plan in place beginning FY 2018 in order to receive formula funding. This program provides funding for construction, operational improvements, freight planning, and performance measures. Up to 10% of these funds may be used for intermodal projects. Generally, the Federal share for this program is 91.24% and the State is responsible for the remaining 8.76%. The State share is typically funded through the HSSRA for projects on state highways and local governments provide the match for local projects.

5.2.8 Highway Safety Improvement Program (HSIP)

HSIP funds are apportioned to Montana for safety improvement projects approved by the Commission and are consistent with the strategic highway safety improvement plan. Projects described in the State strategic highway safety plan must correct or improve a hazardous road location or feature or address a highway safety problem. The Commission approves and awards the projects which are let through a competitive bidding process. Generally, the federal share for the HSIP projects is 90% and the State is responsible for the remaining 10%. Typically, the State share is funded through the HSSRA.

5.2.9 Congestion Mitigation and Air Quality Improvement Program (CMAQ)

Federal funds available under this program are used to finance transportation projects and programs to help improve air quality and meet the requirements of the Clean Air Act. Montana's air pollution problems are attributed to CO and particulate matter (PM10).

Allocations and Matching Requirements

CMAQ funds are Federally-apportioned to Montana and allocated to various eligible programs by formula and by the Commission. As a minimum apportionment state a Federally-required formula-based distribution of CMAQ funds goes to projects in Missoula since it was Montana's only designated and classified air quality non-attainment area. The remaining, non-formula funds, referred to as "flexible CMAQ" is primarily directed to areas of the state with emerging air quality issues through various state programs. The Transportation Commission approves and awards all projects on MDT right-of-way. Infrastructure and capital equipment projects are let through a competitive bidding process. The federal share for this program is 86.58% and the State is responsible for the remaining 13.42%. The State share is funded through the HSSRA for projects on state highways and local governments provide the match for local projects.

Eligibility and Planning Considerations

In general, eligible activities include transit improvements, ADA upgrades, traffic signal synchronization, bicycle pedestrian projects, intersection improvements, travel demand management strategies, traffic flow improvements, air-quality equipment purchases, vehicle-to-infrastructure communication equipment, and public fleet conversions to cleaner fuels. At the project level, the use of CMAQ funds is not constrained to a particular system (i.e., Primary, Urban, and NHS). A requirement for the use of these funds is the estimation of the reduction in pollutants resulting from implementing and program/project. These estimates are reported yearly to FHWA.

5.2.10 Congressionally-directed or Discretionary Funds

Congressionally-directed funds may be received through highway program authorization or annual appropriations processes. These funds are generally described as "demonstration" or "earmark" funds. Discretionary funds are typically awarded through a federal application process or Congressional direction. If a locally-sponsored project receives these types of funds, MDT will administer the funds in accordance with the Montana Transportation Commission Policy #5 – "Policy resolution regarding Congressionally-directed funding: including Demonstration Projects, High Priority Projects, and Project Earmarks."

5.2.11 Nationally Significant Freight and Highway Projects

This program was also established by the FAST Act to create competitive grants or TIFA loans for projects >$100 million. This is a discretionary freight-focused grant program that allows States, MPOs, local governments, tribal governments, special purpose districts and public authorities (including port authorities), and other parties to apply for funding to complete projects that improve safety and hold the greatest promise to eliminate freight bottlenecks and improve critical freight movements. Generally, the Federal share for this program is 91.24% and the State is responsible for the remaining 8.76%. The State provides match for projects on state highways that address MDT identified infrastructure condition deficiencies; local governments provide the match for off-system projects. The State share is typically funded through the HSSRA.

Eligible Activities

- Highway freight projects on the National Highway Freight Network

- NHS highway/bridge projects, projects in National Scenic Areas
- Freight rail/intermodal/port projects
- Rail-highway grade crossings or grade separation projects

Core federal funds can be used for ITS. There are discretionary funding programs that may become available. Programs such as BUILD grants and the Connected Vehicle Pilot studies. The requirements of the program will drive the applicability of the program to the needs in Montana. These specialized programs are highly competitive. If MDT identifies one worthy of pursuing, significant resources will need to be dedicated to the application.

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Section 6

Conclusions and Next Steps

The purpose of this study is to develop recommendations to improve road closure and detour operations throughout the study corridor based upon analysis of the existing conditions within the study area. A summary of the key points is as follows:

- The corridor is rural and carries approximately 2,000 trucks a day. The total AADT of all vehicles, including trucks, varies from 9,000 to 27,000 vehicles per day depending on location. Winter weather conditions are a major factor in maintaining an open facility.

Primary areas of consideration are as follows:

- Improved ability to close the road, when necessary, quickly and safely.
- Improved local treatments to help address operations during closure events.
- Improved traveler information to prevent vehicles from entering a road that is closed.

The major capital improvement options identified in this report are primarily limited to reconfiguring the westbound off-ramp at the Exit 337 interchange, implementing windbreaks in Livingston, and implementing a new advanced synchronized traffic signal system along Park Street in Livingston. There are several action items to be completed by MDT before many of the additional improvement options can be designed or implemented.

6.1 Exit 337 Design

MDT should evaluate the final concept and design for improving the physical westbound exit as compared with other needs in the District to determine if funding is available and justified.

6.2 Livingston Signal System Design

MDT should proceed with a design for a new advanced signal system, which will improve the capabilities of the network to accommodate detour traffic in Livingston. The system must have the ability to implement signal timing plans that foster the movement of through-traffic during wind events.

6.3 Windbreak Implementation

Implementing a windbreak for the two locations identified in Livingston may decrease the need for other improvement options in Livingston due to its major impact in limiting the number of detours through the city during the windy season.

6.4 Gate Design

The design offered by the NDOR is readily available and uses open-source, automated technology. It appears to be an improvement over the current operations and immediate implementation is a reasonable approach.

As an alternative, MDT could initiate a more comprehensive gate design study that would work in coordination with any changes in policies and procedures to determine if a more automated solution is feasible and preferred.

6.5 Policies and Procedures Update

MDT should examine current operational policies and procedures to determine what positive changes should be implemented to improve the efficiency of implementing road closures. This examination may involve local stakeholders. Additionally, new systems that require further design or procurement may be identified. An example would be a new dedicated radio system or smart phone app to aid in interagency coordination.

6.6 Road Closure Warning Sign Design

Concurrent to the update of the policies and procedures, a standard signing approach should be developed for locations that experience frequent closures. This will include a series of new VMS and flashing beacon signs to replace the existing flip-sign warning system. This design should not be finalized until the new policies and procedures are final as changes in operations internal to MDT may affect the optimal design of VMS in the field. One approach is suggested in the improvement options description sheets in **Appendix D**.

6.7 Traveler Information Enhancements

The final requirements for enhancements to the traveler information system are dependent on the final policies and procedures. These enhancements will be primarily through improved event information on road closures.

Appendix A

Site Visit Meeting Minutes

50 West 14th Street, 2nd Floor
Helena, Montana 59601
tel: 406 441-1400

I-90 Closure Planning Study
Columbus Site Visit #1
Minutes

Tuesday, March 20, 2018
11:00 a.m. – 1:30 p.m.
MDT Columbus Maintenance Shop

ATTENDEES

- Tom Tilzey (MDT Billings Maintenance Chief)
- Ken Hembree (MDT Billings Maintenance)
- Chris Rasmussen (MDT Columbus Field Maintenance Supervisor)
- Steve Reed (MDT Big Timber Maintenance)
- Shaheen Siddiqui (CDM Smith)
- Jake Gunther (CDM Smith)

PURPOSE OF MEETING

This meeting served as an opportunity for CDM Smith to meet with the MDT Billings Maintenance District staff to learn how I-90 currently functions within their district during closure incidents.

TOPICS OF DISCUSSION

Existing Conditions Discussion

The staff noted that the city of Columbus should be the main turnaround location for westbound traffic since traffic that passes this point generally continues to whatever problem spot is west of Columbus. If traffic was stopped in Columbus, it could limit problems between the cities of Columbus and Livingston.

While the extended interstate closures that occurred during the 2016/2017 winter were noted as abnormal, the problems that those incidences caused were one of the primary drivers behind this study.

MDT Billings Maintenance staff noted that closure incidents within the Billings district are infrequent and primarily occur due to blowing/drifting snow with low-no-visibility conditions.

When wildfires have threatened the interstate, MDT has generally been able to maintain at least one lane of traffic on I-90 in both the eastbound and westbound directions while closing the lane closest to the fire for firefighting operations.

Interstate flooding within their region on I-90 is not an issue, although maintenance staff did identify one location between Big Timber and Bridger Creek where the possibility of flooding does exist.

The flats on either side of Big Timber are known snow drifting locations, which are the most likely areas to force interstate closures within the MDT Billings Maintenance District's territory.

Given that most interstate closures within the Billings District occur due to inclement winter weather, the first step in the typical process to implement a closure requires that maintenance staff cease plowing operations and return to the maintenance shop. Once they arrive back at the shop, they gather the necessary signs, traffic control devices, and barricades and load them into a two-wheel-drive (2WD) pickup truck before heading back out to the interstate to begin implementing the closure. Working in blowing snow with low-to-no visibility conditions, staff risks their safety to manually set up signs and traffic control devices while exposed to traffic.

The 2WD pickup truck is not capable of traveling within the snow-covered median and can get stuck while out on closure missions, so they must remain on the interstate shoulders as they set up the closure. The amount of time required to implement an interstate closure was noted to be between 2-4 hours.

The MDT Billings District has one permanent variable messaging sign (VMS) for westbound traffic located approximately 1 mile east of the city of Columbus, and they have a total of seven portable VMSs between the cities of Hardin and Big Timber, an area covering approximately 130 miles of I-90 between the cities.

Trucks occasionally attempt to take US 191 (P-45), a two-lane road which runs in a northerly direction from the city of Big Timber. This route experiences blowing snow and exposes vehicles to near-continual broadside winds as it is a north-south route with typical westerly winds. As a result, the traffic attempting to circumvent the I-90 closure during a storm is at an increased risk of becoming stuck or getting lost, which further diverts MDT maintenance staff and emergency services resources. There is another road (S-306) that heads towards the town of Rapelje, but it is unpaved and exposes traffic to worse conditions than those on US 191.

Some of the miscellaneous items discussed during the existing conditions portion of the meeting are noted below:

- Staff noted that vehicles traveling on US 212 (P-28) are predominantly heading in an easterly direction and are unlikely to be impacted by interstate closures west of Laurel.
- MDT staff noted that the area near the twin bridges over the railroad and Yellowstone River (approximate RP 398) do not have a workable detour if they get plugged by accidents.
- The following locations were noted as existing truck storage locations during closures: the city of Columbus, the Columbus Rest Area, and the city of Big Timber. The Greycliff rest area is not a good option as it is past where wind events typically occur, and parking trucks on the interstate is ineffectual as they get blown in and immobilized with snow. That said, none of these individual areas, nor all of them collectively, can provide for the amount of traffic that can back up in the hours it takes to implement a closure. Providing additional truck storage locations was not considered to be a practical alternative by maintenance staff, and the city of Billings was identified as the only location that can handle the amount of trucks that can back up during closures.
- MDT staff noted that additional enforcement to ensure that closures are observed by all traffic may be needed.
- Maintenance staff recommended that CDM Smith contact Stefan Streeter directly to get his thoughts/recommendations for improvements.

Maintenance Staff Input

Because MDT Maintenance staff has institutional knowledge through their experience of the issues and problems surrounding the closures, understanding their suggestions was a key component of our meeting. The biggest takeaway was that maintenance staff generally need quicker and safer methods to close the interstate and inform the public of the closures.

The following suggestions from maintenance staff aim to improve the closure of I-90 in the Billings District:

1. **Install interstate closure gate(s) for westbound traffic at the western Big Timber Interchange Exit 367. Install interstate closure gate(s) for eastbound traffic at the eastern Big Timber Interchange Exit 370**. This layout will ensure that interstate traffic in either direction is approaching the closure gates on a tangent section of I-90 with maximum visibility of traffic ahead. It also allows for traffic to maintain the option of exiting at either of the Big Timber interchanges. Gate(s) would be needed on the interstate at either exit, and at the respective on-ramp entrances.
2. **Install interstate closure gate(s) for westbound traffic at the Columbus Interchange Exit 408**. It was noted at the meeting that one gate would be needed on the interstate to force traffic to the

westbound off-ramp and a second gate would be needed at the westbound on-ramp entrance. *Note: After observing the existing Livingston closure gate layouts, consideration of a similar layout here with two gates for the interstate itself and a third for the on-ramp entrance may be warranted.*

3. **Install an interstate closure gate at the westbound on-ramp at the Springtime Interchange Exit (RP TBD).** This would prevent vehicles traveling the frontage road between the city of Columbus and Springtime Interchange from circumventing the interstate closure at the Columbus Interchange.

4. **Install a permanent VMS on the west side of the weigh station west of the city of Laurel, near mile marker 438.** It was not noted at the meeting whether this VMS should be single-sided for westbound traffic only, or whether it should be double-sided to function for traffic in either direction. *Note: If a double-sided sign is used, it may be beneficial to locate the sign within the median near the canal overpass as existing guardrail adjacent to the median in both directions of travel could be utilized to protect the sign.*

5. **Install permanent VMS(s) east of the city of Billings to provide westbound traffic with advanced warning.** Informing westbound traffic with advanced warning of potential closures prior to them reaching Billings will allow for them to consider alternate routes or to make the decision to wait in Billings.

6. **Install a permanent VMS near the town of Park City.** It was not noted at the meeting whether this VMS should be single-sided for westbound traffic only, or if it should be double-sided to function for traffic in either direction.

Additional comments received:

- Improved communications between MDT/Motor Carrier Services and trucking companies during incident events could help minimize impacts.

- Consider adding gates to close the frontage road between Columbus and the Springtime Interchange. The frontage road tends to get clogged up with snow drifts and it could be beneficial to prevent vehicles from trying to circumvent the interstate closure.

- Consider adding gates to close the frontage road on west side of Big Timber and to close the frontage road on east side of Big Timber. The frontage roads become impassable due to snow drifts; it would be beneficial to prevent vehicles from trying to circumvent the interstate closure.

- If possible, an Amber Alert-style warning system would be helpful to quickly get the message out during closure events.
- Google provides real-time traffic information in their Google Map application. Coordinating the closures with Google (and other similar map application companies) to provide Map users interstate closure information could keep them from driving beyond where they should and potentially minimize congestion at the closure areas. Based on discussions with MDT Maintenance staff in Livingston, the inclusion of remotely-controlled blackout signs in advance of interstate closure gates at Columbus and Big Timber would increase the safety of MDT maintenance staff while implementing closures. *Note: This was not discussed at the Billings district meeting.*

50 West 14th Street, 2nd Floor
Helena, Montana 59601
tel: 406 441-1400

I-90 Closure Planning Study
Livingston Site Visit #1
Minutes

Wednesday, March 21, 2018

10:30 a.m. – 12:30 p.m.

MDT Livingston Maintenance Shop

ATTENDEES

- Kyle DeMars (MDT Bozeman Maintenance Chief)
- Bill Pierce (MDT Bozeman Maintenance Superintendent)
- Larry Chapel (MDT Livingston Field Maintenance Supervisor)
- Shaheen Siddiqui (CDM Smith)
- Jake Gunther (CDM Smith)

PURPOSE OF MEETING

This meeting was an opportunity to meet with the MDT Bozeman Maintenance District staff to learn how I-90 currently functions within their district during closure incidents.

TOPICS OF DISCUSSION

Existing Conditions Discussion

The discussion primarily considered two topics: frequent closures due to wind events that occur frequently around Livingston itself; and less frequent closures and weather events within the overall Bozeman District's maintenance area.

The MDT maintenance crew described the different types of advisories/detour/closure scenarios that occur in the Livingston area and the process required to implement each Wind event that primarily occur from late October through March are the primary trigger for I-90 warnings/detours/closures in the areas, with the worst events compounded by blowing snow and low-to-no visibility conditions.

On average, two wind events occur every week during the windy season noted above (partial or full detours between Exit 330 and Exit 337), with wind event durations lasting up to two days. There are two critical wind event locations that impact primarily westbound truck traffic. They occur between the west Livingston Exit 330, and the east Livingston Exit 337.

The first problem area is near mile marker 332 east of Livingston Exit 330. The second problem area is near mile marker 334 east of the bridge over the Yellowstone River. Existing wind gauges are installed near each critical wind event location. A third known wind location that does not have a history of truck turnovers occurring along the flats just east of mile marker 336.

The four primary types of incidents in the Livingston area are illustrated in the following Incident Scenarios:

1. *Severe Cross-Winds Warning:* Triggered when wind speed reaches 40 mph.
2. *Partial I-90 Closure between Exit 330 and Exit 337, Trucks/Towing Vehicles must take detour route through Livingston:* Triggered when wind speeds reach 50 mph. During these partial closures truck traffic is closed between exits 330 and 337. MDT staff noted that some trucks ignore these partial closures), and that limited enforcement mechanisms exist for partial closures.
3. *Full I-90 Closure between Exit 330 and Exit 337, All Vehicles must take detour route through Livingston:* Triggered when wind speeds reach 60 mph, or as deemed necessary by the MDT Bozeman Maintenance Superintendent, based on weather conditions. During full closures, the interstate is closed to all traffic between exits 330 and 337. MDT staff noted that they must close I-90 to all traffic to force semi-trucks/towing vehicles off the interstate, even though passenger vehicles would generally be able to safely traverse the high-wind segments.
4. *Full I-90 Closure East (or West) of Livingston, Interstate completely closed to the east or west of Livingston:* This type of incident is rare, and primarily occurs when blowing snow between Livingston and Big Timber creates low-visibility conditions. Closure of the Bozeman pass west of Livingston for similar reasons is even less common but still a possibility. During full closures traffic is routed through Livingston in the same manner as noted under Incident Scenario 3 above. In these situations, drivers must find alternate routes, U-turn, or shelter in place, if room exists, until the closure is lifted.

The process of implementing a detour/closure currently takes between two and five hours from start to finish, depending on weather conditions, and whether partial or full closure is implemented.

Systems that aid in notifying the traveling public of advisories/detours/closures include the dial-in 511 system, MDT's Travel and Weather Information website, and the Highway Advisory Radio (HAR) station on AM radio station 530. The HAR sign for westbound travel was noted to be within the closed detour segment of I-90, rendering it ineffective. Additionally, the HAR radio signal was noted to be weak and staticky, particularly near the Big Timber area.

The impacts of the detour route through the town of Livingston were discussed, with the following items noted:

- During full closure events traffic quickly fills up the entirety of Highway 10 and Park Street/Highway 89. Problems created by the traffic jam include: the inability of cross traffic to navigate through town, and, critically, the ability of ambulances and other emergency service vehicles to safely and efficiently navigate through Livingston, and to/from the Hospital.

- When passing trains cause the gates at the railroad crossing at the Y-intersection between Highway 10 and Park Street to be closed during detour events, traffic on both sides of the crossing comes to a standstill which ripples out to the vehicles that are still backed up onto the interstate. Neither MDT nor state/local police currently possess the ability to stop train traffic during closure events.

- The traffic signals in town do not currently have the flexibility to run in a detour phase, which could more efficiently transport detour traffic through town. The signals can either be run with their normal timing, or they can be switched to a flashing-red, 4-way stop configuration. While the flashing-red configuration can provide some relief, it is inadequate for dealing with the number of vehicles that are backed up in the detour route.

  - MDT Maintenance staff noted that MDT is conducting a traffic signal timing study for daily operations within Livingston. CDM Smith will contact MDT Traffic to determine whether any information pertinent to the incident management study may be obtained.

- During detour events, eastbound traffic on Park Street is limited in making the permitted left-turn maneuver from left turn lane at the Y-intersection between Highway 10 and Park Street due to the lack of a designated signal phase allowing them to cross the steady stream of westbound traffic merging onto Highway 10.

- During hard closure events, where interstate travel eastbound from exit 337 or westbound from exit 330 are closed, the lack of adequate truck storage locations in the town of Livingston further magnifies the issues noted above. Increasing the amount of available truck storage within Livingston was not seen as a feasible option by MDT maintenance staff.

  - Local city/county staff has identified an empty parcel near exit 337 that has potential to be improved to provide increased vehicle storage capacity during closure events, provided that an agreement could be reached with the landowner. MDT is not involved with this process and further exploration of this item is not within the scope of this study.

Additional comments received:

MDT Maintenance Staff Input

CDM Smith staff was interested in the suggestions of MDT Bozeman Maintenance staff. They have intimate knowledge of the relevant issues in their district and understand some of the best ways to improve the safety of their crews and the traveling public during detour/closure events.

The following input was presented:

1. **Reconfigure the I-90 Westbound off-ramp at Exit 337**. Could help remedy the existing geometry, improve visibility of interstate closure gates, improve visibility of stopped traffic on the off-ramp during detour/closure events, provide additional detour storage capacity, and to more efficiently route traffic through the detour route. An improved off-ramp could increase safety for the traveling public by eliminating the need to make the stop-controlled left turn onto Highway 89 westbound.

    - MDT owns the right-of-way for the old frontage road (no longer in service) on the north side of the interstate between Exit 337 and Exit 340. Utilizing the old roadbed for a reconfigured ramp and connection to the existing Highway 89 westbound would not require additional right-of-way for the reconfigured off-ramp.
    - MDT staff would like to see the reconfigured exit 337 westbound off-ramp pushed as far to the east as practicable to increase the amount of vehicle storage during detour/closure events along a tangent section of road.
    - It was noted that a reconfigured westbound off-ramp would lie on a tangent section of interstate so that approximately 1-3 miles of visibility would be available (depending on the location of the reconfigured off-ramp). The increased visibility could be a significant safety improvement for MDT staff initiating detours/closures, and for the traveling public, who would have better sight lines of stopped traffic on the interstate in advance of the existing condition.

2. **Install an additional permanent double-sided variable messaging sign (VMS) a minimum of two miles west of Exit 330.** The existing permanent VMS is located too close to the Exit 330 eastbound off-ramp and could potentially be a candidate to be relocated further to the west. To allow for a new permanent VMS to be double-sided and serve both directions of travel, it would need to be

located near the east end of the horizontal curve near mile marker 328.5 (only 1.5 miles from Exit 330). Another option may be to install two new single-sided permanent VMS further west of that point where the eastbound and westbound interstate alignments are detached from each other. The first permanent VMS that eastbound traffic traveling from the west of exit 330 reaches should include flashers.

3. **Install an additional permanent single-sided VMS a minimum of two miles east of Exit 337.** Given that the existing permanent VMS is located around mile marker 338, it may be beneficial to consider locating the new permanent VMS on the east side of Exit 340. Placing the sign near mile marker 341 would provide westbound interstate traffic with warning of advisory/detour/closure events prior to the horizontal curve near the same mile marker which would be a safety benefit in scenarios where traffic has backed up onto the interstate. The first permanent VMS that westbound traffic traveling from the east of Exit 337 reaches should include flashers.

4. **Replace all existing Flip-Signs with electronically controlled Blackout signs capable of being updated remotely from MDT Maintenance shop(s).** Increase the number of blackout warning signs and extend their starting locations further from the closure points. Adding flashing lights on select key blackout signs would draw additional attention to them and should be considered.

5. Add a dedicated portable VMS on Highway 89 near the South Interchange Exit 333 to notify travelers when the eastbound/westbound interstate on-ramps are closed due to the interstate detour.

6. **Upgrade the wind speed gauge near mile marker 334 to enable it to provide real-time data to MDT staff remotely.** The existing wind speed gauge requires that maintenance staff manually download data. Maintenance staff having access to real-time wind-speed data may allow them to initiate and implement closures more efficiently.

7. **Upgrade the interstate closure gates to eliminate the need for 2-3 people to close them during wind events.** MDT Maintenance staff will still need to be physically present to close the gates, but a remote style opening/closing mechanism that would function during high winds without requiring multiple people to close the gates would improve safety and efficiency by allowing for maintenance staff to divide their efforts in multiple locations.

8. **Two new permanent VMS are needed near the Highway 287/Three Forks Exit 274 to provide advanced warnings during detour/closure events.** The VMS west of highway 287 would be single-sided to warn travelers of closures on the Butte Hill. The VMS east of highway 287 would be double-sided to warn travelers about incidents to both the west and the east of the sign.

9. Add a dedicated VMS east of Belgrade's Airway Blvd Interchange to provide warning to eastbound travelers leaving the airport or coming from Jackrabbit Lane/Highway 85.

10. **A double-sided portable VMS may be needed to replace the existing single-sided portable VMS that is located between mile marker 324 and 325.** This would allow for more effective communication for both eastbound and westbound traffic between Bozeman and Livingston.

11. Add a dedicated portable VMS on Highway 89 north of the Wilsall Interchange Exit 340 to inform southbound travelers on Highway 89 of advisories/detours/closures.

12. **Improve the clarity and effectiveness of the Highway Advisory Radio (HAR) on AM Station 530.** The existing radio station is staticky and has a poor signal that grows noticeably weaker near Big Timber. An upgraded radio outreach system should at a minimum maintain clarity between Livingston and Big Timber. **Relocate the existing HAR sign(s) that are currently located within the detoured portion of I-90 between Exit 330 and Exit 337.** The relocated signs should be placed outside of the detoured segment for maximum effectiveness.

13. **Investigate the possibility of constructing 'wind walls' to guide wind gusts above the truck traffic at the two known wind event locations where truck tip-overs frequently occur.** The first problem spot is near mile marker 332 just east of Livingston Exit 330. The second problem spot is near mile marker 334 just east of the bridge over the Yellowstone River. Construction alternatives for potential 'wind walls' could include earthen embankments, sound barrier walls, living walls, other systems, or any combination thereof. *Note: This improvement could drastically decrease the number of partial and full detour closures caused by the risk of truck tip-overs in the wind gust locations.*

Additional considerations:

- Consider ways to improve the existing 511 call-in information system. Statewide communication is currently an issue. There are many passes and valleys where cellular and radio coverage is not available. Statewide fiberoptic cable statewide is too costly for the small amount of traffic. Crowdsourced information such as Google and Waze are also sporadic due to the lack of coverage and lack of "crowds" in a large rural state like Montana. Some states in the Northwest Passage have citizen-reporting systems that allow everyday citizens to call in or use an app to report events and conditions, which could be a consideration.

- Consider studies being conducted by other states on the effectiveness of different colors for VMS and flashing/warning lights that may be more effective/noticeable to the traveling public. Consider informational real-time wind speed signs within the city of Livingston along the detour route. These signs could operate similarly to speed signs that are posted within cities, updating their message based on wind-speed limits that correspond to MDT's existing closure practices. Three signs could be most effective, with one sign on the west end of Livingston, one in the middle of the detour route, and one on the east end of Livingston.

- MDT Maintenance staff noted that there is an on-going MDT project to upgrade all the lights on MDT system roads to LED. This improvement should enhance safety in the corridor.

Appendix B

Notes from Discussion with MDT 511

50 West 14th Street, 2nd Floor
Helena, Montana 59601
tel: 406 441-1400

I-90 Closure Planning Study
Traveler Information System
Discussion Notes

Friday, April 13, 2018

11:00 a.m. – 11:30 a.m.

Phone Conversation

ATTENDEES

- Brandi Hamilton (MDT Traveler Information System)
- Jeff Hochmuth (CDM Smith)

PURPOSE OF CONVERSATION

This meeting served as an opportunity for CDM Smith to understand current and planned corridor and statewide traveler information system capabilities.

TOPICS OF DISCUSSION

Background

Jeff Hochmuth provided a quick overview of the project, although Brandi Hamilton had passing knowledge of the project.

Brandi explained that the 511 system for Montana was created and has been maintained by MDT staff – both her group and the MDT IT staff. She added that the MDT.gov site does have a truckers page, although the focus is more on permitting and restrictions than real time information.

Current Operations

The 511 web page had over 10 million hits this past winter. Brandi believes that a lot of truckers continue to call 511 as it is more of a national norm.

Construction information is entered manually every week. Project managers are supposed to update if there are any changes, although compliance is sporadic. During winter, snow plow drivers report conditions through the MDT radio dispatch center. The information is not automated but is updated within minutes.

Known Issues

Brandi stated that without a central traffic management center – a place dedicated to collecting traffic information – it is difficult to keep the information current. During the winter (typically November to the first week of April) the traveler information systems are staffed 24/7. Outside of winter, Brandi and one staff are on call to remotely add events as needed.

The 511 system is Oracle based and "near the end of its life". The maintenance division just purchased a major system to upgrade their asset management system.

Statewide communications is an issue. There are many passes and valleys with no cellular or radio coverage. Fiberoptic cable statewide is too expensive for the small amount of traffic. Crowdsourced information such as Google and Waze are also sporadic due to the lack of coverage and lack of "crowds" in a large rural state.

Planned Efforts

Brandi added that the Motor Carriers Service division of MDT is creating a truck routing software application. She is not sure if it will have real time information included.

Brandi is pursuing federal funding for upgrading the traveler information system. If state funded, she would need legislative approval. They are trying to use FHWA highway safety planning funds and already have federal approval but now need to obligate the funds. The money may be used to purchase and modify an off the shelf traveler information system or may be used to pay MDT staff to create.

MDT does work some with the Western Transportation Institute out of University of Montana (Steve Albert). Brandi is also the MDT representative for the Northwest Passage coalition. Some of the other states in NW Passage have citizen reporting systems that allow everyday citizens to call in or use an app to report events and conditions. This has been fairly successful. Montana may try to implement this system.

This study may support the need for traveler information system improvements; Brandi will have an opportunity to comment on the draft study report.

Appendix C

Gate Memo

Memorandum

To: *Montana Department of Transportation*

From: *CDM Smith*

Date: *November 9, 2018*

Subject: *I-90 Three Forks to Billings Road Closure/Detour Analysis*
Road Closure Gate Tech Memo

Feedback received from MDT Maintenance staff revealed that there is a strong desire to upgrade road closure gates to allow for automated operation to alleviate the amount of manpower required to operate closure gates while experiencing high winds (currently 2-3 staff are required to operate the gates in Livingston).

This technical memorandum evaluates the road closure gate systems, signage, and procedures used by the Wyoming Department of Transportation (WYDOT) and the Nebraska Department of Roads (NDOR). The intent of this memo is to provide the Montana Department of Transportation (MDT) with crash-tested real-world examples of how gate systems are employed by other rural states that experience frequent weather-related interstate closures comparable to those experienced in Montana.

Wyoming Department of Transportation (WYDOT)

The Wyoming DOT employs manually operated vertical drop-down gates that are a light-weight version of railroad crossing gates commonly seen throughout the country. Their gates are mounted on lighted luminaire poles with breakaway foundations that may or may not include additional supplemental flashers installed on the luminaire depending on the gate location. The fiberglass gate arms on their installations all include flashing red LED warning lights spaced at 6-feet on center.

Wyoming deploys closure gates directly on the interstate as well as at interstate on-ramps. On mainline installations, initial warning is provided by pairs of regulatory static message signs stating '*ROAD CLOSED 1/2 MILE WHEN FLASHING'* with flashing amber lights that are installed within the median and on the shoulder. The next pair of regulatory static message signs utilizes red flashing lights and is installed 500-feet in advance of interstate off-ramps and states '*[ROUTE SYMBOL] CLOSED RETURN TO XXXXXX WHEN FLASHING'*. The flashers on all the static message signs are typically operated remotely from WYDOT's centralized traffic control center but are capable of manually operated on-site. Mainline closure gates are installed in staggered pairs with the initial gate being deployed from the shoulder just after interstate off-ramps. The second gate is installed in the median, offset 60-foot beyond the initial gate to allow for plows and emergency services personnel to circumvent the closures as needed. Compliance with road closures is strongly encouraged by way of regulatory static message signs stating, '*VIOLATORS WILL BE PROSECUTED JAIL OR $750* FINE'.

Phone conversations with WYDOT maintenance staff revealed that WYDOT performed a trial installation of four automated gates to determine whether it made sense to adopt them on a more wide-spread basis. While the automated gates performed well initially, problems quickly arose, and it became apparent that the frequent maintenance required to keep them operable was not economical, particularly on a state-wide basis. WYDOT continues to operate these gates manually. Maintenance staff reported that their closure gates are used because of winter weather approximately 90% of the time, while the other 10% of the usage is for traffic management (accidents or construction).

WYDOT provides the Wyoming Highway Patrol with the ability to operate the gates without the use of advanced warning or flashers provided that the gates are manned by a trooper throughout the closure period.

The WYDOT gates have been through formal crash-testing procedures which has led to them being adopted by many states around the country including Nebraska.

Refer to Appendix A for a selection of WYDOT Detailed Drawings that illustrate the closure gates and signage used by WYDOT.

Nebraska Department of Roads (NDOR)

Automated Gate Technology

The Nebraska DOR has been working towards automated gates since the mid-2000's, with an initial rollout of four sets of automated gates between 2006-2008. The automated gates had several methods of closing including: Central office control using Advanced Traffic Management System (ATMS) software, short-distance Dual Tone Multi Frequency (DTMF) radio control from NDOR vehicles, push button on the side of the gate to lower, and manually using a drill and a winch. The automated features of the gates in this initial installation performed well initially but began to fail after one year due to the following reasons: gate actuator water damage, ATMS communication breakdown, and coordination issues between NDOR and the gate vendor.

Not to be deterred, the NDOR worked in partnership with a new gate vendor to update the automated technologies to improve upon the initial installation with the goal of deploying automated gates on all Interstate 80 interchange on-ramps from the Wyoming border to the Omaha metro area. Upon completion of the study and construction plans, updated automated gates were installed in three rounds at over 70 interchanges on I-80 over the course of the 2016-2018 construction seasons at a cost of $17,000 per gate. The updated gates have four methods of control:

1. Remote operation using ATMS – specifically, the Intelligent Roadway Information System (IRIS) which is an open-sourced ATMS software developed by the Minnesota DOT.
2. Short-range radio code

3. Push buttons in controller cabinets
4. Manual winch operation

Each automated gate controller cabinet includes the following features: a fiber panel, an Uninterruptible DC Power Supply (UPS), activation buttons, Programmable Logic Controllers (PLC), terminals and fuses, and a radio decoder.

The automated gate technology employed by NDOR is open-sourced which would allow for its adoption in Montana.

The Nebraska DOR also installed towers with CCTV cameras at each interchange that received gate installations to allow for remote monitoring of the interchange on-ramp gates. Note that while the gates are capable of being viewed and operated remotely, NDOR maintenance staff is present on-site for all gate operations to ensure that gates are not unintentionally closed on vehicles.

Early reports from NDOR maintenance staff reveal that the automated gates are performing adequately to-date, with the initial round of gates making it through the 2016/2017 and the 2017/2018 winter seasons.

Typical NDOR Gate Installations

The NDOR employs manually operated vertical drop-down gates that are a light-weight version of railroad crossing gates. Their gates are mounted on poles with breakaway foundations. The fiberglass gate arms on their installations include three flashing red LED warning lights installed on top of the gate arm at equal spacing with the left-most beacon located 1' from the left edge of the roadway surface and the right-most beacon located above the right edge of the roadway surface. NDOR utilizes both single-gate installations and 2-gate installations where each fiberglass gate arm covers half of the road being closed.

Interchange closures are communicated to travelers attempting to enter I-80 by way of static message signs with flashing beacons that are operated remotely. Closures are communicated to travelers already on the interstate with a combination of Dynamic Message Signs (DMS) and static message signs with flashing beacons informing drivers '*I-80 CLOSED WHEN FLASHING EXIT HERE*'.

NDOR Closure Procedures

When it comes to implementing interchange closures, the NDOR follows the general process listed below:

1. NDOR Districts prepare road closures in advance of when weather systems move in.
2. Intelligent Transportation Systems (ITS) and other physical components are deployed prior to closing gates:
    - Dynamic Message Signs (DMS) turn on within I-80
    - Flashing Warning Signs and arrow boards turn on, advising upcoming drivers '*I-80 CLOSED WHEN FLASHING EXIT HERE*'.

- State highway patrol use traffic barrels to close specific ramps.

3. NDOR maintenance staff begin closing gates from on-site.

Note that the NDOR does not utilize mainline interstate closure gates so their procedures are limited to interchange on-ramp gate closures.

Refer to Appendix B for a selection of NDOR details and plans that illustrate the closure gates and signage used by NDOR. The automated gate specifications used by NDOR are also included within this appendix.

Considerations & Takeaways

There are many similarities between the closure gates and signage used by the Wyoming DOT and the Nebraska DOR to shut down interstate routes in their states, much of which is directly applicable here in Montana.

Automated Gate Considerations

The Nebraska DOR is one of the only states in the country that has implemented automated gates for interstate closures on a wide-scale basis (automated gates are more commonly installed to manage reversible lanes in major population centers). Their success with this recent deployment of automated gates has provided MDT with a feasible open-sourced automated alternative to upgrade existing and future manually operated gates. That said, there are several factors specific to the I-90 study area that should be considered:

- Automated gates require significantly more maintenance than manually operated gates.
  - Wind events in Livingston occur on a much more frequent basis than weather-related closures in Nebraska. The NDOR automated gate mechanisms have not been tested through such an extreme use schedule so it is difficult to predict the level of maintenance that would be required in Livingston.
    - Note that automated gates installed outside of the Livingston area intended to be used for weather-related closures only can be expected to perform similarly to those in Nebraska.
- The automated gates do not change anything about how the gate arm physically deploys from the upright to the down position – this is relevant to Livingston where high winds have commonly required 2-3 MDT maintenance staff to lower gate arms. Existing MDT practice to lower their gates requires one person to operate the gate winch while a second person uses a shovel to leverage the gate arm against the post to allow for the arm to release from the guides at the top. This second staff member then uses a rope attached to the gate arm to counteract the winds while the 1st staff member lowers the gate to the horizontal position. The additional support of the gate arm is required because the fiberglass gate arms are not capable of withstanding high winds lacking that extra support. The process to raise the gate is reversed with one staff member operating the winch while

the other person counteracts the high winds with a rope attached to the gate arm until the gate arm can be directed back into the post guides.
  - Note that automated gates used by NDOR would likely reduce the manpower requirement to lower gates in high winds as a single maintenance staff member could focus on steadying the gate arm with a rope while allowing the automated mechanism to lower/raise the gate arm.
  - One potential solution to help mitigate the difficulties associated with raising and lowering the gate arms would be to install additional more closely spaced guides on the posts to help guide the gate arm back into position. Guides could be strategically tapered to further minimizes the issues caused by high winds. Note that while these measures would likely help, it is possible that the rope may still be required.
  - Increasing the ability for the gate arms to resist wind forces could be made, but any changes to gate arm composition or cross sectional dimensions would likely require that MDT conduct crash testing.
- On-site MDT maintenance staff would still be required for gate operations.
- MDT would need to determine if they wanted to install CCTV cameras near gate locations to allow for remote monitoring.

<u>Gate Placement Considerations</u>

Mainline closure gates need to be staggered and offset from each other to allow for plows and emergency services personnel to circumvent closures as needed. WYDOT prefers to install their gates just after the off-ramp that traffic is being detoured onto. This contrasts with existing MDT practice in Livingston where the initial gate is deployed in advance of the off-ramp to funnel traffic into the right lane at the exit. Given the difficulties with detour compliance that MDT has experienced over the years it seems preferable to continue using MDT's existing staggered gate configuration.

While not stated within the WYDOT details, the visibility of closure gates and flashers should be a primary consideration for mainline installations as most weather-related closures occur because of poor visibility. Increased visibility is provided by flashers mounted on the gate arms which can be further supplemented with additional flashers mounted on the gate pole(s).

Both WYDOT and NDOR lay out their ramp closure gates at the entrance to interstate on-ramps in a similar configuration that is in line with existing MDT practices.

<u>Signage & Advanced Warning</u>

One of the key components of both the WYDOT and NDOR closure gate layouts is the use of cost-effective remotely operated flashing lights mounted on static signs. The ability to immediately turn on flashers helps to streamline the closure process by immediately informing travelers of imminent closures while maintenance staff mobilize to implement the physical closure of the interstate. This advanced warning encourages travelers to pre-emptively get off the road and is the type of information that is likely to be promptly relayed between truck drivers further away from the closure via CB radio. More advanced communications using Variable Message Signs (VMS) should be used to supplement the static signs.

Some of the benefits of Static Message Signs with remotely operated flashers:

- Would provide MDT with the ability to immediately begin informing travelers of upcoming detours/closures as soon as the decision to detour or close the road was made and before maintenance staff has a chance to mobilize to implement the physical closures.
- The minimal cost of these signs (relative to VMS) makes it practical to install them in pairs with one on the shoulder and one within the median. This layout ensures that communications reach both lanes of travel which is particularly important in low-visibility conditions. The reasonable cost for these installations would also allow for additional sets of signs to be installed further in advance of closures in known problem areas like Livingston.
- Static message sign text can be modified to account for specific situations in individual locations. This is ideal for a location like Livingston where there are varying degrees of detours (Trucks & RV's Only vs. All Vehicles).
    - Combination Static/Variable message signs could be used in Livingston to handle different detour/closure types – similar to Rest Area signs that have a variable message that can alternate between 'Open' and 'Closed'. In this scenario, most of the sign would consist of a static message with the underlined text denoting information that would be contained within a smaller variable message board along the lines of: 'I-*90 CLOSED TO <u>[TRUCKS & RV'S] / [ALL VEHICLES]</u> WHEN FLASHING EXIT HERE*'. This layout would allow MDT staff in Livingston the flexibility to quickly modify their signs depending on the severity of the wind event.
        - Alternatively, multiple sets of static signs with flashers could be installed that would provide different messages depending on which types of detour needed to be implemented. For truck only detours those specific sign flashers would turn on whereas in a full detour or closure all flashers on all signs would turn on.

<u>Enforcement</u>

The lack of an existing enforcement mechanism to encourage vehicles to comply with detours and closures was an issue cited by all the involved organizations including: MDT maintenance staff, Park County emergency services, and City of Livingston emergency services staff. It is expected that Montana Highway Patrol would have similar views, although to this point MHP stakeholders have not had a chance to respond.

If Montana law allows, the addition of regulatory signs like those used by WYDOT would immediately discourage travelers from ignoring detours & closures. The language used by WYDOT states: '*VIOLATORS WILL BE PROSECUTED JAIL OR $750 FINE*'. The specific message and amount of the fine could be modified to suit Montana's needs.

Road Closure Procedure Best Practices
Similar road closure plans are employed by both WYDOT and NDOR, the highlights of which are documented below and tailored to MDT specifically:

- In instances where weather forecasting predicts significant storms that are anticipated to potentially force closure of the road, DOT and emergency services personnel pre-emptively prepare for closures by increasing staffing (if possible) and staging of traffic control devices needed to supplement permanent closure infrastructure.

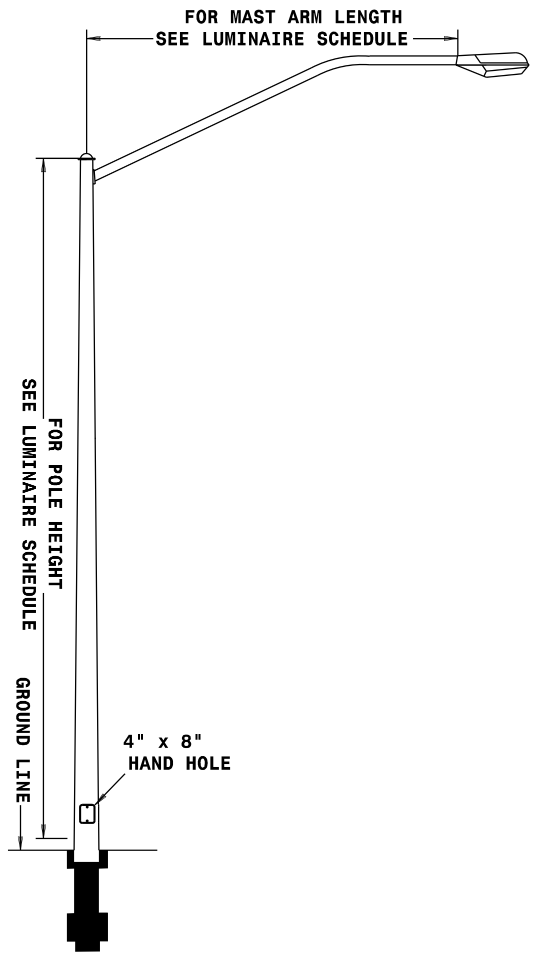
1. Once the decision has been made to implement a road closure, centralized traffic control centers for both WYDOT and NDOR immediately activate flashing beacons on static message signs informing travelers that the interstate is closed and to exit now. Variable Message Signs are remotely activated at the same time with pre-written messages depending upon the detour or closure scenario.
    - MDT should consider the benefits that a centralized traffic control center provides to other state DOT's like WYDOT and NDOR.
2. Standard procedure should then require the same person (or people) activating the flashers to immediately inform adjoining MDT maintenance districts and emergency services personnel of the imminent closure – this would remove this responsibility from field maintenance personnel who will be busy implementing the physical closure.
3. Deploy MDT Maintenance personnel to install temporary traffic control devices required to implement closures (if applicable).
4. Once all the necessary traffic control devices are in place, MDT maintenance personnel activate closure gates.
    - Note that an opportunity exists to supplement MDT maintenance staff with local and state emergency services personnel. This would require MDT to provide training to outside staff on how to operate gates and implement closures. MDT Policy would need to clarify that emergency services personnel would only be allowed to do so at the specific request of MDT maintenance division chiefs to ensure that MDT did not cede any authority over their roadways.

Final Thoughts

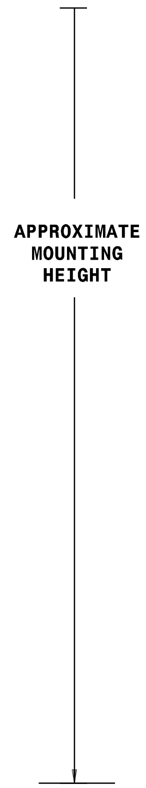
This memorandum is intended to provide information that can be used to help MDT make more informed decisions about how to implement detours and closures by learning from the best practices from other state DOT's.

It is anticipated that a dedicated design/construction project focusing on the gate upgrades would more fully explore available gate and automated technologies than was allowed within the scope of this study.

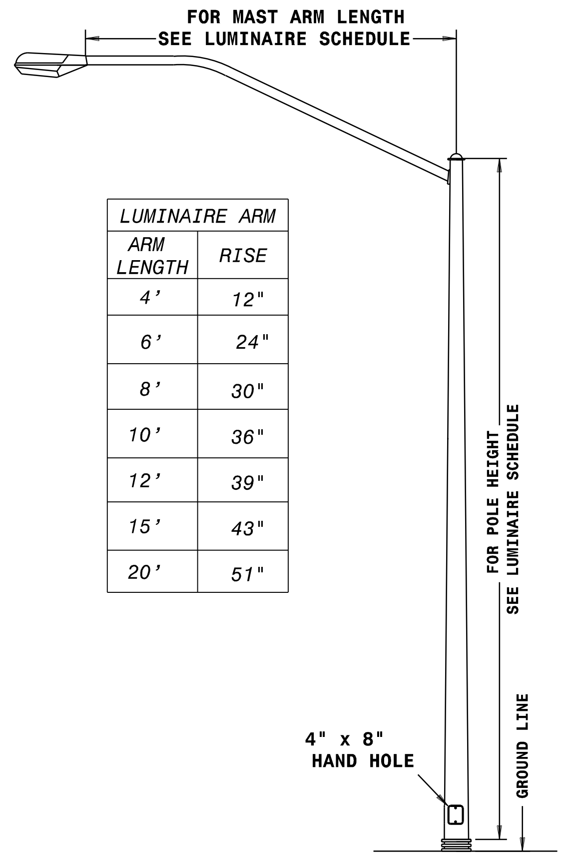
APPENDIX A – WYOMING DEPARTMENT OF TRANSPORTATION STANDARD DRAWINGS RELATED TO ROAD CLOSURE GATES



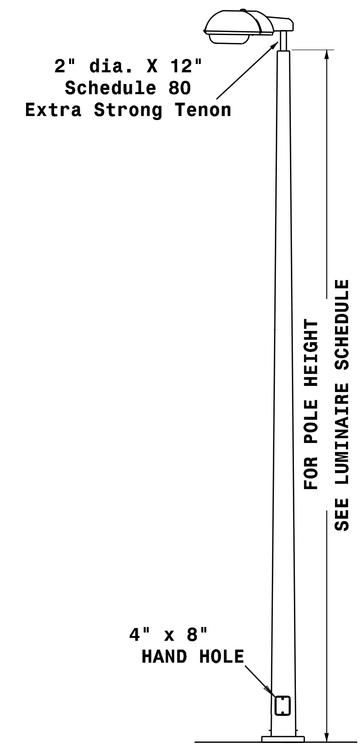
FIBERGLASS POLE TYPE VII



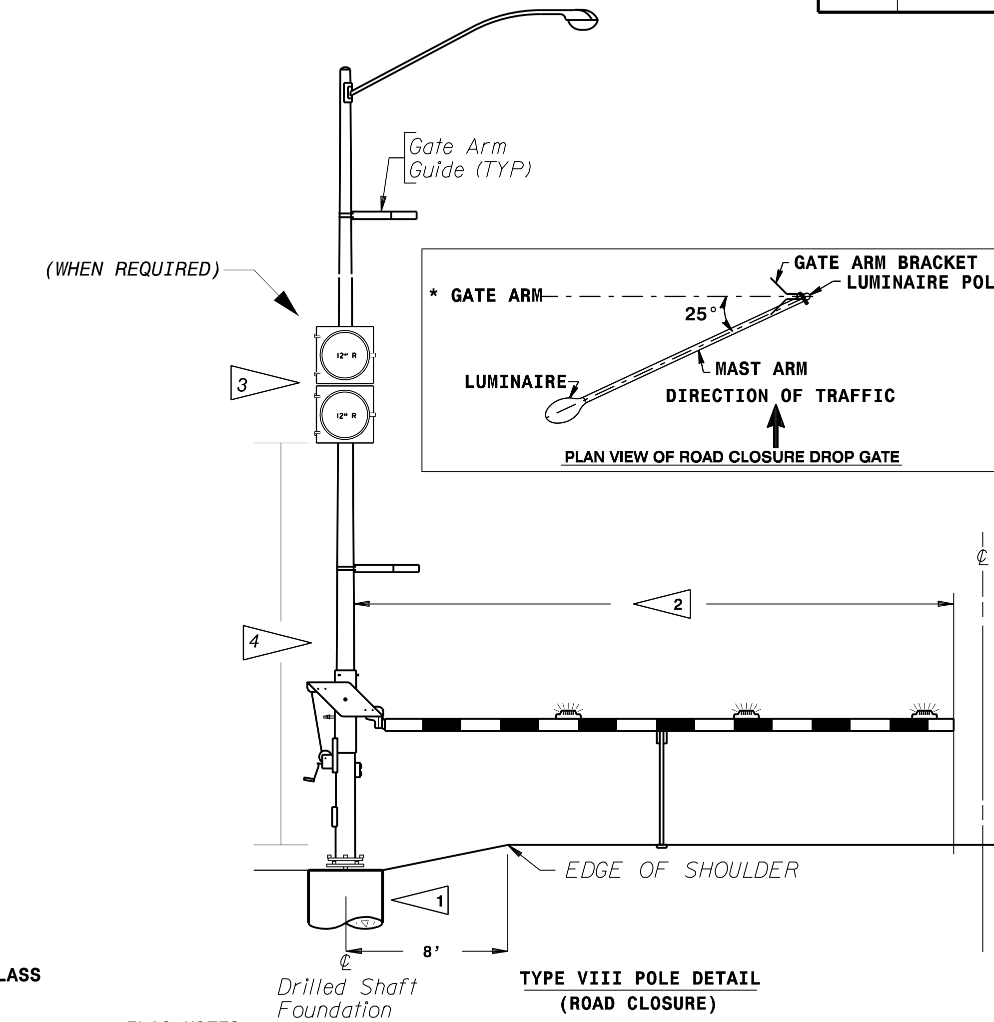
LUMINAIRE ARM	
ARM LENGTH	RISE
4'	12"
6'	24"
8'	30"
10'	36"
12'	39"
15'	43"
20'	51"



STEEL POLE TYPE VII



STEEL POLE TYPE VI OR FIBERGLASS POLE WITH TENON MOUNT



TYPE VIII POLE DETAIL
(ROAD CLOSURE)

GENERAL NOTES:
SEE POLE AND LUMINAIRE SCHEDULE FOR POLE MATERIAL AND BREAKAWAY REQUIREMENTS.

LUMINAIRE POLE INSTALLATION REQUIREMENTS FOR LUMINAIRE MAST ARM CAP SCREWS AND NUTS OF ANCHOR BOLTS:
WRENCH TIGHTEN ALL BOTTOM NUTS FIRMLY AGAINST BASE PLATE BEFORE TIGHTENING TOP NUTS. USE A STICK WAX TO FIELD LUBRICATE BEARING FACE AND THREADS OF CAP SCREWS AND TOP ANCHOR BOLT NUTS. TIGHTEN CAP SCREWS AND TOP NUTS TO SNUG-TIGHT. SNUG TIGHT IS DEFINED AS THE TIGHTNESS THAT EXISTS WHEN THE MEMBER'S BASE PLATE IS IN FIRM CONTACT WITH THE THREADED FLANGE PLATE OR WITH THE TOP AND BOTTOM NUTS AND IS ATTAINED BY THE FULL EFFORT OF A MAN USING A WRENCH WITH A LENGTH OF 16" FOR THE CAP SCREWS AND 21" FOR THE ANCHOR BOLT NUTS.

AFTER THE SNUG-TIGHT CONDITION IS ATTAINED, RETIGHTEN BOTTOM NUTS TO ENSURE FIRM CONTACT AGAINST THE BASE PLATE. ROTATE THE CAP SCREWS AN ADDITIONAL 1/4 TURN (90 DEG) AND ROTATE THE TOP NUTS AN ADDITIONAL 1/8 TURN (45 DEG). TIGHTEN IN TWO SEPARATE PASSES OF 1/8 TURN (CAP SCREWS) AND 1/16 TURN (TOP NUTS) IN EACH PASS. ROTATION TOLERANCES ARE PLUS AND MINUS 10 DEGREES FOR THE CAP SCREWS, AND PLUS 20 DEGREES AND MINUS 0 DEGREES FOR THE TOP NUTS.

FIBERGLASS POLE BACK FILL REQUIREMENTS:
USE CEMENTIOUS EARTH BACK FILL. MIX ONE PART CEMENT POWDER TO FIFTEEN PARTS CLEAN, WASHED SAND. TAMP BACK FILL AT 9" INTERVALS UP TO BOTTOM OF THE CABLE ENTRANCES, MAKING SURE POLE IS PLUMB, FINISH FILLING AND TAMPING TO 2" ABOVE FINAL GROUND LINE. NOTE THIS IS A DRY MIX, NOT A SLURRY MIX.

FLAG NOTES

1. WHERE PRACTICAL, PLACE THE DRILLED SHAFT FOUNDATION 8' OFF OF EDGE OF PAVEMENT. THIS DISTANCE CAN BE FIELD ADJUSTED.
2. DETERMINE THE GATE ARM LENGTH BY MEASURING THE DISTANCE FROM THE POLE TO THE LANE LINE OF THE LANE TO BE CLOSED AND SUBTRACTING 1 FOOT. ENSURE THAT THE GATE ARM DOES NOT EXTEND PAST THE LANE LINE. THIS APPLIES TO 2-LANE, 2-WAY HIGHWAYS AS WELL AS INTERSTATE ROAD CLOSURE INSTALLATIONS.
3. INSTALL 2-12" BLACK SIGNAL INDICATIONS AS SHOWN WITH RED LED LENS. THESE INDICATIONS WILL BE ENERGIZED WHEN THE GATE(S) ARE IN THE DOWN POSITION AND FLASH ALTERNATELY (BOUNCING BALL TYPE). MOUNT INDICATIONS WITH STANDARD BRACKET ASSEMBLY, PART NO. AS-0125-2-84 AS MANUFACTURED BY PELCO OR APPROVED EQUAL.
4. WITH INTERSTATE APPLICATIONS THE DISTANCE FROM THE TOP OF THE ROADWAY TO THE BOTTOM OF THE SIGNAL INDICATION IS 16' ON THE RIGHT SHOULDER AND 10' ON THE MEDIAN. ALL OTHER APPLICATIONS WILL BE 10'.

WYOMING DEPARTMENT OF TRANSPORTATION

ELECTRICAL LUMINAIRE POLE INSTALLATION DETAILS AND NOTES

DESIGNER: EP	DATE: 10/29/2015	REV: FINAL
ENGINEER: RA	SHEET 1 OF 1	

STATE OF WYOMING	PROJECT NO.	SHEET NO.	TOTAL SHEETS
	X	X	X

GENERAL NOTES

SPECIFICATIONS: WYDOT's Standard Specifications for Road and Bridge Construction, 2010 Edition

STEEL LUMINAIRE POLES: Use round steel luminaire poles with an 8" outside diameter at the base, a 0.17" minimum wall thickness, and a uniform taper throughout.

GALVANIZING: Ensure the steel luminaire poles, mast arms, drop gate pivots, supports, and guides and all associated hardware are galvanized in accordance with Subsection 815.14, Galvanized Coating. Ensure rough edges and burrs are ground smooth prior to galvanizing.

Paint all exposed bolt threads with two coats of zinc rich paint conforming with the requirements of ASTM A 780, after assembly of road closure gate.

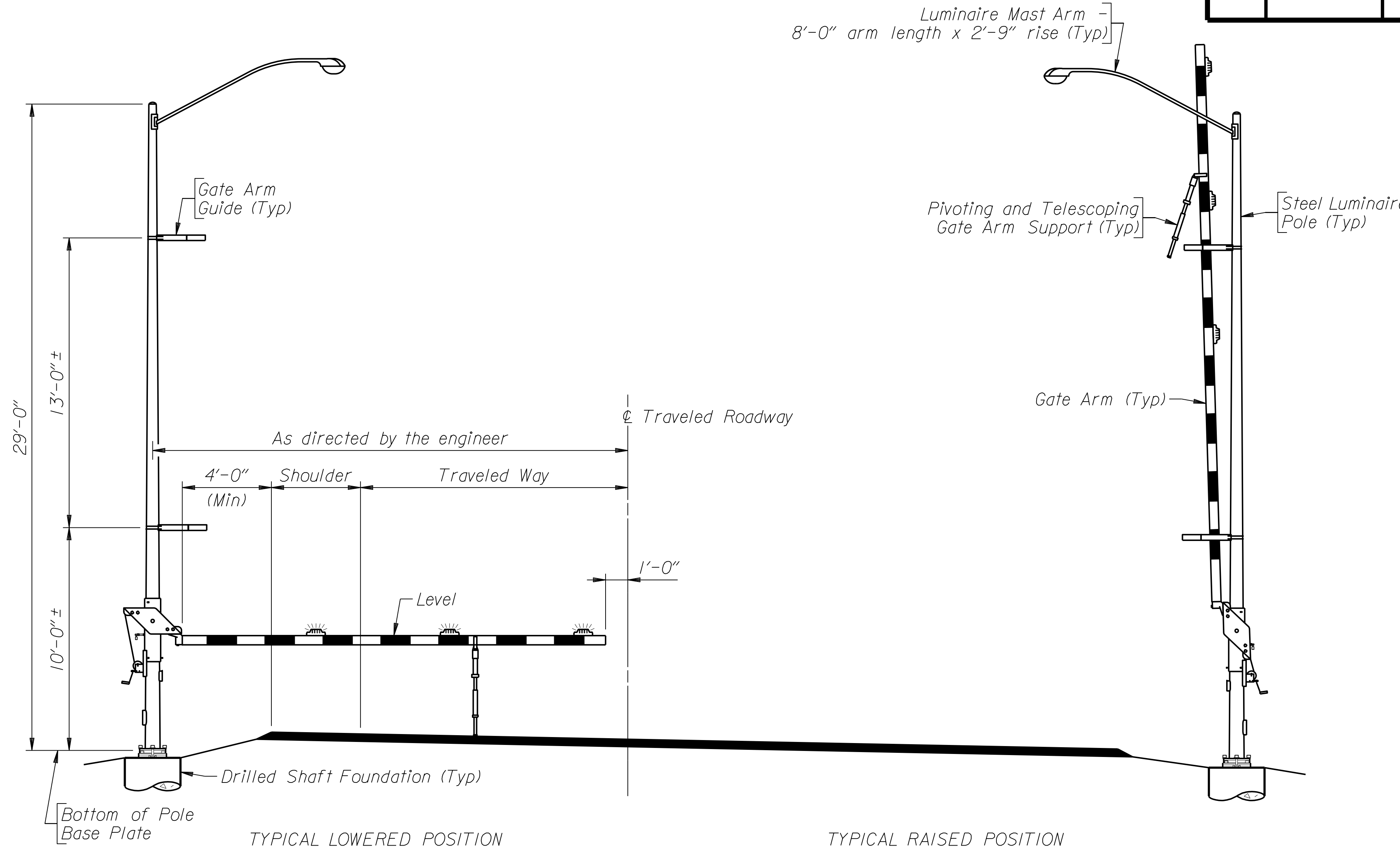
BOLTED CONNECTIONS: Use bolts conforming to ASTM A 307, Grade A, unless designated as HS (High Strength), then use bolts conforming to ASTM A 325.

FIELD ASSEMBLY: In some installations, the connection plates for the luminaire arms may require modification to allow the pivot sleeve to slip over. Repair damage to the galvanizing with two coats of zinc rich paint conforming with the requirements of ASTM A 780.

REFERENCES

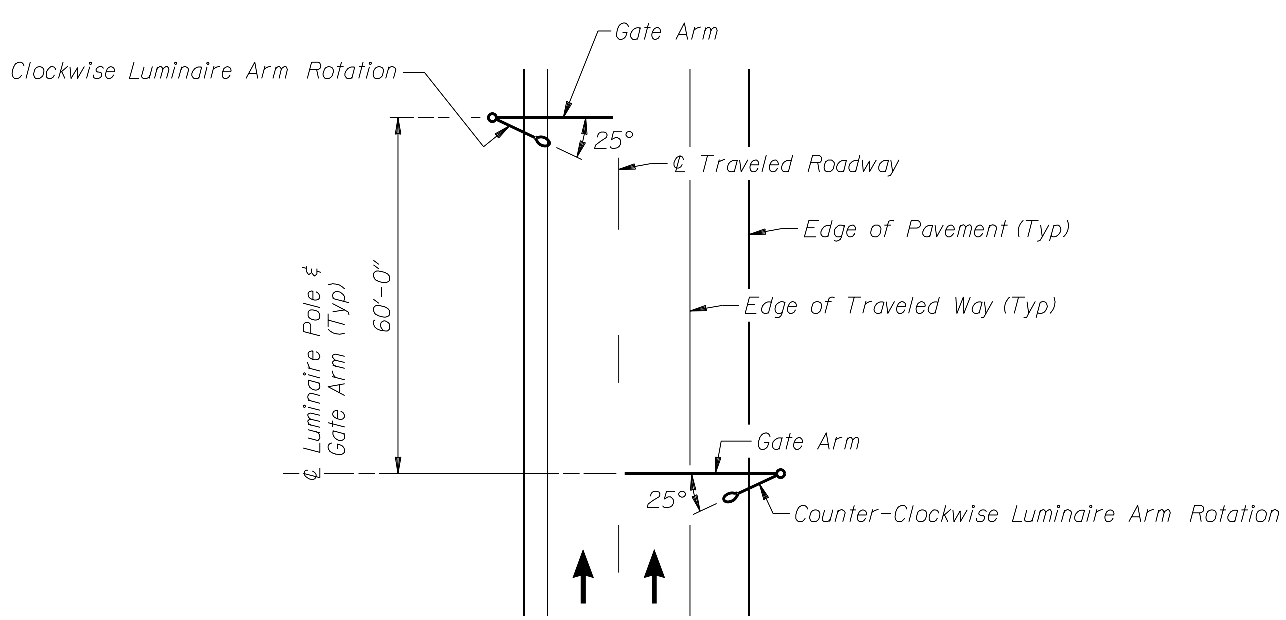
WYDOT Standard Traffic Details:

Drilled Shaft Foundation, Trench & Conduit Placement Detail
Lighting Pole 4-Bolt Slip Base Details



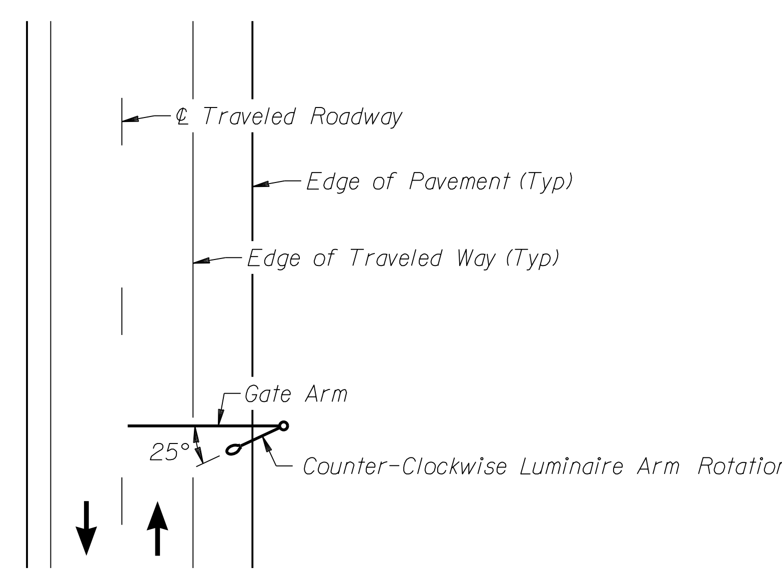
ELEVATION

Divided Highway installation shown



DIVIDED HIGHWAY INSTALLATION

(2 Gates req'd)



TWO-WAY HIGHWAY INSTALLATION

(1 Gate req'd)

Note: 1) Engineer will verify the location of road closure gates and mounting height of gate arm pivot.
2) Height of gate arm guides may be varied as required for warning light clearance.

REVISIONS	
Revised for WYDOT's 2003 Standard Specifications.	14-Jan-05

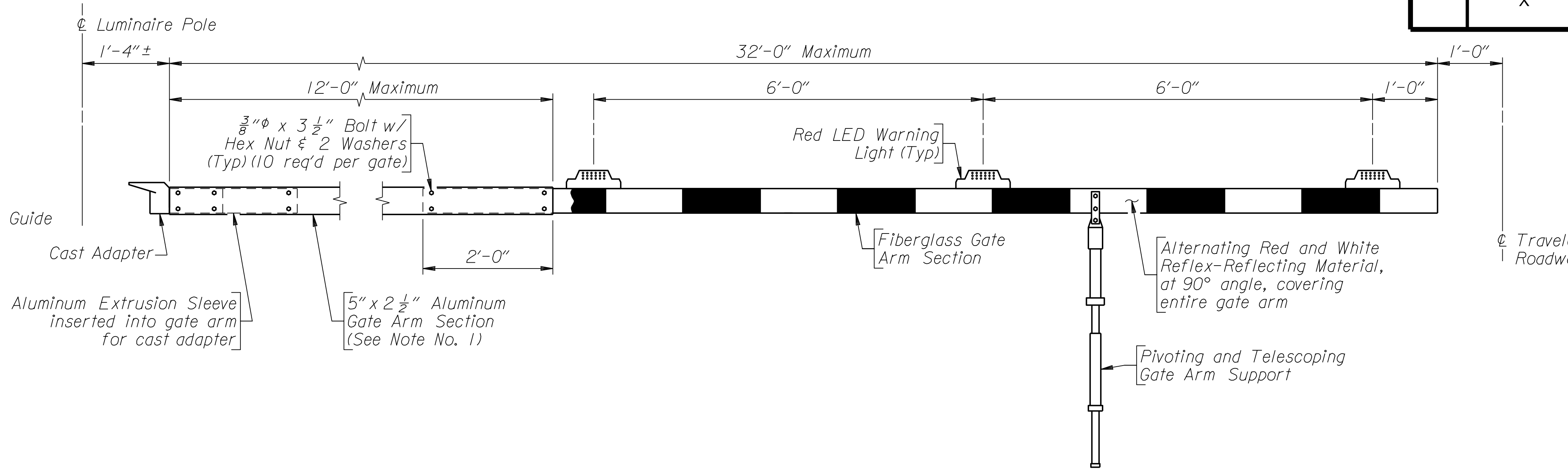
WYOMING DEPARTMENT OF TRANSPORTATION

STANDARD ROAD CLOSURE
DROP GATE DETAILS
(Drop Gate Pivot Details)

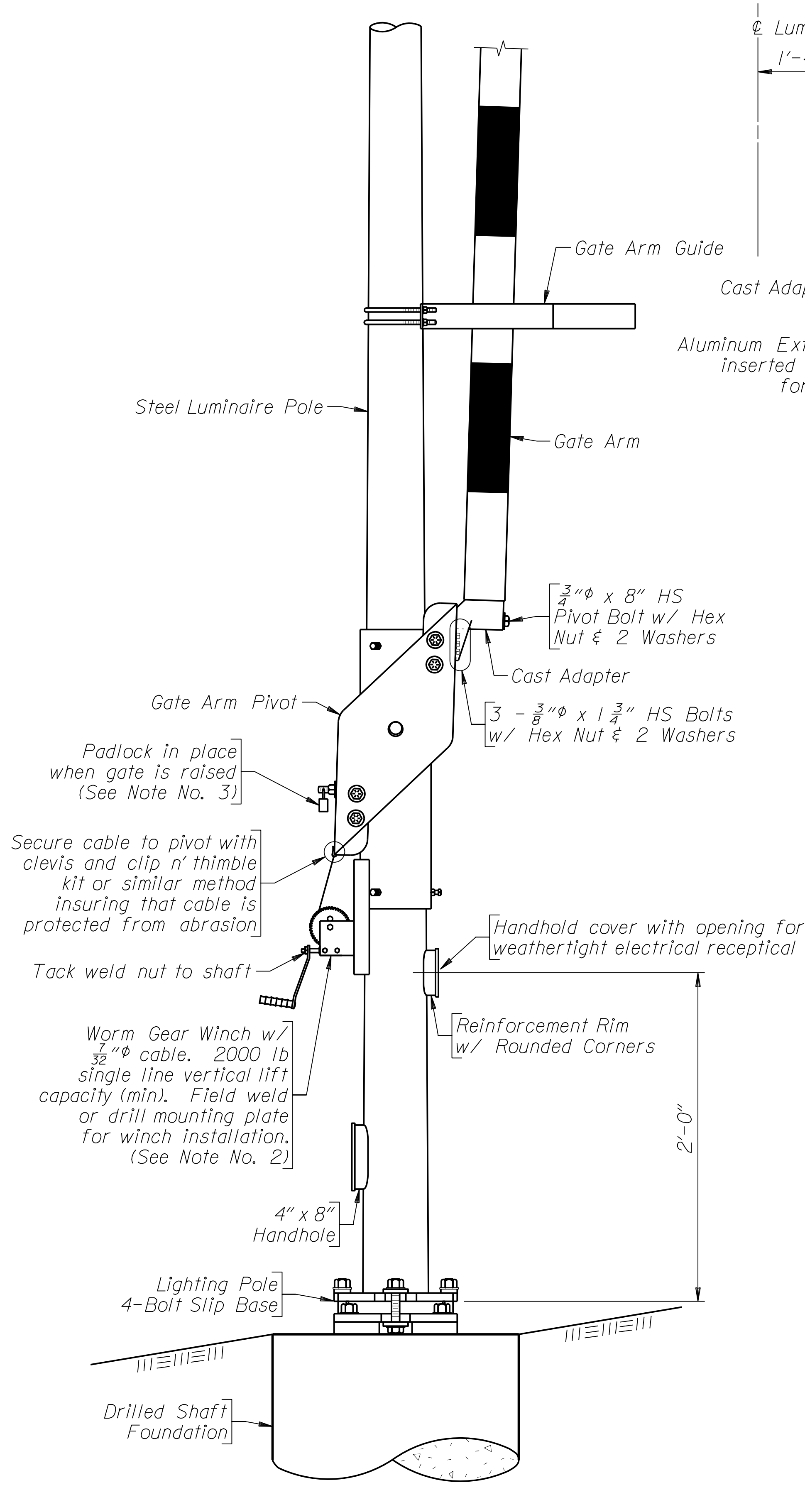
Date: 14-Apr-17 | Sheet 1 of 3

clgate1e17.dgn

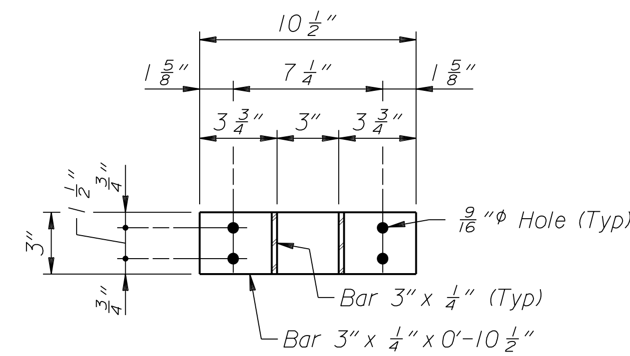
STATE OF WYOMING	PROJECT NO.	SHEET NO.	TOTAL SHEETS
	X	X	X



GATE ARM DETAIL

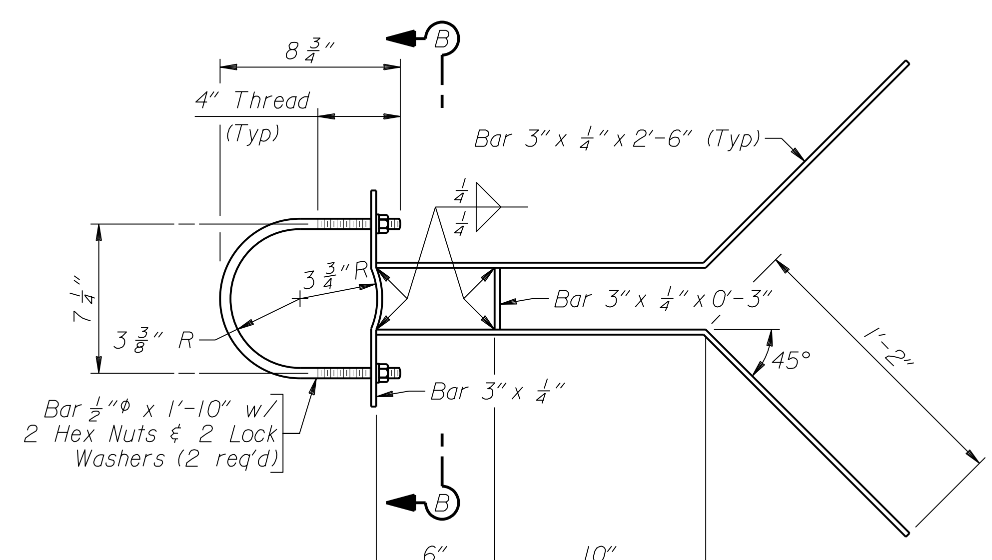


PIVOT ASSEMBLY



SECTION B-B

U-Bolts not shown



GATE ARM GUIDE DETAIL

Note:
1) Use the fiberglass/aluminum gate arm and cast adapter as supplied by Safetran, or equivalent.
2) Use worm gear winch and cable by Dutton - Lainson (Stock number 4Z183), or equivalent.
3) When the gate is fully raised, ensure the nut and washer are placed snugly against the outside of the rear channel and padlocked in place. Supply one heavy, weatherproof padlock with 2 keys for each gate arm pivot. For paired pivots (Divided highway), ensure padlocks are keyed alike.

REVISIONS	
Revised for WYDOT's 2003 Standard Specifications.	14-Jan-05

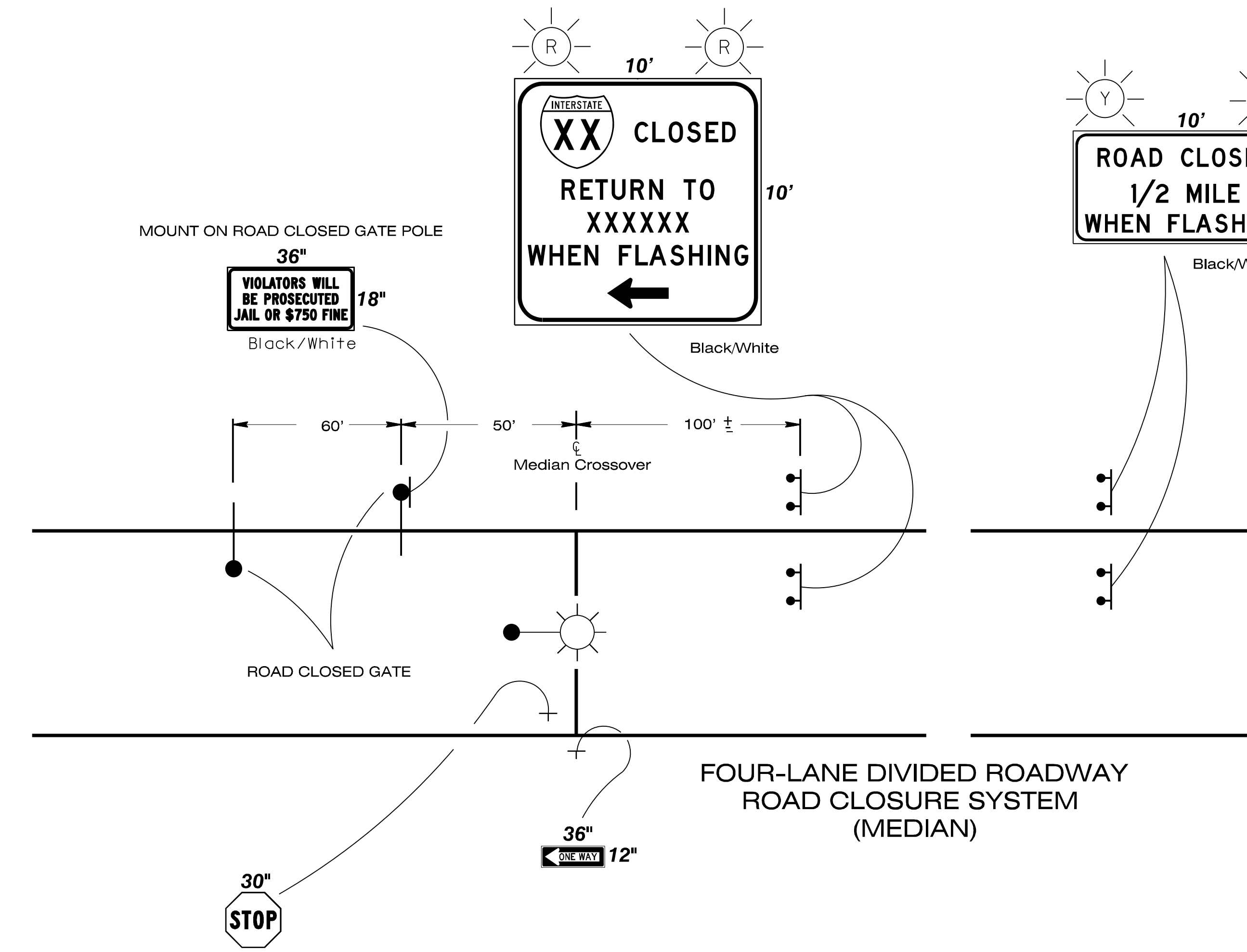
WYOMING DEPARTMENT OF TRANSPORTATION

STANDARD ROAD CLOSURE
DROP GATE DETAILS
(Drop Gate Pivot Details)

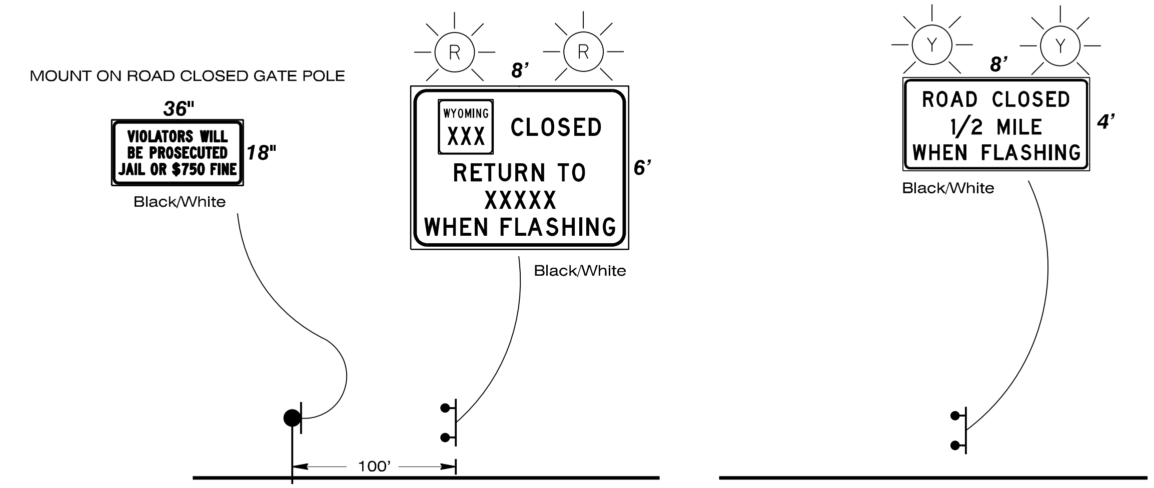
Date: 14-Apr-17 | Sheet 2 of 3

clgate2e17.dgn

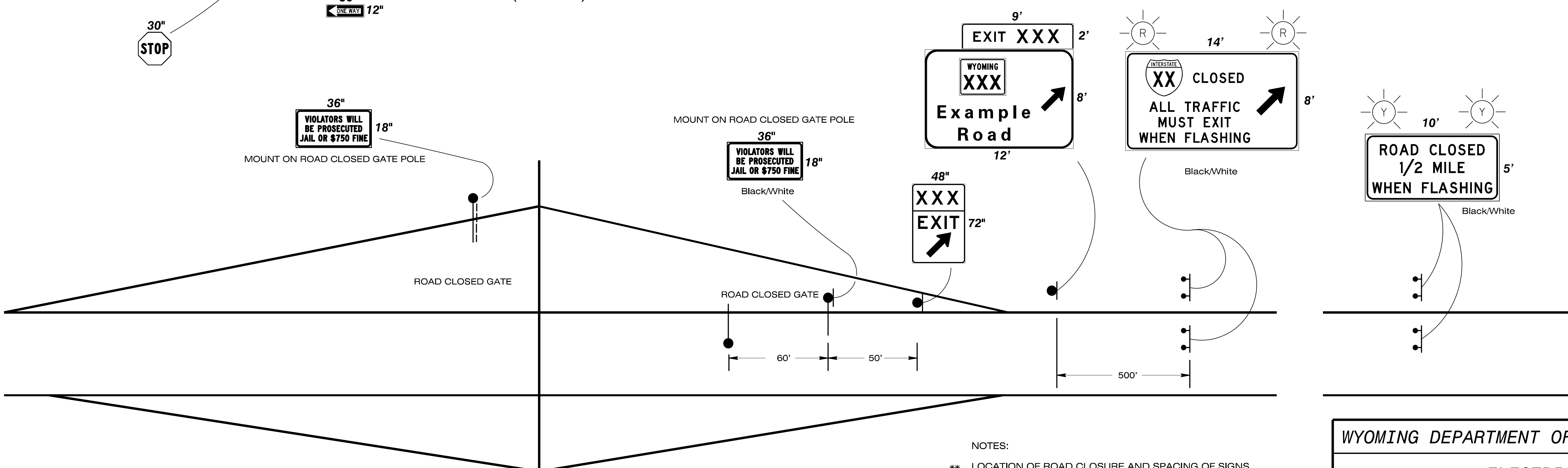
STATE OF WYOMING	PROJ. NO.	SHEET NO.	TOTAL SHEETS
	.	.	.



FOUR-LANE DIVIDED ROADWAY
ROAD CLOSURE SYSTEM
(MEDIAN)



TWO-LANE - TWO-WAY ROADWAY
ROAD CLOSURE SYSTEM



FOUR-LANE DIVIDED ROADWAY
ROAD CLOSURE SYSTEM
(INTERCHANGE)

NOTES:

** LOCATION OF ROAD CLOSURE AND SPACING OF SIGNS WILL VARY DEPENDING UPON LOCAL CONDITIONS.

MESSAGE WILL VARY DEPENDING UPON LOCATION AND DISTRICT CRITERIA.

FOR SIZE AND TYPE OF SIGN PANEL OR POST SEE RESPECTIVE SIGNING SUMMARY SHEET(S).

WYOMING DEPARTMENT OF TRANSPORTATION

ELECTRICAL

ROAD CLOSURE SYSTEM DETAIL

DESIGNER:	DATE:	REV:
ENGINEER:	SHEET _ OF	

APPENDIX B – NEBRASKA DEPARTMENT OF ROADS STANDARD DRAWINGS & SPECIFICATIONS RELATED TO ROAD CLOSURE GATES

OPERATIONS DIVISION

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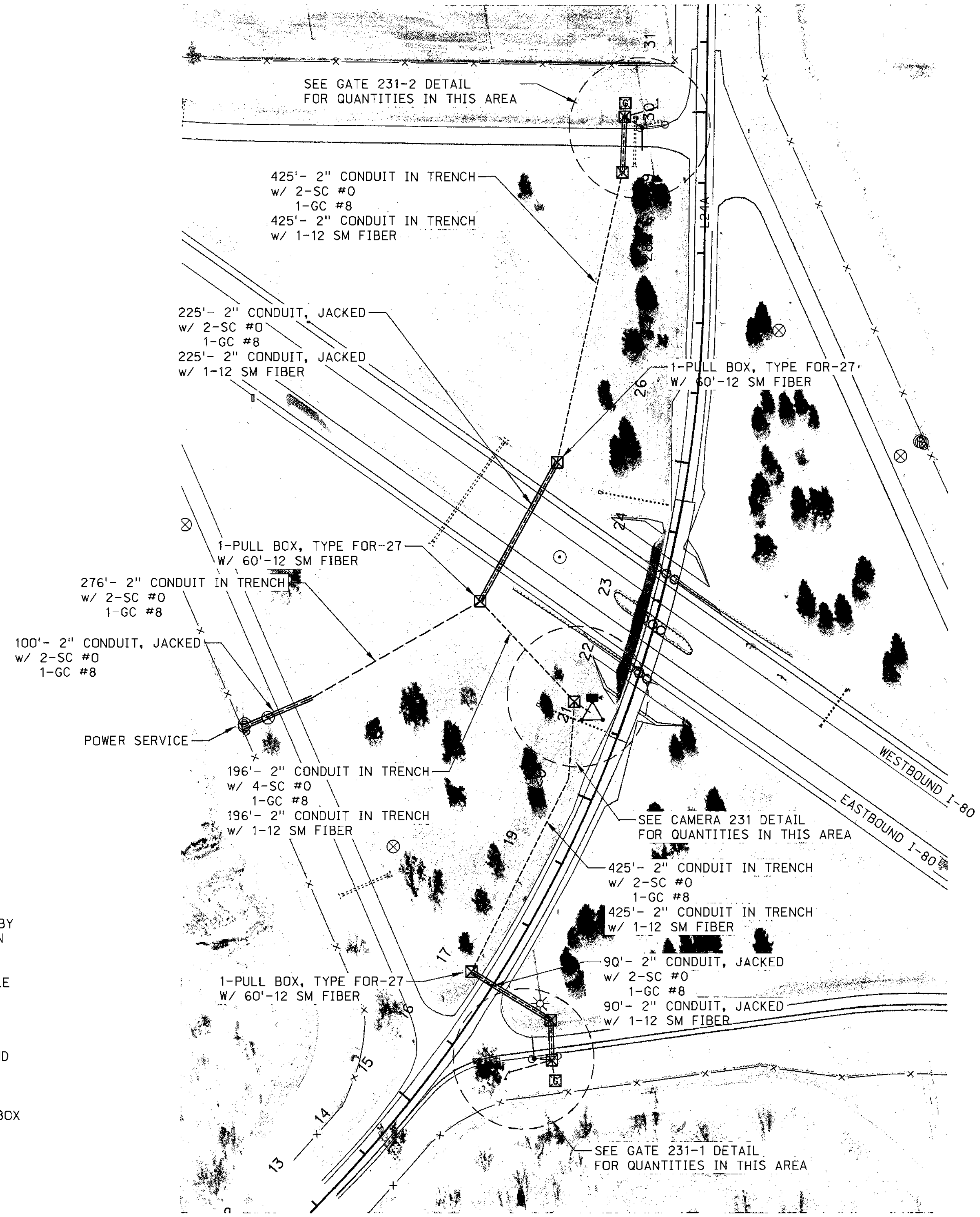
File: 61579Ots.dgn Scale: 1:100



LOCATION 6

SUMMARY OF QUANTITIES

ITEM	UNIT	QUANTITY
2" CONDUIT IN TRENCH	LF	2368
2" CONDUIT, JACKED	LF	730
#0 AWG CU CONDUCTOR (SC #0)	LF	3866
#8 GROUNDING CONDUCTOR	LF	1737
12 SM FIBER OPTIC CABLE	LF	1541
PULL BOX, TYPE FOR-27	EA	3

LEGEND

- DETAIL SHEET AREA
- PULL BOX
- AUTO GATE
- GATE CONTROLLER CABINET
- CAMERA ON TOWER
- SINGLE CONDUIT IN TRENCH
- MULTIPLE CONDUIT IN TRENCH
- CONDUIT JACKED
- EXISTING PULL BOX
- EXISTING ELECTRICAL DISCONNECT
- EXISTING POWER SUPPLY
- EXISTING LIGHTING CONTROL CENTER
- EXISTING LIGHTING UNIT
- EXISTING POWER POLE
- ROW FENCE LINE
- EXISTING POWER LINE
- EXISTING CONDUIT

1. THE LOCATIONS OF ALL AERIAL AND UNDERGROUND UTILITY FACILITIES ARE NOT INDICATED ON THESE PLANS. UNDERGROUND UTILITIES WHETHER SHOWN OR NOT WILL BE LOCATED AND FLAGGED BY THE UTILITIES UPON REQUEST OF THE CONTRACTOR. NO EXCAVATION WILL BE PERMITTED IN THE AREA OF UNDERGROUND UTILITIES UNTIL ALL SUCH FACILITIES HAVE BEEN LOCATED AND IDENTIFIED TO THE SATISFACTION OF PARTIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTION OF ALL UNDERGROUND AND AERIAL UTILITIES AND CONSTRUCTIONS.
2. ALL SURFACE MATERIALS THAT ARE DISTURBED BY EXCAVATION AND BACKFILLING OPERATIONS SHALL BE REPLACED AND RESTORED IN KIND EQUAL TO OR EXCEEDING THE ORIGINAL CONDITION, INCLUDING SODDING AND SEEDING.
3. LINEAR MEASUREMENTS ARE TAKEN BETWEEN TOWER BASE AND PULL BOX CENTERS AND DO NOT INCLUDE ALLOWANCES FOR VERTICAL RISES OR SPLICES.
4. POWER PROVIDED AT EXISTING SERVICE DROP
5. ALL CONDUIT IN TRENCH AND CONDUIT, JACKED SHALL BE PE.
6. THE INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE. INSPECTIONS WILL BE PERFORMED BY DEPARTMENT OF ROADS PERSONNEL. INSPECTION BY OTHER STATE OR LOCAL AGENCIES IS NOT REQUIRED.
7. NDOR SHALL REMOVE EXISTING GATES.

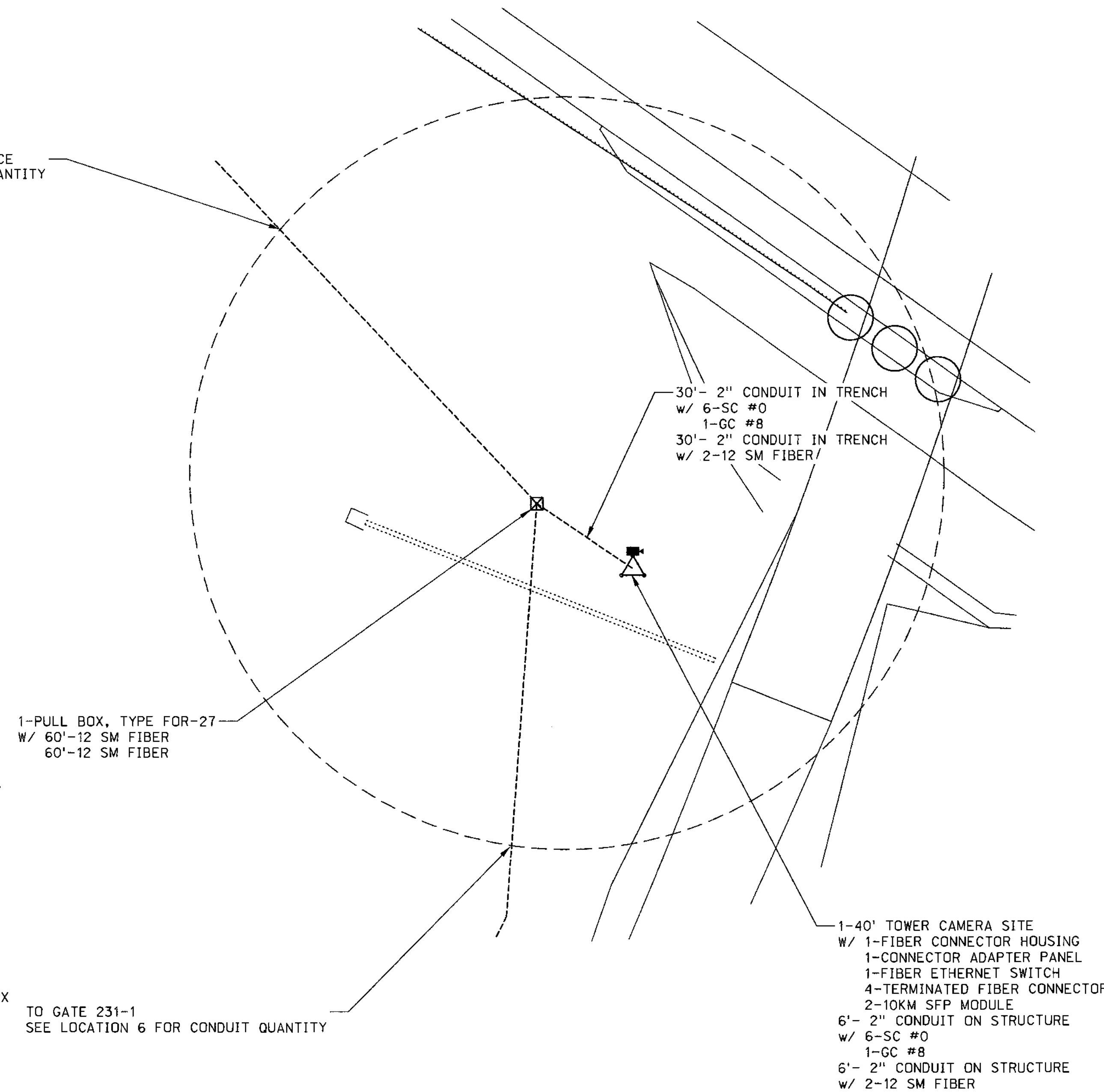
PROFESSIONAL ENGINEER ALICEA F. McCLUSKEY E-12602 17 Aug 16 STATE OF NEBRASKA

NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

LOCATION PLANS

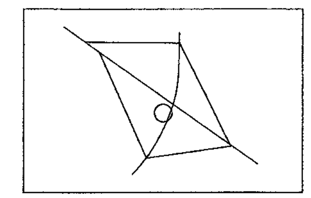
DESIGNED	I-80 R.P. 231.13	6/7
DOR19078	DARR INTERCHANGE	
APPROVED	DATE DRAWN 05/15/2016	ENGINEER	DATE

OPERATIONS DIVISION



SUMMARY OF QUANTITIES

ITEM	UNIT	QUANTITY
2" CONDUIT IN TRENCH	LF	60
2" CONDUIT ON STRUCTURE	LF	12
#0 AWG CU CONDUCTOR (SC #0)	LF	216
#8 GROUNDING CONDUCTOR (GC #8)	LF	36
12 SM FIBER OPTIC CABLE	LF	192
40' TOWER CAMERA SITE	EA	1
FIBER CONNECTOR HOUSING	EA	1
CONNECTOR ADAPTER PANEL	EA	1
FIBER ETHERNET SWITCH	EA	1
TERMINATED FIBER CONNECTOR	EA	4
10 KM SFP MODULE	EA	2
PULL BOX, TYPE FOR-27	EA	1



N

40' TOWER CAMERA SITE

DEVICE	STATION	SIDE	OFFSET (FT)
CAMERA 231	21+16	Lt	45

LEGEND

- PULL BOX
- CAMERA TOWER
- MULTIPLE CONDUIT IN TRENCH
- CONDUIT, JACKED
- EXISTING CAMERA TOWER
- EXISTING PULL BOX
- EXISTING LIGHTING UNIT
- EXISTING POWER POLE
- ROW FENCE LINE
- EXISTING POWER LINE
- EXISTING CONDUIT
- WETLANDS - DO NOT DISTURB

CAMERA GENERAL NOTES

1 THE LOCATIONS OF ALL AERIAL AND UNDERGROUND UTILITY FACILITIES ARE NOT INDICATED ON THESE PLANS. UNDERGROUND UTILITIES WHETHER SHOWN OR NOT WILL BE LOCATED AND FLAGGED BY THE UTILITIES UPON REQUEST OF THE CONTRACTOR. NO EXCAVATION WILL BE PERMITTED IN THE AREA OF UNDERGROUND UTILITIES UNTIL ALL SUCH FACILITIES HAVE BEEN LOCATED AND IDENTIFIED TO THE SATISFACTION OF PARTIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTION OF ALL UNDERGROUND AND AERIAL UTILITIES AND CONSTRUCTIONS.

2 ALL SURFACE MATERIALS THAT ARE DISTURBED BY EXCAVATION AND BACKFILLING OPERATIONS SHALL BE REPLACED AND RESTORED IN KIND EQUAL TO OR EXCEEDING THE ORIGINAL CONDITION, INCLUDING SODDING AND SEEDING.

3 LINEAR MEASUREMENTS ARE TAKEN BETWEEN TOWER BASE AND PULL BOX CENTERS AND DO NOT INCLUDE ALLOWANCES FOR VERTICAL RISES OR SPLICES.

4 THE INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE. INSPECTIONS WILL BE PERFORMED BY DEPARTMENT OF ROADS PERSONNEL. INSPECTION BY OTHER STATE OR LOCAL AGENCIES IS NOT REQUIRED.

5 CONDUIT IN TRENCH AND CONDUIT, JACKED SHALL BE PE CONDUIT.

6 MINIMUM CLEARANCE OF 6.5 FT. SHALL BE PROVIDED BETWEEN THE NEAR SIDE OF GUARDRAIL AND THE BOTTOM OF THE TOWER STRUCTURE.

PROFESSIONAL CIVIL ENGINEER
ALICEA F. McCLUSKEY
E-12602
STATE OF NEBRASKA

NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

INTERCHANGE 231 DETAIL SHEET

DESIGNED	CAMERA 231 DETAIL SOUTHWEST QUADRANT		1/3
DOR19078			
APPROVED	DATE DRAWN	ENGINEER	DATE
	03/15/2016		

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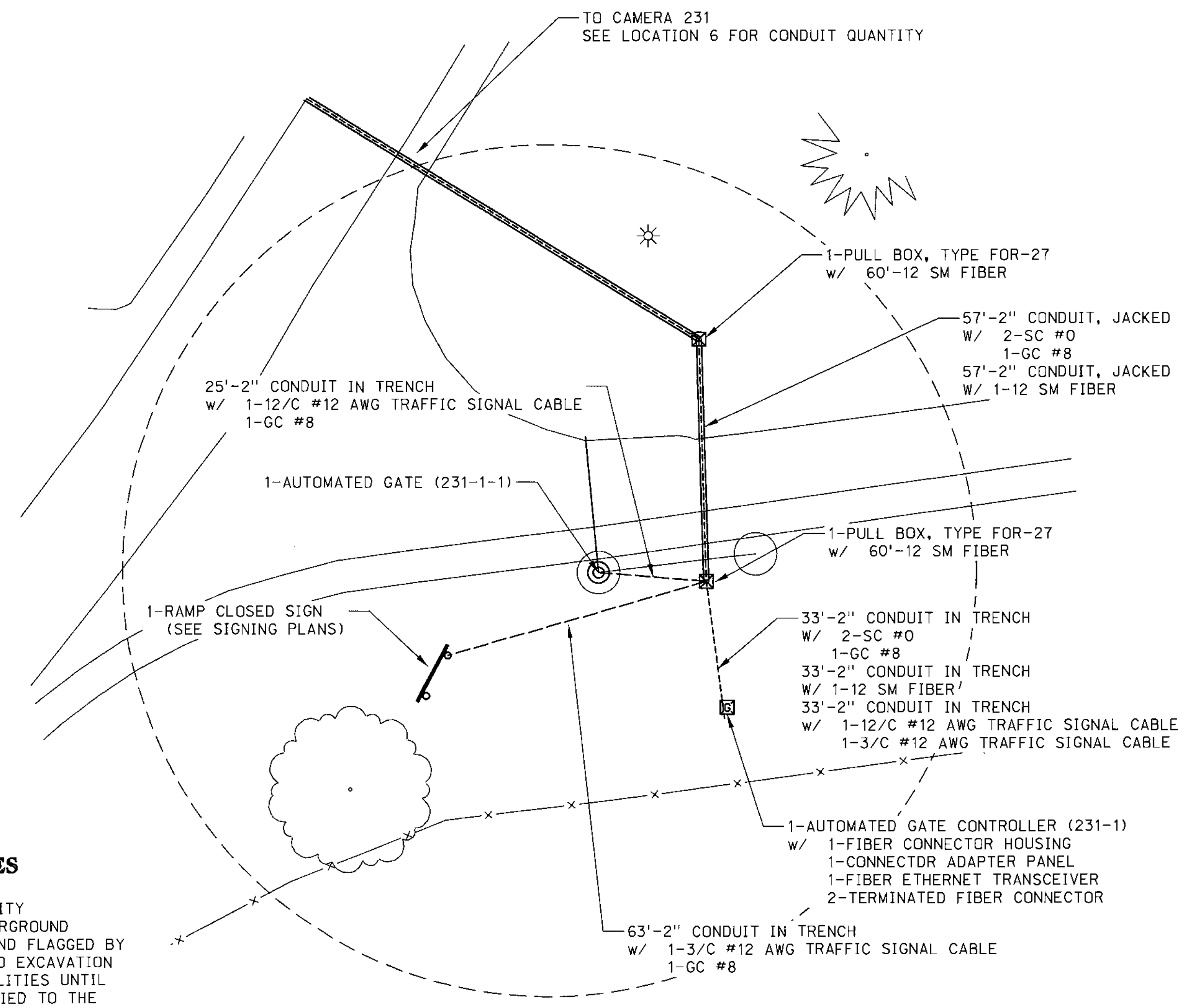
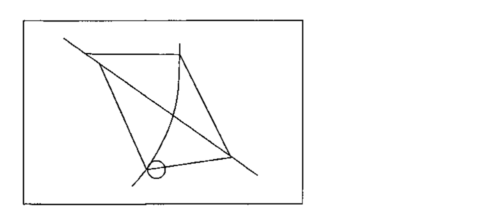
PROJECT NO.	SHEET NO.
ITSN(44)	26

C.N. 61579



SUMMARY OF QUANTITIES

ITEM	UNIT	QUANTITY
2" CONDUIT IN TRENCH	LF	187
2" CONDUIT, JACKED	LF	114
#0 AWG CU CONDUCTOR (SC #0)	LF	180
#8 GROUNDING CONDUCTOR (GC #8)	LF	178
12 SM FIBER OPTIC CABLE	LF	210
AUTOMATED GATE CONTROLLER	EA	1
FIBER CONNECTOR HOUSING	EA	1
CONNECTOR ADAPTER PANEL	EA	1
FIBER ETHERNET TRANSCEIVER	EA	1
TERMINATED FIBER CONNECTOR	EA	2
AUTOMATED GATE	EA	1
12/C #12 AWG TRAFFIC SIGNAL CABLE	LF	58
3/C #12 AWG TRAFFIC SIGNAL CABLE	LF	96
PULL BOX, TYPE FOR-27	EA	2



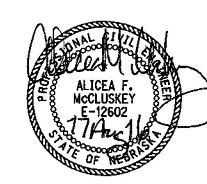
LEGEND

- PULL BOX
- AUTO GATE
- GATE CONTROLLER CABINET
- SINGLE CONDUIT IN TRENCH
- MULTIPLE CONDUIT IN TRENCH
- CONDUIT JACKED
- EXISTING CCTV CAMERA
- EXISTING PULL BOX
- EXISTING ELECTRICAL DISCONNECT
- EXISTING POWER SUPPLY
- EXISTING LIGHTING CONTROL CENTER
- EXISTING LIGHTING UNIT
- EXISTING POWER POLE
- ROW FENCE LINE
- EXISTING POWER LINE
- EXISTING CONDUIT
- WETLANDS - DO NOT DISTURB
- TEMPORARY IMPACTED WETLANDS

AUTOMATED GATE				
DEVICE	STATION	SIDE	OFFSET (FT)	ARM LENGTH
GATE 231-1-1	29+72	Rt	89	31

AUTOMATED GATE GENERAL NOTES

1. THE LOCATIONS OF ALL AERIAL AND UNDERGROUND UTILITY FACILITIES ARE NOT INDICATED ON THESE PLANS. UNDERGROUND UTILITIES WHETHER SHOWN OR NOT WILL BE LOCATED AND FLAGGED BY THE UTILITIES UPON REQUEST OF THE CONTRACTOR. NO EXCAVATION WILL BE PERMITTED IN THE AREA OF UNDERGROUND UTILITIES UNTIL ALL SUCH FACILITIES HAVE BEEN LOCATED AND IDENTIFIED TO THE SATISFACTION OF PARTIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTION OF ALL UNDERGROUND AND AERIAL UTILITIES AND CONSTRUCTIONS.
2. ALL SURFACE MATERIALS THAT ARE DISTURBED BY EXCAVATION AND BACKFILLING OPERATIONS SHALL BE REPLACED AND RESTORED IN KIND EQUAL TO OR EXCEEDING THE ORIGINAL CONDITION, INCLUDING SODDING AND SEEDING.
3. LINEAR MEASUREMENTS ARE TAKEN BETWEEN POLE BASE AND PULL BOX CENTERS AND DO NOT INCLUDE ALLOWANCES FOR VERTICAL RISES OR SPLICES.
4. THE INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE. INSPECTIONS WILL BE PERFORMED BY DEPARTMENT OF ROADS PERSONNEL. INSPECTION BY OTHER STATE OR LOCAL AGENCIES IS NOT REQUIRED.
5. GATE ARM LENGTH SHOWN ON PLANS IS APPROXIMATE. CONTRACTOR SHALL FIELD VERIFY REQUIRED LENGTH PRIOR TO INSTALLATION.
6. MINIMUM CLEARANCE OF 30 FT. SHALL BE PROVIDED BETWEEN THE OUTSIDE EDGE OF TRAVEL LANE AND AUTOMATED GATE CONTROLLER.
7. CONDUIT IN TRENCH AND CONDUIT, JACKED SHALL BE PE CONDUIT.
8. EXISTING GATES SHALL BE REMOVED BY NDOR.



NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

INTERCHANGE 231 DETAIL SHEET

DESIGNED	GATE 231-1 DETAIL EASTBOUND I-80 ON-RAMP		2/3
DOR19078			
APPROVED	DATE DRAWN	ENGINEER	DATE
	05/15/2016		

PROJECT NO.	SHEET NO.
ITSN(44)	27

C.N. 61579

OPERATIONS DIVISION

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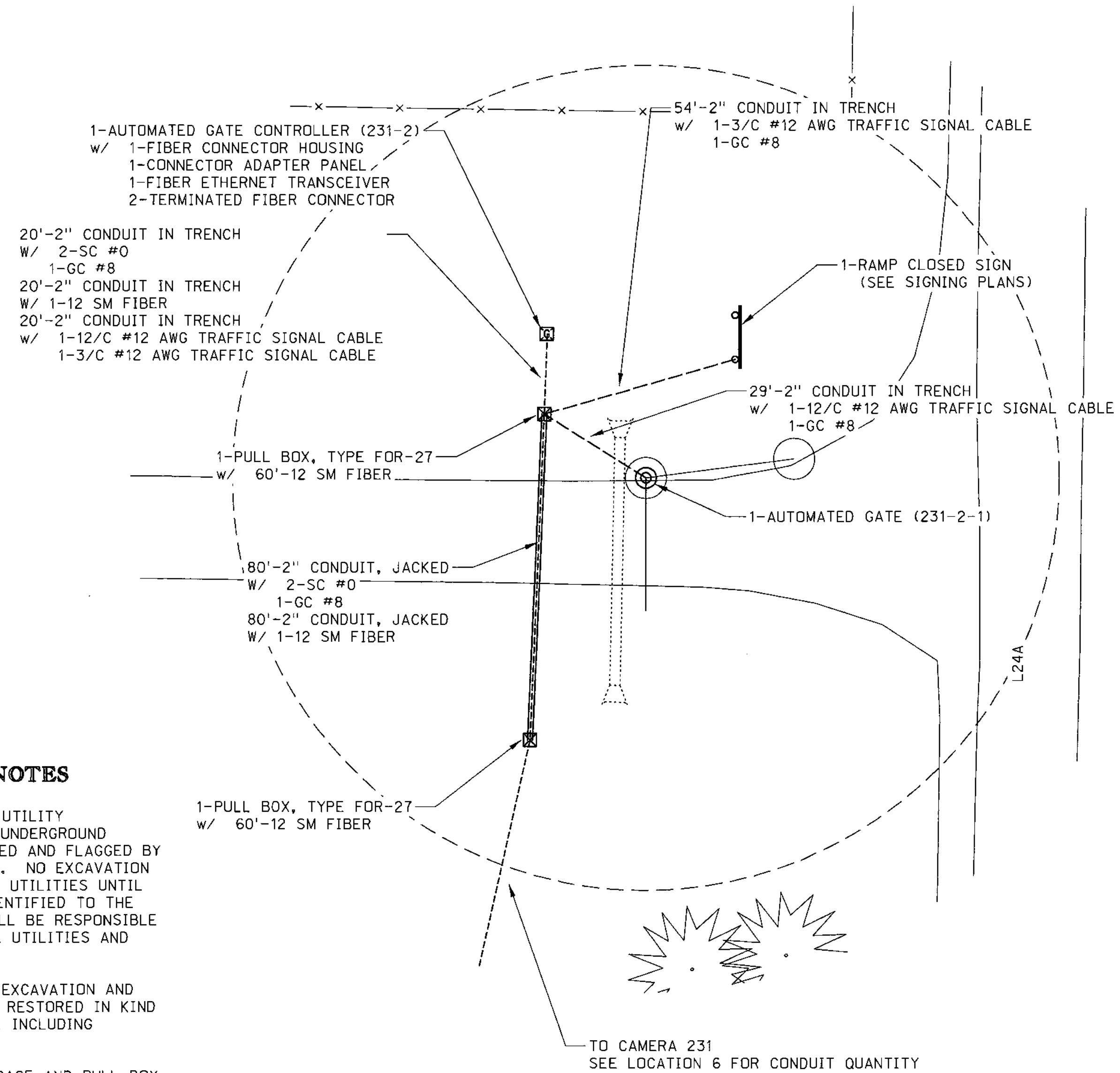
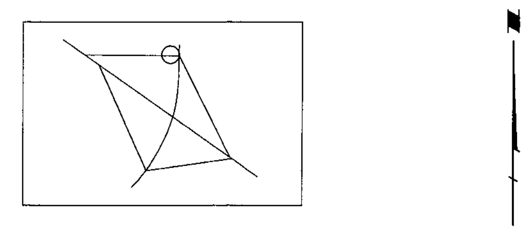


SUMMARY OF QUANTITIES

ITEM	UNIT	QUANTITY
2" CONDUIT IN TRENCH	LF	143
2" CONDUIT, JACKED	LF	160
#0 AWG CU CONDUCTOR (SC #0)	LF	200
#8 GROUNDING CONDUCTOR (GC #8)	LF	183
12 SM FIBER OPTIC CABLE	LF	220
AUTOMATED GATE CONTROLLER	EA	1
FIBER CONNECTOR HOUSING	EA	1
CONNECTOR ADAPTER PANEL	EA	1
FIBER ETHERNET TRANSCEIVER	EA	1
TERMINATED FIBER CONNECTOR	EA	2
AUTOMATED GATE	EA	1
12/C #12 AWG TRAFFIC SIGNAL CABLE	LF	49
3/C #12 AWG TRAFFIC SIGNAL CABLE	LF	74
PULL BOX, TYPE FOR-27	EA	2



LEGEND

- PULL BOX
- AUTO GATE
- GATE CONTROLLER CABINET
- SINGLE CONDUIT IN TRENCH
- MULTIPLE CONDUIT IN TRENCH
- CONDUIT JACKED
- EXISTING CCTV CAMERA
- EXISTING PULL BOX
- EXISTING ELECTRICAL DISCONNECT
- EXISTING POWER SUPPLY
- EXISTING LIGHTING CONTROL CENTER
- EXISTING LIGHTING UNIT
- EXISTING POWER POLE
- ROW FENCE LINE
- EXISTING POWER LINE
- EXISTING CONDUIT
- WETLANDS - DO NOT DISTURB
- TEMPORARY IMPACTED WETLANDS

AUTOMATED GATE				
DEVICE	STATION	SIDE	OFFSET (FT)	ARM LENGTH
GATE 231-2-1	29+72	Lt.	89	29

AUTOMATED GATE GENERAL NOTES

1 THE LOCATIONS OF ALL AERIAL AND UNDERGROUND UTILITY FACILITIES ARE NOT INDICATED ON THESE PLANS. UNDERGROUND UTILITIES WHETHER SHOWN OR NOT WILL BE LOCATED AND FLAGGED BY THE UTILITIES UPON REQUEST OF THE CONTRACTOR. NO EXCAVATION WILL BE PERMITTED IN THE AREA OF UNDERGROUND UTILITIES UNTIL ALL SUCH FACILITIES HAVE BEEN LOCATED AND IDENTIFIED TO THE SATISFACTION OF PARTIES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTION OF ALL UNDERGROUND AND AERIAL UTILITIES AND CONSTRUCTIONS.

2 ALL SURFACE MATERIALS THAT ARE DISTURBED BY EXCAVATION AND BACKFILLING OPERATIONS SHALL BE REPLACED AND RESTORED IN KIND EQUAL TO OR EXCEEDING THE ORIGINAL CONDITION, INCLUDING SODDING AND SEEDING.

3 LINEAR MEASUREMENTS ARE TAKEN BETWEEN POLE BASE AND PULL BOX CENTERS AND DO NOT INCLUDE ALLOWANCES FOR VERTICAL RISES OR SPLICES.

4 THE INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE. INSPECTIONS WILL BE PERFORMED BY DEPARTMENT OF ROADS PERSONNEL. INSPECTION BY OTHER STATE OR LOCAL AGENCIES IS NOT REQUIRED.

5 GATE ARM LENGTH SHOWN ON PLANS IS APPROXIMATE. CONTRACTOR SHALL FIELD VERIFY REQUIRED LENGTH PRIOR TO INSTALLATION.

6 MINIMUM CLEARANCE OF 30 FT. SHALL BE PROVIDED BETWEEN THE OUTSIDE EDGE OF TRAVEL LANE AND AUTOMATED GATE CONTROLLER.

7 CONDUIT IN TRENCH AND CONDUIT, JACKED SHALL BE PE CONDUIT.

8 EXISTING GATES SHALL BE REMOVED BY NDOR.

PROFESSIONAL CIVIL ENGINEER ALICEA F. McCLUSKEY E-12602 STATE OF NEBRASKA 17Aug16

NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

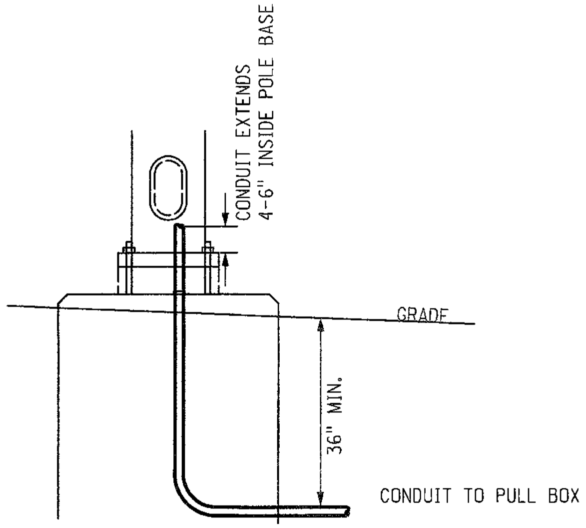
INTERCHANGE 231 DETAIL SHEET

DESIGNED	GATE 231-2 DETAIL		3/3
DOR19078	WESTBOUND I-80 ON-RAMP		
APPROVED	DATE DRAWN	ENGINEER	DATE
	05/15/2016		

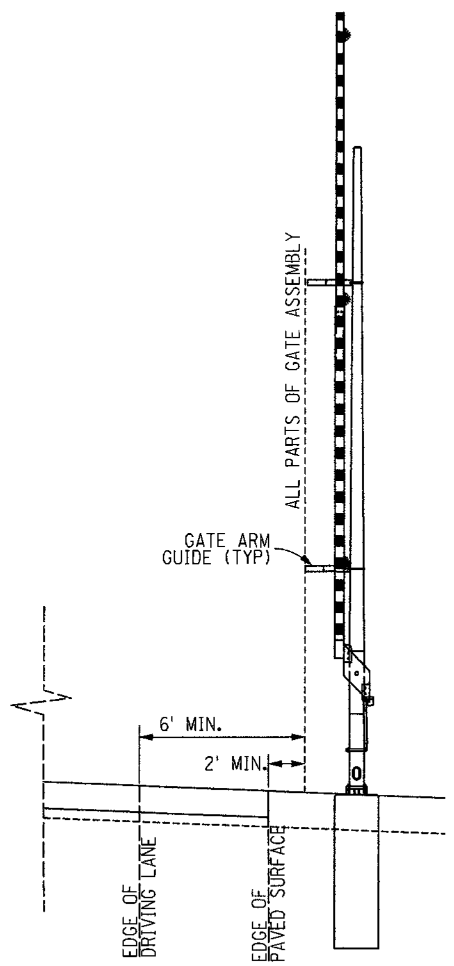
PROJECT NO.	SHEET NO.
ITSN(44)	36

C.N. 61579

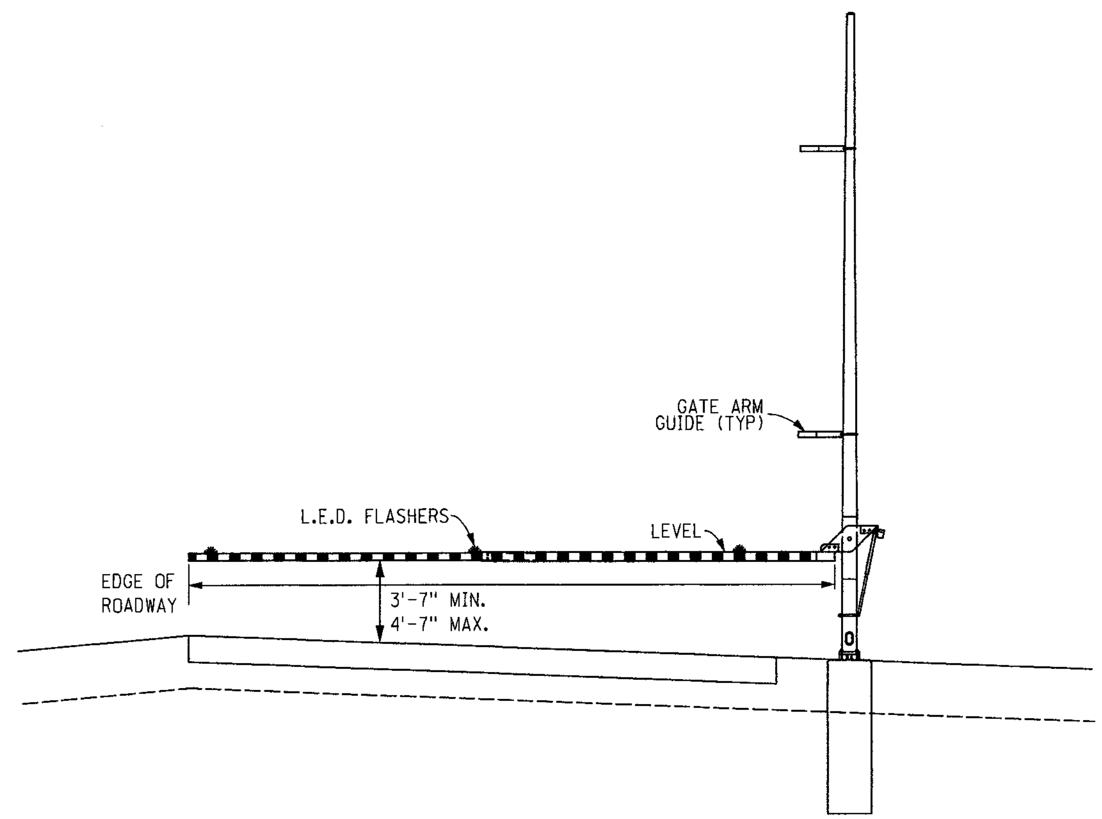
TRAFFIC ENGINEERING DIVISION



CONDUIT IN FOUNDATION



AUTOMATED GATE
CLEARANCE IN UP POSITION



TYPICAL SECTION OF INSTALLED
AUTOMATED GATE IN DOWN POSITION

AUTO GATE GENERAL NOTES

1 MINIMUM CLEARANCE OF 2 FT. SHALL BE PROVIDED BETWEEN THE OUTSIDE EDGE OF PAVEMENT AND ALL PARTS OF THE AUTOMATED GATE AND SUPPORT WHEN GATE IS IN THE UP (VERTICAL) POSITION.

MINIMUM CLEARANCE OF 6 FT. SHALL BE PROVIDED BETWEEN THE OUTSIDE EDGE OF DRIVING LANE AND ALL PARTS OF THE AUTOMATED GATE AND SUPPORT WHEN GATE IS IN THE UP (VERTICAL) POSITION.

2 GATE FOUNDATION SHALL BE INSTALLED ON THE SIDE OF ROAD NOTED IN THE PLANS.

3 GATE ARM SHALL EXTEND TO THE OPPOSITE EDGE OF ROADWAY WHEN IN THE DOWN (HORIZONTAL) POSITION.

4 INSTALLED GATE ARM SHALL BE LEVEL WHEN IN THE DOWN (HORIZONTAL) POSITION

5 POWER AND CONTROL FOR AUTOMATED GATE SHALL BE PROVIDED BY THE AUTOMATED GATE CONTROLLER CABINET.

6 THREE BEACONS SHALL BE INSTALLED ON TOP OF THE GATE ARM AT EQUAL SPACING WITH THE LEFT-MOST BEACON LOCATED 1' FROM THE LEFT EDGE OF THE ROADWAY SURFACE AND RIGHT-MOST BEACON LOCATED ABOVE THE RIGHT EDGE OF THE ROADWAY SURFACE.

7 THE INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE. INSPECTIONS WILL BE PERFORMED BY DEPARTMENT OF ROADS PERSONNEL. INSPECTION BY OTHER STATE OR LOCAL AGENCIES IS NOT REQUIRED.

File: automated gate typical.dgn Scale: 1:50 Date: 18-MAY-2016 10:56 User: dor19078 Computer: DROPERATIONS100

PROFESSIONAL CIVIL ENGINEER ALICEA F. McCLUSKEY E-12902 STATE OF NEBRASKA

NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

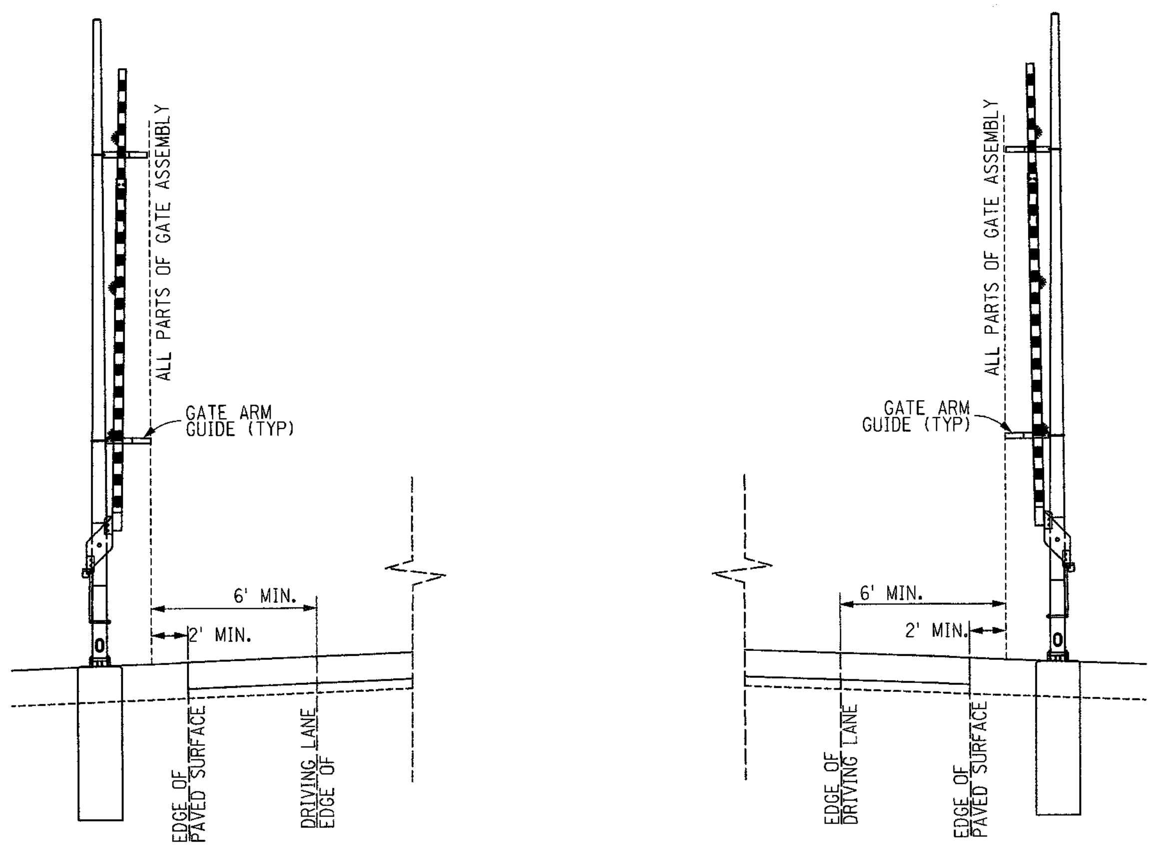
AUTOMATED GATE TYPICAL

DESIGNED DOR19078	AUTOMATED GATE ASSEMBLY ROADWAY WIDTHS LESS THAN 30'		1/1
REVIEWED			
APPROVED	DATE DRAWN 3/17/2016	ENGINEER	DATE

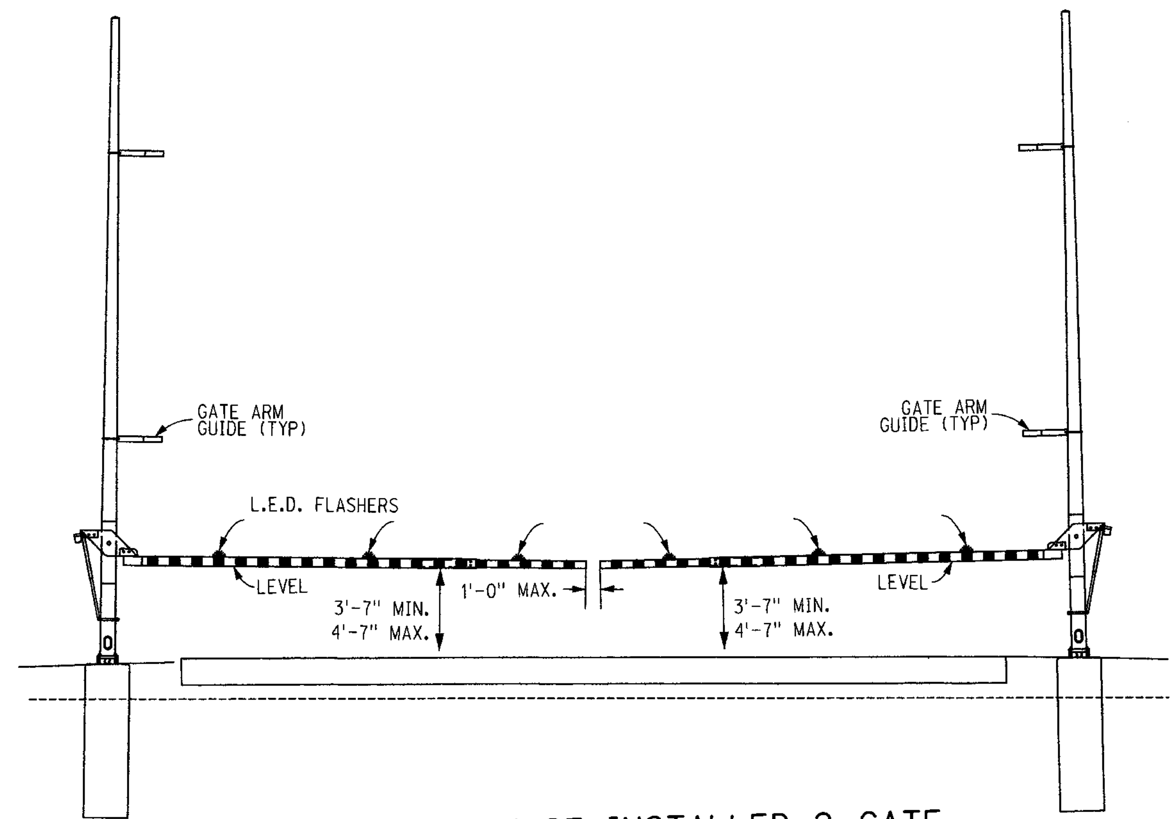
PROJECT NO.	SHEET NO.
ITSN(44)	37

C.N. 61579

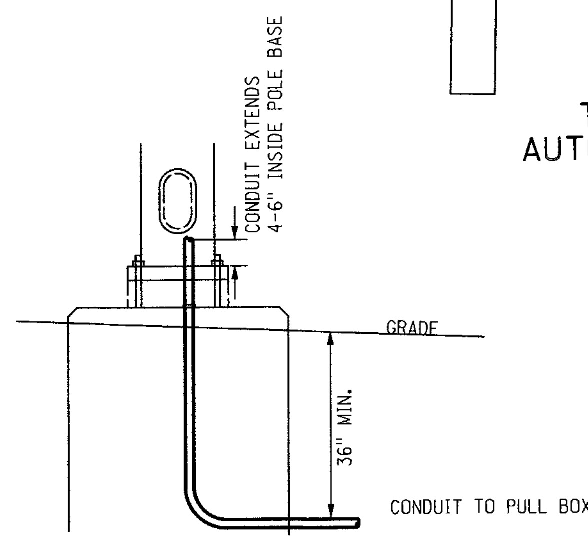
TRAFFIC ENGINEERING DIVISION



AUTOMATED GATE ASSEMBLY CLEARANCE IN UP POSITION



TYPICAL SECTION OF INSTALLED 2-GATE AUTOMATED GATE ASSEMBLY IN DOWN POSITION



CONDUIT IN ASSEMBLY BASE

AUTO GATE GENERAL NOTES

1 MINIMUM CLEARANCE OF 2 FT. SHALL BE PROVIDED BETWEEN THE OUTSIDE EDGE OF PAVEMENT AND ALL PARTS OF THE AUTOMATED GATE AND SUPPORT WHEN GATE IS IN THE UP (VERTICAL) POSITION.

MINIMUM CLEARANCE OF 6 FT. SHALL BE PROVIDED BETWEEN THE OUTSIDE EDGE OF DRIVING LANE AND ALL PARTS OF THE AUTOMATED GATE AND SUPPORT WHEN GATE IS IN THE UP (VERTICAL) POSITION.

2 GATE ASSEMBLY SHALL BE INSTALLED SO THAT THE GATE ARMS IN THE DOWN (HORIZONTAL) POSITION FORM A SINGLE STRAIGHT LINE.

GATE ARMS SHALL HAVE A MAXIMUM GAP OF 1' BETWEEN THEM WHEN IN THE DOWN POSITION.

3 POWER AND CONTROL FOR GATES SHALL BE PROVIDED BY THE AUTOMATED GATE CONTROLLER.

4 SIX BEACONS SHALL BE INSTALLED ON TOP OF THE GATE ARMS AT EQUAL SPACING WITH THE LEFT-MOST BEACON ON THE LEFT GATE ARM LOCATED ABOVE THE LEFT EDGE OF THE ROADWAY SURFACE AND THE RIGHT-MOST BEACON ON THE RIGHT GATE ARM LOCATED ABOVE THE RIGHT EDGE OF THE ROADWAY SURFACE.

5 THE INSTALLATION SHALL BE IN ACCORDANCE WITH THE NATIONAL ELECTRIC CODE. INSPECTIONS WILL BE PERFORMED BY DEPARTMENT OF ROADS PERSONNEL. INSPECTION BY OTHER STATE OR LOCAL AGENCIES IS NOT REQUIRED.

Computer: DROPERATIONS100 User: dor19078 Date: 18-MAY-2016 10:56
File: automated gate typical.dgn
Scale: 1:50

PROFESSIONAL CIVIL ENGINEER ALICEA F. McCLUSKEY E-12602 STATE OF NEBRASKA

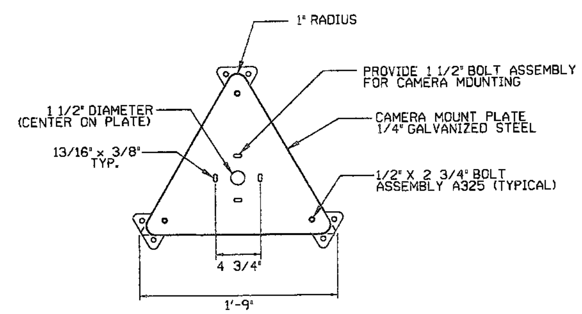
NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

AUTOMATED GATE ASSEMBLY TYPICAL

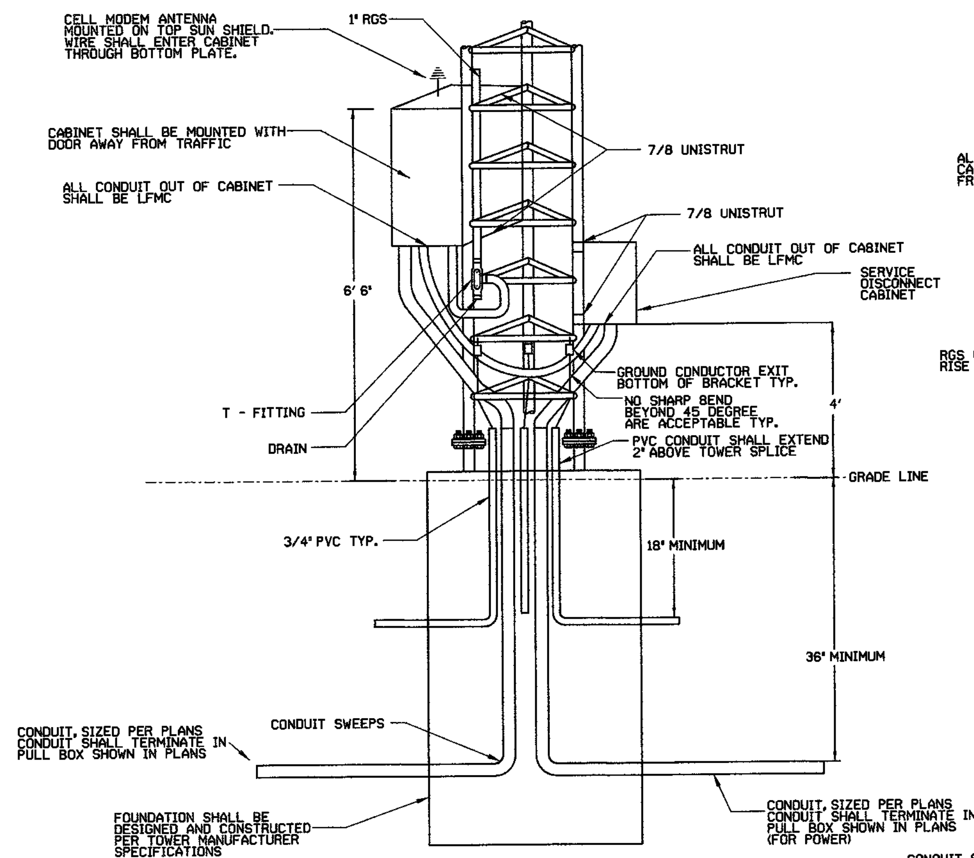
DESIGNED DOR19078	TWO GATE ARRANGEMENT ROADWAY WIDTHS GREATER THAN 30'	1/1
REVIEWED		
APPROVED	DATE DRAWN 3/17/2016	ENGINEER / DATE

PROJECT NO.	SHEET NO.
ITSN(44)	39

C.N. 61579

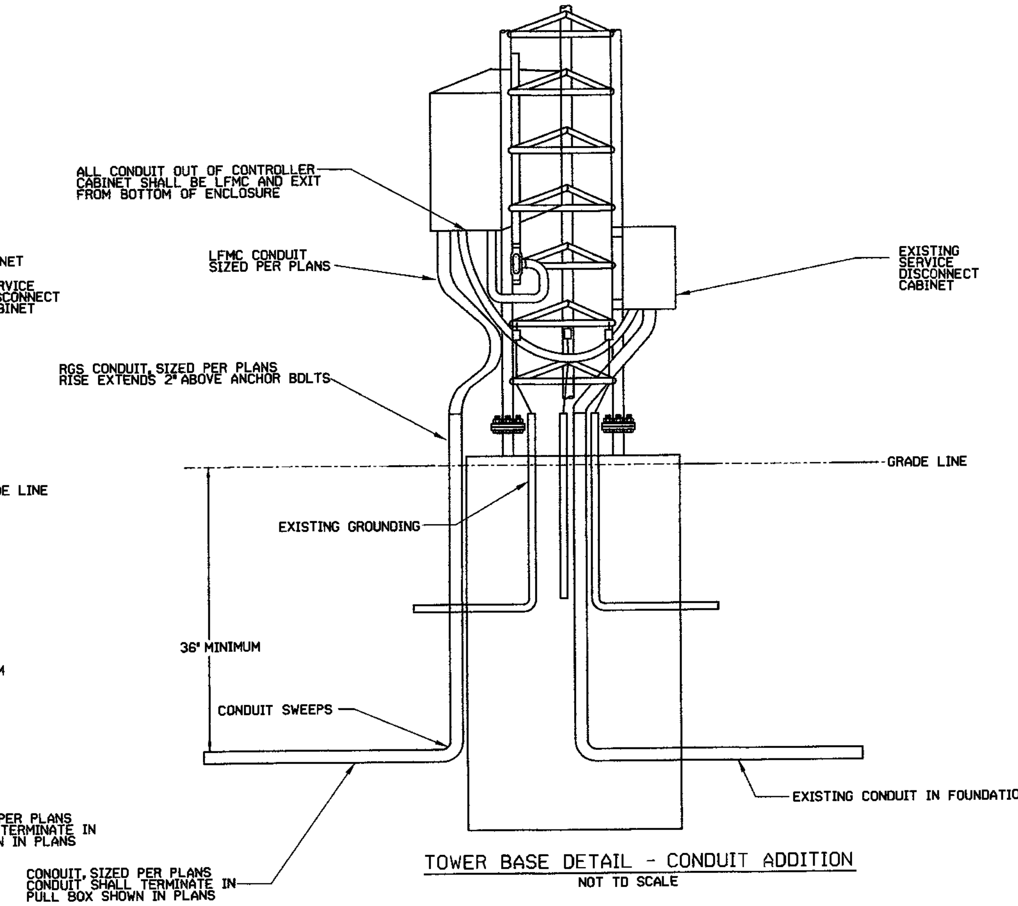


CAMERA MOUNT PLATE
NOT TO SCALE



TOWER BASE DETAIL - NEW CONSTRUCTION
NOT TO SCALE

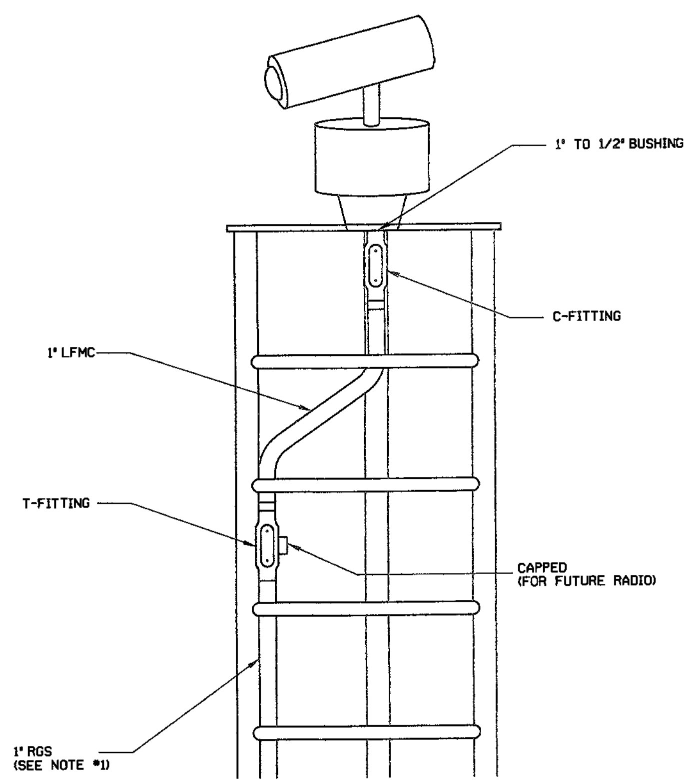
LOCATIONS 1, 2, 4, 5, 6



TOWER BASE DETAIL - CONDUIT ADDITION
NOT TO SCALE

TYPICAL CONDUIT ADDITION TO EXISTING CAMERA TOWER SITE

LOCATIONS 3, 7



TOP CAMERA MOUNT DETAIL
NOT TO SCALE

GENERAL NOTES:

1. ALL CONNECTIONS TO CONTROL ENCLOSURE SHALL BE MADE THROUGH THE BOTTOM OF THE ENCLOSURE.
2. LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC) MUST HAVE A DRIP LOOP THAT EXTENDS 12" BELOW THE LOWEST DEVICE OR FITTING.
3. ALL GROUNDING CONDUITS SHALL NOT HAVE SHARP BENDS BEYOND 45 DEGREES.
4. THE 1" RGS CONDUIT ON THE INSIDE OF THE TOWER SHALL BE 35' FOR 40' TOWERS, 45' FOR 50' TOWERS, AND 55' FOR 60' TOWERS.
5. THE CAMERA SHALL NOT BE MOUNTED UNTIL THE TOWER IS ERECTED.
6. THE CAMERA SHALL BE TOP MOUNTED UNLESS SPECIFIED.

NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

CAMERA TYPICAL PLAN

DESIGNED	CAMERA TOWER
REVIEWED	CONDUIT AND MOUNTING DETAIL
APPROVED	DATE DRAWN / ENGINEER / DATE

OPERATIONS DIVISION
Computer: DROPERATIONS100
User: dor19078
Date: 20-MAY-2016 14:13
File: camera tower detail.dgn
Scale: 1:100

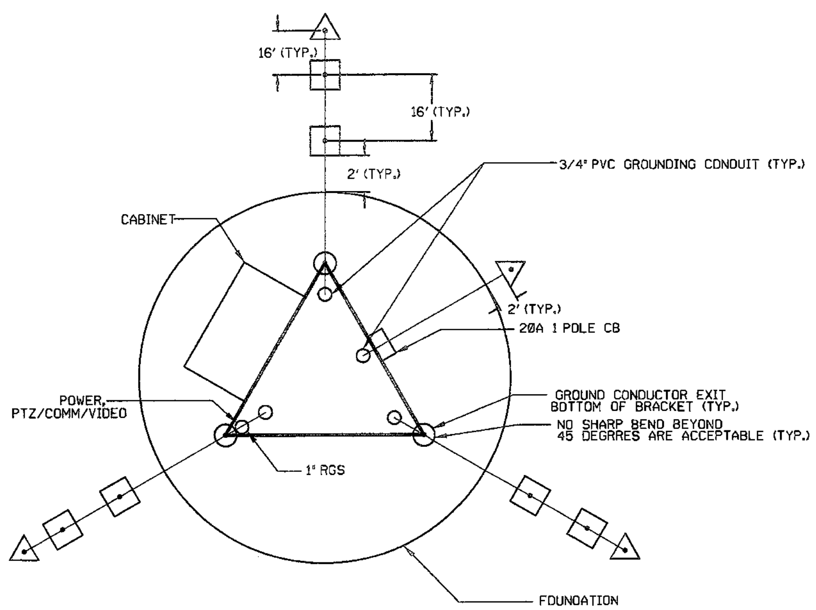
PROJECT NO.	SHEET NO.
ITSN(44)	40

C.N. 61579

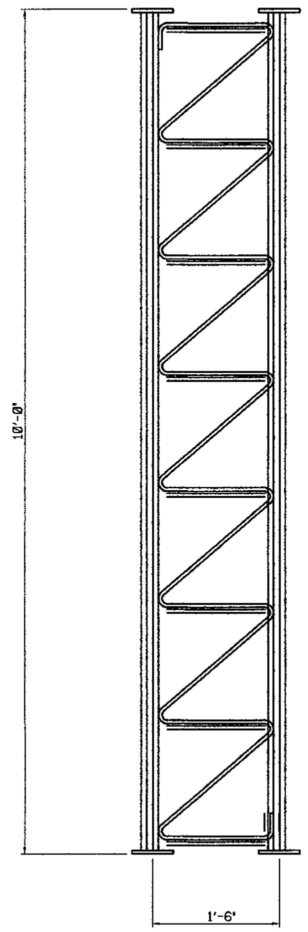
OPERATIONS DIVISION

LEGEND

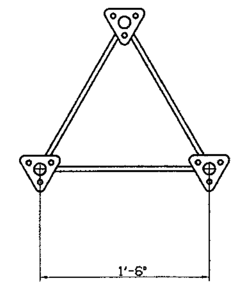
- △ SELF SUPPORTING TOWER
- — #2 BARE COPPER WIRE, MINIMUM OF 18" BELOW GRADE
- ⊙ CADWELD TYPE VB, REMOVE 1 SQ. IN. OF GALVANIZING
- ⊡ CADWELD TYPE GT W/3/4" X 8 ft COPPER CLAD GROUND ROD
- ⚠ CADWELD TYPE GR W/3/4" X 8 ft COPPER CLAD GROUND ROD



GROUNDING DETAIL
NOT TO SCALE

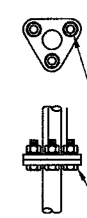


TOWER SECTION
NOT TO SCALE



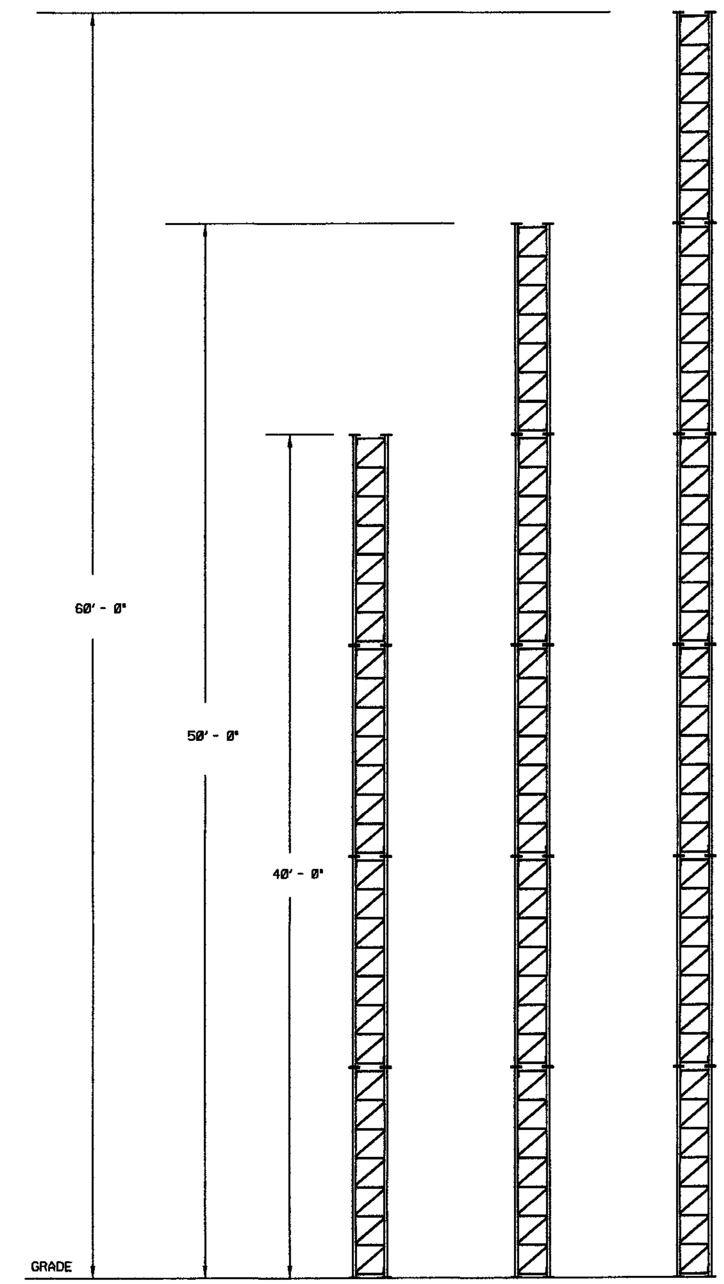
(TYPICAL)

TOWER SECTION
NOT TO SCALE



SPLICE DETAIL
NOT TO SCALE

CONSULT TOWER MANUFACTURER FOR BOLT ASSEMBLY DETAILS



TOWER HEIGHT DETAIL
NOT TO SCALE

GENERAL NOTES:

1. MAXIMUM GROUND RESISTENCE SHALL BE 20 OHMS OR LESS.
2. THE DISTANCE BETWEEN THE END POINTS OF THE GROUND LEADS SHALL NOT BE LESS THAN THE LENGTH OF THE LONGEST LEAD.
3. GROUNDING SHALL EXIT FOUNDATION AS ILLUSTRATED.
4. GROUNDING ARRAY SHALL BE MAPPED IN AS-BUILTS.

BOLT INSTALLATION NOTES:

1. BOLTS FOR TOWERS SHALL BE INSTALLED WITH THE NUTS FACING TO THE TOP OF THE TOWER.
2. ALL HIGH STRENGTH BOLTS SHALL BE TIGHTENED TO A SNUG-TIGHT CONDITION, PER NDOR SPECIFICATIONS.
3. ALL NUTS SHALL BE EQUIPPED WITH SOME TYPE OF NUT LOCKING DEVICE. SEE THE TOWER MANUFACTURER FOR THE TYPE OF NUT LOCKING DEVICE TO BE USED FOR EACH INDIVIDUAL APPLICATION.

PROFESSIONAL CIVIL ENGINEER
MATTHEW J. BAKER
E-12761
STATE OF NEBRASKA

NEBRASKA DEPARTMENT OF ROADS
OPERATIONS DIVISION ITS

CAMERA TYPICAL PLAN

DESIGNED	CAMERA TOWER AND GROUNDING DETAIL
REVIEWED	
APPROVED	DATE DRAWN / ENGINEER / DATE

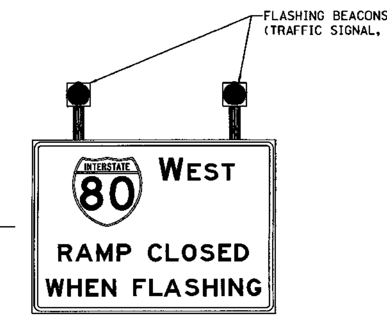
File: camera tower detail.dgn
Scale: 1:100
Date: 20-MAY-2016 14:13
User: dor19078
Computer: DROPERATIONS100

PROJECT NO.	SHEET NO.
ITSN(44)	50

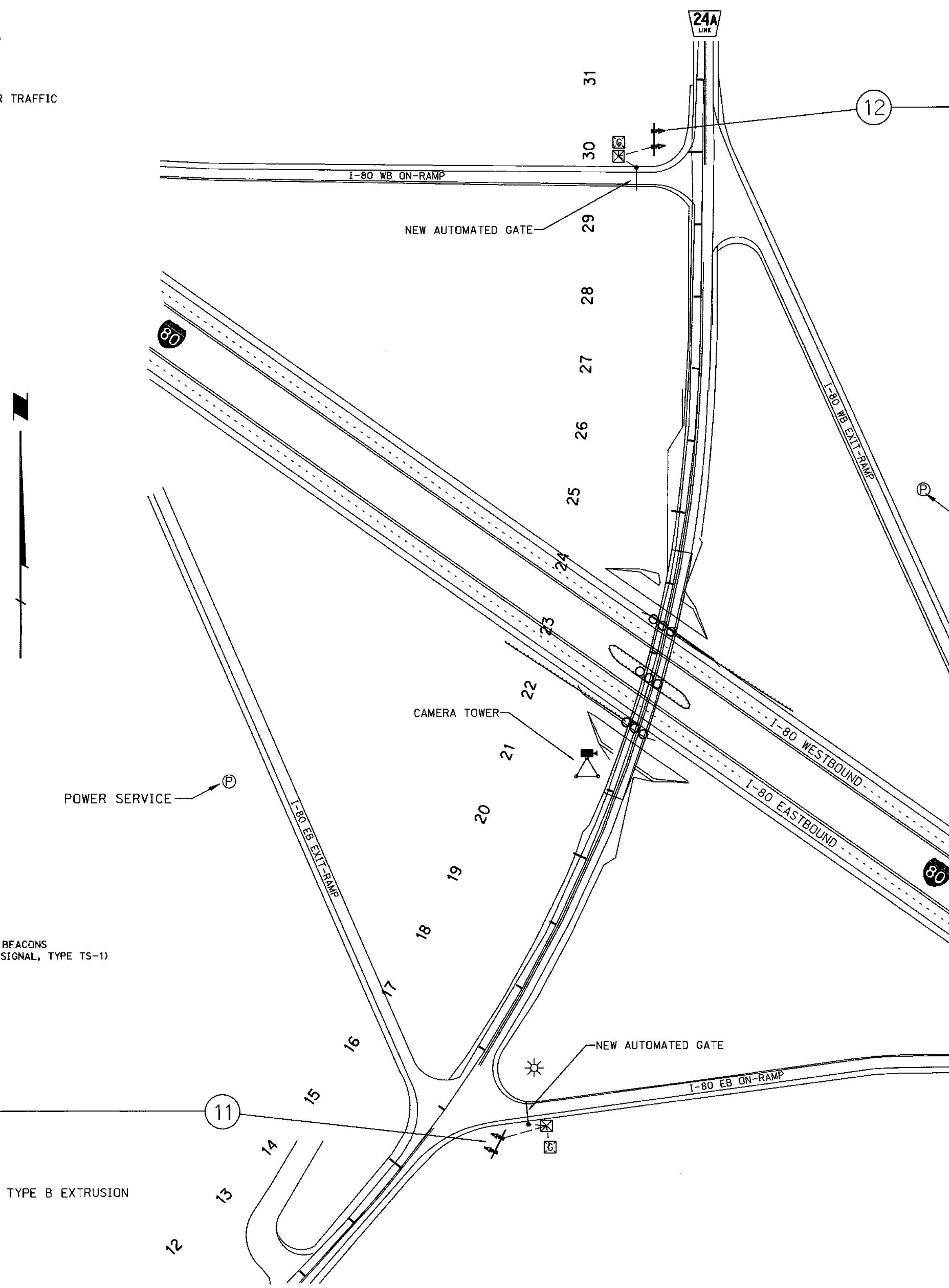
C.N. 61579

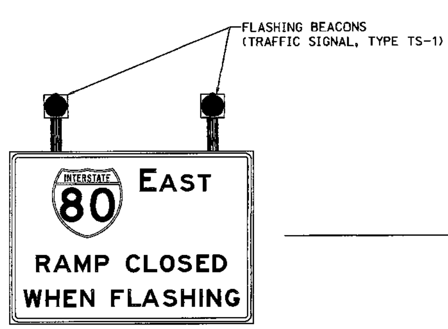
GENERAL NOTES

1. FURNISH, BUILD, AND INSTALL TYPE 'B' SIGN(S).
2. FURNISH, BUILD, AND INSTALL BREAK-A-WAY SIGN SUPPORTS AND FOOTINGS USING 4" X 6" WOOD POSTS.
3. FURNISH, BUILD, AND INSTALL TWO (2) TRAFFIC SIGNALS, TYPE TS-1; T11 FACE, VISOR, WITH RED LED LAMPS.
4. INSTALL SIGN(S) AT A MINIMUM 5' MOUNTING HEIGHT ABOVE ROADWAY ELEVATION.
5. SIGN(S) SHALL NOT BE INSTALLED SO AS TO OBSTRUCT THE MOTORIST'S VIEW OF OTHER TRAFFIC CONTROL DEVICES.



SIGN NO: R40-9D-84 (I-80 WEST), TYPE B - EXTRUSION
SIZE: 7'-0" X 5'-0"
STA.: 30+15 LT
NOTES: 1, 2, 3, 4, 5





SIGN NO.: R40-9D-84 (I-80 EAST), TYPE B EXTRUSION
SIZE: 7'-0" X 5'-0"
STA.: 15+07 RT
NOTES: 1, 2, 3, 4, 5

LEGEND

- SINGLE POST SIGN
- DOUBLE POST SIGN

PROFESSIONAL INDUSTRIAL ENGINEER — KRISTINE S. FORNOFF — E-12765 — STATE OF NEBRASKA

NEBRASKA DEPARTMENT OF ROADS
TRAFFIC ENGINEERING DIVISION

SIGNING PLAN - INSTALLS

DESIGNED KSF	I-80 EXIT 231, R.P. 231.13 I-80 & LINK-24A DARR INTERCHANGE		6/11
REVIEWED			
APPROVED	DATE DRAWN 08/16	TRAFFIC ENGINEER	DATE

TRAFFIC ENGINEERING DIVISION

Computer: DRTRAFFIC45 User: dor33240 Date: 29-AUG-2016 12:33

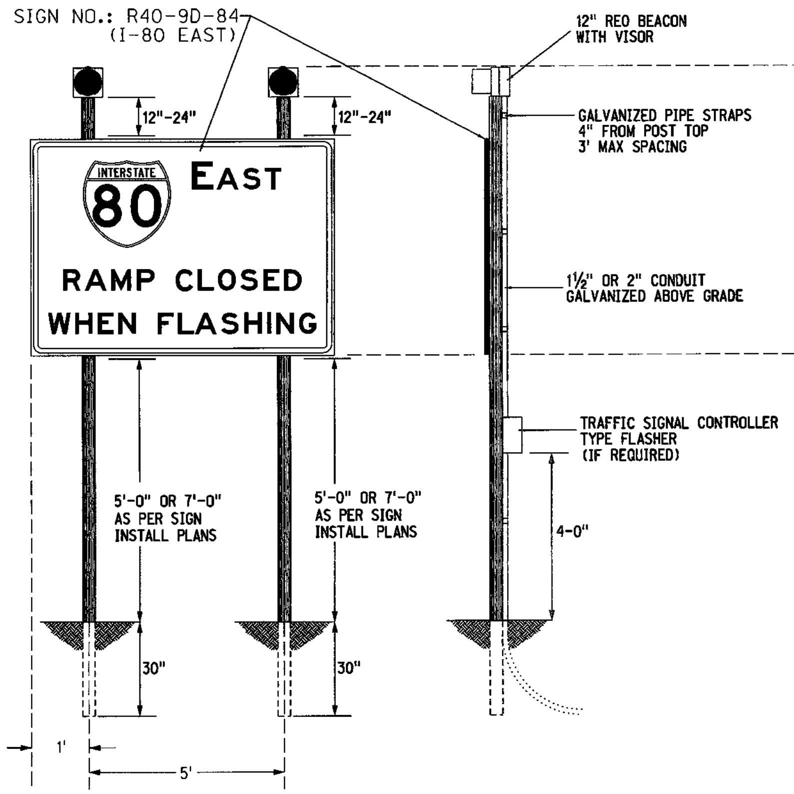
File: q61579.dgn
Scale: 1:97.2224

PROJECT NO.	SHEET NO.
ITSN(44)	52

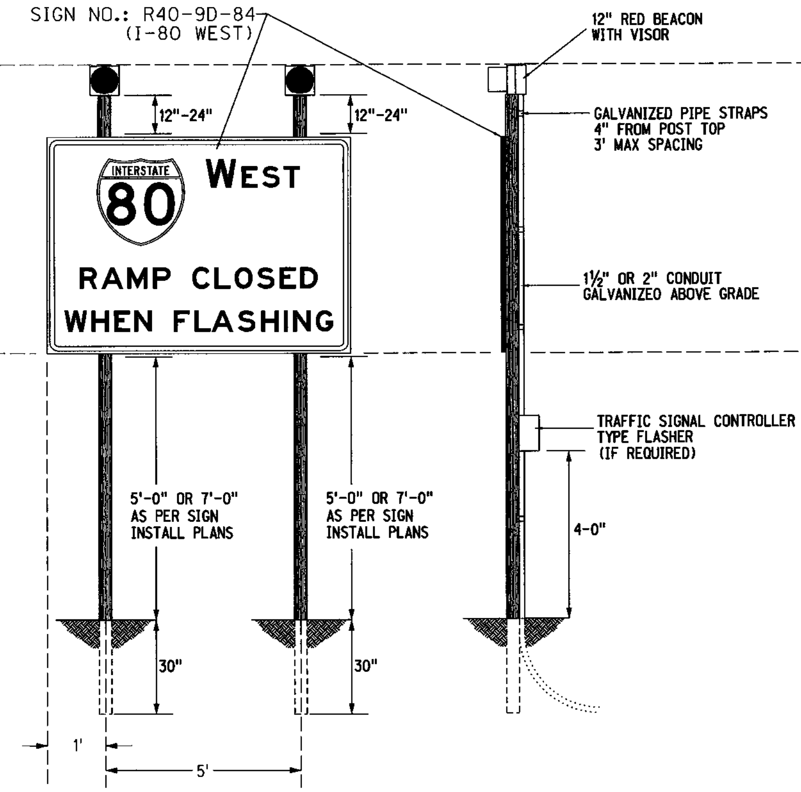
C.N. 61579

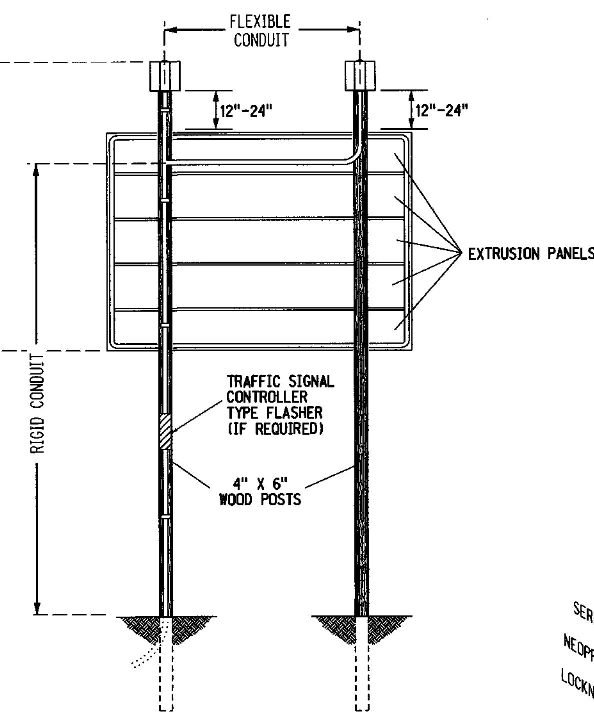
TRAFFIC ENGINEERING DIVISION

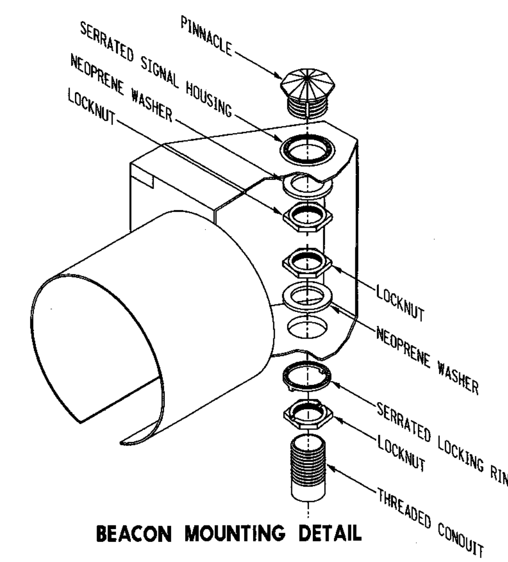
POST MOUNTED BEACON DETAILS



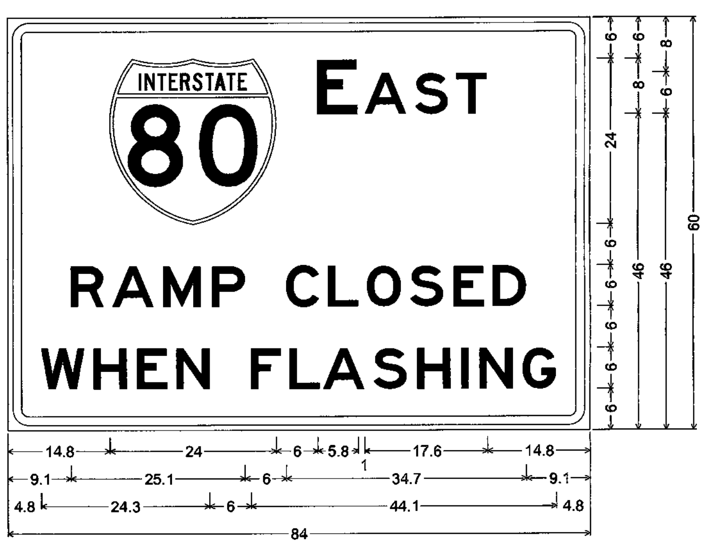
POST MOUNTED BEACON DETAILS







BEACON MOUNTING DETAIL



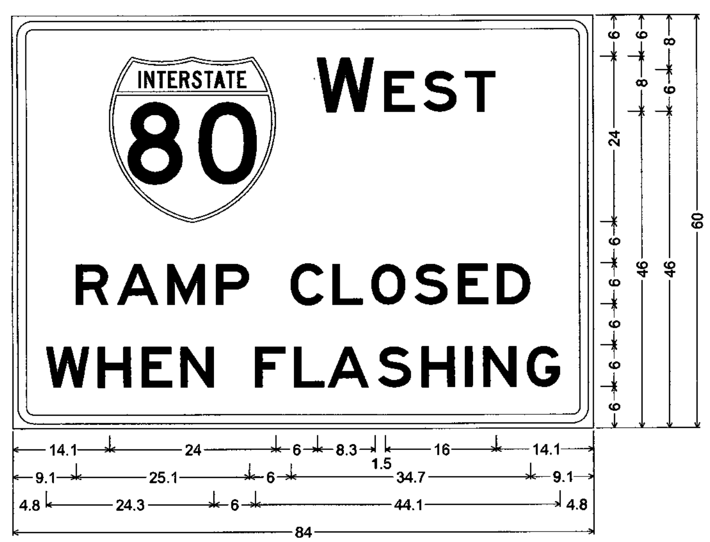
3.0" Radius, 1.3" Border, 0.8" Indent, Black on White;
[EAST] E; [RAMP CLOSED] E; [WHEN FLASHING] E;
Table of distances between letter and object lefts.

	(I-80 shield)	E	A	S	T	
14.8	30.0	6.8	7.2	6.0	4.4	14.8

	R	A	M	P	C	L	O	S	E	D	
9.1	6.1	7.2	7.1	10.7	6.1	5.6	6.2	6.3	5.7	4.8	9.1

	W	H	E	N	F	L	A	S	H	I	N	G	
4.8	7.6	6.3	5.6	10.8	5.7	4.8	7.2	6.3	6.4	2.5	6.4	4.8	4.8

SIGN NO.: R40-9D-84 (I-80 EAST), TYPE B - EXTRUSION
SIZE: 7'-0" X 5'-0"
COLOR: BLACK ON WHITE
NO. REQUIRED: 8



3.0" Radius, 1.3" Border, 0.8" Indent, Black on White;
[WEST] E; [RAMP CLOSED] E; [WHEN FLASHING] E;
Table of distances between letter and object lefts.

	(I-80 shield)	W	E	S	T	
14.1	30.0	9.8	5.6	6.0	4.4	14.1

	R	A	M	P	C	L	O	S	E	D	
9.1	6.1	7.2	7.1	10.7	6.1	5.6	6.2	6.3	5.7	4.8	9.1

	W	H	E	N	F	L	A	S	H	I	N	G	
4.8	7.6	6.3	5.6	10.8	5.7	4.8	7.2	6.3	6.4	2.5	6.4	4.8	4.8

SIGN NO.: R40-9D-84 (I-80 WEST), TYPE B - EXTRUSION
SIZE: 7'-0" X 5'-0"
COLOR: BLACK ON WHITE
NO. REQUIRED: 8

GENERAL NOTES

1. ALL SURFACE MATERIALS THAT ARE DISTURBED BY EXCAVATION AND BACKFILLING OPERATIONS SHALL BE REPLACED AND RESTORED IN KIND EQUAL TO OR EXCEEDING THE ORIGINAL CONDITION: INCLUDING SODDING AND SEEDING.
2. LINEAR MEASUREMENTS ARE TAKEN BETWEEN POLE BASE AND PULL BOX CENTERS AND DO NOT INCLUDE ALLOWANCES FOR MAST ARM LENGTHS, VERTICAL RISES, OR SPLICES
3. SIGNAL HEAD LENSES AND LED MODULES SHALL BE ORIENTED ACCORDING TO THE MANUFACTURER'S RECOMMENDATIONS STAMPED ON THE LENS.

NEBRASKA DEPARTMENT OF ROADS
TRAFFIC ENGINEERING DIVISION

DESIGN DETAILS

DESIGNED	KSF	SIGNING, BEACON, & POST MOUNTED DETAILS SIGN NO.: R40-9D-84 (I-80 EAST & WEST)	8/11
REVIEWED			
APPROVED	DATE DRAWN 05/16	TRAFFIC ENGINEER	DATE

Computer: DRTRAFFIC45 User: dor33240 Date: 19-MAY-2016 15:10

File: q61579.dgn Scale: 1:97.2224

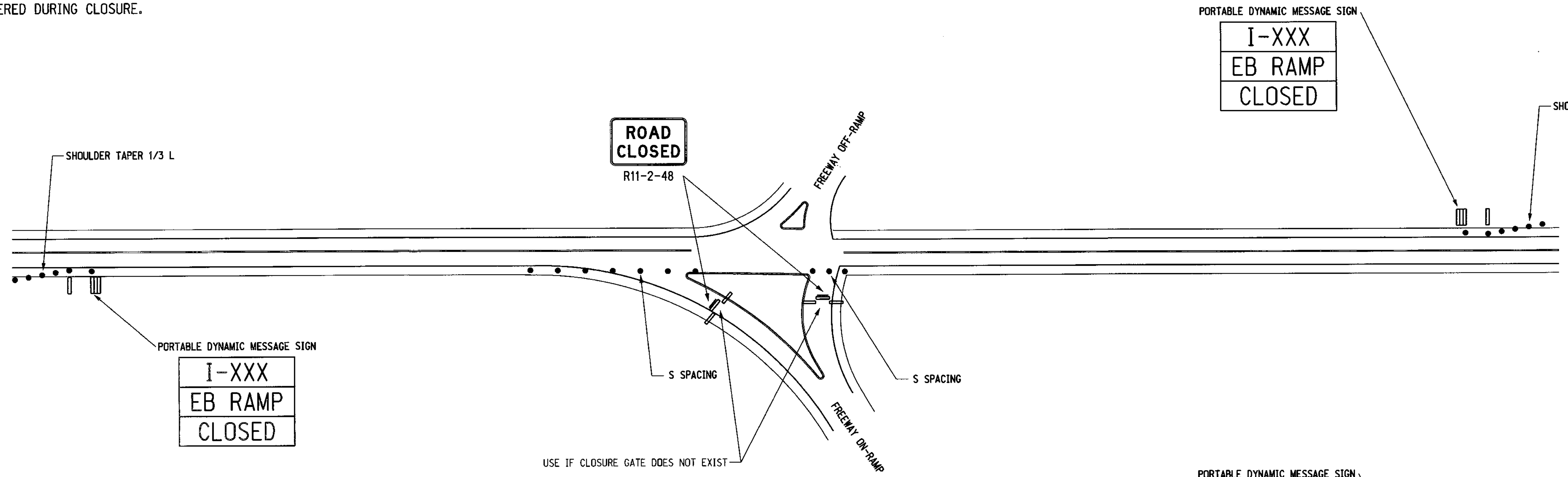
TRAFFIC ENGINEERING DIVISION
Computer: DRTRAFFIC45
User: dor33240
Date: 19-MAY-2016 15:18
File: freeway on ramp closure r1.dgn
Scale: 1:97.2222

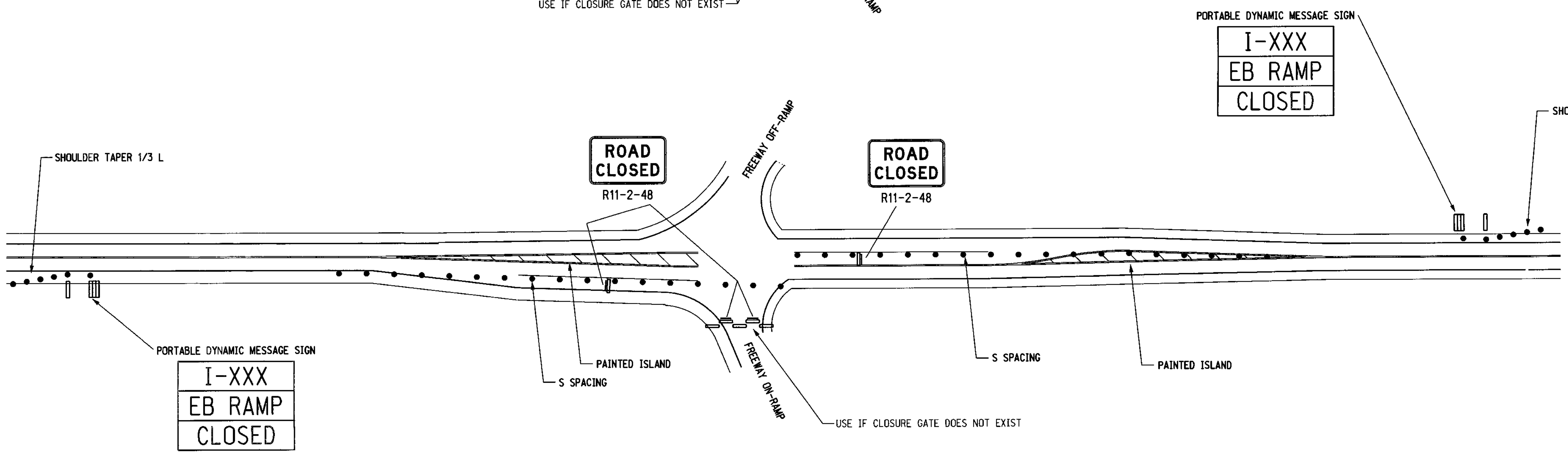
PROJECT NO.	SHEET NO.
ITSN(44)	58

C.N. 61579

NOTES

1. EXISTING SIGNS THAT ARE NOT APPLICABLE SHALL BE COVERED DURING CLOSURE.





TAPER FORMULA

L = S x W FOR SPEEDS OF 45 MPH OR MORE.

L = $\frac{WS^2}{60}$ FOR SPEEDS OF 40 MPH OR LESS.

WHERE:

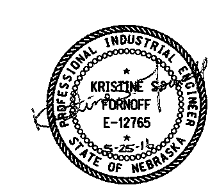
L = MINIMUM LENGTH OF TAPER.

S = NUMERICAL VALUE OF POSTED SPEED LIMIT PRIOR TO WORK IN MPH.

W = WIDTH OF OFFSET (LANE WIDTH) IN FEET.

LEGEND

- TYPE III BARRICADE
- REFLECTORIZED PLASTIC DRUM
- PORTABLE DYNAMIC MESSAGE SIGN (PDMS)
- SIGN



NEBRASKA DEPARTMENT OF ROADS
TRAFFIC ENGINEERING DIVISION

TYPICAL TRAFFIC CONTROL PLAN

DESIGNED	SR	FREEWAY ON-RAMP CLOSURE	1/1
REVIEWED			
APPROVED	DATE DRAWN 12/12	TRAFFIC ENGINEER	DATE

AUTOMATED GATE CONTROLLER

GENERAL

A. This section consists of the material requirements, construction details, testing, methods of measurement and basis of payment necessary to construct an Automated Gate Controller, as described in the Contract Documents.

B. Contractor shall supply new materials only. All materials and installations shall comply with the Underwriter's Laboratory and National Electric Code.

C. The Engineer shall authorize any changes to the contract documents in writing before performing the installation. No additional compensation shall be provided for additional work associated with or resulting from unauthorized changes to the Contract Documents.

D. Components, accessories, and hardware shall be compatible.

E. All Manufacturers manuals, instructions and warrantees shall be transferred to NDOR.

F. Required Submittals: In addition to submissions required under each pay item, Contractor shall provide shop drawings or catalog cuts for each material prescribed including manufacturer name and model number.

G. Material shall operate in an environment of –50˚ F to +122˚ F and relative humidity of 0% to 95% (non-condensing) without the assistance of fan-forced cooling.

H. It shall be the responsibility of the Contractor to coordinate with the Engineer to configure network and hardware settings on all Contractor-provided equipment and hardware, and to place into service a complete and functioning system. Prior to installation, the Contractor shall deliver the PLC's to the Engineer for configuration and programming. The Engineer shall return the PLC's to the Contractor for installation. The PLC's will be configured on a per-site basis and shall be installed in the indicated location with inputs and outputs indicated in the plans. The Contractor shall allow 3 weeks in their installation schedule for Engineer configuration activities.

1.0 MATERIAL

1.01 CONTROLLER CABINET

A. The cabinet shall have a single door capable of being locked by the State's standard pad lock. The cabinet shall be 60"x24"x18" in size. Cabinet shall incorporate backpanels on the back and sides. The internal equipment and arrangement in the cabinet shall be per the drawings. All automated gate controller cabinets shall be the same size.

B. The cabinet shall be sealed and non-ventilated, without fans, vents, lights, or louvers.

C. Cabinets shall be provided with an integral sun shield on the top of the cabinet.

D. Cabinets shall be aluminum or stainless steel. Painted steel shall not be acceptable.

E. Contractor shall design, furnish and install electrical surge protection and grounding for cabinets and internal equipment shown in the plans.

F. The cabinet internal ground shall consist of one or more ground bus-bars permanently affixed to the cabinet and connected to the grounding electrode. Use bare stranded No. 6 AWG copper wire between bus-bars and between the bus-bar and grounding electrode. Each copper ground bus-bar shall have a minimum of 20 connector points. Each connector point shall be capable of securing at least one No.1 AWG conductor. AC neutral and equipment ground wiring shall return to the bus-bars.

G. The Contractor shall provide a factory acceptance test for the cabinets, witnessed by the NDOR ITS Project Manager, which tests power and network connections within the cabinet to verify proper wiring and system operation. All cabinets shall be subjected to a 24-hour burn-in period prior to the factory test, where power is applied to the main terminals for a continuous 24 hour period.

H. Installation of cabinets shall use stainless steel hardware and shall maintain NEMA 3R or NEMA 4 classification.

I. Cabinet shall allow entry of conduit prescribed in the plans on the bottom surface. Conduit ends shall include bushing to protect cables.

1.02 CONTROLLER FOUNDATION

A. The controller shall be placed on a concrete foundation as shown in the plans.

B. Concrete shall conform to the requirements of Section 1002 for 47B concrete.

C. The Controller Foundation shall not be placed in a ditch or depression that is subject to water ponding or flooding.

1.03 PROGRAMMABLE LOGIC CONTROLLER

A. The PLC shall have a minimum of 20 onboard 120V AC digital input points and 12 120V AC digital output points.

B. The PLC shall have onboard Ethernet/IP communications.

C. The PLC shall be 120V AC powered.

D. The PLC I/O shall be capable of further expansion via DIN-rail mounted digital I/O modules with 120V AC voltage level.

E. All I/O points shall be wired from the PLC I/O modules to terminal blocks or interposing relays as indicated by the drawings. Physical device outputs shall be wired to the normally open contact of these relays unless otherwise indicated. Connections from the equipment panel to field devices shall only be made from terminal blocks or interposing relays, not directly from the PLC I/O modules.

1.04 TERMINAL BLOCKS

A. Terminal blocks for power distribution and digital signals shall comply with the following requirements:

1. Terminal blocks shall be UL rated for 600V, 30A minimum.
2. Terminal blocks shall have a compression-style screw clamp connection.
3. Terminal blocks shall be capable of accepting #12 AWG wire.
4. Terminal blocks directly associated with digital I/O signals shall be two-tier with pre-manufactured jumper bars for distribution of common signals.
5. DIN-rail mounted suitable for panel installation.

B. All terminal blocks shall be designed for DIN rail mounting. Extra deep 15 mm DIN rail shall be used.

C. Contractor shall provide terminal block end sections and end stops as necessary for a complete installation.

D. Terminal blocks shall be provided with snap-on label strips. Stick-on labeling is not acceptable. Contractor shall clearly label all terminal blocks in every control panel; unlabeled terminal blocks are not acceptable.

E. Terminal blocks shall be Allen-Bradley, Phoenix Contact, or Weidmuller.

1.05 INTERPOSING RELAYS

A. Interposing relays shall comply with the following requirements:

1. Relays shall be plug-in style with a DIN-rail mountable base
2. Relays shall have LED-based on/off indication

B. Interposing relays shall be used for all digital outputs from the PLC.

C. Interposing relays shall be SPDT with 120 VAC or 24VDC coils as shown in the plans.

D. Interposing relays shall be Allen-Bradley 700-HK series, IDEC RJ series, or NDOR approved equal.

1.06 PUSHBUTTON CONTROL STATION

A. Pushbutton Control Stations shall comply with the following requirements:

1. Material: Metal or Plastic
2. Contacts: Two (2) Normally Open
3. Contact Rating: 5A @ 120 VAC

4. Operation: Two (2) Momentary Pushbuttons. Top pushbutton shall be factory labeled “UP”. Bottom pushbutton shall be factory labeled “Down”

5. Pushbutton Terminations: Screw Clamp

B. Each pushbutton station shall have an engraved phenolic nameplate mounted above it to indicate which gate it controls. Stickers shall not be acceptable.

C. Pushbutton Stations shall be Square D, Allen-Bradley, or NDOR approved equal.

1.07 WIRE DUCTING

A. Wire Ducting shall comply with the following requirements:

1. Material: Lead-Free PVC
2. Color: Light Gray
3. Nominal Size: 2” Wide x 2” Tall

B. Wire Ducting shall be supplied with matching cover.

C. Wire Ducting shall be Panduit, Iboco, or NDOR approved equal.

1.08 AC UPS

A. AC UPS shall comply with the following minimum requirements:

1. Voltage Output: 120 VAC
2. Power Output: 750 VA
3. Output Connections: NEMA 5-15R
4. Waveform Type: Stepped approximation to a sinewave

1.09 MOLDED-CASE CIRCUIT BREAKER

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products
2. General Electric Co.; Electrical Distribution & Control Division
3. Square D/Group Schneider

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

D. Molded-Case Circuit-Breaker Features and Accessories:

1. Verify that accessories retained below are available and appropriate for circuit-breaker types and ratings specified.
2. Standard frame sizes, trip ratings, and number of poles.

3. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.

E. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

F. Enclosure: NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1.10 FLASHER CONTROLLER

A. Flasher shall solid state or relay socket based. If flasher is relay socket based, the relay base shall be included.

B. Flasher shall be panel or DIN-rail mounted.

C. Wire connections shall be screw or clamp type.

D. Coil voltage shall be 120 VAC. Contact rating shall be 10 amps @ 120 VAC.

E. Controller shall be 2 pole and 60 flashes per minute.

1.11 RADIO SCANNER/DTMF COMPONENT

A. Contractor shall install state supplied surface mounted radio scanner, DTMF decoder component in the controller cabinet at the location shown in the plans.

B. Engineer shall provide site specific component when returning programmed PLC. Contractor shall install in indicated controller cabinet.

C. Component requires one (1) 120V ac outlet for power. Size of the component is approximately 11” x 12” x 4” thick. Component shall be installed in a manner that allows installation and maintenance of wiring.

D. Contractor shall supply copper wire connections between the component and PLC as shown in plans.

1.12 ACCEPTANCE TESTING AND SYSTEM VERIFICATION PLAN

A. Contractor shall meet all requirements as described, including providing all necessary resources (labor, staffing, equipment, etc.) for system acceptance testing at each location.

B. Contractor shall, upon construction completion of the automated gate system, conduct Test Case 1. Test shall be executed or witnessed by an NDOR operator.

C. NDOR shall conduct Test Case 1 at any time within 30-days after approval of initial Test Case 1. Number of tests conducted is at sole discretion of NDOR.

D. In the event that any requirements are not met during any conducted test case, Contractor shall create a test variance document. The variance document shall be completed through the resolution of the variance. The Contractor shall resolve each variance until approved by the NDOR ITS Project Manager.

E. The Contractor will be responsible to prepare and provide an updated plan with the proposed scheduled dates and times for testing. The Contractor shall provide the NDOR ITS Project Manager two weeks advance notice before testing begins.

NDOR Automated Gate Deployment Test Documentation
Variance Report Form
Variance # __ - ________________

Variance Date:	____________	Contractor Rep:	____________
Variance Time:	____________	NDOR Rep:	____________
Equipment Involved:	____________	Test Section:	____________
	____________		____________
Variance Level:	____________	Requirement #:	____________

Variance Description:

Variance Resolution:

Contractor Rep. Signature	____________	**NDOR Rep. Signature**	____________

Test Case 1
Automated Gate Demonstration

Verification Procedure	Test Location	Date	Results		Comments
			Pass	Fail	
Each gate up push button initiates the corresponding gate operation.					
Each gate down push button initiates the corresponding gate operation.					
Each radio up signal initiates the corresponding gate operation.					
Each radio down signal initiates the corresponding gate operation.					
Gate opens with signal from NDOR ATMS.					
Gate closes with signal from NDOR ATMS.					
Gate arm beacons operate while arm is closing, opening or is closed.					
Ramp sign beacons operate while corresponding gates are closing, opening or are closed.					
All beacons are off when corresponding gate is open.					
Gate arm and ramp sign beacons flash while in operation.					
Gate arm can be lowered or raised with hand winch.					

2.0 Method of Measurement

A. Automated Gate Controller shall be paid by the each.

B. All design work, concrete for foundation, electrical connections, materials, tools, labor and testing necessary to complete an Automated Gate Controller as described in the contract documents are considered subsidiary to the pay item.

3.0 Basis of Payment

Pay Item	Pay Unit
Automated Gate Controller	Each (ea)

Payment is full compensation for all work prescribed in this Section.

AUTOMATED GATE

GENERAL

A. This section consists of the material requirements, construction details, testing, methods of measurement and basis of payment necessary to construct an Automated Gate, as described in the Contract Documents.

B. Contractor shall supply new materials only. All materials and installations shall comply with the Underwriter's Laboratory and National Electric Code.

C. The Engineer shall authorize any changes to the contract documents in writing before performing the installation. No additional compensation shall be provided for additional work associated with or resulting from unauthorized changes to the Contract Documents.

D. Components, accessories, and hardware shall be compatible.

E. All Manufacturers manuals, instructions and warrantees shall be transferred to NDOR.

F. Required Submittals: In addition to submissions required under each pay item, Contractor shall provide shop drawings or catalog cuts for each material prescribed including manufacturer name and model number.

G. Material shall operate in an environment of –50˚ F to +122˚ F and relative humidity of 0% to 95% (non-condensing) without the assistance of fan-forced cooling.

1.0 MATERIAL

A. Automated Gate assembly shall be NCHRP 350 approved crashworthy. Contractor shall supply written proof of certification.

B. Gate arm shall span the width of the associated pavement when in the closed position as shown in the plans.

C. Gate shall include a manual winch for operation of the gate in the event of power loss. Winch shall be operational by hand without the aid of tools.

D. Gate arm shall include retroreflective vertical stripping alternated between red and white at 16 inch intervals. Retroreflective stripping shall face sides with approaching traffic.

E. Gate arm shall include 3 red LED beacons. Beacons shall be individually wired for flash control by the Automated Gate Controller. Beacon spacing on the arm shall be as shown in the plans.

F. Gate assembly shall include an arm receiver to control the end of the arm while in the open position for winds up to 80 mph non-gusting.

G. Arm movement shall be vertical. The closed position shall be horizontal above the roadway. The open position shall be vertical to the roadway. The orientation of the gate assembly shall be perpendicular to the roadway to be closed or as shown in the plans.

H. Assembly shall include an electrically driven actuator for operation of the gate arm. Actuator shall receive power source as shown in the plans. Actuator shall be sealed to prevent moisture intrusion in all positions of operation. Actuator shall include limit switches that report full travel up and full travel down. The limit switch shall be closed

I. Automated Gate shall only receive operational commands from the Automated Gate Controller as detailed in the contract documents.

J. Gate structure shall follow the latest edition of the AASHTO publication “Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals”.

K. Foundation concrete shall follow Section 1002.

L. Anchor bolts and anchor bolt template shall meet manufacturer requirements and NDOR standard specification.

M. Gate assembly shall include a hand hole with cover and watertight gasket near the foundation for access to electrical connections associated with the Automated Gate as shown in the plans.

2.0 CONSTRUCTION

A. Contractor shall design, furnish all materials, and install an Automated Gate as detailed in the contract documents

B. Contractor shall make all electrical connections described in the Automated Gate Controller to the Automated Gate.

3.0 RELOCATION

A. When shown in the plans, the Contractor shall relocate the Automated Gate. The Automated Gate shall be carefully dismantled, stored, and protected from damage. The Engineer may designate specific areas for temporary storage of the materials. The Automated Gate shall be installed at the prescribed new location and connected electronically as shown in the plans. Missing, damaged or non-reusable components shall be replaced by the Contractor before final payment will be made.

4.0 Method of Measurement

A. Automated Gate and Relocate Automated Gate shall be measured by the each.

B. All design work, concrete for foundation, electrical connections, materials, tools, labor and testing necessary to complete an Automated Gate as described in the contract documents are considered subsidiary to the pay item.

5.0 Basis of Payment

Pay Item	**Pay Unit**
Automated Gate	Each (ea)
Relocate Automatic Gate	Each (ea)

Payment is full compensation for all work prescribed in this Section.

REMOVE AND REPLACE CABINET

GENERAL

A. This section consists of the material requirements, construction details, testing, methods of measurement, and basis of payment necessary for the replacement of an ITS cabinet, as described in the Contract Documents. Contractor shall salvage and reinstall all necessary existing components to place the device back in working order. This work shall include all materials, labor, tools, and incidentals required to return the ITS device to working order.

B. Contractor shall supply new materials only. All materials and installations shall comply with the Underwriter's Laboratory and National Electric Code.

C. The Engineer shall authorize any changes to the contract documents in writing before performing the installation. No additional compensation shall be provided for work associated with or resulting from unauthorized changes to the Contract Documents.

D. Components, accessories, and hardware shall be compatible.

E. All Manufacturers manuals, instructions and warrantees shall be transferred to NDOR.

F. Required Submittals: In addition to submissions required under each pay item, Contractor shall provide shop drawings or catalog cuts for each material prescribed including manufacturer name and model number.

G. Material shall operate without fan-forced cooling or heaters.

Appendix D

Improvement Options

Improvement Option #	Improvement Option Name	Construction Cost Estimate	CE/TC/Mobilization Cost Estimate	Total Estimated Cost
1	VMS - Three Forks	$125,000	$50,000	**$175,000**
2	VMS - Belgrade	$50,000	$20,000	**$70,000**
3	Road Closure Signage - Bear Canyon Road Exit 313	$38,000	$15,000	**$53,000**
4	Gates - Bear Canyon Road Exit 313	$75,000	$30,000	**$105,000**
5	Livingston EB I-90 Parking Area Expansion	$1,664,000	$666,000	**$2,330,000**
6	Road Closure Signage - Livingston Exit 330	$234,000	$94,000	**$328,000**
7	Gates - Livingston Exit 330	$75,000	$30,000	**$105,000**
8	Road Closure Signage - Livingston Exit 333 On-Ramps	$20,000	$8,000	**$28,000**
9	Gates - Livingston Exit 333 On-Ramps	$50,000	$20,000	**$70,000**
10	Livingston Windbreak	$1,300,000	$520,000	*** $2,070,000**
11	Livingston Wind Speed Gauge Upgrade	$30,000	$12,000	**$42,000**
12	Livingston Exit 337 Parking	$1,632,000	$653,000	**$2,285,000**
13	Road Closure Signage - Livingston Exit 337	$209,000	$84,000	**$293,000**
14	Gates - Livingston Exit 337	$75,000	$30,000	**$105,000**
15	Reconfigure/Reconstruct WB Off-Ramp at Livingston Exit 337	$1,500,000	$600,000	**** $2,400,000**
16	Road Closure Signage - White Sulphur Springs Exit 340	$13,000	$5,000	**$18,000**
17	Gates - White Sulphur Springs Exit 340	$25,000	$10,000	**$35,000**
18	Road Closure Signage - Big Timber Exit 367	$45,000	$18,000	**$63,000**
19	Gates - Big Timber Exit 367	$100,000	$40,000	**$140,000**
20	Road Closure Signage - Big Timber Exit 370	$45,000	$18,000	**$63,000**
21	Gates - Big Timber Exit 370	$100,000	$40,000	**$140,000**
22	Big Timber Exit 370 Parking	$998,000	$399,000	**$1,397,000**
23	Road Closure Signage - Columbus	$53,000	$21,000	**$74,000**
24	Gates - Columbus	$125,000	$50,000	**$175,000**
25	VMS - Park City	$50,000	$20,000	**$70,000**
26	VMS - Laurel	$50,000	$20,000	**$70,000**
27	VMS - Lockwood	$50,000	$20,000	**$70,000**

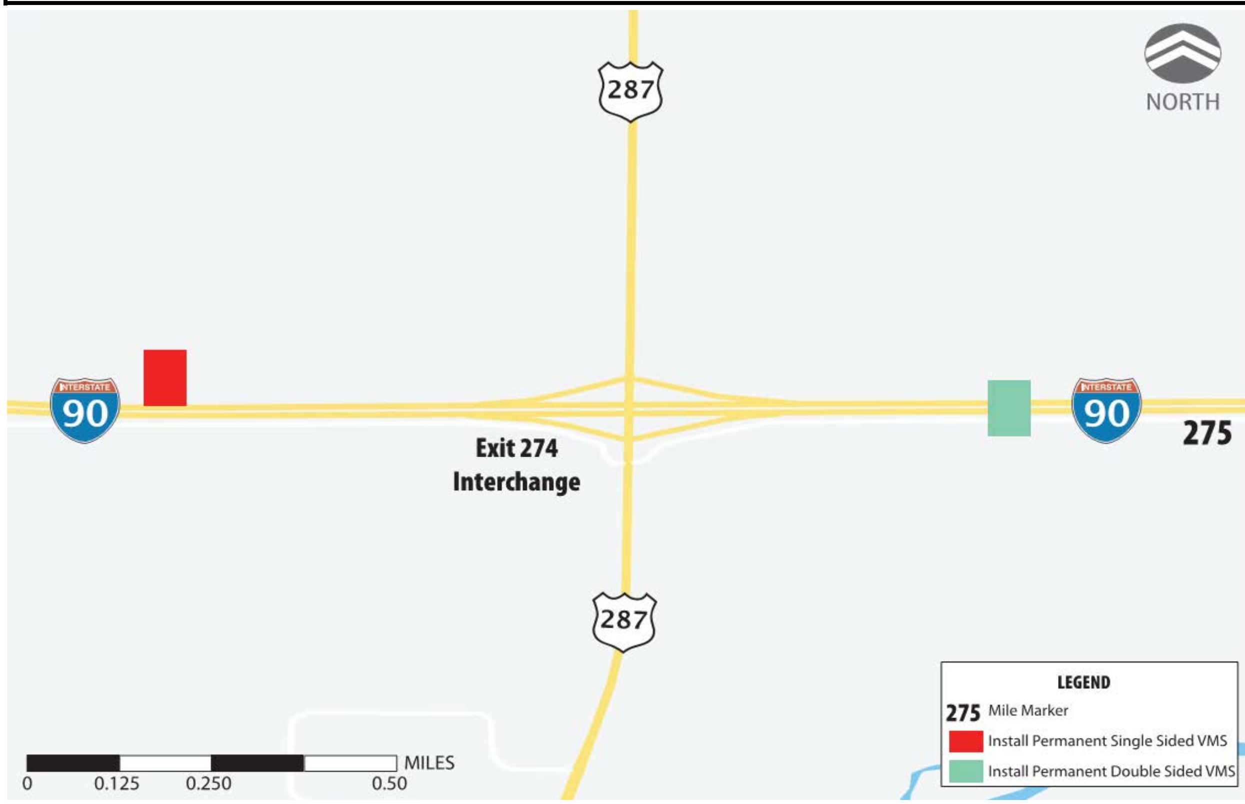
* Improvement Option #10 Total Cost includes $250,000 for Engineering Design

** Improvement Option #15 Total Cost includes $300,000 for Engineering Design

Owner		Cost
Montana DOT		Construction $ 125,000 CE/TC/Mobilization @ 40% $ 50,000 Total $ 175,000
Improvement Option		
Install permanent single-sided VMS for westbound I-90 traffic west of the Three Forks Exit 274 interchange. Install permanent double-sided VMS for both directions of I-90 traffic east of the Three Forks Exit 274 interchange.		
Closest Interchange RP	Improvement Name	Improvement Option No.
274	VMS - Three Forks	#1

Description

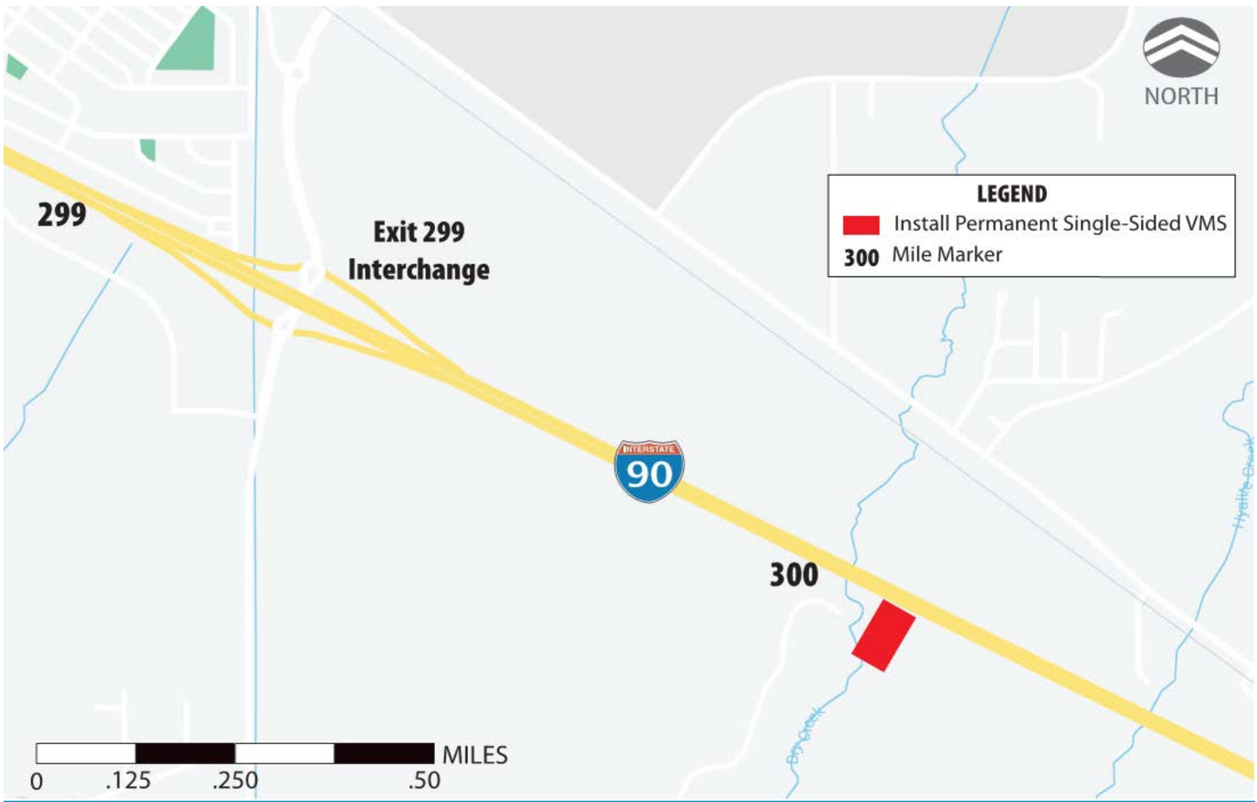
This improvement proposes installing a single-sided permanent VMS sign to the west of the Three Forks Exit 274 interchange to communicate messages to Hwy 287 traffic merging onto westbound I-90. An additional double-sided permanent VMS sign is proposed within the interstate median to the east of the Three Forks Exit 274 interchange. These VMS signs are recommended for early warning of weather/traffic events east and west of this interchange.



Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Single-Sided VMS	Each	1	$ 50,000	$ 50,000
Double-Sided VMS	Each	1	$ 75,000	$ 75,000
Total				$ 125,000

Owner		Cost
Montana DOT		Construction $ 50,000 CE/TC/Mobilization @ 40% $ 20,000 Total $ 70,000
Improvement Option		
Install permanent VMS sign for eastbound I-90 traffic east of the Exit 299 Airway Blvd interchange east of Belgrade		
Closest Interchange RP	Improvement Name	Improvement Option No.
299	VMS - Belgrade	#2
Description		
This improvement proposes installing a permanent single-sided VMS sign for eastbound I-90 travelers to the east of the Exit 299 Airway Blvd interchange. This sign is intended to communicate information to eastbound I-90 travelers about weather/traffic events occuring east of Bozeman.		



Construction Cost Estimate

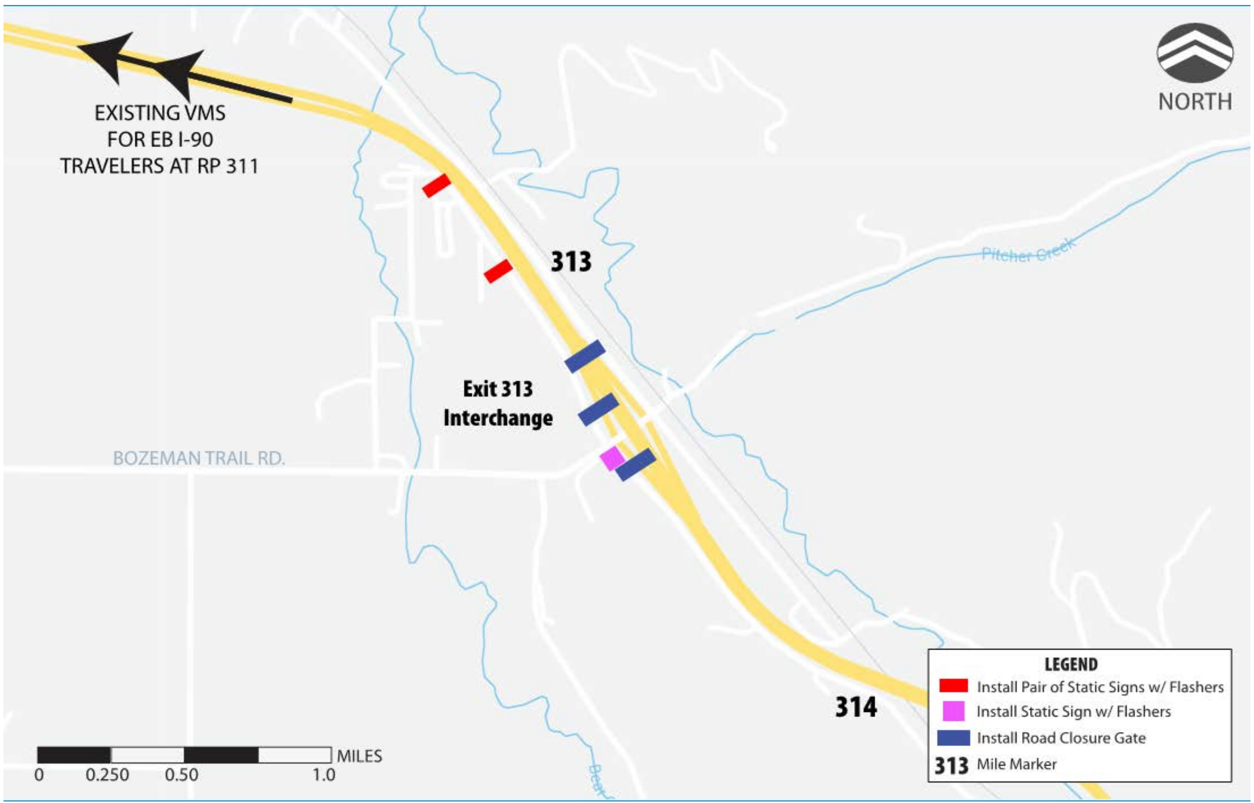
Item	Unit	Quantity	Unit Cost	Total Cost
Install Single-Sided VMS	Each	1	$ 50,000	$ 50,000
Total				$ 50,000

Owner		Cost
Montana DOT		
Improvement Option		Construction $ 38,000
Road Closure Signage at the Bear Canyon Road Exit 313 interchange east of Bozeman		CE/TC/Mobilization @ 40% $ 15,000
		Total $ 53,000
Closest Interchange RP	Improvement Name	Improvement Option No.
313	Road Closure Signage - Bear Canyon Road Exit 313	#3

Description

This improvement proposes installing static signs with flashers at the Bozeman Exit 313 interchange at the bottom of the pass that could be paired with new closure gates (see Improvement Option #4). The key feature of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure to the east of this location as Bozeman has more capability to handle detoured/stranded travelers than the communities of Livingston and Big Timber to the east. Traveler safety will be increased by preventing travelers from traversing the mountainous Bozeman Pass in hazardous conditions.

Note that Improvement Option #3 is proposed in conjunction with Improvement Option #4.



Construction Cost Estimate

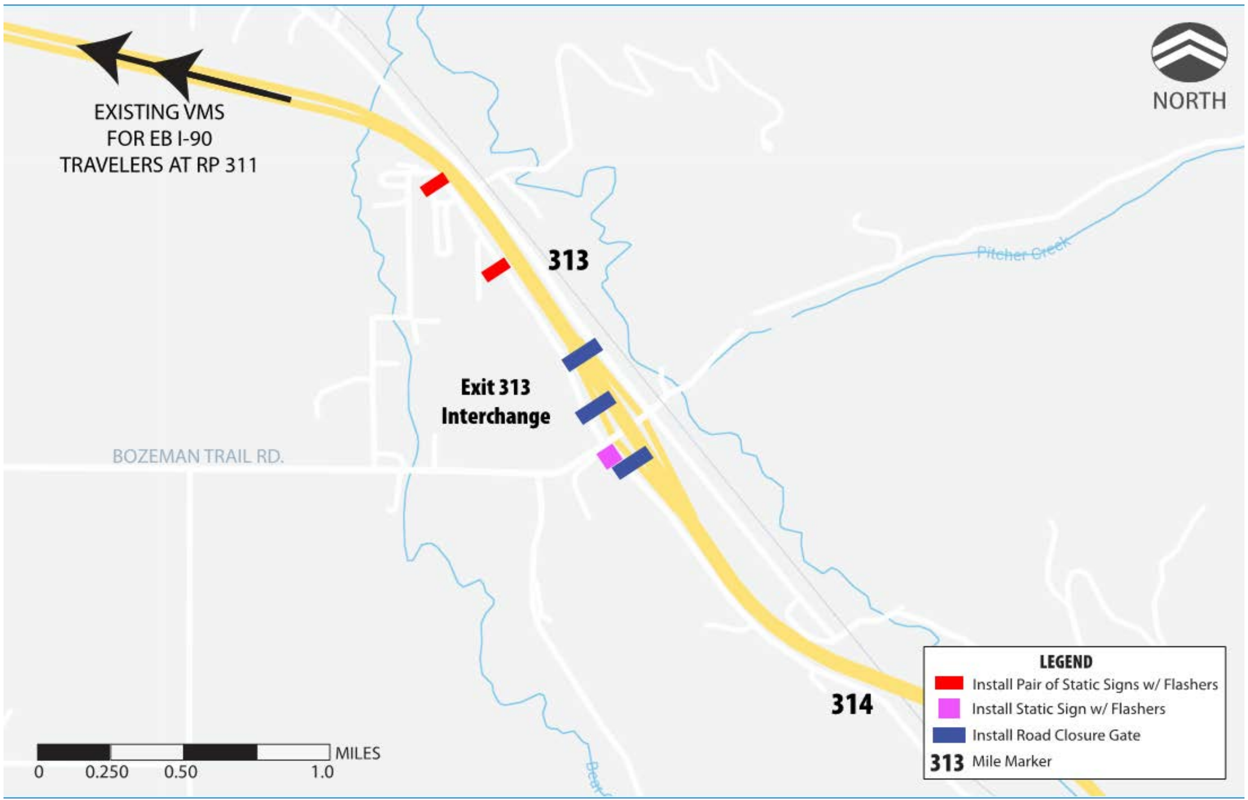
Item	Unit	Quantity	Unit Cost	Total Cost
Static Sign w/ Flashers	Each	5	$ 7,500	$ 37,500
Total				$ 37,500

Owner		Cost
Montana DOT		Construction $ 75,000 CE/TC/Mobilization @ 40% $ 30,000 Total $ 105,000
Improvement Option		
Automated closure gate system at the Bear Canyon Road Exit 313 interchange east of Bozeman		
Closest Interchange RP	Improvement Name	Improvement Option No.
313	Gates - Bear Canyon Road Exit 313	#4

Description

This improvement proposes installing new automated closure gates to allow for eastbound I-90 closure at the Bear Canyon Road Exit 313 interchange east of Bozeman, including a gate to close the EB I-90 On-Ramp. Closing I-90 to eastbound travel at the bottom of the Bozeman Pass prevents the public from driving through the mountainous pass during hazardous conditions. This closure location becomes increasingly important in instances where EB I-90 traffic is being turned around at the Livingston Exit 330 interchange (forcing travelers to head back over the pass to Bozeman.

Note that Improvement #4 is proposed in conjunction with Imrovement Option #3.



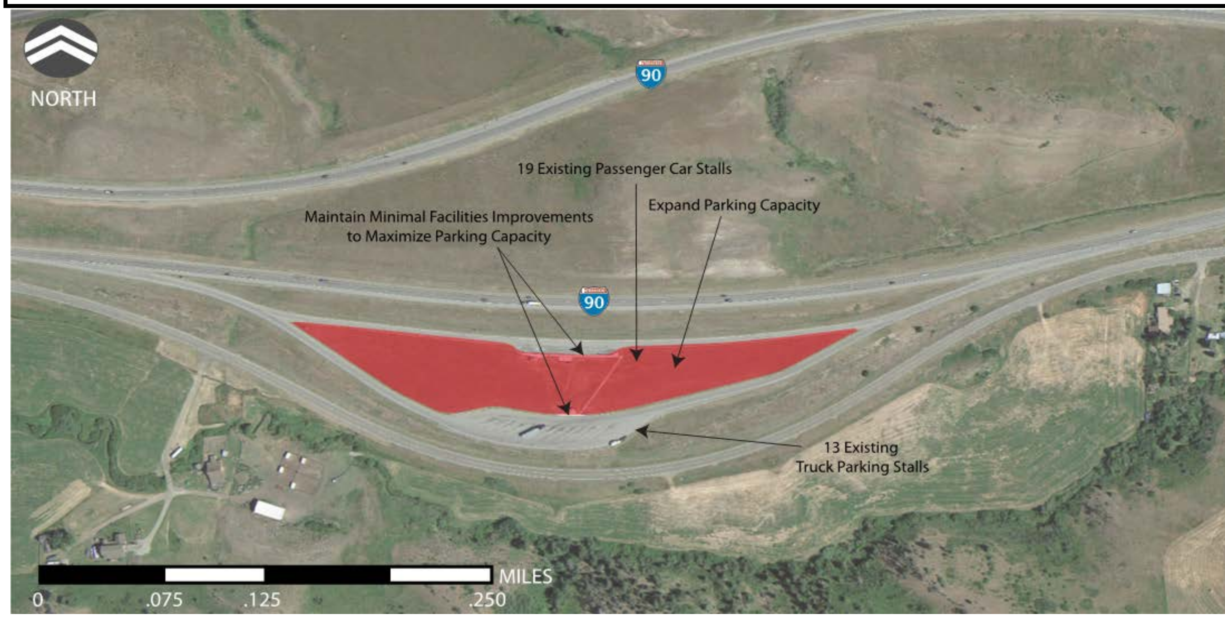
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	3	$ 25,000	$ 75,000
Total				$ 75,000

Owner		Cost
Montana DOT		
Improvement Option		Construction $ 1,664,000
Expand the Existing Livingston Parking Area on Eastbound I-90		CE/TC/Mobilization @ 40% $ 666,000
		Total $ 2,330,000
Closest Interchange RP	Improvement Name	Improvement Option No.
330	Livingston EB I-90 Parking Area Expansion	#5

Description

This improvement will consist of expanding the truck and car parking capacity at the existing EB I-90 Parking Area at RP 326.5. Facilities improvements should be limited as much as possible in order to allow for the maximum number of new parking stalls. This would provide a large number of additional parking stalls. The cost assumes a paved surface but a less costly option could be to use gravel surfacing to expand the parking area.



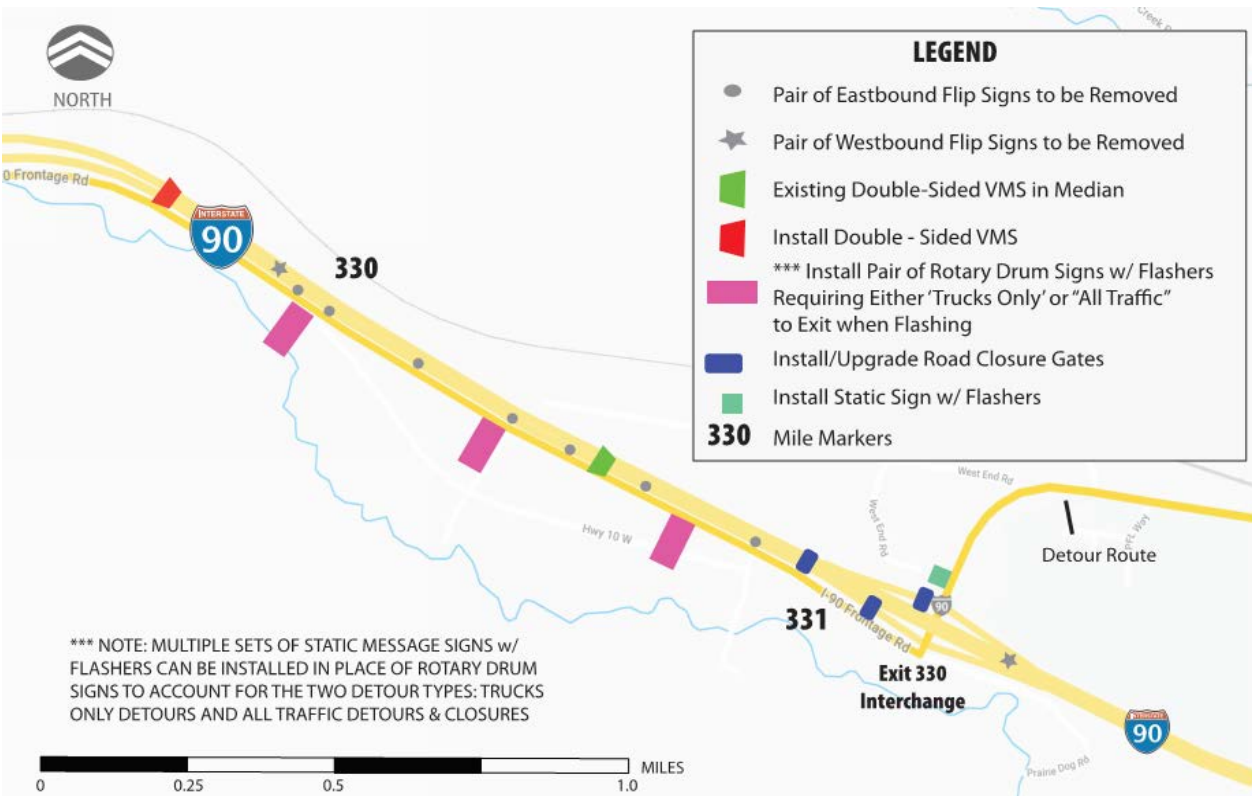
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Earthwork	Sq Yard	25600	$ 5	$ 128,000
Pavement (incl. gravel)	Sq Yard	25600	$ 60	$ 1,536,000
Total				$ 1,664,000

Owner		Cost
Montana DOT		
Improvement Option		Construction $ 234,000
Road Closure Signage at Livingston Exit 330		CE/TC/Mobilization @ 40% $ 94,000
		Total $ 328,000
Closest Interchange RP	Improvement Name	Improvement Option No.
330	Road Closure Signage - Livingston Exit 330	#6

Description

This improvement proposes removing the existing flip-signs at the Livingston Exit 330 interchange and replacing them with a combination of VMS, static signs with flashers, and/or rotary drum signs. The key feature of all of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure. Removing the requirement for MDT maintenance staff to manually operate the existing flip-signs will lead to a drastic improvement in the efficiency that detours and closures can be implemented.
Note that Improvement Option #6 is proposed in conjunction with Improvement Option #7.

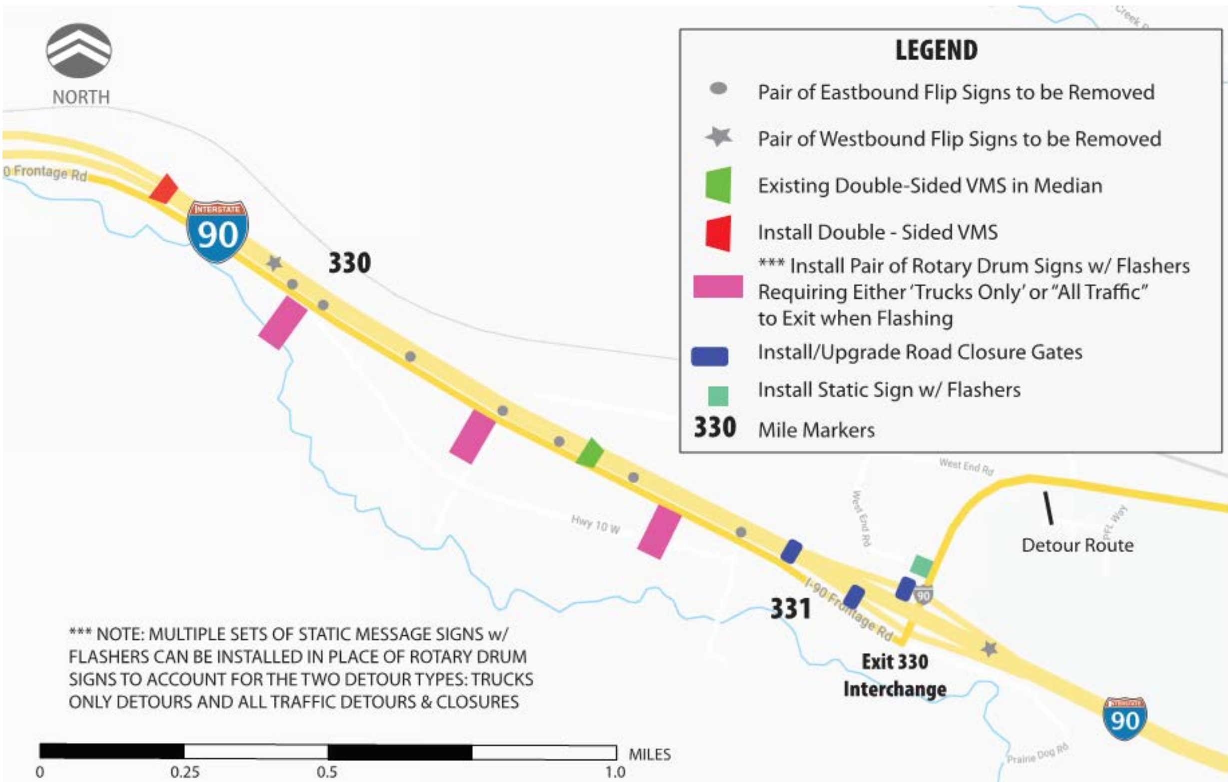


Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Remove Flip-Signs	Each	18	$ 60	$ 1,080
Double-Sided VMS	Each	1	$ 75,000	$ 75,000
Drum Sign w/ Flashers	Each	6	$ 25,000	$ 150,000
Static Sign w/ Flashers	Each	1	$ 7,500	$ 7,500
Total				$ 233,580

Owner		Cost
Montana DOT		
Improvement Option		Construction $ 75,000
Automated closure gate system at the Livingston Exit 330 interchange		CE/TC/Mobilization @ 40% $ 30,000
		Total $ 105,000
Closest Interchange RP	Improvement Name	Improvement Option No.
330	Gates - Livingston Exit 330	#7

Description
This improvement proposes upgrading and/or installing new automated closure gates to allow for interstate closure at the Livingston Exit 330 interchange, including the installation of a new gate to close the EB I-90 On-Ramp. Note that Improvement #7 is proposed in conjunction with Imrovement Option #6.



Construction Cost Estimate

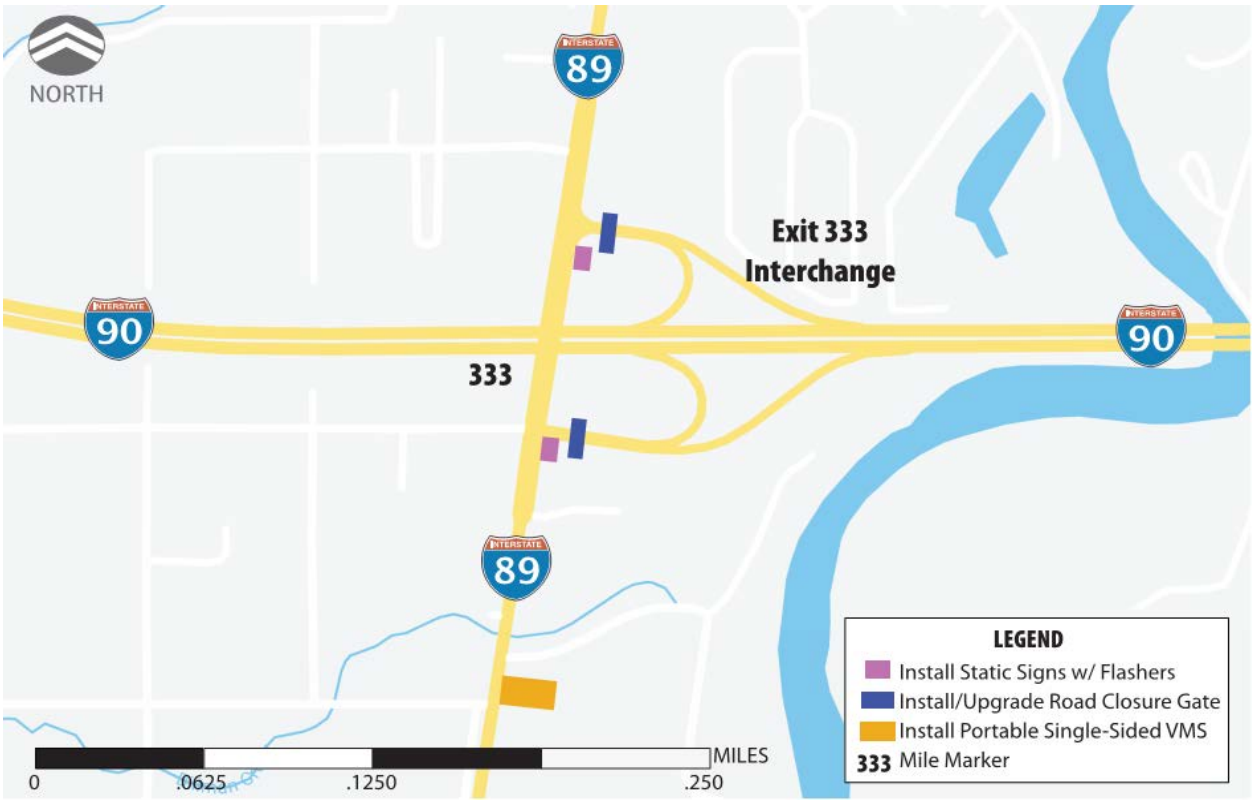
Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	3	$ 25,000	$ 75,000
Total				$ 75,000

Owner	Cost
Montana DOT	
Improvement Option	Construction $ 20,000
Road Closure Signage at the Livingston Exit 333 interchange on-ramps	CE/TC/Mobilization @ 40% $ 8,000
	Total $ 28,000

Closest Interchange RP	Improvement Name	Improvement Option No.
333	Road Closure Signage - Livingston Exit 333 On-Ramps	#8

Description

This improvement proposes installing static signs with flashers at both of the Livingston Exit 333 interchange on-ramps. The key feature of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure. A dedicated portable VMS is included in addition to the gate signage in order to provide MDT with an increased ability to communicate to travelers entering Livingston from the south.
Note that Improvement #8 is proposed in conjunction with Imrovement Option #9.

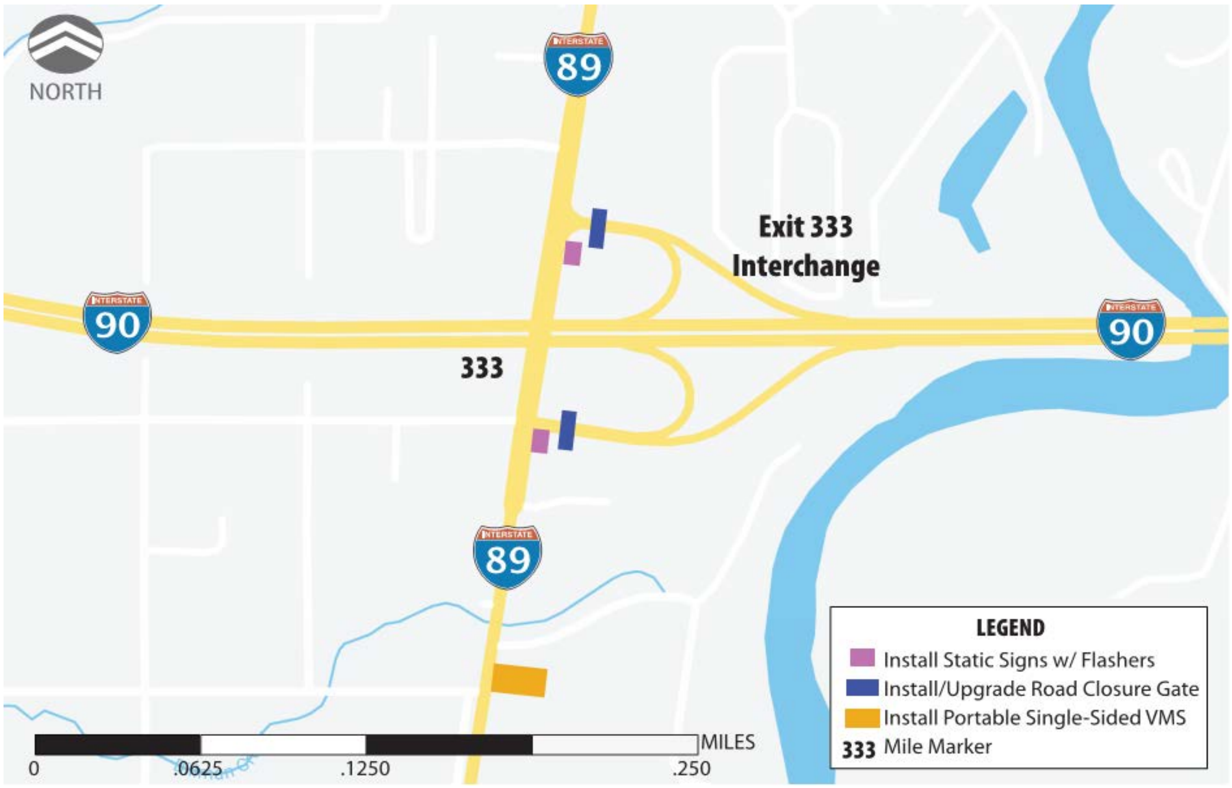


Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Portable Single-Sided VMS	Each	1	$ 5,000	$ 5,000
Static Sign w/ Flashers	Each	2	$ 7,500	$ 15,000
Total				$ 20,000

Owner		Cost
Montana DOT		Construction $ 50,000
Improvement Option		CE/TC/Mobilization @ 40% $ 20,000
Automated closure gate system for the I-90 WB & EB On-Ramps at the Livingston Exit 333 interchange		Total $ 70,000
Closest Interchange RP	**Improvement Name**	**Improvement Option No.**
333	Gates - Livingston Exit 333 On-Ramps	#9

Description
This improvement proposes upgrading or installing new automated closure gates on the eastbound and westbound on-ramps at the Livingston Exit 333 interchange to prevent travelers from entering I-90 when detours/closures are in effect. Note that Improvement #9 is proposed in conjunction with Imrovement Option #8.



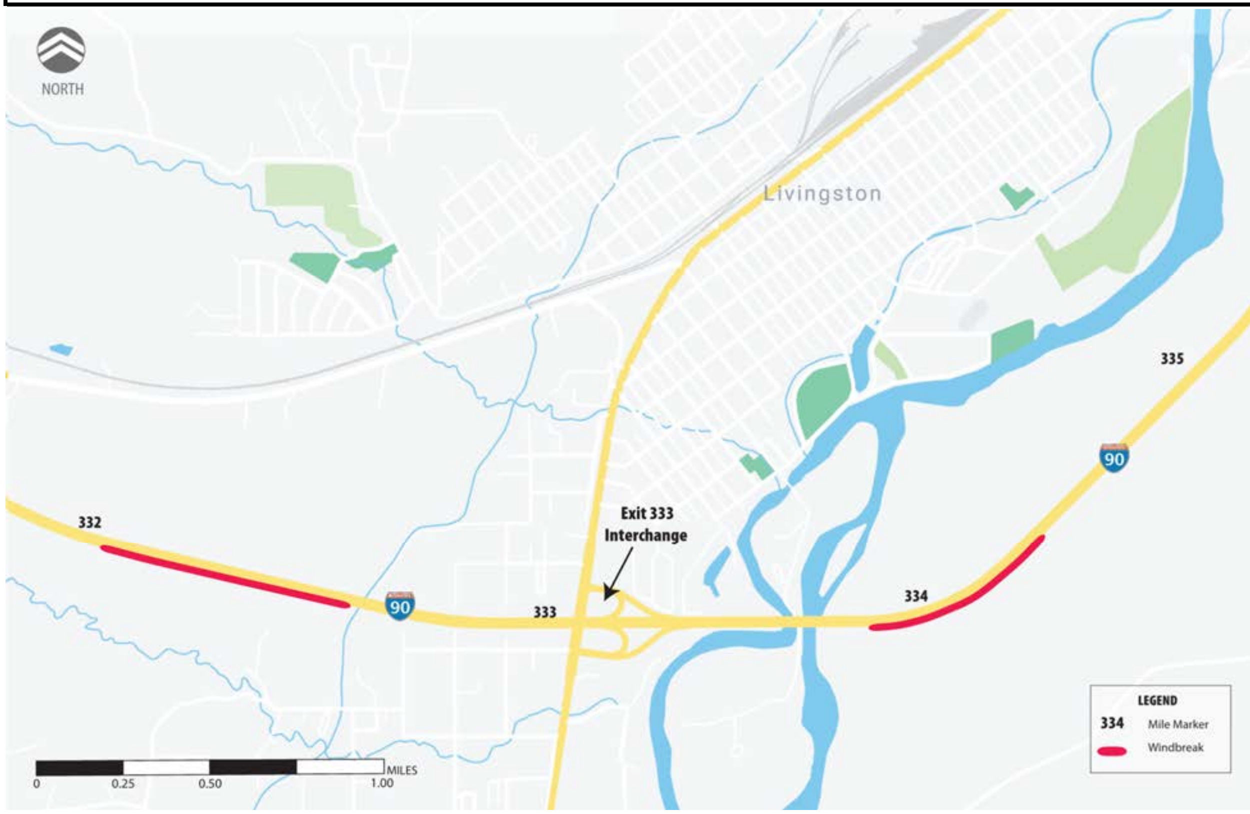
Construction Cost Estimate

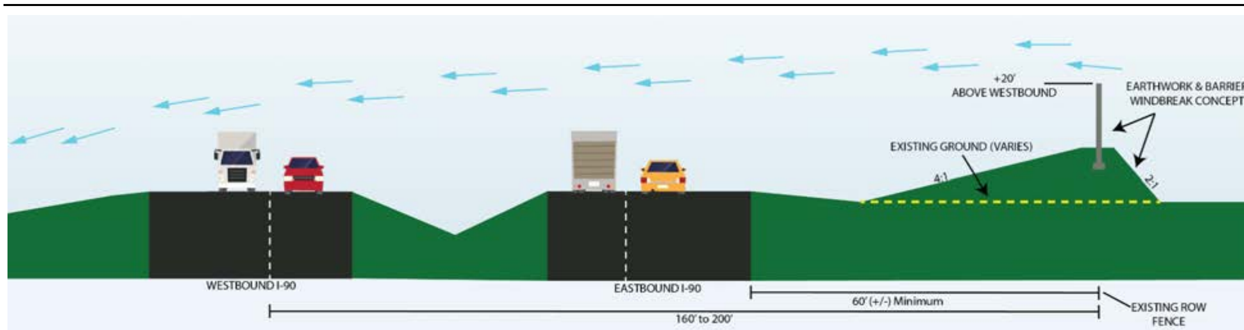
Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	2	$ 25,000	$ 50,000
Total				$ 50,000

Owner		Cost	
Montana DOT		Engineering Design	$ 250,000
Improvement Option		Construction	$ 1,300,000
Construct Windbreaks at RP 332 and RP 334		CE/TC/Mobilization @ 40% Const.	$ 520,000
		Total	$ 2,070,000
Closest Interchange RP	Improvement Name	Improvement Option No.	
333	Livingston Windbreak	#10	

Description

This improvement proposes constructing two physical windbreaks to decrease the wind speed across I-90 in the critical wind event locations at RP 332 and RP 334 that require the detours through Livingston. A variety of different windbreak concepts could be utilized, but the proposed concept is an earth berm with a man-made barrier installed on top of the berm. The physical feature on top of the berm should be slightly-porous to prevent/reduce turbulence behind the windbreak. The construction cost estimate is based on 3,000 linear feet of windbreak. A separate project will be required to design the windbreaks to select the specific treatment details.

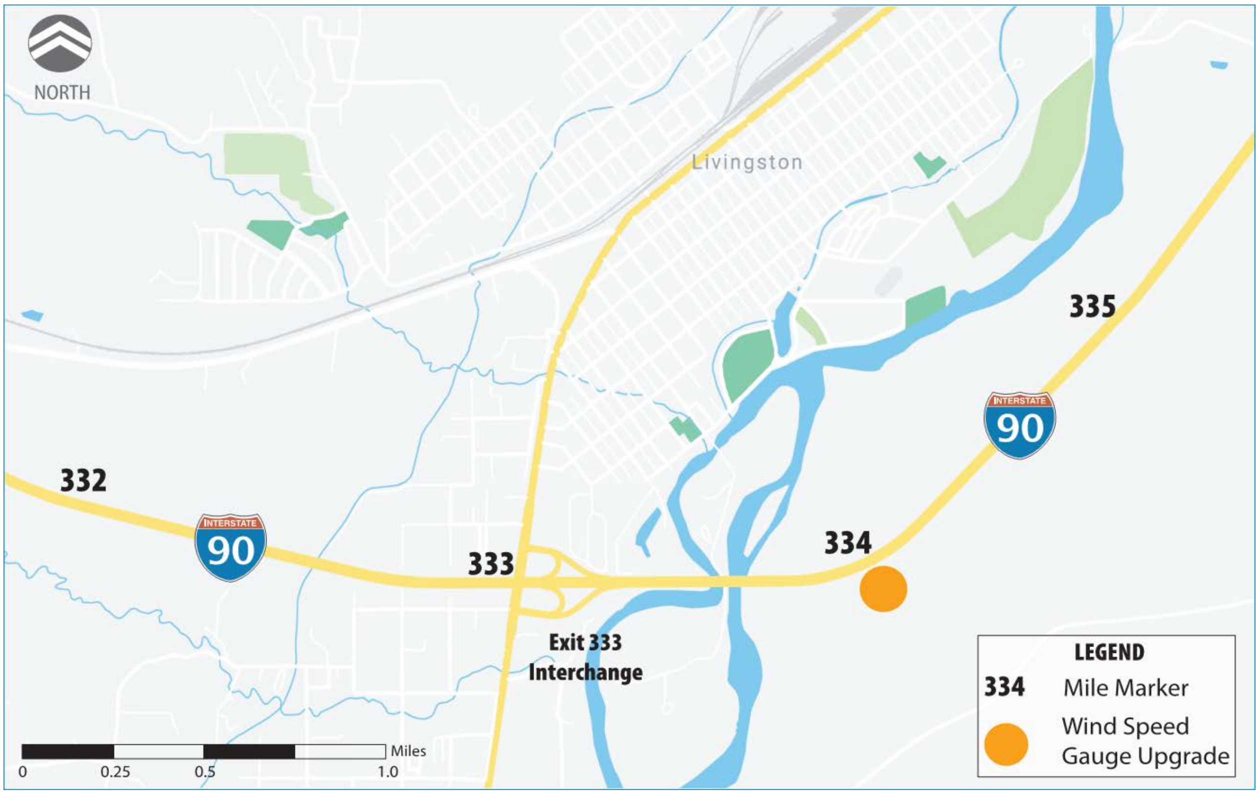




Owner		Cost		
Montana DOT				
Improvement Option		Construction	$	30,000
New wind speed gauge at RP 334		CE/TC/Mobilization @ 40%	$	12,000
		Total	$	42,000
Closest Interchange RP	Improvement Name	Improvement Option No.		
333	Livingston Wind Speed Gauge Upgrade	#11		

Description

This improvement consists of installing an upgraded wind speed gauge to replace the existing one at RP 334. The new wind speed gauge will be able to communicate real-time wind speed information to MDT to allow for more timely decisions regarding when to detour or close the interstate. MDT could consider installing additional wind speed gauges in critical locations to further improve the quality of weather-data accessible to maintenance staff. To gain the trust of the travelers, the wind speed could be shared with the public.



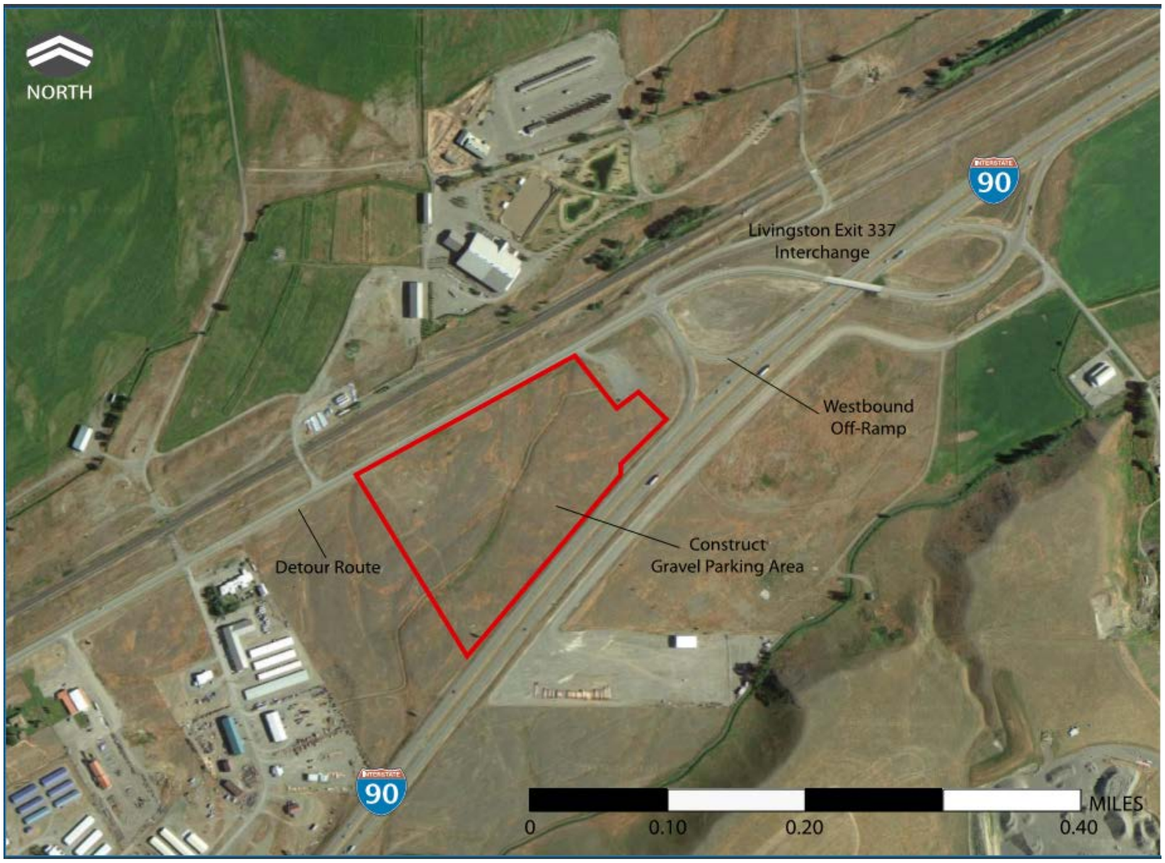
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Wind Speed Gauge	Each	1	$ 30,000	$ 30,000
Total				$ 30,000

Owner		Cost
Montana 40 Acre LLC		Construction $ 1,632,000 CE/TC/Mobilization @ 40% $ 653,000 Total $ 2,285,000
Improvement Option		
Acquire the private parcel adjacent to the westbound Exit 337 on-ramp and construct a gravel parking area.		
Closest Interchange RP	Improvement Name	Improvement Option No.
337	Livingston Exit 337 Parking	#12

Description

This improvement proposes acquiring the privately-owned Montana 40 Acre LLC parcel (Geocode: 49-0803-04-3-01-02-0000) and constructing a gravel parking area to accommodate stranded motorists during closure events. No facilities improvements are included in the improvement recommendation to allow for the maximum number of new parking stalls. The cost estimate is based on gravel surfacing the area outlined in the exhibit below. Right-of-way, site improvements and lighting are not included in this cost estimate. Note that an alternative option would be to agree to a PPP with the private landowner allowing MDT to construct the parking lot without acquiring right-of way.



Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Earthwork	Sq Yard	108800	$ 5	$ 544,000
Gravel	Sq Yard	108800	$ 10	$ 1,088,000
Total				$ 1,632,000

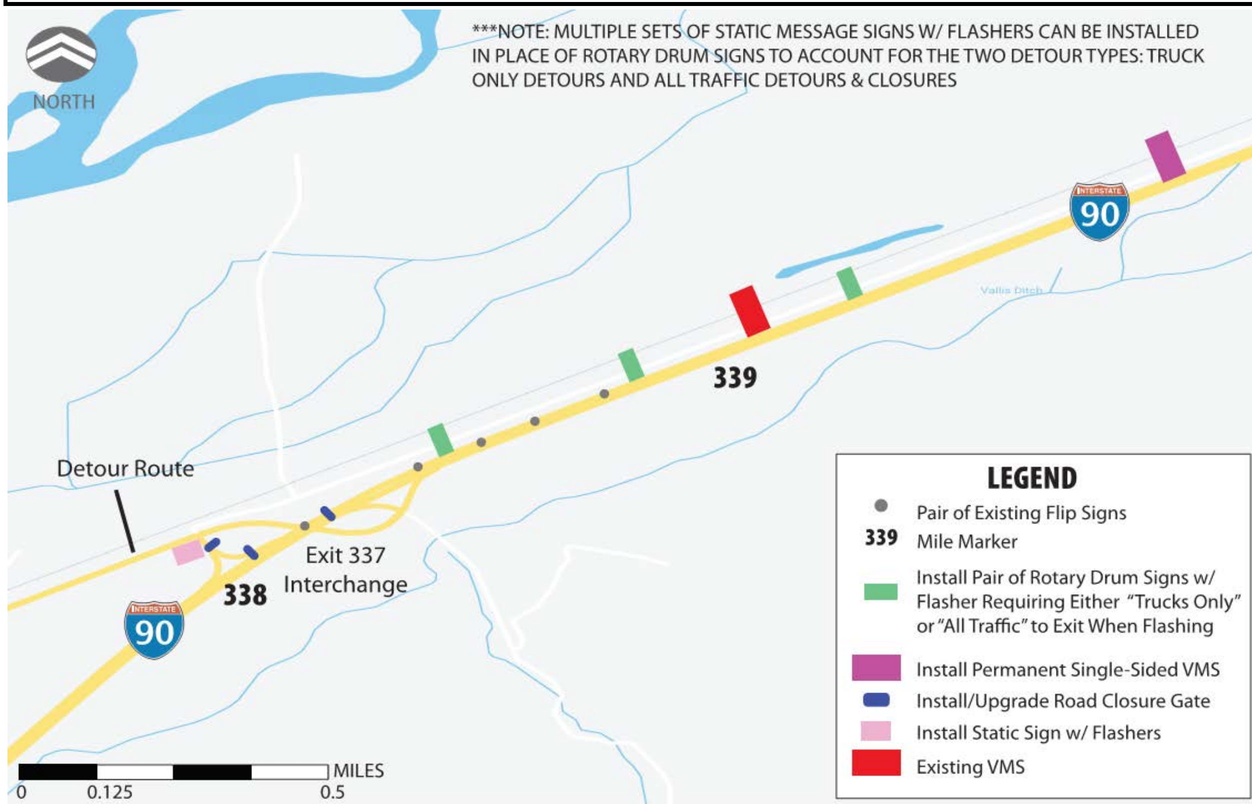
Owner	Cost
Montana DOT	
Improvement Option	Construction $ 209,000
Road Closure Signage at the Livingston Exit 337 interchange	CE/TC/Mobilization @ 40% $ 84,000
	Total $ 293,000

Closest Interchange RP	Improvement Name	Improvement Option No.
337	Road Closure Signage - Livingston Exit 337	#13

Description

This improvement proposes removing the existing flip-signs at the Livingston Exit 337 interchange and replacing them with a combination of VMS, static signs with flashers, and/or rotary drum signs. The key feature of all of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure. Removing the requirement for MDT maintenance staff to manually operate the existing flip-signs will lead to more efficient implementation of detours and closures of the interstate.

Note that Improvement Option #13 is proposed in conjunction with Improvement Option #14.

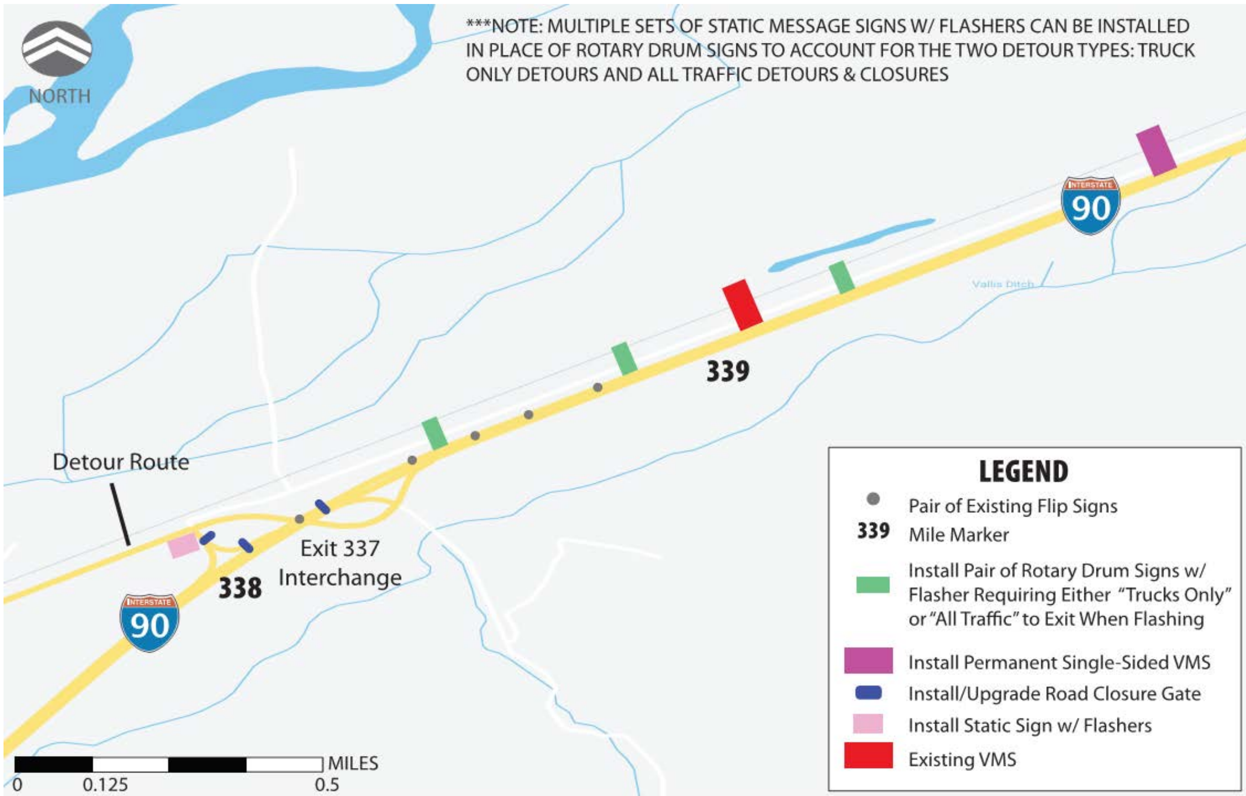


Construction Cost Estimate

Item	Unit	Quant	Unit Cost	Total Cost
Remove Flip-Signs	Each	10	$ 60	$ 600
Single-Sided VMS	Each	1	$ 50,000	$ 50,000
Drum Sign w/ Flashers	Each	6	$ 25,000	$ 150,000
Static Sign w/ Flashers	Each	1	$ 7,500	$ 7,500
Total				$ 208,100

Owner		Cost
Montana DOT		Construction $ 75,000 CE/TC/Mobilization @ 40% $ 30,000 Total $ 105,000
Improvement Option		
Automated closure gate system for the Livingston Exit 337 interchange		
Closest Interchange RP	**Improvement Name**	**Improvement Option No.**
337	Gates - Livingston Exit 337	#14

Description
This improvement proposes upgrading and/or installing new closure gates to allow for automated gate operation at the Livingston Exit 337 interchange, including the installation of a new gate to close the WB I-90 On-Ramp. Recommend relocating/replacing the eastern-most existing gate directly adjacent to the interstate overpass to the east of the overpass to improve gate visibility. Note that Improvement Option #14 is proposed in conjunction with Improvement Option #13.



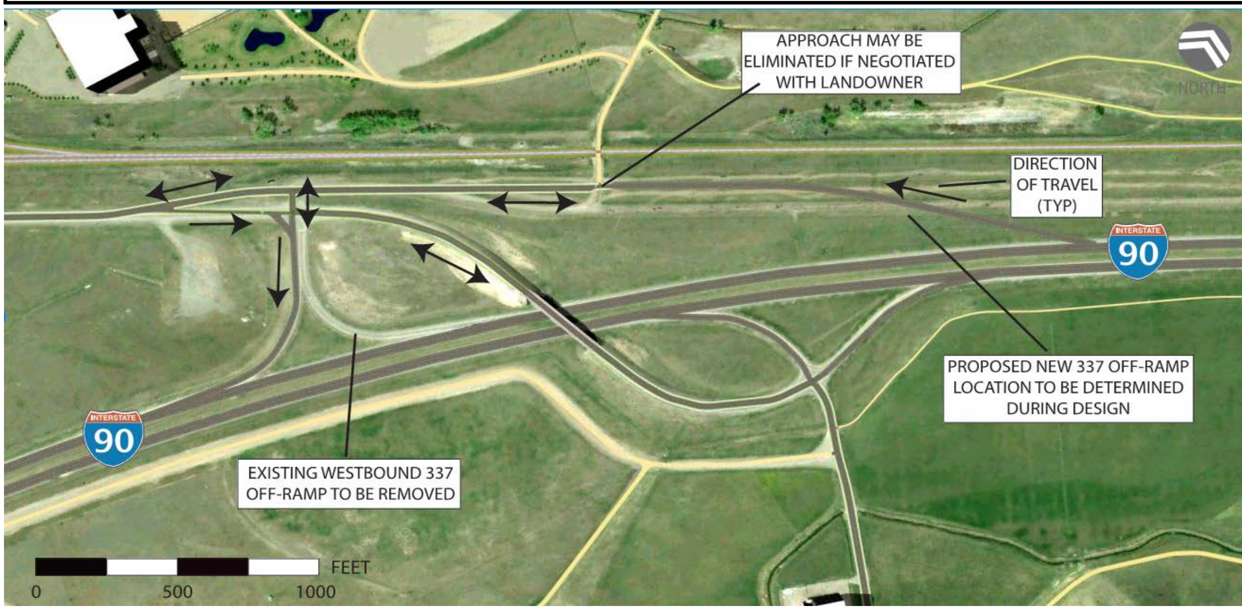
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	3	$ 25,000	$ 75,000
Total				$ 75,000

Owner	Cost	
Montana DOT	Engineering Design $	300,000
Improvement Option	Construction $	1,500,000
Reconfigure/Reconstruct the westbound I-90 off-ramp at Exit 337 further to the east in order to improve operations during detour and closure events	CE/TC/Mobilization @ 40% of Const. $	600,000
	Total $	2,400,000

Closest Interchange RP	Improvement Name	Improvement Option No.
337	Reconfigure/Reconstruct WB Off-Ramp at Livingston Exit 337	#15

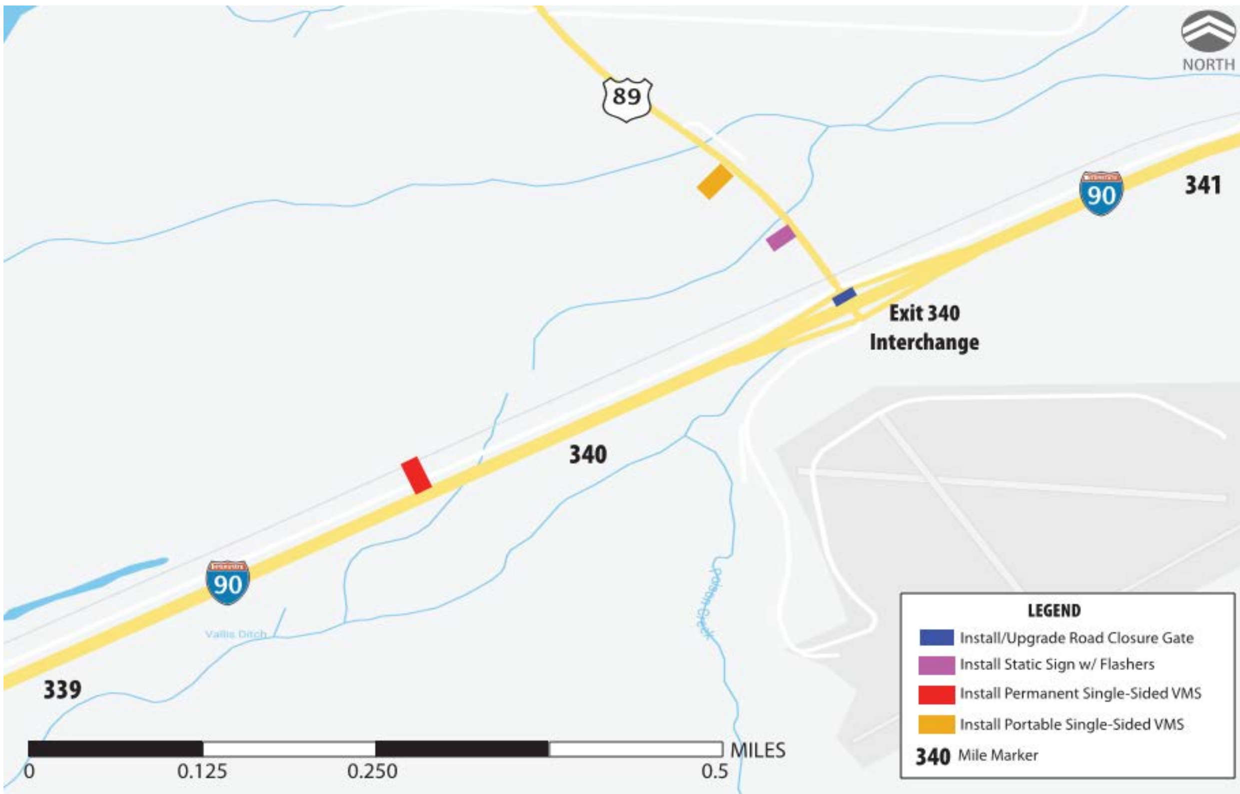
Description
This improvement proposes designing and constructing a new westbound I-90 off-ramp at the Exit 337 interchange. Replacing the existing WB Exit 337 off-ramp will solve numerous issues that were identified by MDT and local stakeholders; most notably improved safety for interstate travelers and improved traffic operations through the city of Livingston during detour or closure events. It is assumed that all of the right-of-way required to construct the new off-ramp is owned by MDT. No obvious environmentally sensitive areas exist within the construction limits based on an aerial review of the area. Note that in the event that Improvement Option #15 is implemented, mainline I-90 closure gate and sign installations associated with Improvement Options #13 & #14 would need to be adjusted to work in conjunction with the new WB off-ramp.



Owner		Cost	
Montana DOT		Construction	$ 13,000
Improvement Option		CE/TC/Mobilization @ 40%	$ 5,000
Road Closure Signage at the White Sulphur Springs Exit 340 interchange		Total	$ 18,000
Closest Interchange RP	Improvement Name	Improvement Option No.	
340	Road Closure Signage - White Sulphur Springs Exit 340	#16	

Description

This improvement proposes installing static sign(s) with flashers at the White Sulphur Springs Exit 340 interchange in conjunction with the recommended closure gate installation included in Improvement Option #17. The key feature of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure. A dedicated portable VMS is included in addition to the gate signage in order to provide MDT with an increased ability to communicate to southbound travelers merging with I-90 from Highway 89. The new VMS located on the improvement exhibit below is included in the construction cost estimate for the Exit 337 Signs.
Note that Improvement Option #16 is proposed in conjunction with Improvement Option #17.



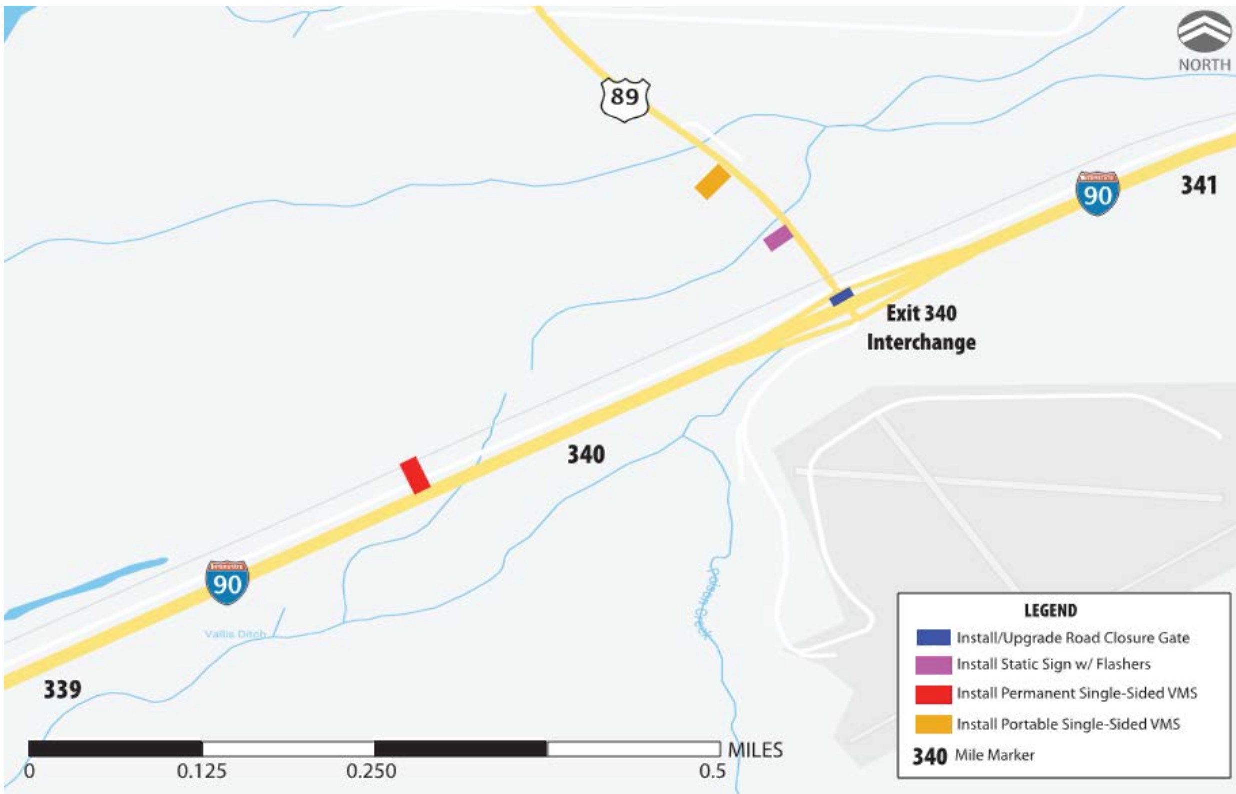
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Portable Single-Sided VMS	Each	1	$ 5,000	$ 5,000
Static Sign w/ Flashers	Each	1	$ 7,500	$ 7,500
Total				$ 12,500

Owner		Cost
Montana DOT		Construction $ 25,000 CE/TC/Mobilization @ 40% $ 10,000 Total $ 35,000
Improvement Option		
Automated Gate at the White Sulphur Springs Exit 340 interchange		
Closest Interchange RP	Improvement Name	Improvement Option No.
340	Gate - White Sulphur Springs Exit 340	#17

Description

This improvement proposes upgrading and/or installing a new closure gate to allow for automated gate operation at the White Sulphur Springs Exit 340 interchange. Recommend upgrading/replacing the existing gate in its current location.
Note that Improvement Option #17 is proposed in conjunction with Improvement Option #16.



Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	1	$ 25,000	$ 25,000
Total				$ 25,000

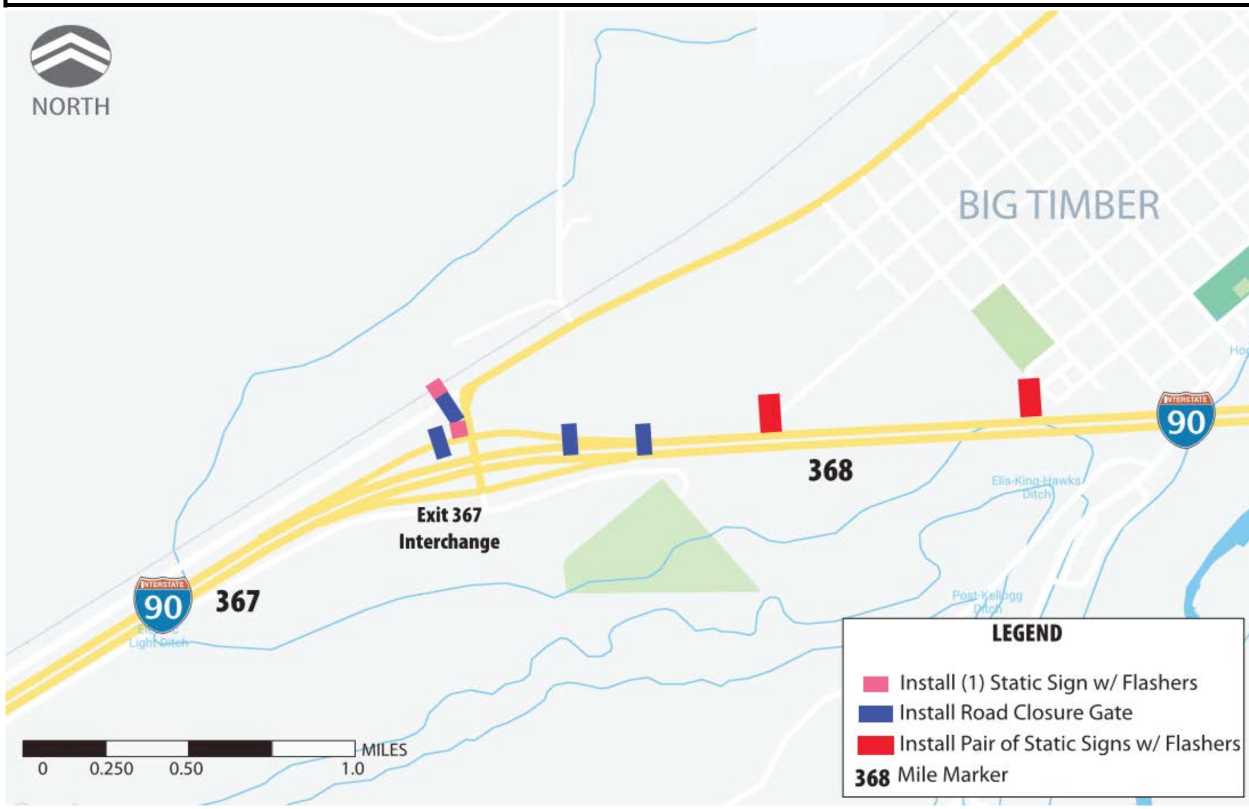
Owner	Cost		
Montana DOT			
Improvement Option	Construction	$	45,000
Road Closure Signage at the Big Timber Exit 367 interchange	CE/TC/Mobilization @ 40%	$	18,000
	Total	$	63,000

Closest Interchange RP	Improvement Name	Improvement Option No.
367	Road Closure Signage - Big Timber Exit 367	#18

Description

This improvement proposes installing static sign(s) with flashers at the Big Timber Exit 367 interchange in conjunction with the recommended automated closure gate installation included in Improvement Option #19. The key feature of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure, which allows for efficient implementation of interstate closures.

Note that Improvement Option #18 is proposed in conjunction with Improvement Option #19.



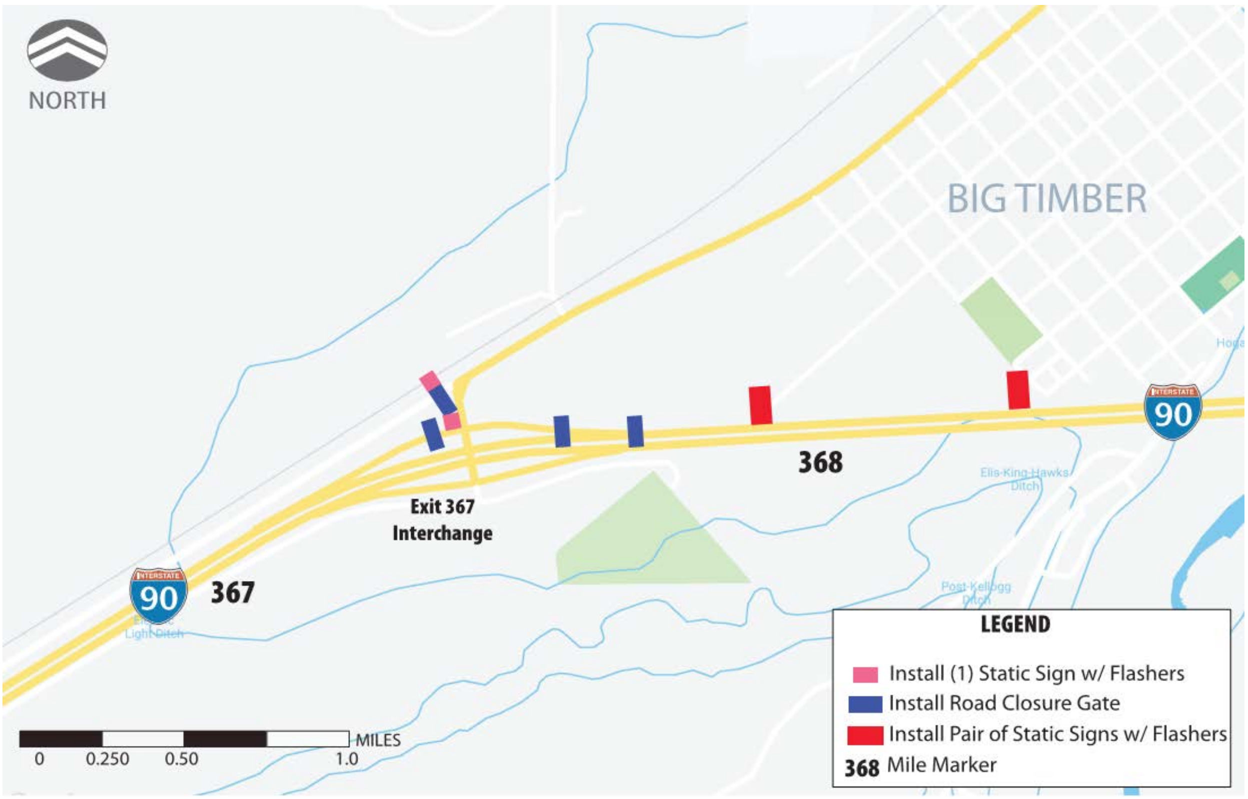
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Static Sign w/ Flashers	Each	6	$ 7,500	$ 45,000
Total				$ 45,000

Owner		Cost
Montana DOT		Construction $ 100,000 CE/TC/Mobilization @ 40% $ 40,000 Total $ 140,000
Improvement Option		
Automated closure gate system for the Big Timber Exit 367 interchange		
Closest Interchange RP	**Improvement Name**	**Improvement Option No.**
367	Gates - Big Timber Exit 367	#19

Description

This improvement proposes new closure gates to allow for automated gate operation at the Big Timber Exit 367 interchange, including the installation of a gate to close the WB I-90 On-Ramp. An additional gate is recommended to close the frontage road north of I-90 to traffic in the westbound direction.
Note that Improvement Option #19 is proposed in conjunction with Improvement Option #18.



Construction Cost Estimate

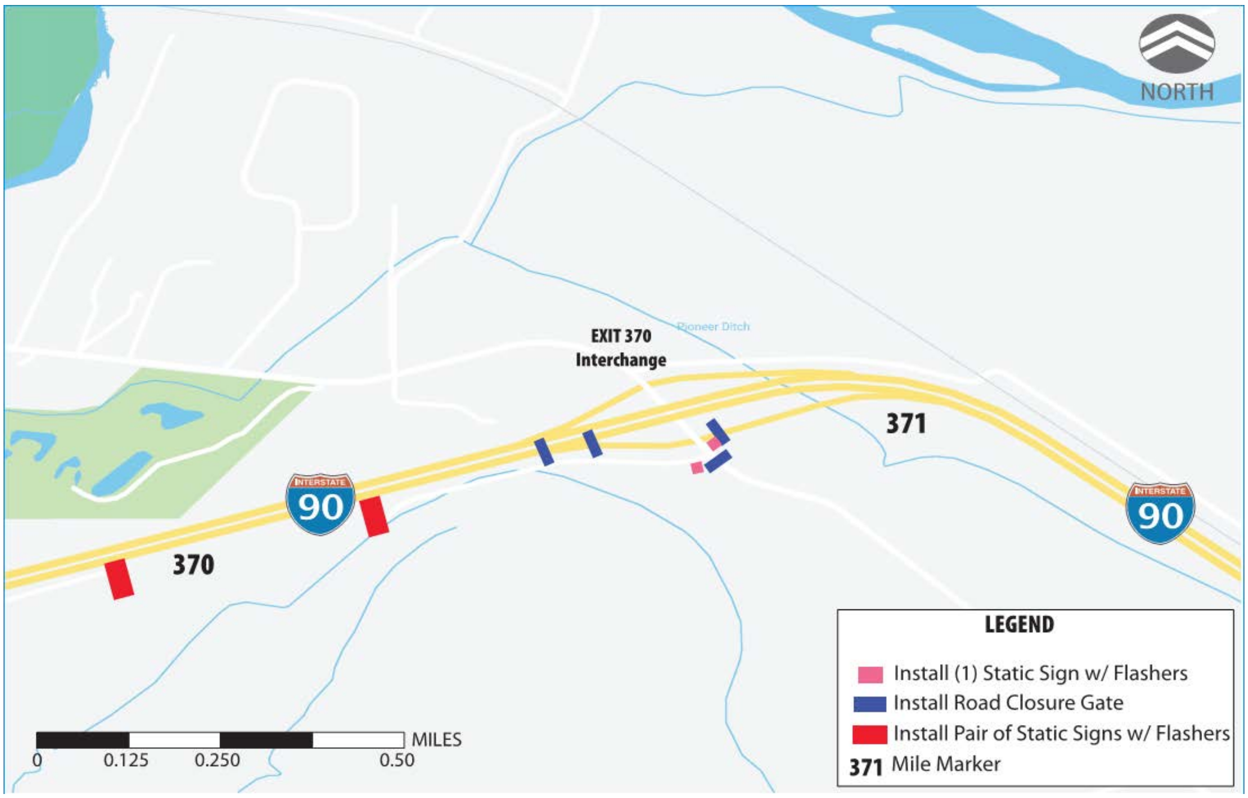
Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	4	$ 25,000	$ 100,000
Total				$ 100,000

Owner	Cost
Montana DOT	
Improvement Option	Construction $ 45,000
Road Closure Signage at the Big Timber Exit 370 interchange	CE/TC/Mobilization @ 40% $ 18,000
	Total $ 63,000

Closest Interchange RP	Improvement Name	Improvement Option No.
370	Road Closure Signage - Big Timber Exit 370	#20

Description

This improvement proposes installing static sign(s) with flashers at the Big Timber Exit 370 interchange in conjunction with the recommended automated closure gate installation included in Improvement Option #21. The key feature of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure, which allows for efficient implementation of interstate closures.
Note that Improvement Option #20 is proposed in conjunction with Improvement Option #21.



Construction Cost Estimate

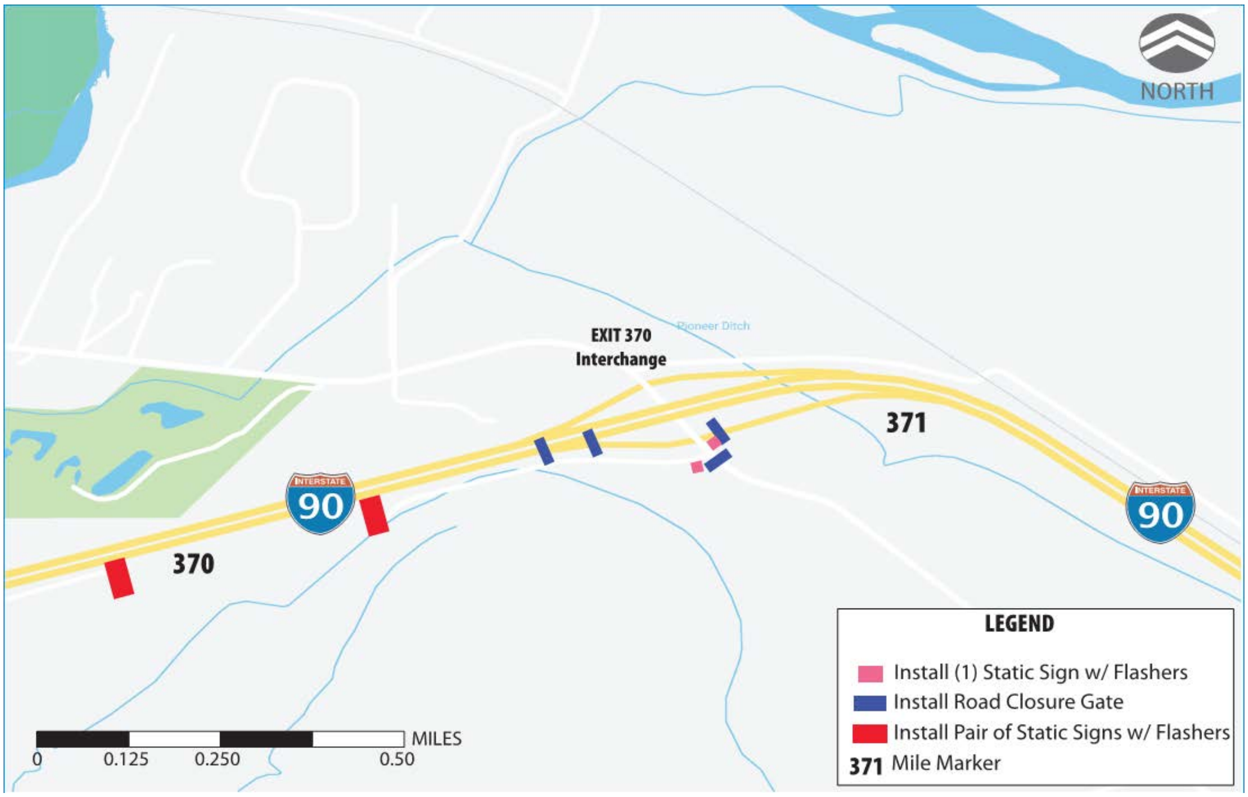
Item	Unit	Quantity	Unit Cost	Total Cost
Install Static Sign	Each	6	$ 7,500	$ 45,000
Total				$ 45,000

Owner		Cost	
Montana DOT			
Improvement Option		Construction $	100,000
Automated closure gate system for Big Timber Exit 370		CE/TC/Mobilization @ 40% $	40,000
		Total $	140,000
Closest Interchange RP	Improvement Name	Improvement Option No.	
370	Gates - Big Timber Exit 370	#21	

Description

This improvement proposes new closure gates to allow for automated gate operation at the Big Timber Exit 370 interchange, including the installation of a gate to close the EB I-90 On-Ramp. An additional gate is recommended to close the frontage road south of I-90 to traffic in the eastbound direction.

Note that Improvement Option #21 is proposed in conjunction with Improvement Option #20.



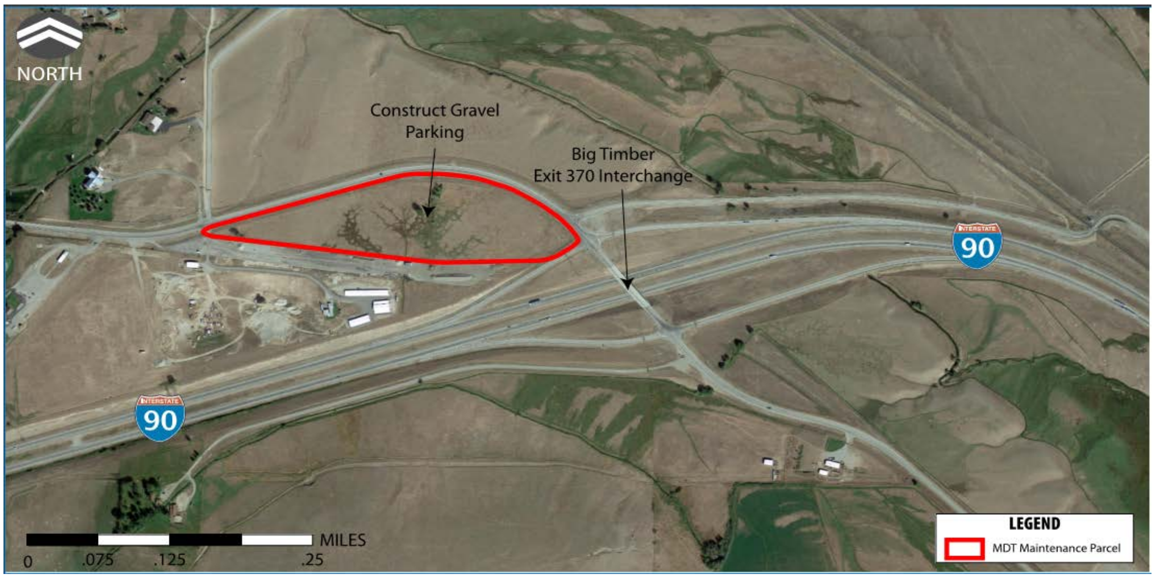
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	4	$ 25,000	$ 100,000
Total				$ 100,000

Owner		Cost
Montana DOT		Construction $ 998,000 CE/TC/Mobilization @ 40% $ 399,000 Total $ 1,397,000
Improvement Option		
Construct Gravel Parking Lot at the MDT Big Timber Maintenance Yard adjacent to the Exit 370 interchange		
Closest Interchange RP	Improvement Name	Improvement Option No.
370	Big Timber Exit 370 Parking	#22

Description

This improvement consists of constructing a gravel parking area at the MDT Maintenance yard adjacent to the Big Timber Exit 370 interchange to accommodate stranded motorists during closure events. No facilities are included in the improvement recommendation to allow for the maximum number of new parking stalls. Care would need to be taken to construct the parking area in a manner that did not conflict with existing or future MDT maintenance yard activities. Additional site improvements and lighting are not included in the cost estimate.



Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Earthwork	Sq Yard	66500	$ 5	$ 332,500
Gravel	Sq Yard	66500	$ 10	$ 665,000
Total				$ 997,500

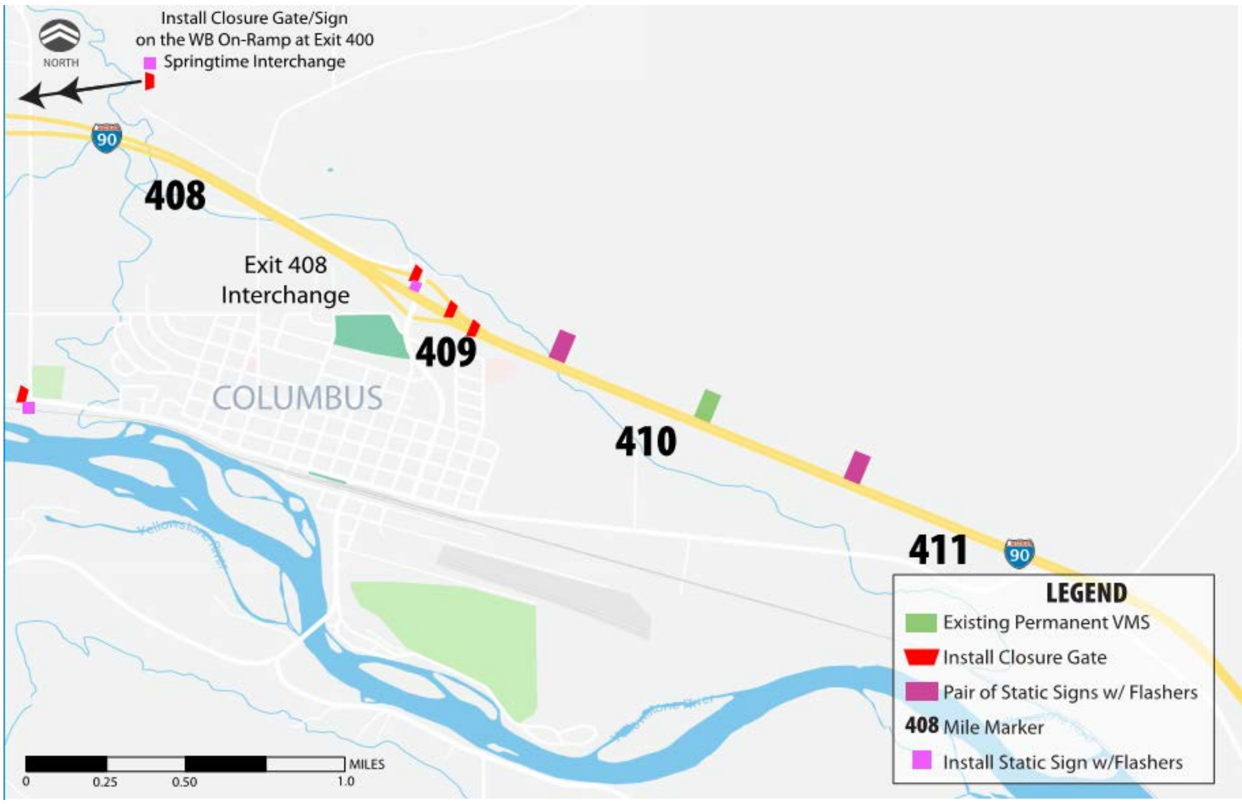
Owner	Cost
Montana DOT	
Improvement Option	Construction $ 53,000
Road Closure Signage at the Columbus Exit 408, the Springtime Exit 400 WB On-Ramp, and to close the frontage road departing Columbus to the west.	CE/TC/Mobilization @ 40% $ 21,000 Total $ 74,000

Closest Interchange RP	Improvement Name	Improvement Option No.
408	Road Closure Signage - Columbus	#23

Description

This improvement proposes installing static sign(s) with flashers in the Columbus area as noted on the exhibit below and in conjunction with the recommended closure gate installation included in Improvement Option #24. The key feature of these signs is their ability to be activated remotely as soon as the decision has been made to implement a detour or closure, which allows for MDT maintenance staff to quickly and efficiently implement closures.

Note that Improvement Option #23 is proposed in conjunction with Improvement Option #24.



Construction Cost Estimate

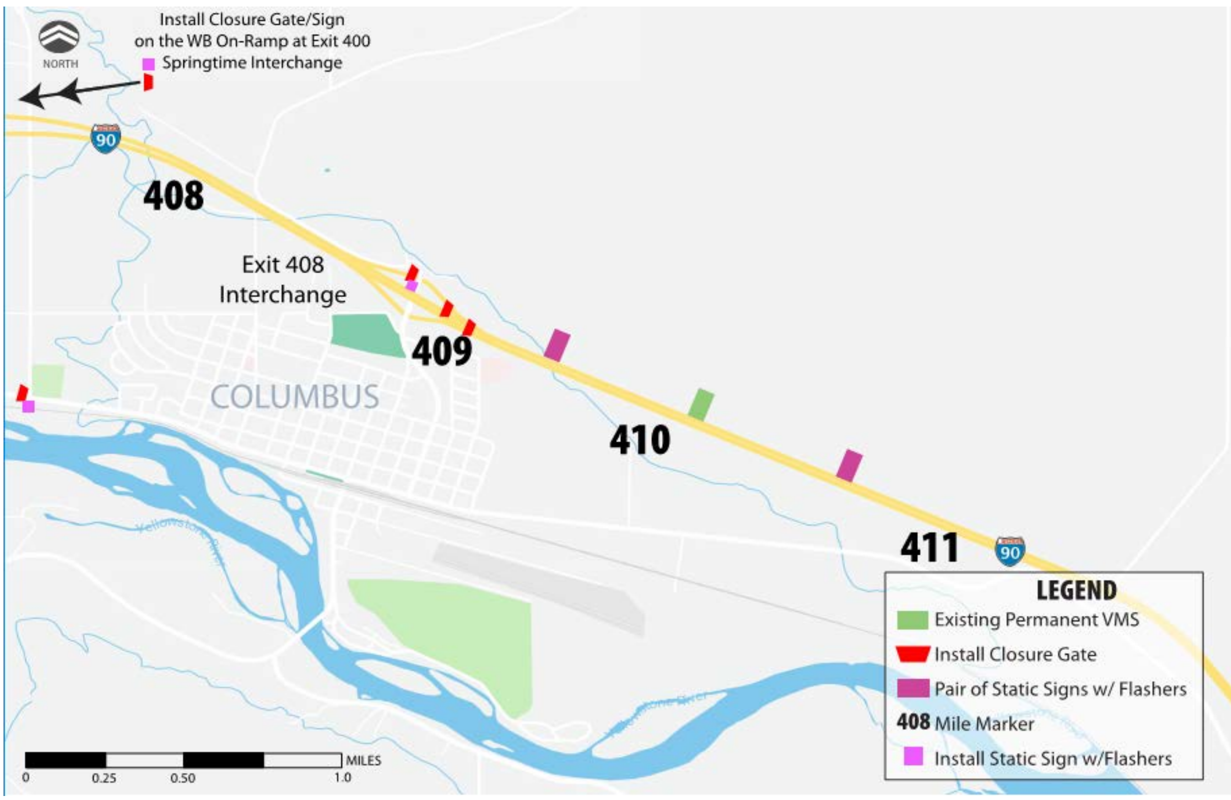
Item	Unit	Quantity	Unit Cost	Total Cost
Static Sign w/ Flashers	Each	7	$ 7,500	$ 52,500
Total				$ 52,500

Owner		Cost
Montana DOT		Construction $ 125,000 CE/TC/Mobilization @ 40% $ 50,000 Total $ 175,000
Improvement Option		
New automated closure gate system for the Columbus area including the Columbus Exit 408 interchange, the Springtime Exit 400 WB On-Ramp, and at frontage road departing Columbus to the west		
Closest Interchange RP	**Improvement Name**	**Improvement Option No.**
408	Gates - Columbus	#24

Description

This improvement proposes installing new automated closure gates for westbound I-90 traffic at the Columbus Exit 408 interchange. Additional closure gates are recommended where Old U.S. Hwy 10 departs Columbus to the west to prevent traffic from circumventing the interstate closure by way of the frontage road to the Springtime Exit 400 interchange, and at the I-90 WB on-ramp at the Exit 400 interchange.

Note that Improvement Option #24 is proposed in conjunction with Improvement Option #23.



Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Automated Gate	Each	5	$ 25,000	$ 125,000
Total				$ 125,000

Owner		Cost
Montana DOT		Construction $ 50,000 CE/TC/Mobilization @ 40% $ 20,000 Total $ 70,000
Improvement Option		
Install permanent VMS sign for westbound I-90 traffic to the east of Park City		
Closest Interchange RP	Improvement Name	Improvement Option No.
426	VMS - Park City	#25

Description

This improvement proposes a dedicated permanent VMS sign for westbound I-90 travelers to the east of the Park City Exit 426 interchange. The sign is intended to convey information to westbound I-90 travelers only and could be installed on the interstate shoulder.

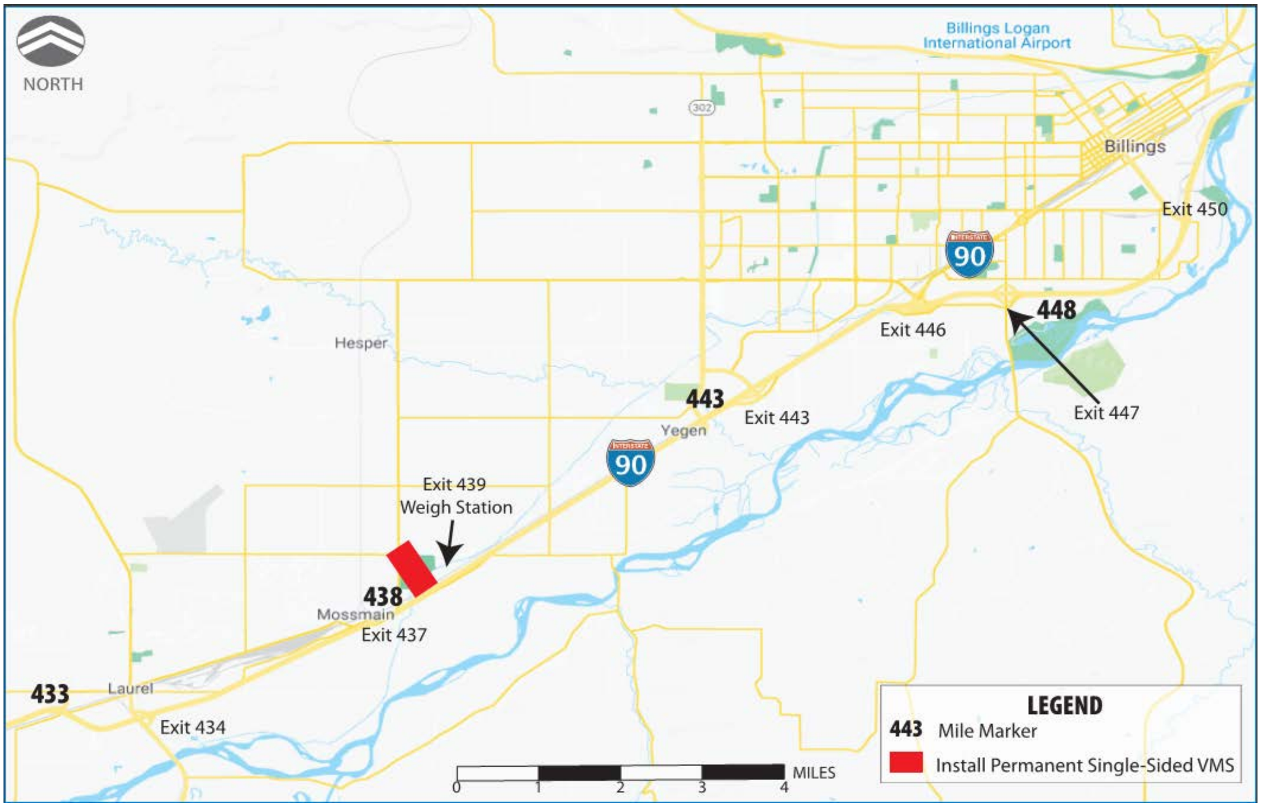
Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Single-Sided VMS	Each	1	$ 50,000	$ 50,000
Total				$ 50,000

Owner		Cost
Montana DOT		Construction $ 50,000
Improvement Option		CE/TC/Mobilization @ 40% $ 20,000
Install permanent VMS sign for westbound I-90 traffic to the west of the Exit 439 Weigh Station		Total $ 70,000
Closest Interchange RP	Improvement Name	Improvement Option No.
437	VMS - Laurel	#26

Description

This improvement consists of installing a dedicated permanent VMS sign for westbound I-90 travelers to the west of the Exit 439 weigh station. The sign is intended to convey information to westbound I-90 travelers only and could be installed on the interstate shoulder. Note that there is the potential of installing this sign within the median behind existing guardrail near RP 437.5, possibly requiring the guardrail to be extended. A median installation would allow for the sign to be double-sided which would allow for the VMS to be used for both WB and EB I-90 travelers.



Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Single-Sided VMS	Each	1	$ 50,000	$ 50,000
Total				$ 50,000

Owner	Cost
Montana DOT	Construction $ 50,000 CE/TC/Mobilization @ 40% $ 20,000 Total $ 70,000
Improvement Option	
Install permanent VMS sign for westbound I-90 traffic to the east of the Lockwood Exit 455 interchange	

Closest Interchange RP	Improvement Name	Improvement Option No.
455	VMS - Lockwood	#27

Description

This improvement consists of installing a dedicated permanent VMS sign for westbound I-90 travelers to the east of the Lockwood Exit 455 interchange, near RP 456. As the sign is intended to convey information to westbound I-90 travelers only, it would be installed on the interstate shoulder. The VMS could inform travelers of weather/traffic events occurring west of Billings and limit traffic continuing to travel past Billings. Crucially, Billings has the capability to host travelers during interstate closures.

Construction Cost Estimate

Item	Unit	Quantity	Unit Cost	Total Cost
Single-Sided VMS	Each	1	$ 50,000	$ 50,000
Total				$ 50,000

BASIS FOR COST ESTIMATES

Cost Item	Unit	Unit Cost	Assumptions
Remove Flip-Signs	each	$ 60	Rounded up from $54.88 for sign removals in MDT 2018 Jan-June Average Bid Prices
Portable VMS - Single-Sided	each	$ 5,000	From US DOT ITS Cost database
Portable VMS - Double-Sided	each	$ 7,500	50% more than single
Single-Sided VMS (large)	each	$ 50,000	From US DOT ITS Cost database
Double-Sided VMS (large)	each	$ 75,000	50% more than single
Static Message Sign w/ Flashers (large)	each	$ 7,500	From US DOT ITS Cost database
Drum Sign w/ Flashers (large)	each	$ 25,000	50% of single-sided VMS
New Gate	each	$ 25,000	Based on $17k average cost from Nebraska DOT project referenced
Earthwork	sq. yard	$ 5	Based on avg. 2' depth using MDT 2018 Jan. to June Avg. Bid Price for Excavation - Unclassified (and rounded up)
Gravel	sq. yard	$ 10	Assume 1' section of crushed base course for gravel only surfacing using MDT 2018 Jan. to June Avg. Bid Price (and rounded)
Pavement	sq. yard	$ 60	Assume 0.5' pavement section & For plant mix surfacing use a 2' gravel base course (at MDT 2018 Jan. to June Avg. Bid Price (and rounded)
Windbreak	Lineal Foot	$ 440	The windbreak cost was based on the earthwork quantity per foot as shown in the conceptual drawing at a 12' height with a 10' high barrier on top. The barrier was estimated from *FHWA's Noise Barrier Construction Material Average Unit Cost by Height* (adjusted from 2010 to 2018 @ 3%).
Wind Gauge	each	$ 30,000	Rounded up from $26,400 in MDT 2018 Jan-June Average Bid Prices
Reconfigure Exit 337 WB Off-Ramp	lump sum	$ 1,500,000	This improvement option was based on the surfacing costs of 3,500 feet of roadway with a 32' average width. It was estimated using MDT 2018 Jan. to June Avg. Bid Prices (rounded) with a 0.5' asphalt and 2' crushed base section. To account for the all miscellaneous items, the total cost was estimated using engineering judgement to be 2 times the surfacing costs.
For Trafffic Control, Construction Engineering (CE), and Mobilization	%	40%	Based on engineering judgement

Appendix E

MDT's 2004 Procedure for Closure of I-90 between Livingston & Columbus

serving you with pride

Montana Department of Transportation

David A. Galt, Director
Judy Martz, Governor

Billings District Office
424 Morey Street
PO Box 20437
Billings, MT 59104-0437

April 19, 2004

Pat Dringman
Sweet Grass County Attorney
P.O. Box 1188
Big Timber, MT 59011-1188

Subject: Procedure for Closure of I-90 between Livingston & Columbus

Attached please find a draft procedure for the closure of I-90 between Livingston and Columbus. I have also included the cover memorandum that was used for internal circulation because it raises some traffic control questions that have not yet been resolved.

The Maintenance Division has ordered additional changeable message signs, but they have not been received. We anticipate having them for use by this fall. Even with the additional signs, the total number of signs in the state will not be significant. It is our intent to pre-position the signs and use them as described in the procedure; however, there may be instances or circumstances that require their use in another location.

Please note that two emergency response personnel from local emergency response groups, will be required to physically man the barricades at Exit 340 and Exit 400. The Montana Department of Transportation does not have personnel for this assignment. The Department will also have to work with the local emergency response groups to formulate a plan for the placement of barricades. Some barricades may be able to be pre-positioned and could be set-in-place by emergency response personnel.

I would appreciate your comments by the end of May. Please feel free to contact me locally at 657-0210, or toll-free at 1-888-863-8465 if have any questions.

Thanks for your assistance in this matter!

Bruce H. Barrett
District Administrator – Billings

S:\ADMIN\Admin\48_GEN_CORRESP\I-90_Closure_ltr.DOC

Attachments

copies: Jim Currie, Deputy Director
John Blacker, Maintenance Administrator
Ross Gammon, Bozeman Maintenance Chief
Jim Stevenson, Billings Maintenance Chief

APR 20 2004

Phone: (406) 252-4138
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Internet: www.mdt.state.us

Montana Department of Transportation
Billings District
Billings, Montana

Memorandum

To: D. John Blacker, Administrator
Maintenance Division

Ross Gammon
Maintenance Chief – Bozeman

From: Bruce H. Barrett
District Administrator – Billings

Date: March 23, 2004

Subject: Procedure for Closure of I-90

Attached please find a draft procedure that has been developed based on our meeting and discussions in Big Timber.

I have a number of issues with our proposed "basic" traffic control at the interchanges. The reason we went to the interchanges rather than a median-U-turn that we talked about in Big Timber is two fold. First there is oncoming traffic and we'd be turning traffic into that, which would require a stop sign on the U-turn plus transitioning the oncoming traffic to the right-hand lane prior to the U-turn. Secondly, with only one officer at the second location trying to get traffic turned around, and with any degree of visibility problems, it looked like a good place for a train wreck. If you consider the turning radius of trucks, we should probably transition to the right-hand lane in the direction of travel so that we provide an adequate turning radius and turning commercial vehicles do not cross both lanes of the opposing traffic.

I think the signing on the attached drawings is fine for the interchanges themselves and lends itself to an officer at the second interchange. My problem is the lack of a lane closure prior to the first interchange. I believe we should be transitioning traffic to the right lane, then off the Interstate. I don't believe this is as critical at the second interchange because the volume of traffic should be considerably less.

Anyway, what's presented here for discussion is generally consistent with what we talked about in Big Timber. Maybe if we put our heads together we can figure out something better.

I would appreciate your comments by March 31st; I'll include them, and then send it out to all that attended the meeting for comments.

Let me know if you need anything else.

WINTER ROAD CLOSURE PROCEEDURE

For

Closing I-90 Between Livingston & Columbus

Criteria For Closure

Wide spread poor visibility for extended periods of time which will be decided by law enforcement and MDT personnel that are on-site during the event.

One or more accidents that block the road or are a hazard to the traveling public that require full closure of I-90.

Hazardous materials incidents will be handled by established procedures for such incidents.

Locations of Closure

Divert eastbound traffic off I-90 at the West Livingston Interchange – Exit 330

Close the eastbound lane at the eastbound off-ramp at Mission Interchange – Exit 340

Divert westbound traffic off I-90 at the Columbus Interchange – Exit 408

Close the westbound lane at the westbound off-ramp at Springtime Interchange – Exit 400

Process to Effect Closure

MDT's Billings or Bozeman office will officially close the road.

On-site personnel from MDT, MHP, and/or local emergency organizations will make the decision to close the road and will contact either the Bozeman or Billings MDT office to implement the closure.

The MDT office receiving the request for closure will contact the other MDT office and will also contact the Park and Stillwater County Sheriff's and advise them of the actual closure time and will notify MHP and the Sweet Grass County Sheriff that the closure process has been initiated and the anticipated closure time.

Process to Implement Closure

Upon receipt of request for closure the MDT dispatcher at the Billings and/or Bozeman office will contact on-site MDT personnel in the Livingston, Big Timber, and Columbus areas to determine the time the closure will go into effect. The actual time the road will be officially closed will be based on when the on-site personnel believe all necessary signing can be installed and manned. MDT dispatch will begin announcements of the pending road closure and MDT and/or emergency response personnel will begin placing and manning barricades. On-site MDT personnel will notify MDT dispatch when everything is in place and the road is actually closed.

MDT will preposition or will transport as necessary the following traffic control devices. MDT or emergency response personnel may relocate pre-positioned barricades to the correct location on the road in accordance with the attached drawings. The MDT dispatcher at the Billings and/or Bozeman office will ensure that someone is assigned to correctly place all of the barricades:

MDT will activate the pre-positioned changeable message signs west of Bozeman and east of Billings if available.

MDT or emergency response individuals will place road-closed barricades at the eastbound off-ramp at Exit 330.

MDT or emergency response individuals will place road-closed barricades at the eastbound off-ramp at Exit 340 and at the eastbound on-ramp. The Park County Sheriff will arrange for one emergency response individual to man the barricade at the off-ramp location.

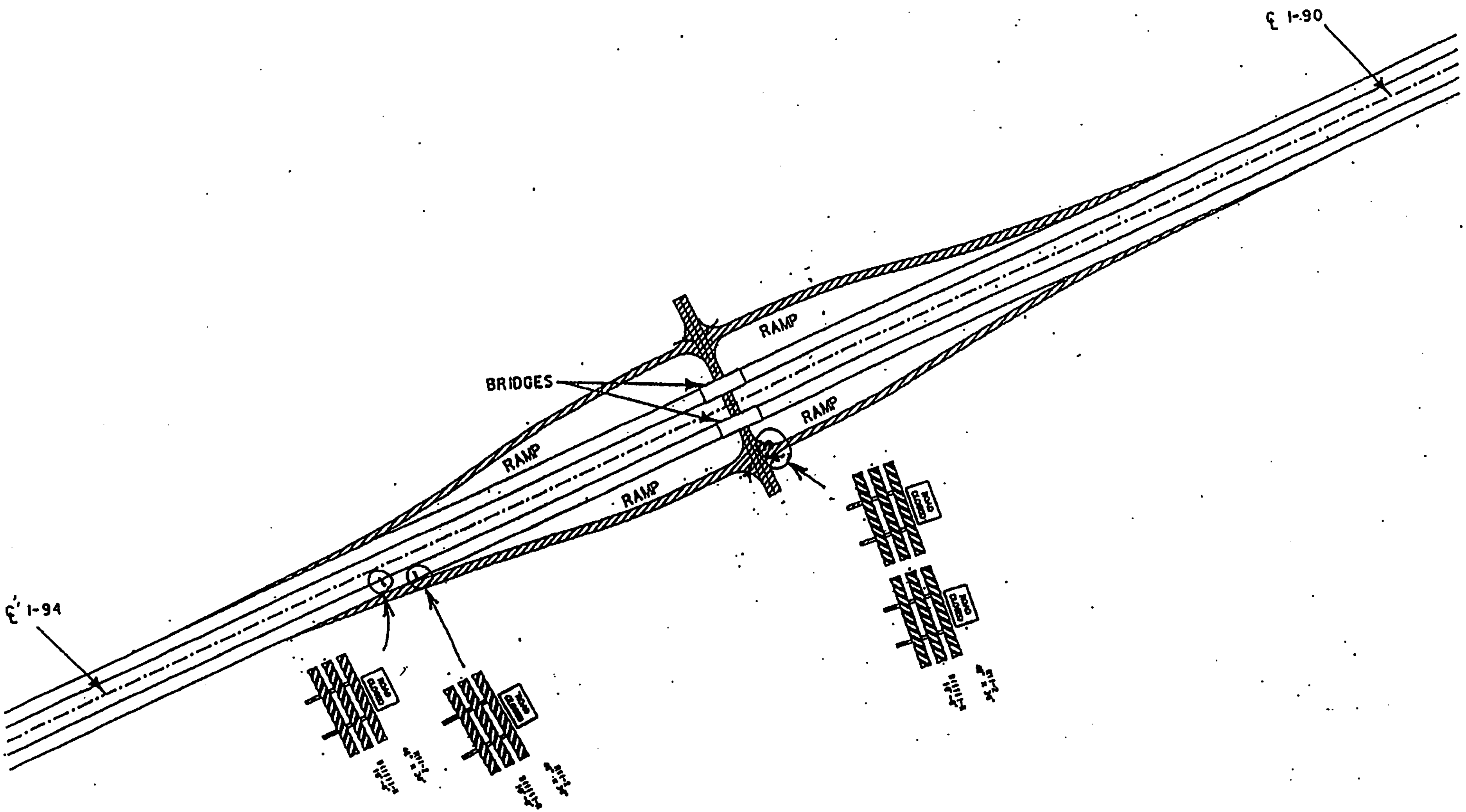
MDT or emergency response individuals will place road-closed barricades at the westbound off-ramp at Exit 408.

MDT or emergency response individuals will place road-closed barricades at the westbound off-ramp at Exit 400 and at the eastbound on-ramp. The Stillwater County Sheriff will arrange for one emergency response individual to man the barricade at the off-ramp location.

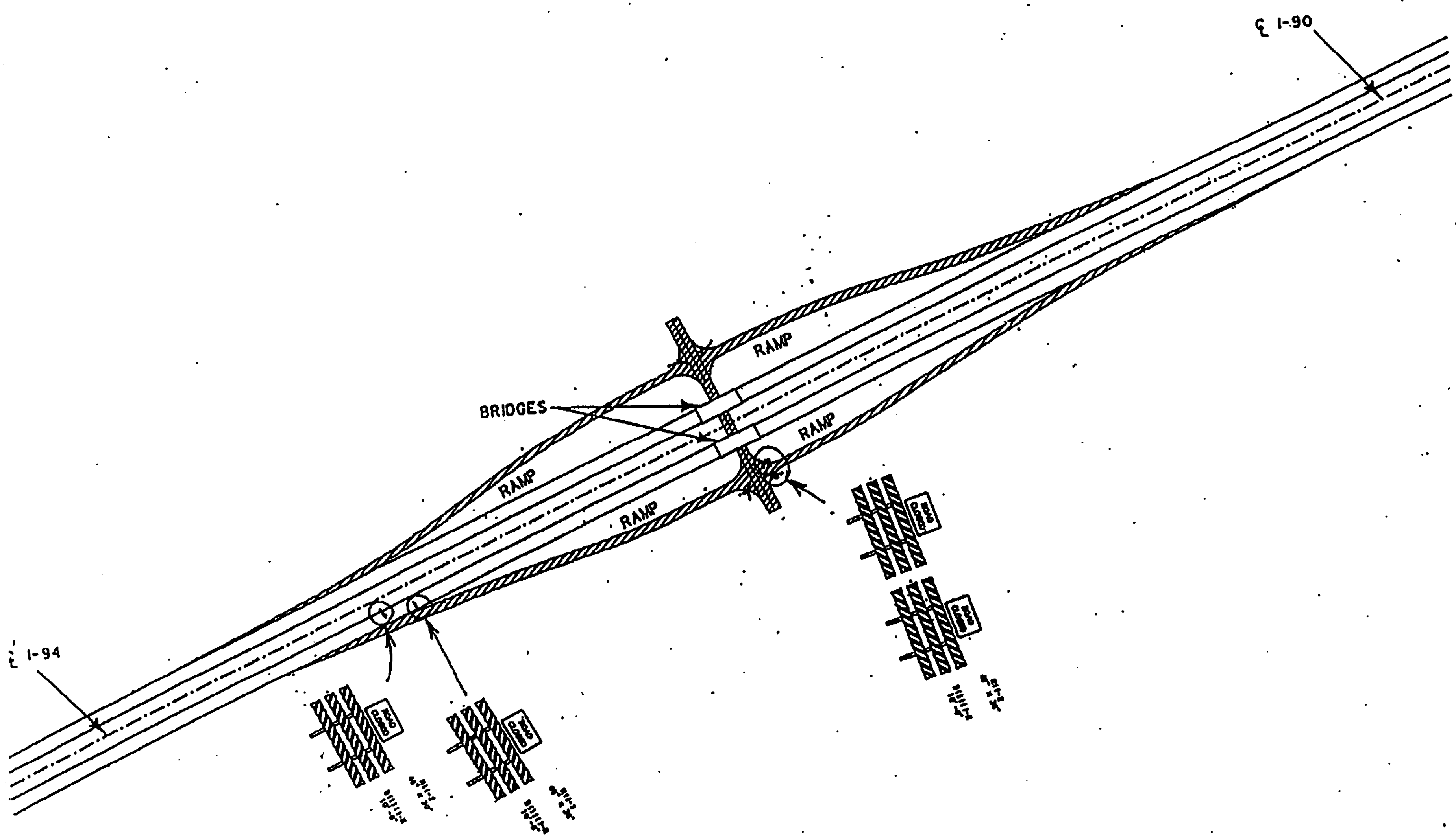
MDT on-site employees will notify MDT dispatch when all barricades are properly positioned and manned. If emergency personnel place and man barricades, they will notify on-site MDT personnel that the barricades are properly placed and manned.

Opening of I-90 will be done in reverse order.

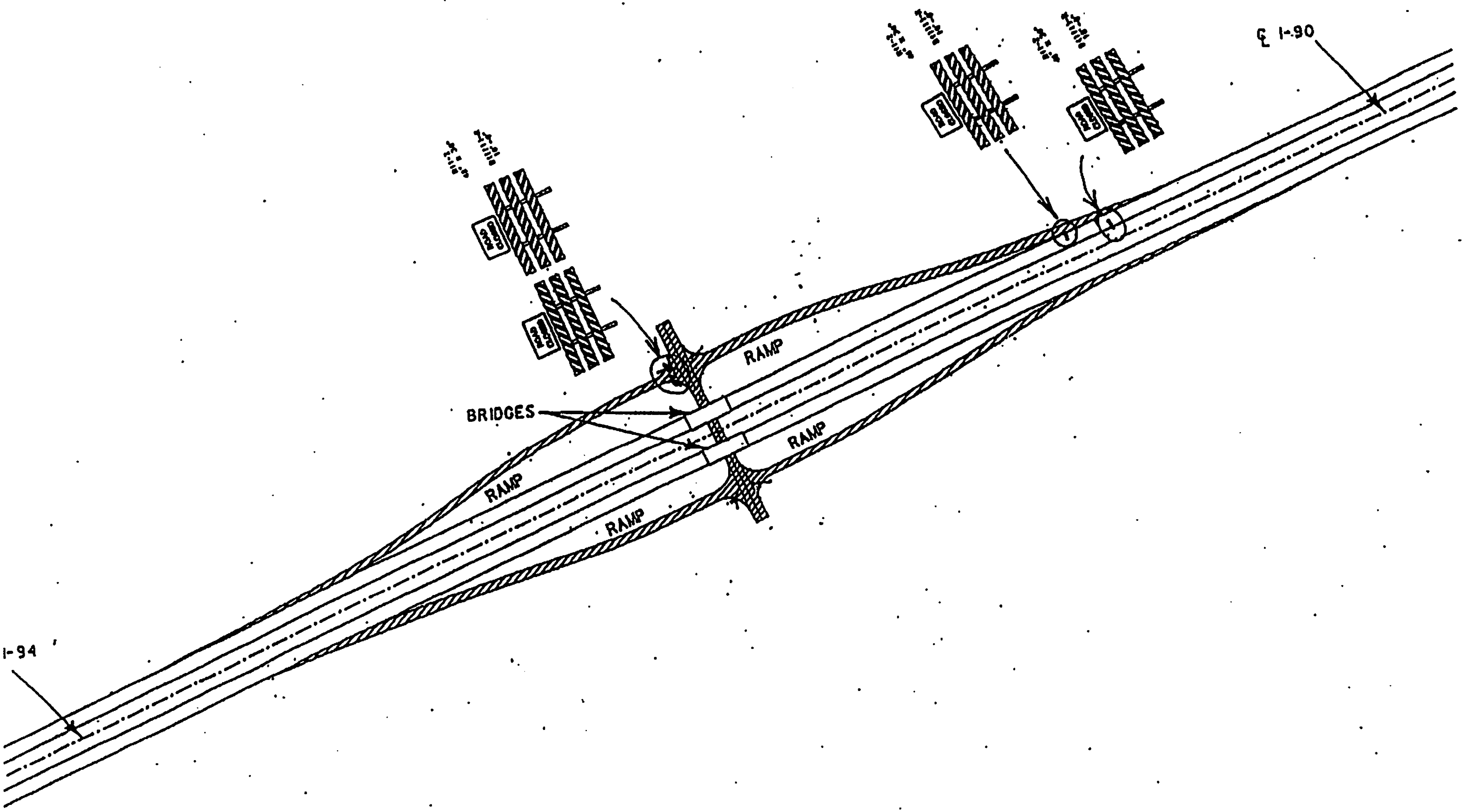
EXIT 330 – DIVERT EASTBOUND TRAFFIC OFF I-90 AT WEST LIVINGSTON INTERCHANGE



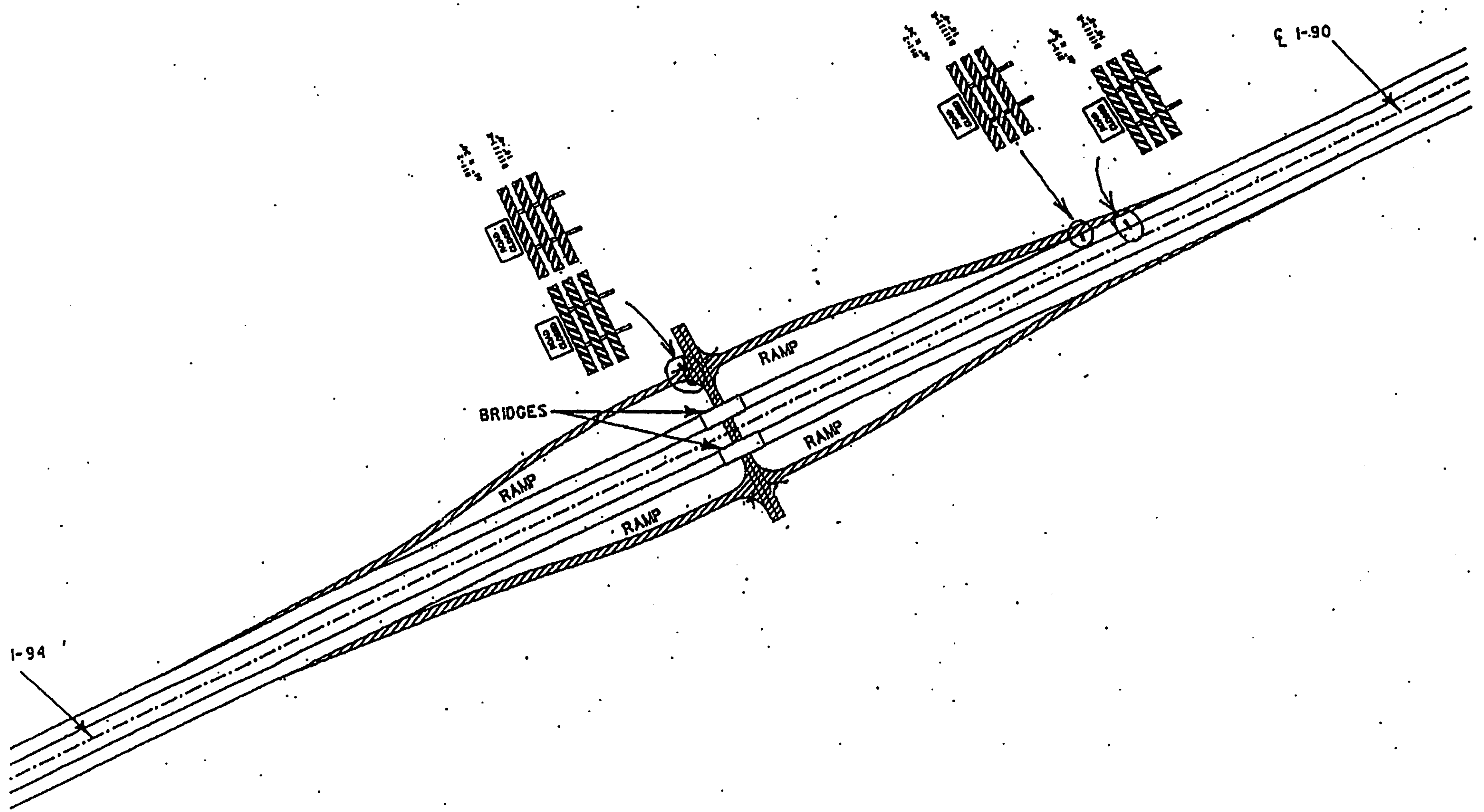
EXIT 340 – CLOSE EASTBOUND LAND AT EASTBOUND OFF-RAMP AT MISSION INTERCHANGE



EXIT 408 – DIVERT WESTBOUND TRAFFIC OFF I-90 AT COLUMBUS INTERCHANGE



EXIT 400 – CLOSE WESTBOUND LANE AT WESTBOUND OFF-RAMP AT SPRINGTIME INTERCHANGE



Appendix F

Stillwater County Stakeholder Letter

STILLWATER COUNTY
OFFICE OF SHERIFF/CORONER
P.O. Box 729
Columbus, MT 59019-0729
(406) 322-5326
Administrative: (406) 322-4386
FAX: (406) 322-5328
E-Mail: cbrophy@scsomt.org

Clifford D. Brophy, Sheriff/Coroner **Charles E. Kem, Undersheriff/Deputy Coroner**

December 18, 2018

Re: Weather impacts on I-90 between Livingston and Billings study

To Whom It May Concern,

Thank you for contacting Stillwater County MT officials for our input into this important study. I was requested by the members of our emergency committee to summarize our recommendations. During our meetings with various representatives of emergency responders and department heads in Stillwater County, we composed a list of some of our ideas and thoughts. We would be happy to visit with you one-on-one if you require additional input. This letter represents my summary of the discussions.

We recognize that closures impact traffic flow as well as the communities near those closures. Small towns are usually overwhelmed within minutes of a shut down in their area. While it's easy to say that the road should be shut down near a large community, we understand that it's not that easy and takes a great deal of time and resources. We also recognize that just the road closure its self requires a lot of resources that most small jurisdictions do not have available.

Our general input is based on a stage to stage process. Initial stage may involve law enforcement and/or other responders to momentarily stop or restrict the flow of traffic. This is commonly done at serious accident scenes. Someone at the scene will then notify Department of Transportation (DOT) that this has occurred. The second stage would require an official notice of closure from DOT. Involvement from the local authorities would include stopping traffic at predetermined access points (generally towns and cities). This would be used for closures of 1 to 2 hours. Scenarios could include multiple vehicle accidents; fires or hazmat spills close to the roadway; snow drifts needing cleared, debris on roadway. The third stage will be for a longer anticipated time frame (2 to 8 hrs.) and involve the same responders. Traffic reroute and physical barriers to stop traffic may be considered. Additionally, predetermined access points would be expanded. For example, instead of just the nearest town being designated as the point to stop traffic in stage two, stage three would be pushed out further and would include more miles of the roadway. Stage four would be used for the extreme cases that could last 8 hrs. or longer. This stage would require traffic rerouting on a large scale. Physical closure of roads with barriers would be used. This could involve communities within a hundred miles either way.

To facilitate the closure of roads during the higher stages, we would suggest using physical barriers. These have been implemented in other areas. Some of these barriers have been swinging gates or drop down gates. We would offer the idea of having local responders trained and having access to the operation of these physical barriers. The local responders would not be given authority to determine when they were to be used. They would have access to operate those barriers only if given direction to do so by designated DOT authorities.

If you would like to visit with any of the officials and departments heads in Stillwater County, please feel free to contact us at your convenience.

Sincerely,

Clifford Brophy
Stillwater County Sheriff/Coroner

MONTANA MDT DEPARTMENT OF TRANSPORTATION

CDM Smith
WWW.CDMSMITH.COM

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