Recommendations for the Implementation

Of High Tension Cable Barrier

In Minnesota

December 2013

A Task force made up of MnDOT staff representing various Districts and functional areas was formed for this study.

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Executive Summary

Background

As traffic volumes have grown, Minnesota has experienced an increase in cross median crashes. High tension cable barrier (HTCB) has proven to be an effective Toward Zero Deaths (TZD) solution at reducing fatal and serious median crashes by about 95% in Minnesota, and 93 % nationally, as identified in a 2012 NCHRP study. In 2004, MnDOT began installing HTCB along the median of some Twin Cities Metropolitan area freeways. Since that time MnDOT has installed over 300 miles of barrier and over 100 more miles planned for 2013. About half of the installed HTCB is in the Twin Cities Metropolitan area and half is distributed on greater Minnesota freeways.

Purpose

In the fall of 2012 the Minnesota Department of Transportation, Operations Division asked the Office of Traffic, Safety and Technology for their recommendation, from a safety perspective, on the fiscally unconstrained use of high tension cable barrier on multilane highways in Minnesota. As a result of these early discussions a task force was formed to investigate the long term use and implementation of HTCB on Minnesota's state highways. The task force looked at current prioritization guidelines from districts within Minnesota and from other states. Funding options for initial installation and maintenance, along with current maintenance practices and costs, were also discussed at length. The purpose of this report is to describe the discussion and recommendations of the task force.

Implementation

It is important to note that this report provides guidance on where to install HTCB relative to barrier use. It includes statewide recommendations on higher risk areas that would benefit from the installation of HTCB. This report does not suggest that HTCB is the highest safety priority. The Department needs to continually weigh the safety needs at all locations along the state highway system and utilize its limited safety dollars where the need is the greatest.

It is recommended that HTCB be installed on all freeways in conjunction with other construction or reconstruction, or as stand-alone projects. It should also be installed on expressways where deemed a high priority and where access density allows. The recommended priority for installation has been determined to be:

1. Highest risk locations as determined by methodology described below, and shown on district maps in the appendix.
2. Remaining interstate sections that did not fall into higher risk categories.

For the purposes of this study, a high level analysis was done on a statewide basis. Variations in design and setting for specific locations were not considered. As projects are proposed, the recommended segments should be further evaluated by each District. It may be appropriate and cost effective to put in barrier at a location with a lower risk rating due to a construction project in the area.

The initial installation costs will be covered by construction dollars when installed as part of a programmed construction project. HSIP funding, along with other special funding as it arises, will be used for standalone installations. To date, maintenance costs have been covered by restitution and district operating funds. It is recommended that Department level discussions on how to fully fund and staff HTCB maintenance costs need to take place.

Prioritization method

The Office of Traffic, Safety and Technology's Safety Section analyzed a 5 year (2008-2012) crash history on all segments of highway in the state that do not currently have any type of median barrier. A comparison was done to look at fatal (K) and severe injury (A) crashes on those segments versus selected criteria that may affect crash severity. Initially, seven criteria were analyzed, including posted speed, volume (ADT), median width, non-severe crash density, severe crash density, heavy commercial volume, and access density. Further analysis determined that four criteria would maximize the benefit/coverage ratio. These four criteria, ADT, median width, severe crash density, and non-severe crash density, were assigned a "star", designating their significance. Segments were then prioritized by using a star system to designate their risk rating. For each of the criteria that a segment met, it was given a star. The more stars a segment has, the higher risk there is for cross median type crashes.

Factor[1]	Criteria	Included Miles[2]	Severe Crashes[3]
Median width	★ ≤ 55 feet	61%	68%
Volume	★ > 20,000 ADT	24%	36%
Severe crash density[4]	★ > 0.0 crashes per mile	60%	100%
Non-severe crash density[4]	★ ≥ 3.3 crashes per mile	46%	62%

1. Other factors were considered, e.g. heavy commercial volume and access density, but rejected as not value added factors for a risk rating.
2. Percent of miles analyzed, i.e. Number of miles receiving star in criteria ÷ Total number of miles analyzed.
3. Percent of fatal and serious injury 2008-2012 head-on, sideswipe opposing, and run-off-road left crashes.
4. 2008-2012 head-on, sideswipe opposing, and run-off-road left crashes.

Recommendations for the Implementation of High Tension Cable Barrier in Minnesota

Purpose

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Introduction

As traffic volumes have grown, Minnesota has experienced an increase in cross median crashes. High tension cable barrier (HTCB) has proven to be an effective Toward Zero Deaths (TZD) solution at reducing fatal and serious median crashes by about 95% in Minnesota, and 93 % nationally, as identified in a 2012 NCHRP study. In 2004, MnDOT began installing HTCB along the median of some Twin Cities Metropolitan area freeways. Since that time MnDOT has installed over 300 miles of barrier and over 100 more miles planned for this year. About half of the barrier is in the Twin Cities Metropolitan area and half is distributed on greater Minnesota freeways.

A task force was formed to develop an implementation strategy for the statewide prioritization and placement of HTCB on state highways. The initial request was to make a fiscally unconstrained study and recommendation for the use of HTCB. Prior to the formation of a task force many questions arose from MnDOT staff related to the cost of installing and maintaining HTCB. Given this, the task force was asked to discuss and make recommendations on four main questions:

1. Where should high tension cable barrier be installed?
2. What should the priority for installation be?
3. How should initial installation costs be covered?
4. What are ongoing maintenance and operation cost considerations?

The task force met seven times and looked at current prioritization guidelines from districts within Minnesota and from other states. Funding options for initial installation and maintenance, along with current maintenance practices and costs, were also discussed at length. The following sections detail the task force discussion and findings on each of the questions that were asked.

Location and Installation Priority of High Tension Cable Barrier

A variety of methods have been used to determine where high tension cable barrier is installed in Minnesota. Initially, some cable barrier was installed after a fatal or severe crash.

- Metro area cable barriers were first installed at crash locations. The Metro District has since developed a rating system utilizing crash density, ADT, median width and speed to assist in prioritizing future installations. Based on their prioritization, the Metro District HTCB system is over 60% complete.
- District 6 used a hybrid of warrants and other standards which included median width, ADT, operating speeds, and alignment for their installation of cable barrier on I-35.
- District 3 installed cable barrier at interchanges first, then other locations based on volumes and crash history, until the interstate was covered within their district boundaries.
- District 4 worked with the OTST Safety section to come up with a star rating system based on volume, speed, median width, proximity to interchanges, and curves to utilize in prioritizing their installations, and are currently working towards covering all of the interstate in their district.
- District 7 has used ADT, median width and proximity to interchanges for existing installations.

NCHRP Report 711 *Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems* includes information on what other states' installation guidelines are for their cable barrier. Guidelines from ten states were included in the report. In these states, cable barrier is installed at median widths varying from 30 to 76 feet, and minimum traffic volumes varying from 0 to 36,000 vehicles per day.

Risk Rating Development

To provide a method of analysis, the OTST Safety Section has investigated head-on, sideswipe opposing and run off road left crashes from 2008-2012 on all interstates, freeways, and expressways that do not have HTCB. Initially, seven criteria, including ADT, median width (median edge of traveled lane to median edge of traveled lane), access density, HCADT, posted speed, severe crash density, and non-severe crash density, were analyzed. Trends in severe crashes were studied to determine high risk parameters for each criterion. Given those parameters, a risk rating of segments across the state was developed. Further analysis showed that four of the criteria, ADT, median width, severe crash density and non-severe crash density showed the most effect of benefit/coverage ratio and were chosen to be utilized in rating the segments. A star rating system was chosen to designate risk. For each of the criteria that a segment met, it was given a star. The more stars a segment has, the higher risk there is for future cross median type crashes. The table below shows the parameters for each of the chosen criteria and the percent of severe and fatal crashes that are captured.

Factor[1]	Criteria	Included Miles[2]	Severe Crashes[3]
Median width	★ ≤ 55 feet	61%	68%
Volume	★ > 20,000 ADT	24%	36%
Severe crash density[4]	★ > 0.0 crashes per mile	60%	100%
Non-severe crash density[4]	★ ≥ 3.3 crashes per mile	46%	62%

1. Other factors were considered, e.g. heavy commercial volume and access density, but rejected as not value added factors for a risk rating.
2. Percent of miles analyzed, i.e. Number of miles receiving star in criteria ÷ Total number of miles analyzed.
3. Percent of fatal and serious injury 2008-2012 head-on, sideswipe opposing, and run-off-road left crashes.
4. 2008-2012 head-on, sideswipe opposing, and run-off-road left crashes.

The task force reviewed a synopsis of the OTST recommendation. Questions arose as to whether speed should be included and what effect it has on high priority mileage. It was determined that since only 2.9% of state highways have posted speeds less than 55 mph, nearly all segments would earn a star for this priority, which negated its importance. There was also discussion as to whether non-severe crashes should be used for prioritization. Property damage crashes significantly increase with the installation of barrier. Non-severe crashes were thought to be an important criterion, as the presence of any type of crash shows the potential for a problem area. Given the 95% effectiveness of high tension cable barrier at reducing fatal and life changing injury crashes, an increase in property damage crashes, while not desired, is an acceptable risk. Access density was also thought to be of possible importance. Analysis showed the number of crashes increased as the number of access points per mile increased. It is acknowledged that multiple access points on expressways contribute to crashes. Districts should assess expressway segments and determine if this problem could be addressed through access management. HTCB placement may be considered as an option for managing access.

Median width and topography were discussed as factors in decisions on where to install HTCB. There was desire to have an upper limit to the median width criteria, where barrier is not necessary. The OTST investigation showed head-on, side swipe opposing, and run off road left crashes happening even in excess of 150 foot median widths, so it does not seem appropriate to set upper limits for that criteria. Topography, such as grades and curves of the roadway, may be a factor in some crashes. An effort was made to try to validate this, but the relationship is difficult to determine. Crash reports have an area to report topography but this is seldom used. It was suggested that cross- section elements such as shoulder width, ditch shape, width and inslope should be considered because of the possibility of rollovers before the cable barrier is even encountered. These items are all discussed in NCHRP Report 711 and MnDOT's current technical memorandum for determining lateral placement of HTCB.

The task force was in agreement that a combination of crash history and other high risk criteria, including median width and ADT, in a high level star rating system would be an appropriate way to determine cable barrier installation. Some factors, such as snow and ice, aren't easily quantified in a warrant or criteria, but are still important to consider. A tragedy such as the fatal crash on I-94 near Alexandria in the winter of 2012 could change a priority location. These recommendations provide MnDOT with general guidance on how the Department should move forward with HTCB installations and the methodology to use when making this investment.

The table below shows a breakdown of freeway and expressway mileage by risk rating.

Risk[2]	Expressway		Freeway	
	Miles	Severe Crashes[3]	Miles	Severe Crashes[3]
★★★★	43.8	9	95.1	22
★★★	208.9	59	222.0	36
★★	232.3	28	217.0	22
★	343.6	22	86.2	3
Zero[4]	209.6	0.0	5.7	0.0
Total	**1,038.1**	**118**	**626.0**	**83**

1. Risk rating as of December 2012 due to crash data availability.
2. Divided highways evaluated include all interstates, freeways, and expressways without existing barrier.
3. Fatal and serious injury head-on, sideswipe opposing, and run-off-road left crashes 2008-2012.
4. There are ZERO miles of Interstate receiving no stars; numbers reported here are non-interstate.

Initial Installation Costs of HTCB

Currently there are more than 300 miles of high tension cable barrier installed in Minnesota, and more than 100 miles planned for installation. These installations were funded with a mix of construction dollars and HSIP (Highway Safety Improvement Program) funding. These funding sources are still the most viable options for funding future installations of high tension cable barrier. Task force discussions centered around the fact that it is not easy to prioritize safety improvements when money is available. It may be appropriate and cost effective to put in barrier at a location with a lower risk rating due to a construction project in the area. Questions may arise as to why barrier was placed in one location and not another. It is hard to determine what the benefit/cost ratio of any safety improvement versus a human life. The prevention of fatal and serious injuries is the top priority of the state's Toward Zero Deaths program. Money invested in safety improvements that have been shown to have a high likelihood of reducing fatal and serious injury crashes is consistent with the TZD philosophy. Prioritizing these improvements will always prove to be a difficult task, but with a system in place to help identify high risk locations for crossover crashes, the decision on where to install HTCB when it is the chosen safety improvement, will be easier.

HTCB is considerably less expensive to install than both W-beam guardrail median barrier and concrete median barrier. HSIP funding is approximately $15 million a year, distributed across the state. With the initial installation cost of HTCB being around $150,000 per mile, along with other competing safety priorities, it could take many years to complete the system. The table below shows approximate installation costs for full build out both by district and by risk rating.

Risk[2]	D1	D2	D3	D4	D6	D7	D8	M	Miles	Cost ($M)	% KA[5]
★★★★	17	0	6	0	44	5	0	66	138	20.7	15.4
★★★	14	9	67	61	144	54	0	81	430	64.5	47.3
★★	30	9	52	62	87	119	13	78	450	67.5	24.9
★	122	41	78	61	46	66	7	10	431	64.7	12.4
Zero[3]	52	63	46	11	0	21	20	3	216	32.4	0.0
Total Miles	235	122	249	195	321	265	40	238	1665		
Cost ($M)[4]	35.3	18.3	37.4	29.3	48.2	39.8	6.0	35.7	249.8		

1. Divided highways evaluated include all interstates, freeways, and expressways without existing barrier.
2. Risk rating as of December 2012 due to crash data availability.
3. Zero star non-interstate miles; all interstates have at least one star.
4. Assuming approximate installation cost of $150,000 per mile.
5. Fatal and serious injury head-on, sideswipe opposing, and run-off-road left crashes, (n=201).

Maintenance Considerations

Ongoing Maintenance and Operating Costs of HTCB

New HTCB installations are generally in areas where there was previously no barrier. Because of the proximity to the traveled way, HTCB requires more frequent maintenance due to nuisance hits. Snow and ice control and mowing are also important considerations. The added maintenance costs (i.e. labor, materials, and equipment) and time put an increased demand on budget and personnel. Restitution has proven to be a viable option thus far for covering part of the repair costs, but a high level discussion needs to take place to determine how maintenance costs and staffing will be covered as the HTCB system is expanded. Repairs take personnel away from other responsibilities. If maintenance forces are spread thin, an IDIQ contract could be an option for maintenance.

Currently, districts are able to use restitution funds recovered from hits on the system to fund a portion of their repairs. The Metro District has been documenting maintenance repairs and costs on their high tension cable systems, and shared this information with the task force. They recover about 60% of their repair costs, including materials and labor, through restitution, which funds their repair parts without having to use other maintenance monies. Labor costs are about half of materials costs. Overall in the Metro District, the recovery rate for HTCB is higher than other roadside barriers, and the repair costs per hit are less than those of other roadside barriers, as shown in the table below.

Type of Barrier	Repair cost per hit	Claims Recovered	Claims Unrecovered	Repair Recovery Rate
High Tension Cable Median Barrier	$1,435	$600, 970	$396,300	60.3%
Low Tension Cable Barrier	$1,643	$29,659	$19,636	60.2%
Plate Beam Guardrail	$2,133	$889,541	$929,528	48.9%
Attenuator	$4,183	$150,236	$117,453	56.1%

*Information from Metro District Maintenance records, fiscal year 2012

Districts 3, 6 and Metro reported their average annual hits per mile to be 2.3, 2, and 3.5 respectively. Metro District compiles data on all of the hits on their system and has come up with an average repair cost per hit, including labor and materials, of $1,435 for the 2012 fiscal year. District 3 reported that they estimate their repair cost per hit to be about $2,000. With these estimates, the average repair cost per mile of HTCB at this time is approximately $5,000. These costs can vary considerably dependent on the severity of the winter weather each year.

The following table shows estimated annual repair costs using the recommended installation mileage, by district and risk rating. The costs shown are over and above current costs and before any restitution.

Approximate Added Annual Repair Costs (by Risk Rating and District)

Risk Rating	**D1**	**D2**	**D3**	**D4**	**D6**	**D7**	**D8**	**M**	**Annual Cost**
********	**85000**	**0**	**30,000**	**0**	**220,000**	**25,000**	**0**	**330,000**	**690,000**
*******	**70,000**	**45,000**	**335,000**	**305,000**	**720,000**	**270,000**	**0**	**405,000**	**2,150,000**
******	**150,000**	**45,000**	**260,000**	**310,000**	**435,000**	**595,000**	**65,000**	**390,000**	**2,250,000**
*****	**610,000**	**205,000**	**390,000**	**305,000**	**230,000**	**330,000**	**35,000**	**50,000**	**2,155,000**
Zero[2]	**260,000**	**315,000**	**230,000**	**55,000**	**0**	**105,000**	**100,000**	**15,000**	**1,080,000**
Annua lCost[1]	**1,175,000**	**610,000**	**1,245,000**	**1,891,000**	**1,605,000**	**1,325,000**	**200,000**	**1,190,000**	**8,325,000**

1. Assuming approximate repair cost, including labor and materials, of $5,000 per mile
2. Non-interstate miles not earning star at this time

Mowing and Miscellaneous Maintenance

The Metro district shared their experience with maintenance in areas with HTCB. They have found that it does require more time to mow around HTCB. The mower can cut the grass around the cable barrier, but leaves a small strip between cable and shoulder. Mowing in the Metro area where there is cable barrier requires traffic control. They cannot mow from median because of safety issues. A "spider" mower, also used for mowing around guardrail and low tension cable barrier, is required. The mower costs approximately $45,000, and requires a Laforge hitch, which costs about $14,000. A pressure washer is also needed, at a cost of about $10,000, but is also used for drain and tunnel cleaning and graffiti removal. A swaging machine, which attaches the cables to the turnbuckles, costing about $28,000, is also required for tensioning of the system. There is currently only one swaging machine owned by the state. As the HTCB system is expanded, equipment needs should be assessed for each district.

Snow and Ice

There are some concerns that installing cable could result in snow banks that can increase drifting and icing on the road. Additional cleanup may be necessary in areas where blowing and drifting is a problem. Initially, the Metro District did experience some drifting problems during the winter months, but since mowing operations have been moved to the fall season, snow blows through the cables better. In District 3, the cable can be somewhat buried in the snow, due to placement further into the median. This placement alleviates drifting problems, and does not seem to have any other adverse effects, as the snow tends to slow errant vehicles down before reaching the cable barrier.

District 4 has more instances of blowing resulting in icing. 64% of crashes had a surface condition of snow or ice. This could increase the number of hits on new cable barrier installations in the district, but each hit is a possible life saved.

Training for Maintenance

A training module, course number Main00149, for maintaining HTCB has recently been developed and is available on the MnDOT Learning Center webpage. Field training is also available from the manufacturer.

Construction Considerations

The task force also touched on the effect of construction on HTCB installations. One of the main concerns was what depth of overlay would require the HTCB to be raised. Shoulder width and inslope should be considered in the planning and design of overlay projects. If existing shoulder width and inslope must be maintained, correction of the HTCB height may be necessary.

Another concern was barrier that is out of service during a construction project, and responsibility for removal and replacement. The general consensus was that it is the responsibility of the contractor and should be included as a bid item in the plans for the project. Due to the risk and length of the I-94 unbonded concrete overlay construction project, District 3 felt it was important to maintain barrier, so they required the contractor to install temporary anchors and reconnect the barrier. The risks should be evaluated on each project to determine whether barrier should be maintained during construction.

Training should be considered for construction personnel on installation and inspection procedures.

Life Cycle

There is no hard data on the expected life of cable barriers. This is true for other types of barrier and roadside appurtenances also. Manufacturers have mentioned 15 years as a good estimate, and the task force felt that 20 years would be a realistic timeframe. Maintenance experience has found that concrete post foundations may be a limiting factor because of heaving and cracking, but the usage of metal sockets may prolong the life of the system.

Recommendation

The Task Force recommends that High Tension Cable Barrier (HTCB) should be installed on all freeways and interstates. It may also be installed on expressways where deemed a high priority and the best safety improvement option. The star system risk evaluation method can be utilized by the districts to determine what their highest priority segments are so that they may continue to build out the high tension cable barrier system as projects and funding allow. These guidelines will be included as a tool in the development and use of the District Safety Plans. The safety analysis and star rating should be reevaluated every 3 to 5 years.

The initial installation costs will be covered by construction dollars when installed as part of a programmed construction project. HSIP funding, along with other special funding as it arises, can be used for standalone installations. Department level discussions are needed to determine how to pay for ongoing maintenance and staffing costs.

It is important to note that this report provides guidance on where to install HTCB relative to barrier use and placement. This report does not attempt to make HTCB the highest priority improvement for Districts. The Department needs to continue to annually weigh the safety needs at all locations along the state highway system and utilize its limited safety dollars where the need is the greatest. HTCB should be considered on the State's freeways in conjunction with other construction or reconstruction projects.

Resources

MnDOT Technical Memorandum 13-02-TS-01 Design Guidelines for High-Tension Cable Barriers (HTCB) was recently completed, and is found at: http://techmemos.dot.state.mn.us/

NCHRP Report 711 *Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems* : http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_711.pdf

MnDOT Metro District Maintenance Records

APPENDIX

HTCB Risk Factor Table

Statewide Risk Ratings Table

Brief Summary of Analysis

Analysis Tables

Statewide Risk Rating Map

District Risk Rating Maps

HTCB Risk Factors

Factor[1]	Criteria	Included Miles[2]	Severe Crashes[3]
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1. Other factors were considered, e.g. heavy commercial volume and access density, but rejected as not value added factors for a risk rating.

2. Percent of miles analyzed, i.e. Number of miles receiving star in criteria ÷ Total number of miles analyzed.

3. Percent of fatal and serious injury 2008-2012 head-on, sideswipe opposing, and run-off-road left crashes.

4. 2008-2012 head-on, sideswipe opposing, and run-off-road left crashes.

Risk Rating[1] Miles[2] by District

Risk[2]	D1	D2	D3	D4	D6	D7	D8	M	
★★★★	17	0	6	0	44	5	0	66	**138**
★★★	14	9	67	61	144	54	0	81	**430**
★★	30	9	52	62	87	119	13	78	**450**
★	122	41	78	61	46	66	7	10	**431**
Zero[3]	52	63	46	11	0	21	20	3	**216**
	235	**122**	**249**	**195**	**321**	**265**	**40**	**238**	**1665**

1. Risk rating as of December 2012 due to crash data availability.

2. Divided highways evaluated include all interstates, freeways, and expressways without existing barrier.

3. Zero star non-interstate miles; all interstates have at least one star.

Brief Summary of Analysis

Establishing Risk Factors

To narrow the scope of risk factors considered, analysts with MnDOT Safety Section reviewed existing literature and crash trends. The resulting factors were not intended to be exhaustive but to capture key features of frequent cross-median crashes.

- Median width
- Volume
- Severe crash history
- Non-severe crash history
- Commercial vehicle volume
- Speed limit
- Access / Interchange density

After reviewing the data, three factors were eliminated. Commercial vehicle volume was a weak correlation in the data analyzed. Speed limit was not a value added factor due to limited variation, e.g. 97% of miles are posted over 55mph.

The literature demonstrates that cross-median crashes are more frequent near interchanges. Internal analysis confirmed that increased interchange and access density is correlated to cross-median crashes. However, upon further review this factor was eliminated due to the nature of high tension cable barrier. While increased access may cause more turbulence in traffic flow, it does not necessarily point to cable barrier as the only solution.

Establishing Thresholds

1. Data Mining: Cluster Analysis

First, analysts sought to group segments into high and low risk clusters based on risk factor characteristics. The statistical procedure is an iterative process that calculates the distance between characteristics. The combined distances are minimized so that characteristics that result in similar performance are lumped together.

Thresholds were established that maximized the likelihood of a segment being in one cluster and minimized the error of being improperly classified.

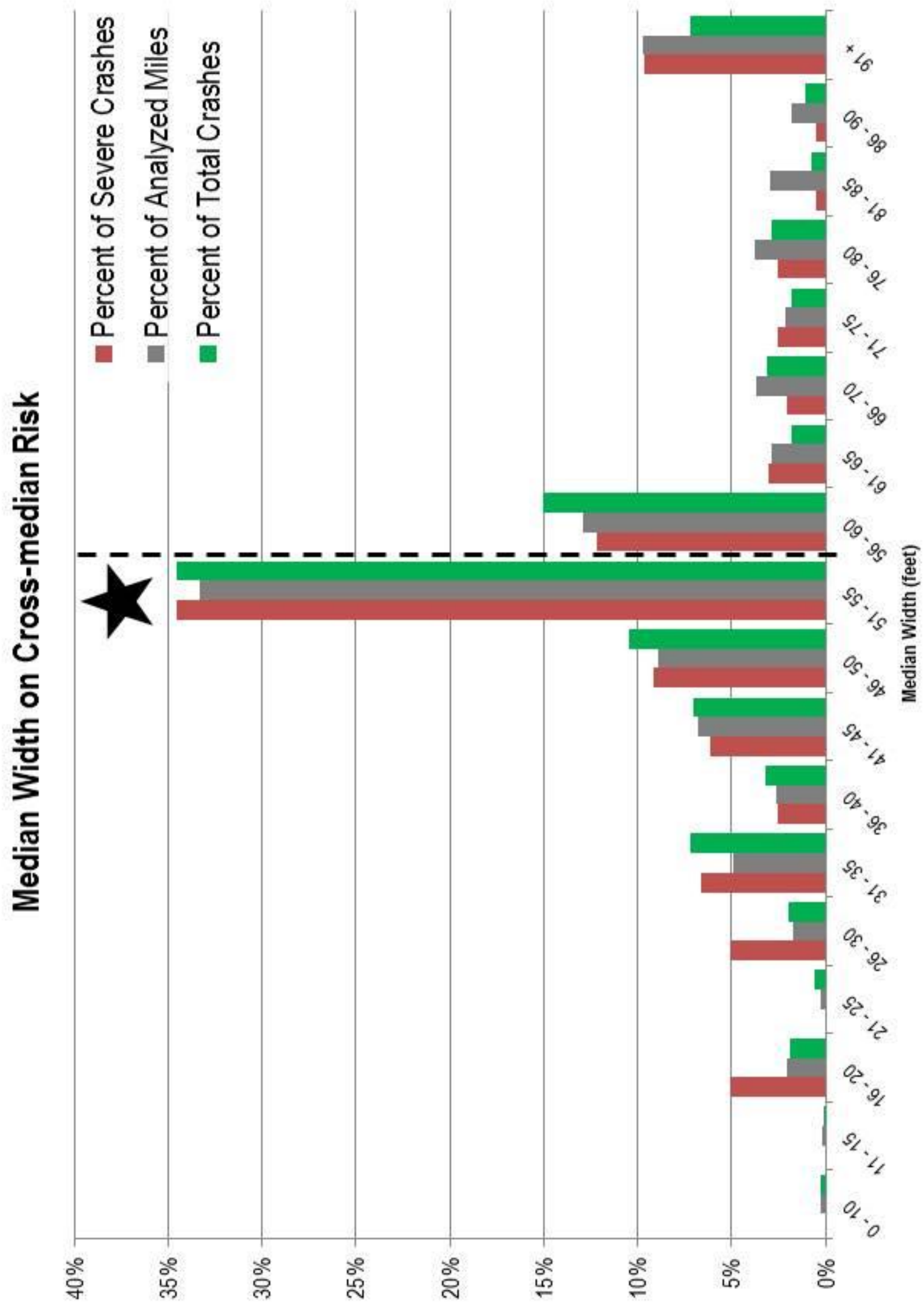
2. Verification: Ratio Comparison

After conducting the data mining techniques described above, analysts compared the derived thresholds to the overall trends in the data. Factors were evaluated based on the percent of fatal and serious injury cross-median crashes identified. It was assumed a successful threshold would capture more severe crashes than no threshold.

This was tested by comparing the percent of severe cross-median crashes captured to the percent of analyzed miles. Calculated thresholds consistently identified a greater perfect of the severe crashes than the number of miles in that category.

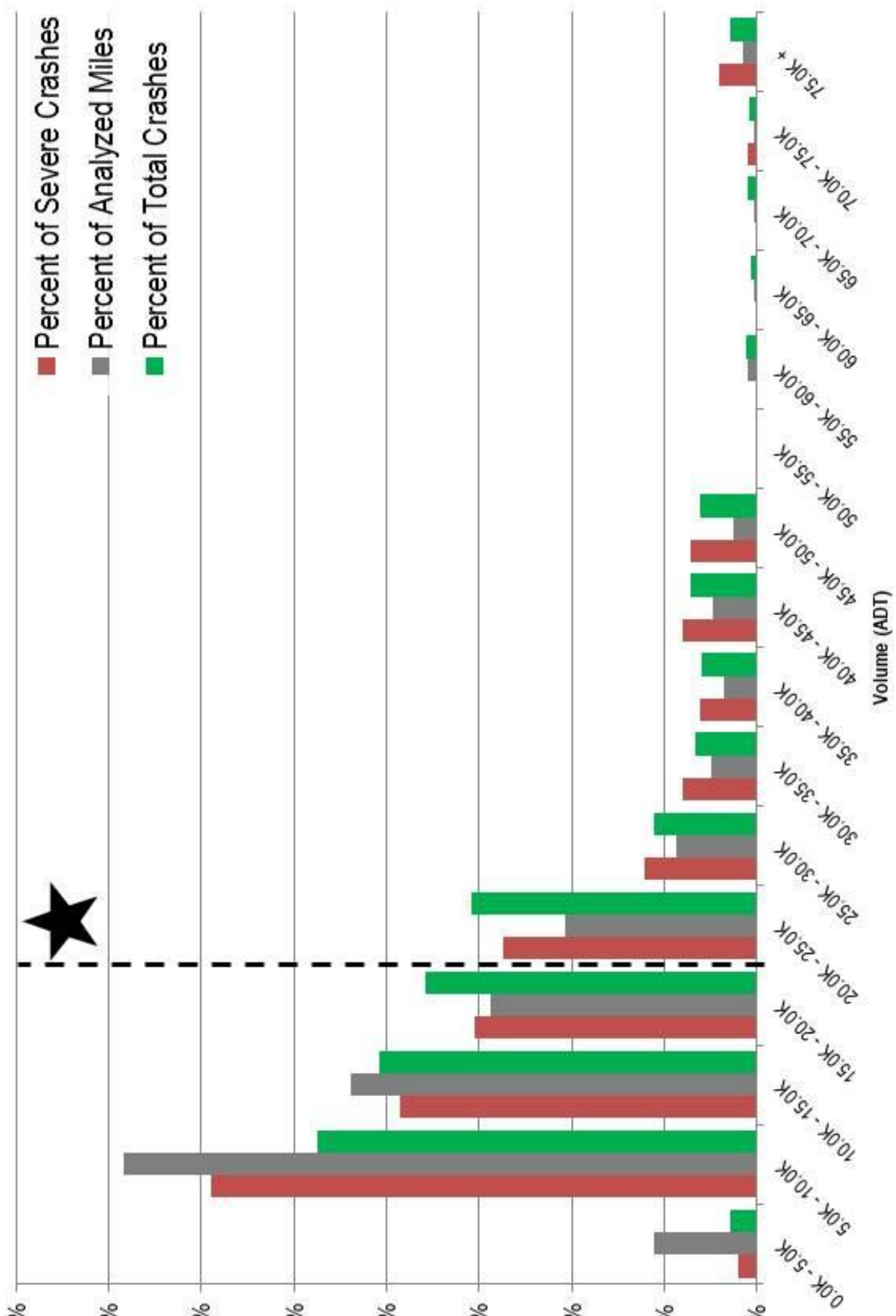
Analysis Tables

December 2013

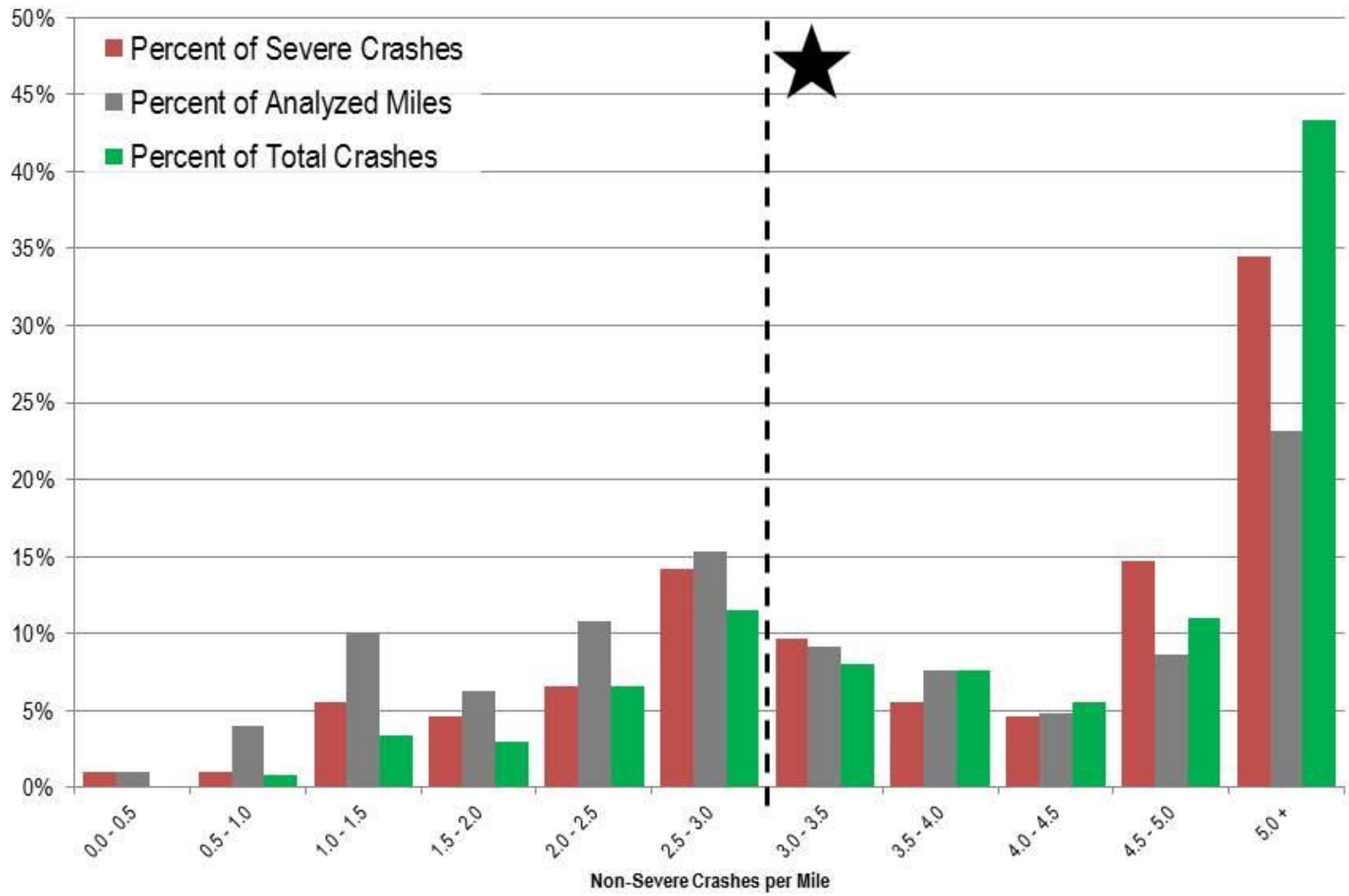


Median Width on Cross-median Risk
Percent of Severe Crashes
Percent of Analyzed Miles
Percent of Total Crashes
40%
35%
30%
25%
20%
15%
10%
5%
0%
0 - 10
11 - 15
16 - 20
21 - 25
26 - 30
31 - 35
36 - 40
41 - 45
46 - 50
51 - 55
56 - 60
61 - 65
66 - 70
71 - 75
76 - 80
81 - 85
86 - 90
91 +
Median Width (feet)

Volume on Cross-median Crash Risk



Non-Severe Crash Density on Cross-median Risk

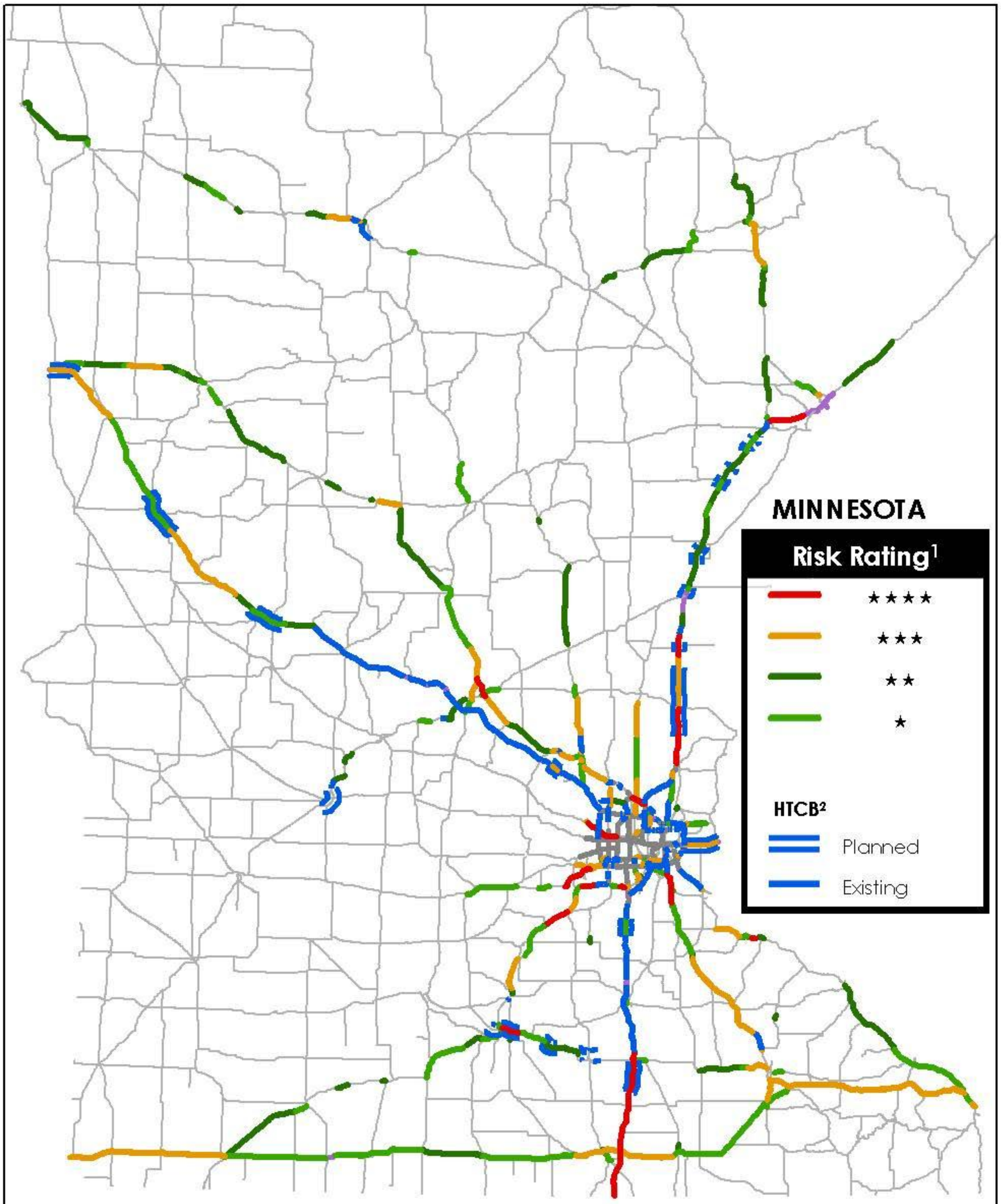


Average = 3.266 non-severe crashes per mile

HTCB Risk Assessment

District Maps

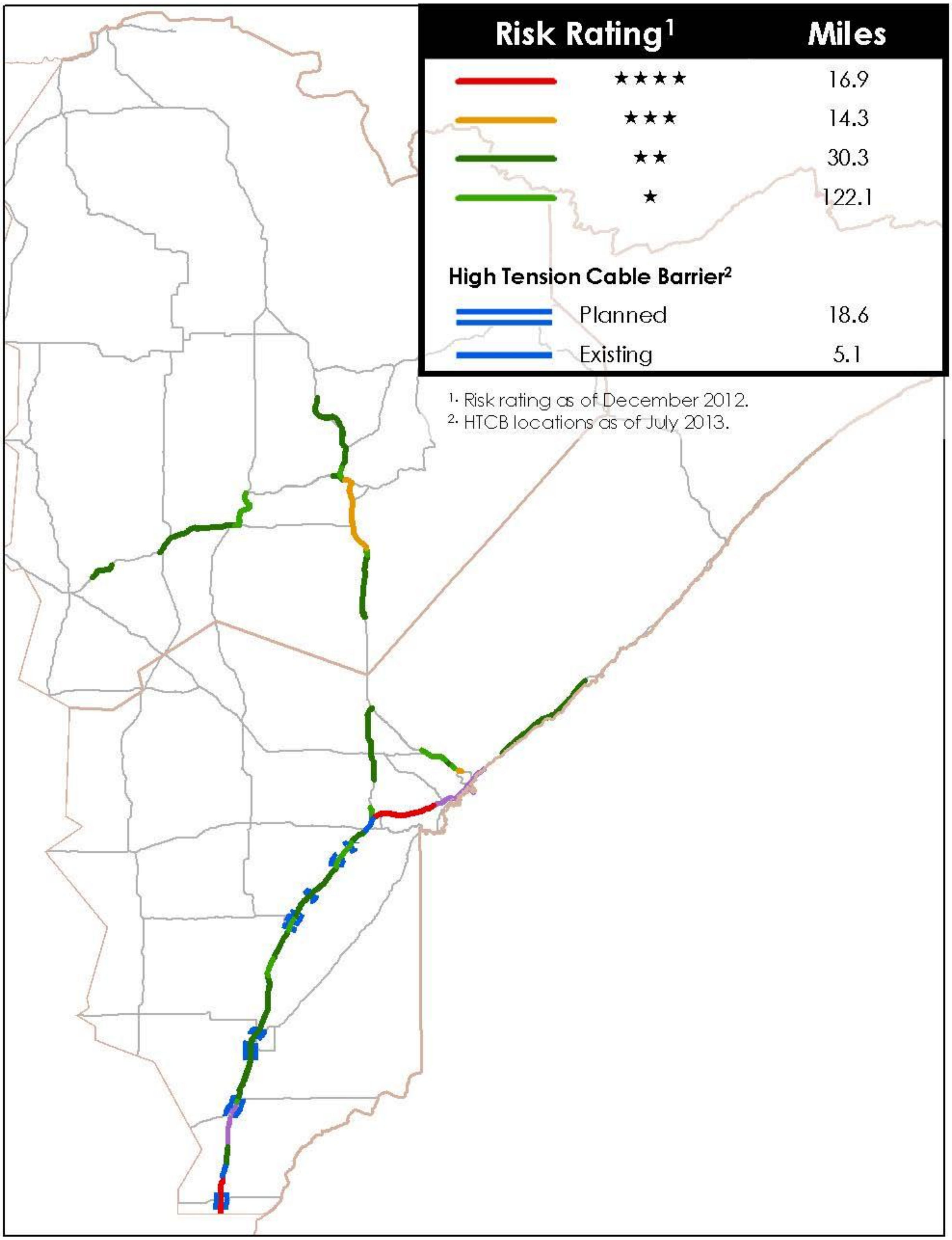
17 January 2014



[1] Risk rating as of December 2012.
[2] HTCB locations as of July 2013.

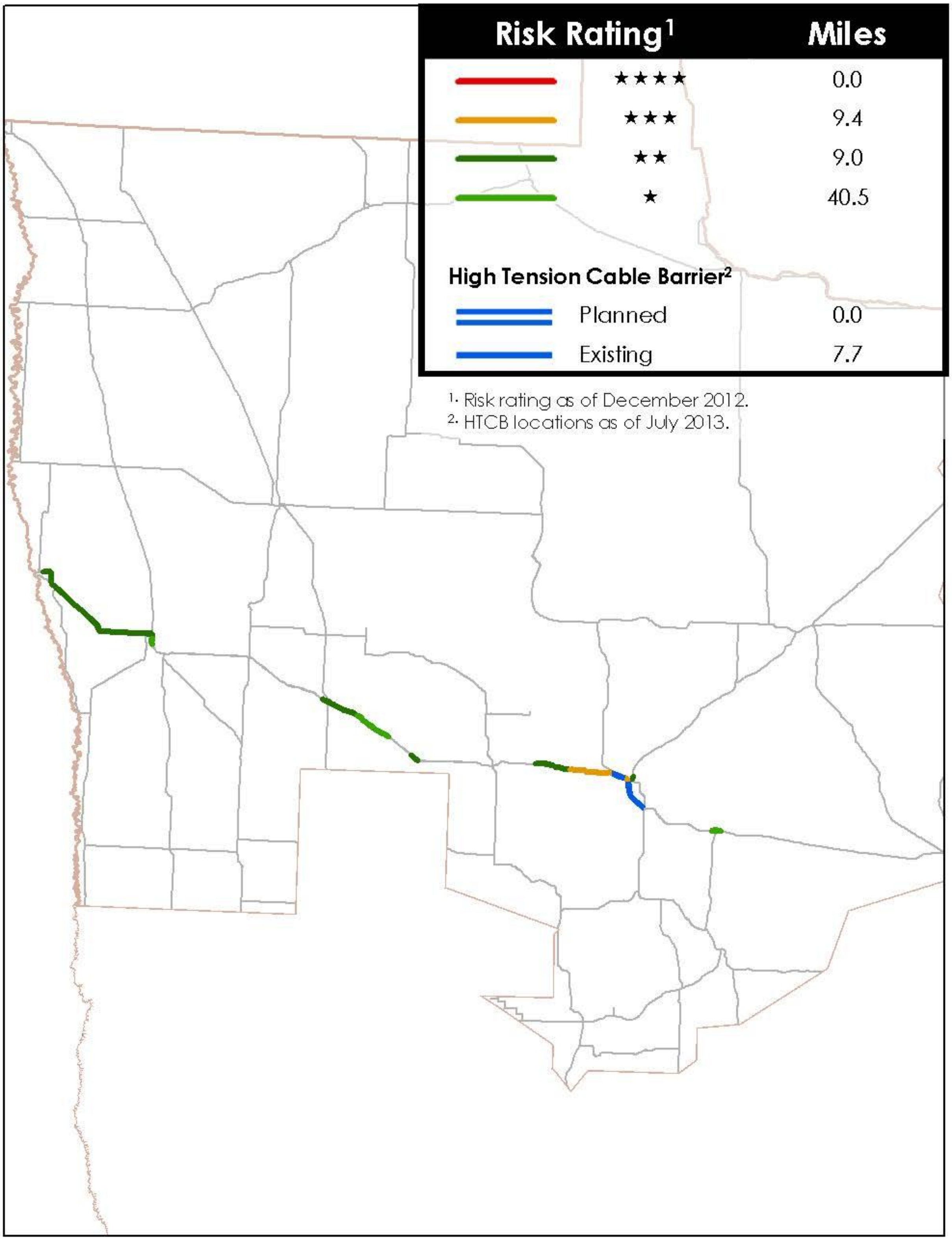
MnDOT, Office of Traffic, Safety & Technology

DISTRICT 1



MnDOT, Office of Traffic, Safety & Technology

DISTRICT 2



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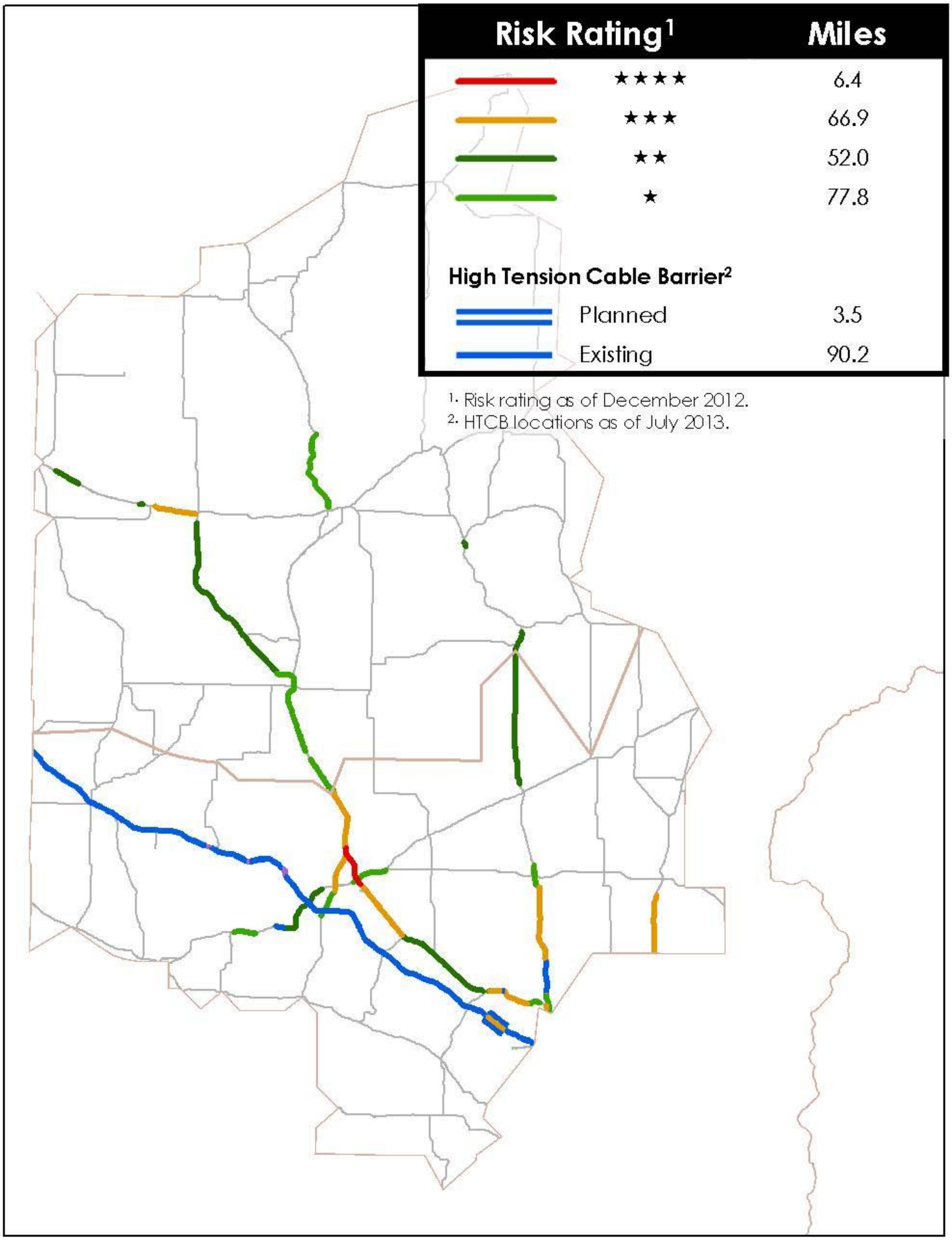
DISTRICT 3



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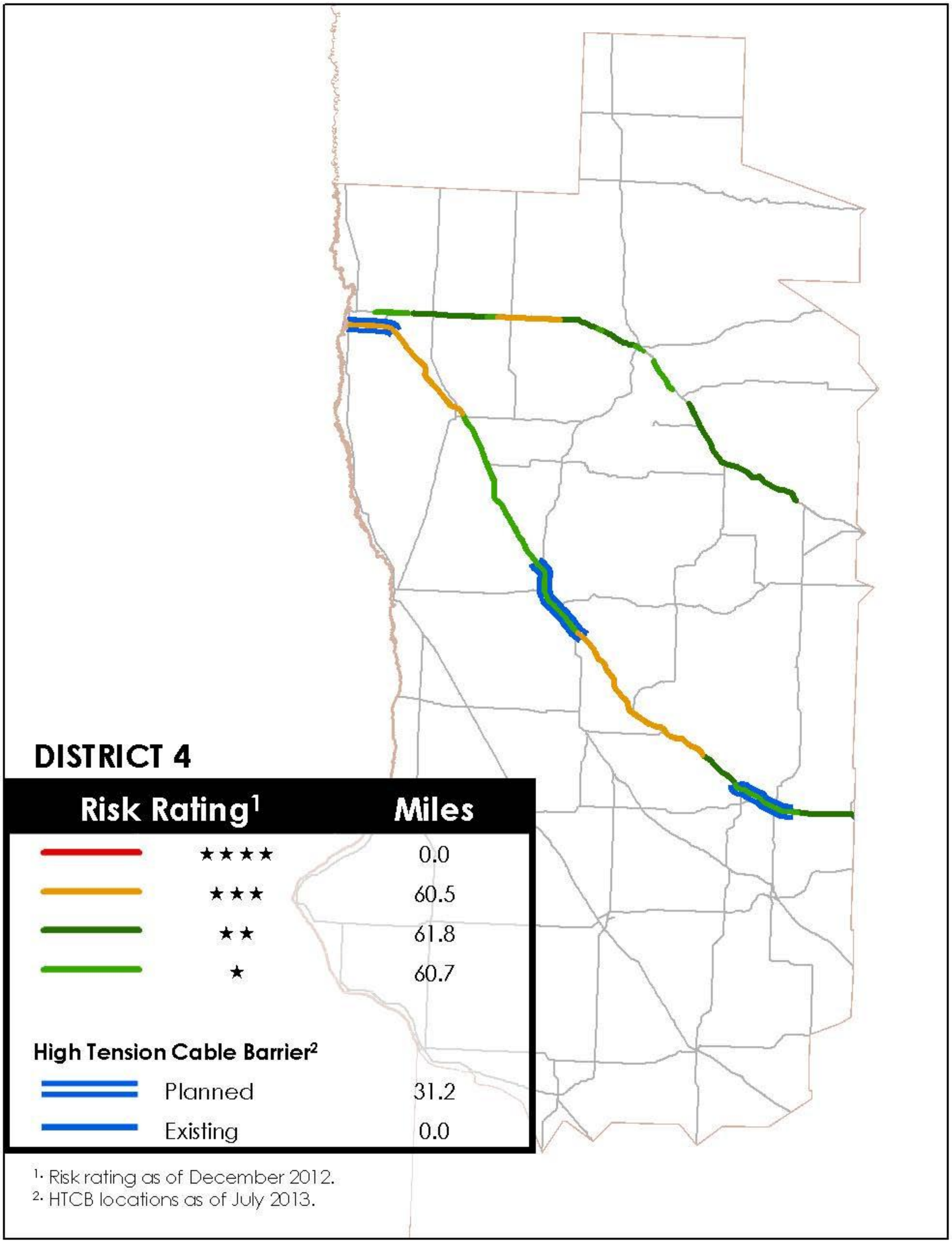

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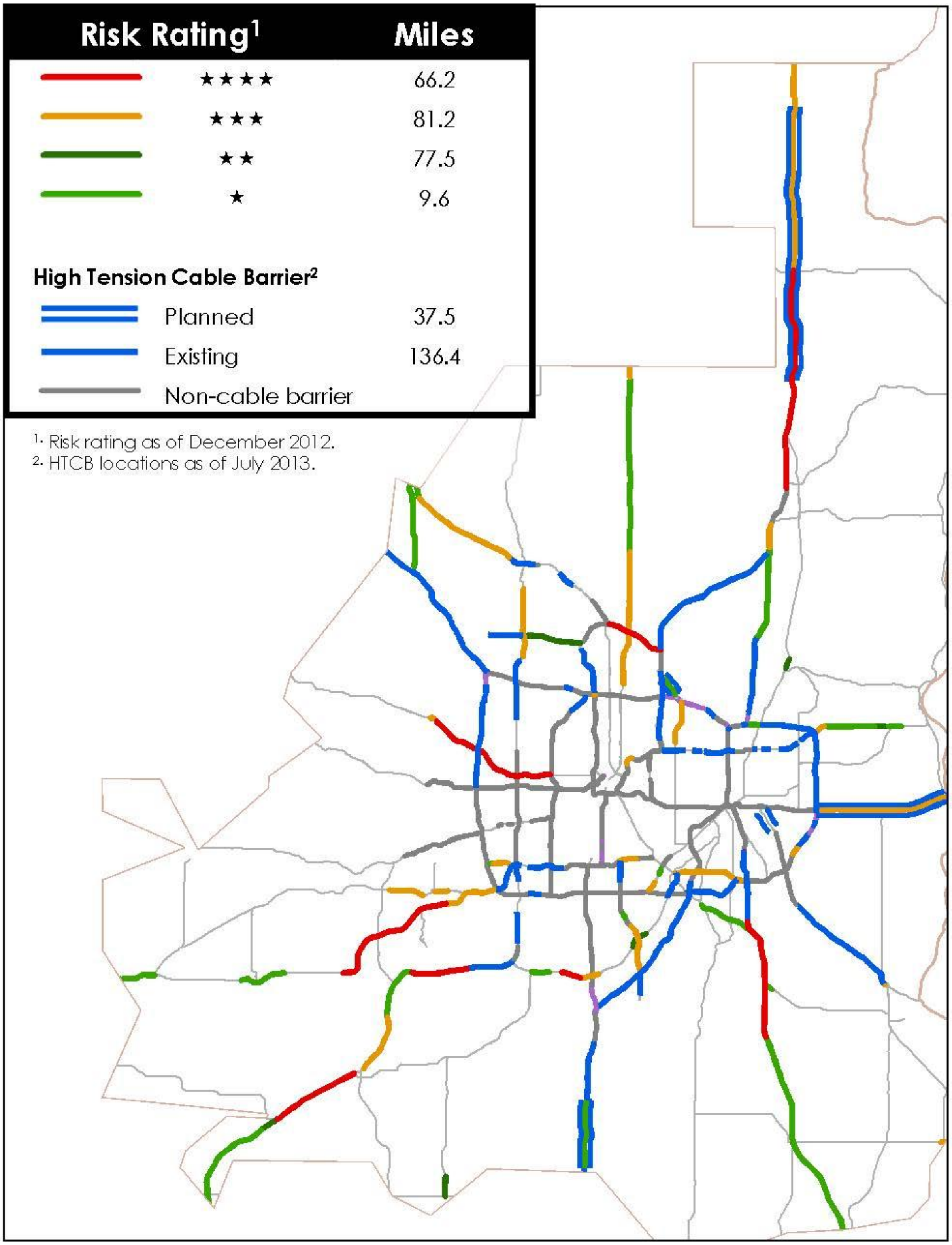
METRO DISTRICT



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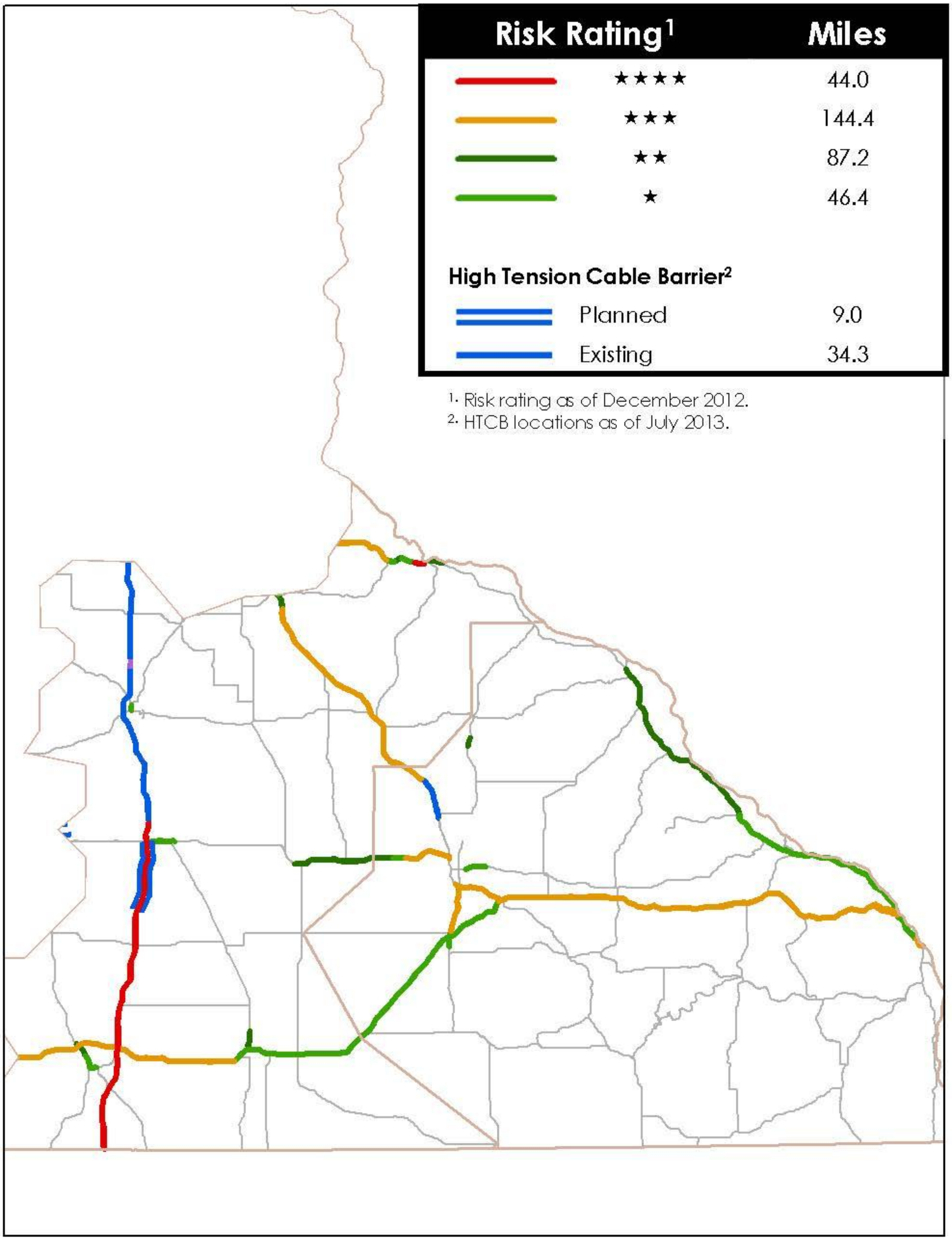
DISTRICT 6



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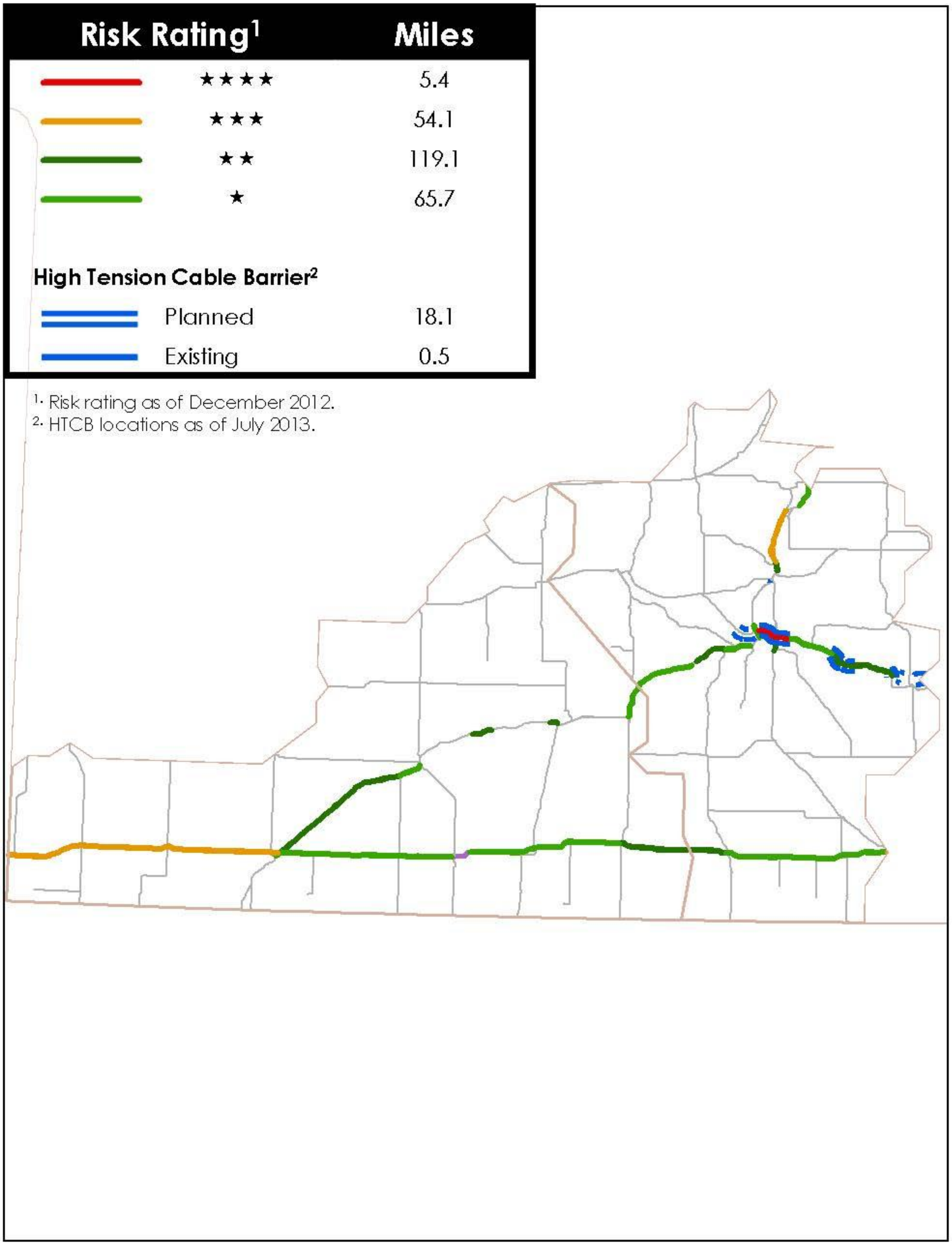
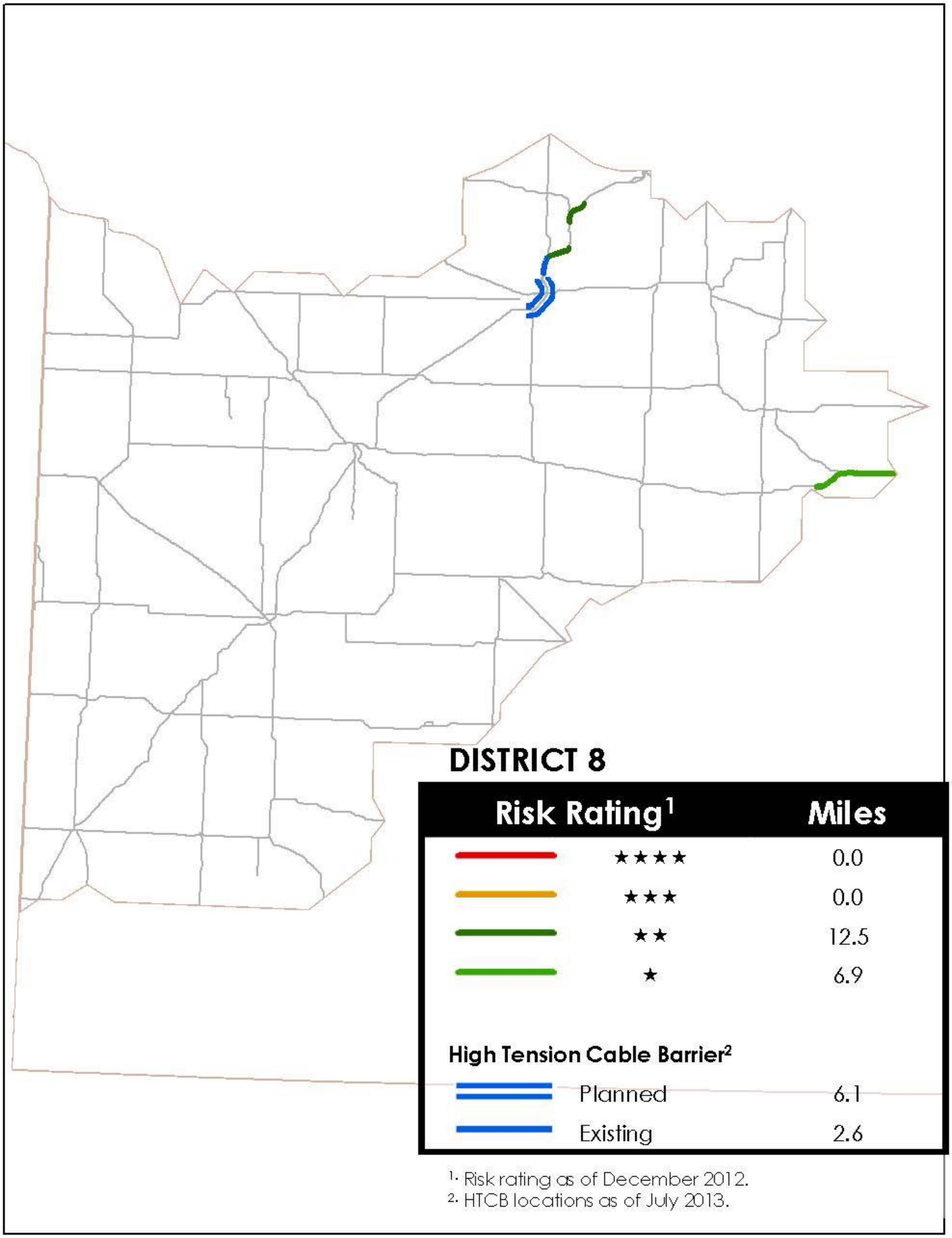
DISTRICT 7


Risk Rating[1] Miles
★★★★ 5.4
★★★ 54.1
★★ 119.1
★ 65.7
High Tension Cable Barrier[2]
Planned 18.1
Existing 0.5
1. Risk rating as of December 2012.
2. HTCB locations as of July 2013.



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