Measures to Alleviate Congestion at Rural Intersections

A Thesis
Presented in Partial Fulfillment of the Requirements for the
Degree of Master of Science
with a
Major in Civil Engineering
in the
College of Graduate Studies
University of Idaho

by
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December 2014

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Abstract

During certain high-travel days on national holidays, state highways experience a surge in traffic flow and vehicles begin forming large platoons. When the platooned traffic pass through rural intersections, vehicles on the minor approach attempting to turn onto the major state highway are subjected to excessive delays. This research documents the characteristics of holiday traffic at different locations in Idaho and presents alternative intersection treatments to alleviate congestion at rural intersections during increased traffic volume on high-travel days. To exemplify how each consideration can be adapted to a specific situation, a case study with the intersection of Idaho State Highway 55 (SH-55) and Banks-Lowman Road was used. The results of the case study showed that in the given situation, signalization of the intersection along with some geometry alternations are the recommended treatments to alleviate the congestion and provide safe, efficient movement for both vehicular and pedestrian traffic at the intersection.

Acknowledgements

I would like to express my deep thanks to all of the University of Idaho staff in helping make this research come together. I am especially grateful to the late Dr. Michael Dixon and Dr. Ahmed Abdel-Rahim, my research supervisors, as well as Dr. Michael Kyte and Dr. Kevin Chang, my committee members, for their patient guidance, continual trust in my abilities from the start, and useful critiques of this research work.

I would also like to thank the Idaho Transportation Department. Not only were they the primary investors that made this research possible, but they also assisted in the field trips required to accomplish it.

Table of Contents

List of Tables

List of Figures

Chapter 1
Introduction

Overview

Many rural highways experience a surge in traffic flow levels on certain “high-travel” days during national holidays. Due to the platooned nature of the traffic on the main highway, vehicles on the minor approach attempting to turn onto the major highway are subjected to excessive delays. This research focuses on alternative intersection treatments to alleviate congestion at rural intersections due to increased traffic volume during high-travel days. The objectives of the research presented herein are: 1) document the characteristics of holiday traffic at different locations in Idaho, 2) review and document possible measures that can be implemented to alleviate congestion resulting from holiday traffic at rural intersections, and 3) conduct in-depth analysis for one intersection that experiences high level of traffic volumes during summer national holidays. As part of the case study, field data and macroscopic and microscopic simulation were used to assess the impact of different measures to alleviate congestion at the intersection. The Highway Safety Manual (HSM) is used to document the potential safety impact of each proposed treatments. Based on the results of the analysis, a set of alleviating measures is recommended.

The case study investigated in this study is the intersection of State Highway 55 (SH-55) and Banks-Lowman Road and Banks-Grade Way (SH 55-Banks intersection). The intersection is a four-legged intersection with each leg oriented roughly in the cardinal directions and is located about 41 miles north of Boise, Idaho. The north and south legs of the intersection are SH-55, the east leg is the Banks-Lowman Road, and the west leg is a one-lane bridge across the North Fork of Payette River to provide access to Banks-Grade Way.

The high hourly traffic volume on SH-55 during holiday weekends, such as Memorial Day and Independence Day weekends, combined with high traffic volumes on Banks-Lowman Road, causes excessive delay for vehicles on Banks-Lowman Road. Traffic flow trends for the intersection were obtained from data collected through several automatic traffic counters continuously monitoring traffic near the intersection. In addition, field data was collected at the intersection during the 2014 Memorial Day and Independence Day weekends (May 23 – 26 and July 3 – 6, respectively). From a trend analysis, three main sources that contribute to the excessive delay were identified as follows: 1) reduced number of acceptable gaps from the main highway as a result of high traffic volumes, 2) possible queue propagation from upstream sites to the intersection being studied, and 3) conflicts arising from the one-lane bridge on the west approach in the intersection (currently, westbound and eastbound vehicles cannot traverse the west leg of the intersection at the same time, which causes delay).

Thesis Organization

The thesis is organized in four chapters. After the introduction, a background and literature review is presented in chapter 2. Chapter 3 documents the results of the case study for the Banks SH 55 intersection. Finally, chapter 4 presents the study conclusions and recommendations.

Chapter 2
Background and Literature Review

Introduction

Many rural highways experience a surge in traffic flow levels on “high-travel” days, such as national holidays. To exemplify this problem, consider US Highway 2 (US 2) on Memorial Day Weekend near Stevens Pass in Washington. Figure 1 is one of several graphics developed by Washington State Department of Transportation (WSDOT) to help drivers make educated decisions of when to travel if the driver used US Highway 2 (US 2) on Memorial Day 2014 (Washington Department of Transportation, 2014a). As indicated in red on the figure, drivers should expect to see “congestion or stop and go traffic” between the hours of 11 AM and 4 PM and that does not even consider the delays that vehicles will have during those hours if entering US 2 from a minor street.

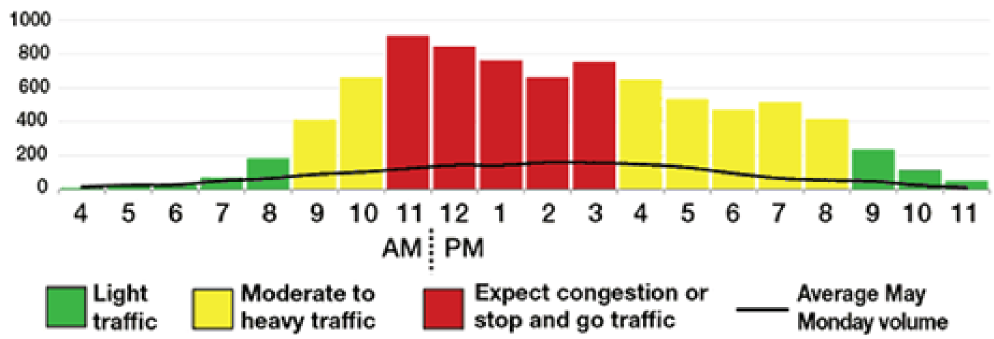


Figure 1: Example of WSDOT congestion warning for the May 26, 2014 westbound commute on US Highway 2

For vehicles trying to enter from a minor street to a major street while both are experiencing high volume traffic, the delays become excessive. This is due to the platooned or grouped nature of the high volume traffic traveling on the main highway. In the Federal Highway Administration’s report titled, *Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation*, it explains that “as vehicles are forced to get closer and closer together, abrupt speed changes can cause shock waves to form in the traffic stream, rippling backward and causing even more vehicles to slow down” (Federal Highway Administration Office of Operations, 2013) As the main road’s vehicles get closer and closer together, the headway or distance between vehicles shrinks and minor street vehicles wanting to enter the major flow are forced to make a choice. Either they must accept really small gaps and risk creating a crash, or they must wait for extended periods of time for a platoon, which can be several miles long, to pass.

Sources of Holiday-Traffic Congestion

From 2009 to 2014, WSDOT yearly publishes congestion charts similar to Figure 1. In a web search using Google.com, other congestion charts were made by WSDOT for Independence Day, Labor Day, and Thanksgiving for a similar time span. However, based on the Google.com search results, never did WSDOT post a congestion chart for any other holiday, such as President's Day. Due to WSDOT's consistency of posting congestion charts for the four previous mentioned holidays, but none for all the other holidays, it is logical to conclude that the congestion is not as noteworthy on the other holidays. So, why do roads, such as US-2 between Leavenworth and Steven's Pass, only get highly congested on select holidays? For that answer, Liu and Sharma's research was explored. Although their research was conducted in Canada and therefore used Canadian holidays, conclusions derived from their research are applicable to the United States too as will be explained later.

Liu and Sharma's research is a leading source of literature regarding holiday traffic. Their report is the first effort to examine statistically the significance of changes in traffic volume due to holiday effects as well as show graphically the holiday effects on traffic volumes in a weeklong period. Data raw traffic counts for their report was first categorized by a special road-type classification and then investigated using nonparametric hypothesis test methods for significance of weekly, daily, and hourly volume changes during various holidays. (Liu & Sharma, 2006)

The graphical comparison shown below in Figure 3 was one of the first results presented by Liu and Sharma and is the focus of this subsection. To help interpret what is being shown, Figure 2 is presented in this report to act as a key to understanding the names used in Figure 3. Liu and Sharma included those figures in their report to visually compare monthly variation traffic volume patterns for the intersections selected.

Liu and Sharma choose five grouping classifications based on Sharma et. al.'s previous research regarding classifications based on driver population (Sharma, Lingras, Hassan, &

Murthy, 1986). According to Liu and Sharma, the classification method used distinguishes itself from others by considering the trip purpose and the trip length distribution as well as temporal volume variations when grouping highways by function. The main advantage of this classification technique is that it leads to a better understanding of the road user's perspective of a highway's function; hence, it provides better insights into the holiday travel characteristics. The grouping process resulted in the five classifications representing different types of roads for which study data would be used: commuter (CM), regional commuter (RCM), rural long distance (RLD), recreational (Rec), and high recreational (HighRec). (Liu & Sharma, 2006)

One vital part of Liu and Sharma's research was to group roads into classifications. Therefore, any attempt to apply the research in the United States requires that intersections with similar classifications be studied. This research used a graphical comparison of Idaho areas, which are known for having seasonal variation in traffic volumes, to test if Liu and Sharma's results are applicable in the state of Idaho. The Idaho intersections are as follows:

- The intersection of 5th St and Larch St in Sandpoint, ID
- An intersection just north of Banks, ID where Banks-Lowman Road and Idaho State Highway 55 intersect (hereafter called the SH 55-Banks intersection)
- The Jackson Hole Bridge along Idaho State Highway 20 in Idaho Falls, ID

Road Type	PTC Site	Location	Available Years of Data
Commuter	002181	Airdrie, 4.6 km south of Highway 2 & 567	15
	016186	Edmonton, 1 km west of Highway 16 & 21	8
Regional commuter	001125	Strathmore 2.8 km east of Highway 1 & 24	7
	043221	Carvel Corner, 0.8 km north of Highway 16 & 43	11
Rural long–distance	001141	Bassano, 1 km west of Highway 1 & 56	12
	003061	MacLeod, 2.6 km west of Highway 2 & 3	12
Recreational	001025	Canmore, 9.62 km east of Highway 1 & Old 1A	7
	001061	Cochrane, 1.5 km west of Highway 1 & 22	14
High recreational	022066	Lundbreck, 3.3 km north of Highway 3 & 22	7
	093001	Lake Louise, 6.6 km south of Highway 1 & 93	11

Figure 2: List of the Permanent Traffic Counters (PTCs) used in Liu and Sharma, 2006

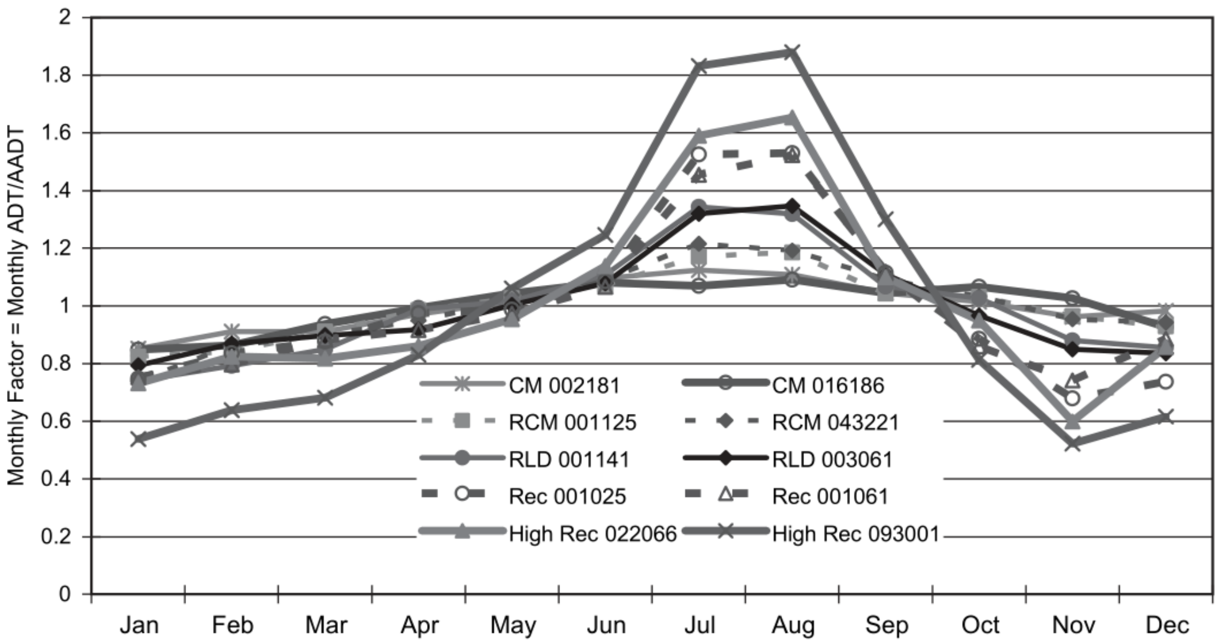


Figure 3: Monthly Variation of PTCs Selected by Liu and Sharma (Figure 1 in their Report, Note that ADT stands for "Average Daily Traffic" AADT stands for "Annual Average Daily Traffic")

At each of the Idaho locations selected, there are automatic traffic counters (ATRs) installed and the Idaho Transportation Department (ITD) monitors and reports all of the counts recorded by the ATRs. Following University of Virginia's justification to use an averaging window of three years to compute the historical congestion trend (Smith & Babiceanu, 2014), averages from ITD's ATR data for the years of 2011 to 2013 were used to calculate monthly factors (Monthly ADT / AADT) for each month in each area. The resultant trends are shown in Figure 4.

Both Figure 3 and Figure 4 have very similar trend lines. For example, the SH 55-Banks Intersection best resembles the "high recreational" classification because the trend's monthly factors peak at about 1.8 in the summer and troughs at about 0.6 in the winter. Furthermore, the two areas follow relatively the same rate of increase and decrease in that the trend line's maximum positive slope occurs during late spring (May) and the most negative slope occurs in the early fall (September).

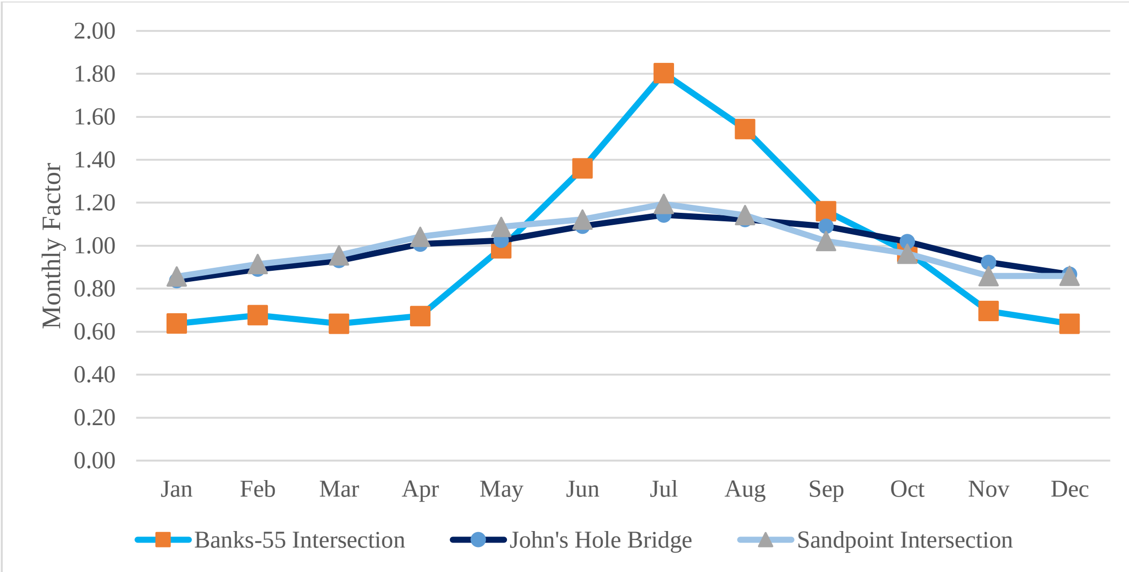


Figure 4: Monthly Variation at the Idaho Sites

It seems logical to conclude that the reason for the similarity is the source of the road facility's demand. Again, using the SH 55-Banks intersection comparison as an example, the SH 55-Banks intersection and its similar Canadian locations are used primarily by "fair-weather-oriented" recreationalists. To be more specific:

- Lunbreck is used as "the eastern entrance to the Crowsnest Pass" (Chinook Country Tourist Association, 2013) which offers a lot of outdoor activities.
- The SH 55-Banks Intersection is directly next to a pullout for water activities down the Payette River.
- Finally, Lake Louse̖ is also a location where a lot of water activities take place.

For all three, both (1) warm weather and (2) people with time dedicated for non-work obligations are typical requirements to get people to visit. Therefore, since the supply of appropriate visiting days is small (about three months of the year), the demand spikes during the summer and is accentuated on holidays due to the typical American receiving dedicated time off for the holiday. WSDOT's does have an exception to that reasoning for Thanksgiving which experiences its high peaks due most likely to the typical national emphasis to "Return home for the Holidays."

Alternative Intersection Treatment to Alleviate Congestion

With the sources of holiday congestion discussed, focus on what is gained by knowing holiday peaks exist will be discussed. As stated by Liu and Sharma, “the increases in travel during statutory holiday periods are substantial, and some critical traffic problems have been reported. An understanding of this substantial variation in the volume of traffic can assist transportation agencies in developing practical countermeasures in aspects such as traffic control plans, signal timing, safety programs, traffic volume monitoring, and prediction.”

As a way to assist agencies in using peak holiday traffic data, this research focuses on alternative intersection treatments to alleviate congestion at rural intersections due to increased traffic volume during high-travel days. Therefore, several sources of literature were reviewed and the findings are summarized in Table 1. Although it is recognized that there are still many different alternatives than those listed in Table 1, the following alterations or treatments are among the more common treatments appropriate for rural intersections that are found in the literature.

Table 1: Improvements Discussed in Transportation Literature

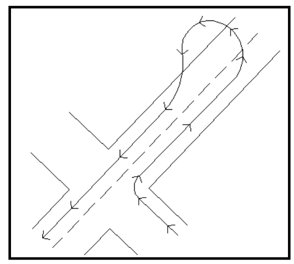
Modification Type	**Improvement Method**	**Improvement Description**
Geometry Modification	Additional Lanes	By adding an additional lane to the major street throughout an intersection, the traffic density would decrease since the same volume of traffic can spread out on the extra lane(s). As density decreases, larger gaps appear in the major street traffic and the minor street vehicles have an increased chance to enter the major street flow. (Institute, 2014)
	J-Turn	In a J-turn, minor street vehicles wanting to make a left turn movement initially turn right, travel a small distance, make a left turn to cross the opposing traffic into a turn-around area, and then take a right out of the turn-around (see figure on the right). This can reduce the delay for minor street vehicles since left turning vehicles must only find gaps in one major street direction of traffic at a time, versus the usual dual direction conflicts required for a left turn which increases the acceptable gap. (Hochstein, Maze, Welch, Preston, & Storm, 2009)  Example of the J-turn
	Receiving Left Turn Lane	Similar to a permitted left-turn through a median on a major street (a Left Turn Acceleration Lane), minor street left turn movements only interact with one direction at a time. This is accomplished by the minor street left turn movement first turning into a major street center lane dedicated to that turn movement before merging with major street's traffic flow. This can reduce delay-induced congestion and increase safety. (Iowa State University)

Table 1: Improvements Discussed in Transportation Literature (Cont.)

Modification Type	**Improvement Method**	**Improvement Description**
Geometry Modification (Cont.)	Roundabout	A roundabout "addresses the crash risk by creating a safer way to move traffic and also reduce queues… during holiday periods" (NZ Transit Agency, 2014) by allowing for continuous flow.
	Turn Pocket	Installing a left turn or right turn lane on the minor approach can allow for two minor movements to occur simultaneously and increase capacity to decrease congestion. (Institute, 2014)
	Grade Separation	Grade separation can increase roadway capacity for a high cost by eliminating left turn conflicts. (Institute, 2014)
	Realignment	Realigning the minor streets so that each intersect the major road at different locations can reduce the number of minor-street-to-minor-street conflicts. With less conflicts, minor streets have more major street gaps allotted to each movement to reduce congestion.
Signalization	Signal Installation	This is the solution that ITD used for the Gooding, Idaho intersection because the timing forced the major street to stop so that the minor streets could have designated times to make movements.

Chapter 3

Case Study: The SH 55-Banks Intersection

Introduction

This case study investigated the intersection of State Highway 55 (SH-55), Banks-Lowman Road, and Banks-Grade Way. The high hourly traffic volume on SH-55 during holiday weekends such as on Memorial Day and Independence Day weekends, combined with high traffic volumes on Banks-Lowman Road, causes excessive delay for vehicles on Banks-Lowman Road. What is meant by "excessive?" An Idaho Transportation Department (ITD) foreman, in an attempt to describe how the holiday traffic affected the SH 55-Banks intersection, described "excessive" as follows:

> *"The traffic backs up on SH-55, all the way from Horseshoe Bend, ID… and the resultant] backed up, stop and go traffic on SH-55 prevented traffic on the Banks-Lowman Road from entering SH-55 completely. People could sit for hours on the Banks-Lowman Road road without moving. Engines would overheat, people needed to use a bathroom, etc. Drivers would get desperate and try to force their way into SH-55 traffic, resulting in accidents and calls to law enforcement. Law enforcement would respond and try to unsnarl the mess, getting stuck at the location for hours. If the weather is good and holiday traffic is heavy, the intersection is just a bad place to be."* (Inwards, 2014)

For Banks-Lowman Road, "excessive delays" not only include sitting and waiting, but waiting so long that it promotes risky behavior in the majority of the public and possibly causes damage to vehicles from waiting so long.

Study Area Description

Located about 41 miles north of Boise as shown in Figure 5(Google Maps, 2014 b), it is a four-legged intersection with each leg oriented roughly in the cardinal directions. The north and south legs are SH-55, while the east leg is the start of Banks-Lowman Road and the west leg is a one-lane bridge across the North Fork Payette River to provide access to Banks-Grade Way (Figure 6).

Classification and Conflict Management Method

According to ITD, the roads are classified as follows: (ITD, 2009)

1. SH-55: Principle Arterial – Other (rural)
2. Bank-Lowman Rd: Minor Arterial (rural)
3. Banks-Grade Way: Minor Collector (rural)

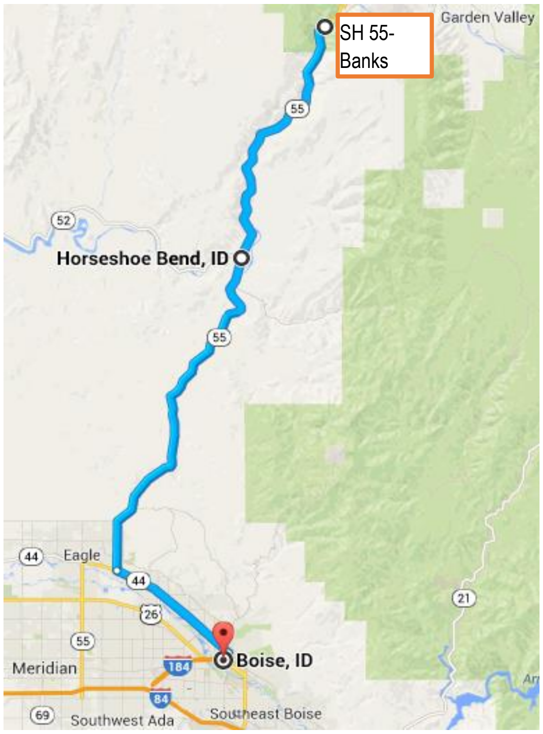


Figure 5: Reference Map

In order to manage the conflict zones shared by those different road types, two-way stop control or TWSC was installed. As a result, the minor legs, Banks-Lowman Road with an approach speed of 50 miles-per-hour (mph) and Banks-Grade Way with an approach speed of 25 mph prior, have to stop, while SH-55, which has a speed limit of 55 mph, is uncontrolled. However, since the existing TWSC is not efficent during summer holiday peaks, ITD deploys flagging to mitigate some congestion on Banks-Lowman Road and puts out a media alert asking drivers to avoid the intersection during the high congestion periods. (Inwards, 2014)

Geometric Description

A simple topography and aerial map of the area is shown in Figure 6. The intersection is also nested in some very confining geographical boundaries. Just southwest of the intersection, the North Fork Payette River (N. Payette) and the South Fork Payette River (S. Payette) join to make the Payette River. Due to that, the Banks-Lowman Road is paralleled on the south side by the S. Payette so that road expansion to the south is limited. By the same token, since the SH-55's south leg of the intersection has to cross the S. Payette, the bridge presents a boundary for the expansion of the SH-55 southern leg in both east and west directions without significant cost. As for the N. Payette, it hinders any westward expansion of the SH-55.

Finally, a slope slightly less than a 1.5: 1 (Vertical: Horizontal) borders the east edge of SH-55 and the north edge of Banks-Lowman Road.

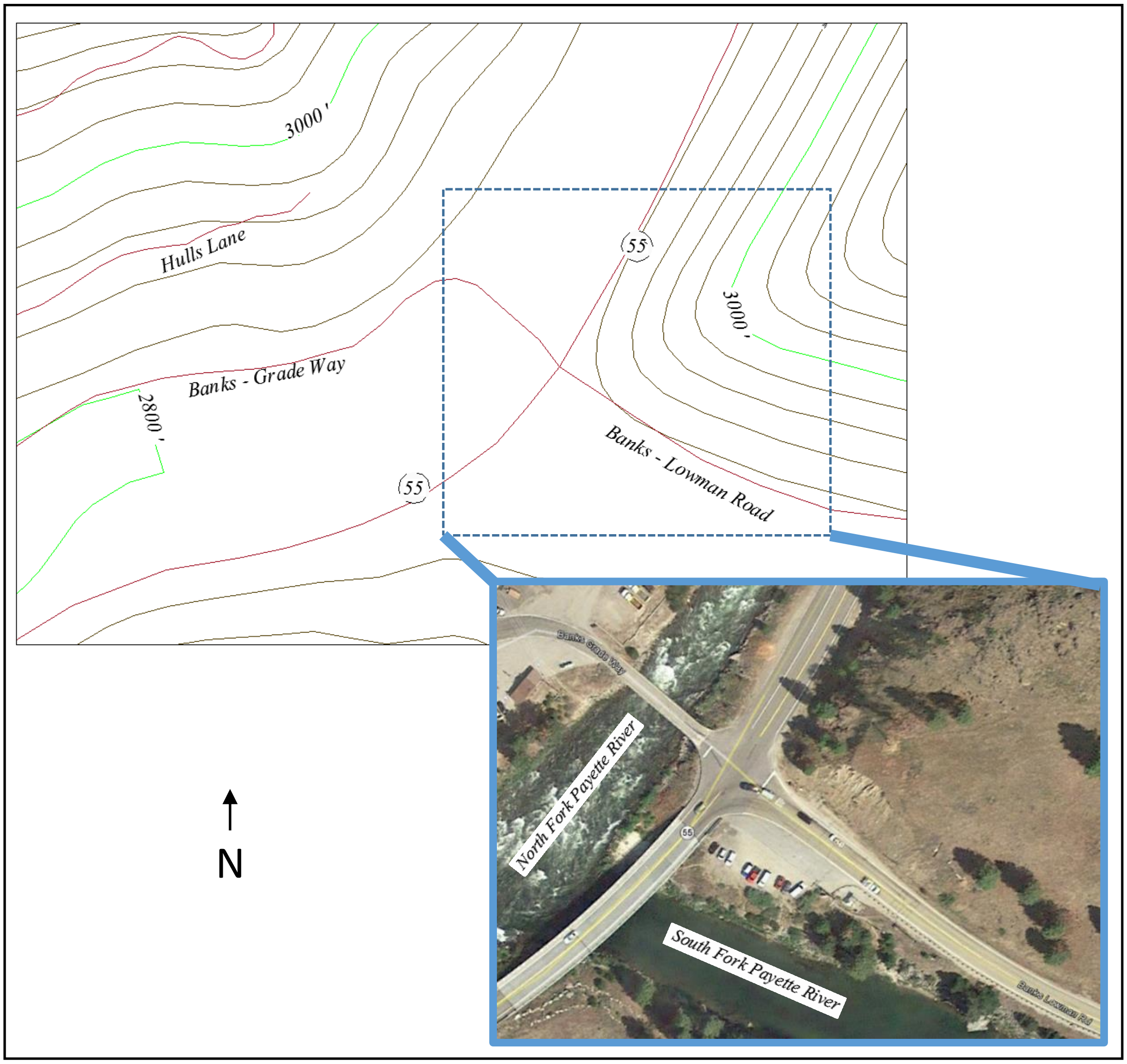


Figure 6: Simplistic Topography Map with 40' contour intervals from the USGS website (USGS, 2012). (Detail) Aerial photo from Google Earth of the SH 55-Banks Intersection (Google, 2014 a)

Existing Condition Data Sources

Three major data sources were used in this study: past automatic traffic recorder (ATR) counts data provided by ITD, Idaho 55 Central Draft Corridor Plan, and field data collected specifically for this study.

Past ATR Count Data

Since late 2006, ITD has been reporting ATR data on three of the four legs in the SH 55-Banks intersection. To facilitate that reporting, there are permanent counter embedded in the north, south and east legs. Each counter is named and numbered as shown in Figure 7 and counts both directions of traffic for their respective legs.

Figure 7: ATR Names and Numbers used for ITD's Reporting

Data was collected from ITD’s Average Daily Traffic (ADT) report for each counter during the years of 2008 – 2013 to define what months are included in the SH 55-Banks intersection’s peak season, and then Monthly Hourly Traffic Volume reports for those peak months were analyzed for trends.

Idaho 55 Central Draft Corridor Plan

This draft was referenced to identify conclusions that had already been discovered about the SH 55-Banks intersection since the northern most intersection discussed in the report is the SH 55-Banks intersection.

Field Studies

Over the 2014 Memorial Day and Independence Day weekends, traffic movements and queue build-up were recorded with video surveillance cameras. Manual post-processing of that video was used to determine turning movements and volumes for all of the approaches as well as identify queue length on the Banks-Lowman Road.

In addition to the video surveillance, over Independence Day weekend only, a floating car method was used to track queue build-up from Horseshoe Bend, ID toward the SH 55-Banks intersection, on July 6, 2014. This was done because in years past, as reported previously by the ITD foreman's quote, ITD employees had reported that vehicles would back up from Horseshoe Bend north through the SH 55-Banks intersection. The floating car was only used on Independence Day weekend because that was the day with the highest traffic volumes during peak season.

Summary of Findings for Existing Conditions

From a trend analysis of the data collected through this study, three main sources that contribute to the excessive delay were identified as follows:

1. Reduced number of acceptable gaps from the main highway as a result of high traffic volumes (Acceptable Gaps),
2. Possible queue propagation from Horseshoe Bend, ID to the intersection being studied (Horseshoe Bend Congestion),
3. Conflicts arising from the one-lane bridge on the west approach to the intersection (One Lane Bridge).

Each of those sources are explained in this section, along with the SH 55-Banks intersection crash history summary (crashes cause congestion so they need to be mentioned).

Acceptable Gaps: Historical Traffic Volume Trends

As shown previously in the literature review, the peak for the traffic takes place during the summer months. However, so that the peak can be better understood, an in-depth analysis was conducted of the historical data. Therefore, a detailed analysis of how to define the seasonal peak (see "The Seasonal Peak" subsection below) was conducted and then how the traffic volumes fluctuate within the peak period

✧ *The Seasonal Peak*

Table 2 shows the monthly average ADT volumes reported by ITD for each ATR at the SH 55-Banks intersection. For emphasis, the July values in red are the peak ADT volumes and the December or January values in blue are the lowest ADT values for each year. For each year, the mean of the maximum and minimum traffic volumes was used to define when the peak season started and ended as shown in Figure 8.

Table 2: Average over 2008 to 2013 of ADT Reported for ATR #182 – 184 (ITD, 2014 c)

ATR*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
182	2515	2647	2343	2272	3285	4497	6154	5323	4026	3376	2619	2272
183	981	1046	1099	1349	1849	2428	3086	2720	2096	1721	1350	1043
184	3421	3578	3351	3402	4991	6787	8817	7889	5837	4884	3727	3261

*Numbering corresponds with Figure 7 above

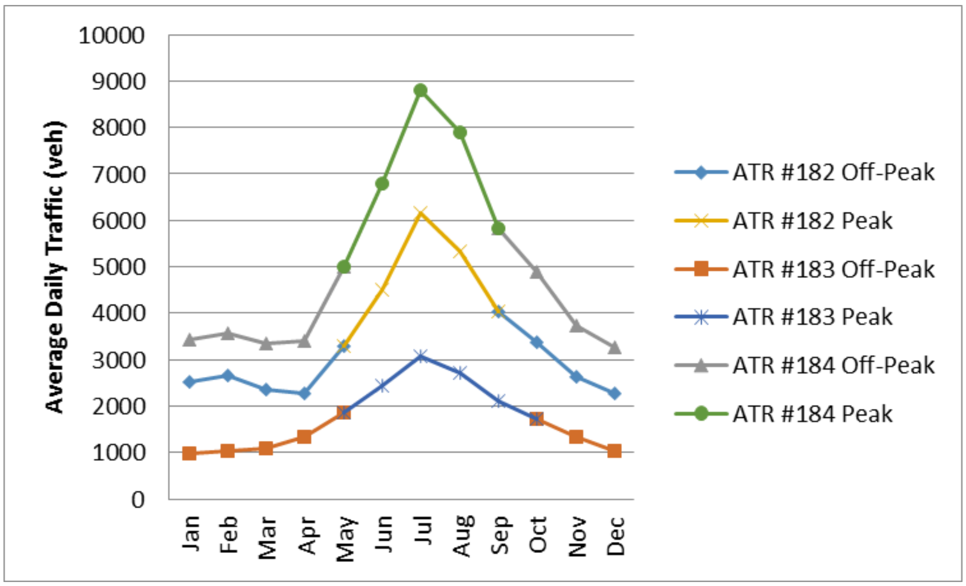


Figure 8: Month-By-Month ATR data at SH 55 Banks Intersection

May was typically when the ADT rose above the mean value and September was when the ADT typically dropped below the mean traffic volume. Therefore, since the peak season was defined as the months of May through September in the Idaho 55 Central Draft Corridor Plan (a document assessing traffic conditions for a section of SH-55 that included the SH 55-Banks intersection), and those are typically the months where warm weather which attracts patrons to the area starts and ends, May through September were adapted as the peak period for this study as well. (ITD, 2014 a)

✧ *Weekly Peaks Within Each Season*

When studying the peaks contain in each week, the Idaho 55 Central Draft Corridor Plan, which used data from ATR #184 (S. Banks), found the average Sunday and Friday peaks are double the peaks of almost any other day of the week for SH-55. When direction was incorporated into this Friday and Sunday peaks were further analyzed in this plan as shown in Figure 10 and Figure 11. Figure 10 shows that the majority of the vehicles traveling Sunday on SH-55 are southbound. Conversely, Figure 11 of the same plan indicates that about the same majority of vehicles are northbound on Fridays. Similar trends to those shown for ATR #184 are found in analyzing ATR #182 and #183 (noting of course that since #183 measures east to west flow, Friday is predominately eastbound and Sunday is predominately westbound)

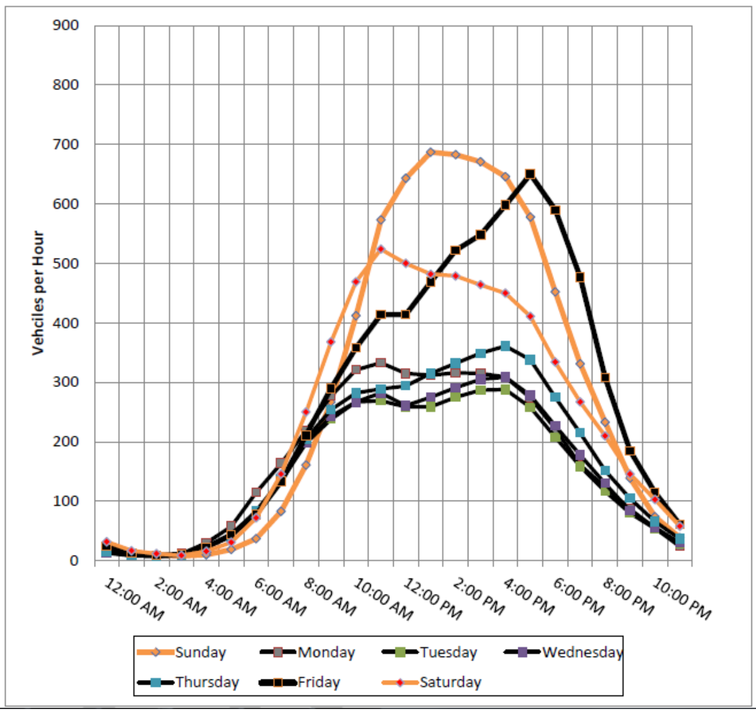


Figure 9: Average Daily ATR data at SH 55 Banks Intersection's NB Approach

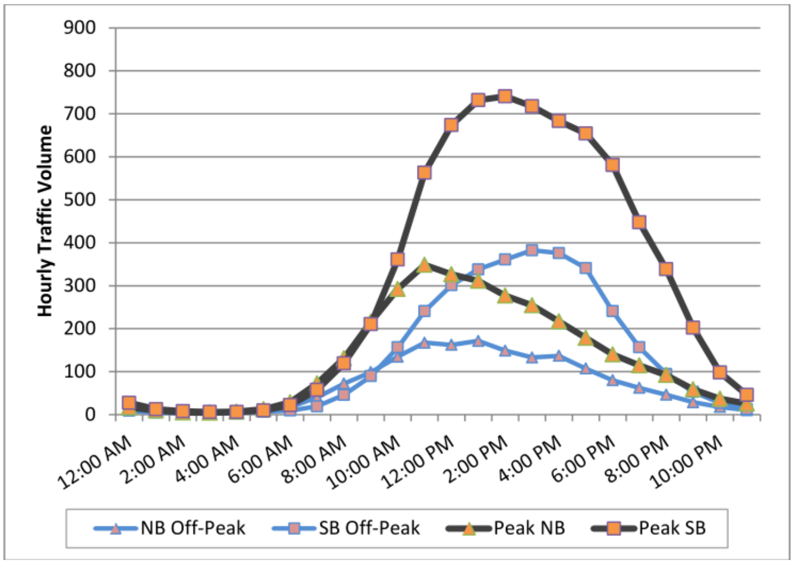


Figure 10: Average Sunday Traffic Volume by Direction by Hour at the SH 55 Banks intersection

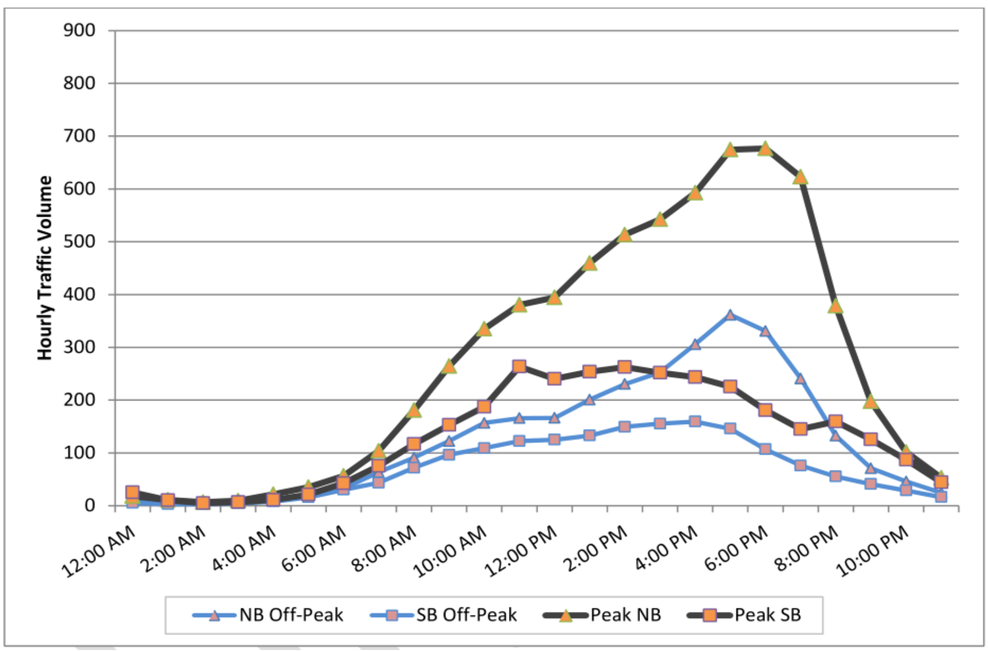


Figure 11: Known as "Figure 24" in the Idaho 55 Central Draft Corridor Plan, this is the "Idaho 55 South of Banks Lowman Road Average Friday Traffic Volume by Direction by Hour"

Although Sunday and Friday peaks are mentioned in the Corridor Plan, it is not the specific day of the week, but what it represents that is important. To quote Liu and Sharma, "one challenge to understanding holiday trends is that the holiday effects may take place not only exactly on holidays. Holiday effects likely cover longer periods, including days adjoining holidays." (Liu & Sharma, 2006) The typical American work week is from Monday through Friday with the majority of workers having Saturday and Sunday off. Therefore, the trend for increased traffic volume occurs typically on Friday and Sunday, but really what is happening is that increased traffic volumes are affecting the last night of the work week with a high peak in the outbound directions (northbound and eastbound for SH 55-Banks intersection) and a high peak in the inbound directions on the last day before work starts (southbound and westbound for the SH 55-Banks intersection).

Where that clarification is necessary is when holidays are on a Friday or Monday. For instance, Memorial Day and Labor Day always fall on Monday. Therefore, the last day before the work starts again is Monday and not Sunday so the southbound peak is shifted accordingly to Monday.

Acceptable Gaps: 2014 Holiday Peak 15 Minute and Turning Movement Counts

Since ATR data is not instantaneously reported by ITD and turning movements cannot be measured with the ATRs at the SH 55-Banks intersection, two field studies were performed during the 2014 peak season. The first study was conducted from May 23 to May 26, 2014 (Memorial Day Weekend) and the second took place over the Independence Day weekend (July 3 to July 6, 2014). From those studies, the northbound and southbound peak hours were identified and are listed in Table 3.

Table 3: Peak Hour Counts from Field Studies

Field Study Weekend	Primary Directions of Travel	Date of the Peak Hour	Peak Hour's Total Count for All Movements
Memorial Day Weekend 2014	Northbound	Friday, May 23rd 5:15 – 6:15 PM	1398 vehicles
	Southbound	Monday, May 26th 11:45 AM – 12:45 PM	1367 vehicles
Independence Day Weekend	Northbound	Thursday, July 3rd 4:49 – 5:49 PM	1303 vehicles
	Southbound	Sunday, July 6th 4:19 – 5:19 PM	1396 vehicles

Knowing that large queues do not form on all of those peak days, a way to differentiate between the flows that induce queues on Banks-Lowman Rd and the peaks that do not. As pointed out in the Highway Capacity Manual, every turning movement in an intersection is placed in priority ranks with "left turn from minor road to major road" being the lowest priority. (Transportation Research Board, 2010) Furthermore, the minimum acceptable gap required in the lane crossed over during the left turn movement is smaller than that which is required in the lane the left turn movement ends. Due to these two facts, when both major and minor approaches are experiencing high traffic volumes, the movement that will experience the most delay is typically a left turn movement from a minor road to the major road. So as to get the worst case scenario for analysis, peak 15 minutes on July 6th were used because both the left turn from the minor road and the major road's receiving lane have the highest volumes that day.

For the SH 55-Banks intersection, the two minor road left turns are off of Banks-Grade Way and Banks-Lowman Road. Banks-Grade Way's traffic is insignificant compared to Banks-Lowman Road's traffic so emphasis is put on the Banks-Lowman Road's left turn movement. Since Banks-Lowman Road's left turns end in the southbound lane of SH-55, the time when the traffic experiences the largest volumes of left turns from the Banks-Lowman Road and southbound SH-55 through movements produces the greatest delay for the minor streets.

Because May 23rd is predominately northbound but July 6th is mostly southbound, the July 6th data's peak 15 minute volumes were used and are shown below in Figure 12.

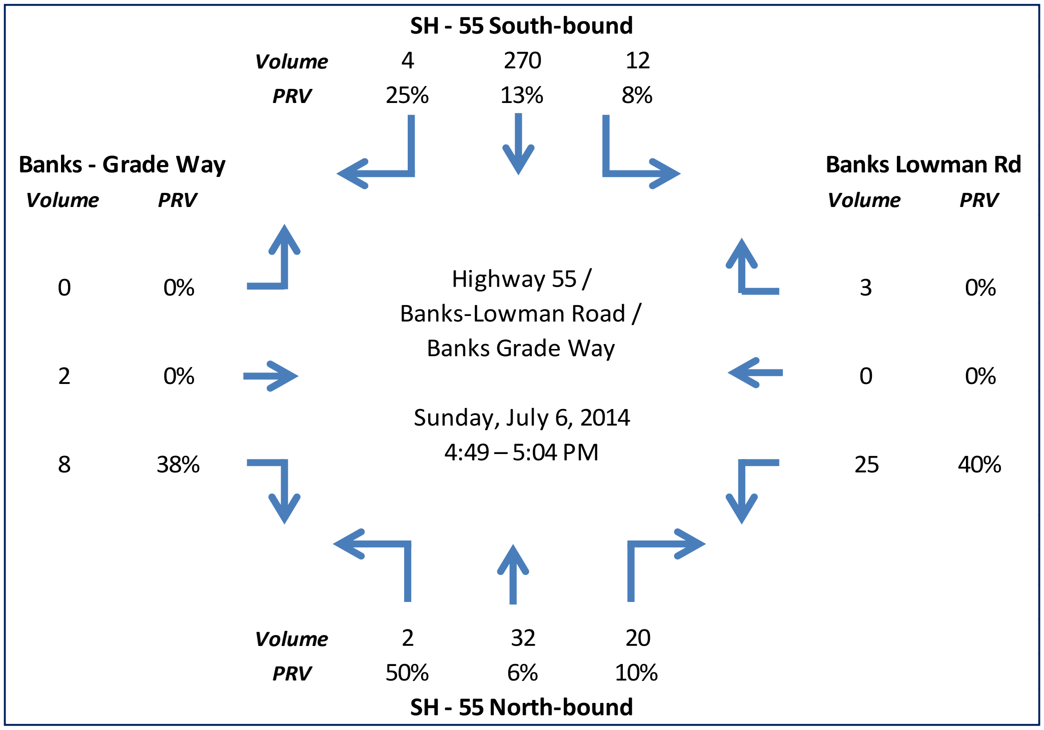


Figure 12: Independence Day Weekend's Southbound Peak 15 Minutes

Acceptable Gaps: Resultant 2014 Holiday Levels of Service

During the peak hour on July 6, flaggers controlled the SH 55-Banks intersection. For this report, McTrans *HCS 2010* was used to determine all of the levels of service (LOSs) which meant adapting the "Streets" module in HCS 2010 to represent the flagging operation. To do that, timestamps on the recorded video were used to calculate the percent service time for SH-55, Banks-Grade Way, and Banks-Lowman Road shown in Table 4. Using those values and the peak 15 minute volumes from Figure 12 in the Highway Capacity Manual's, Table 5 indicates that the average vehicle delay has a LOS E.

Table 4: Break-down of Cycle Length Inputs for HCS 2010's Street Module

Approach	**% of Time Given to the Approach by Flaggers**	**Seconds Allotted to Each Phase in HCS 2010 Street Module**
SH-55	68%	82
Banks-Grade Way	9%	11
Banks-Lowman Road	17%	20
All-Red Time	6%	7
Totals	100%	120

Note: Although other cycle lengths were tested and a cycle length of 90 seconds was more optimum with regard for reducing the delay in the intersection, the 120 second cycle produced delay in the flagging operation which seemed closer to what was observed in the field

Table 5: LOS Report from HCS 2010 Streets Module for Existing Flagging Operation

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (*v*), veh/h		29			239			204			1045	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1374			1476			1590			1617	
Queue Service Time (g_s), s		2.6			14.9			0.0			43.6	
Cycle Queue Clearance Time (g_c), s		2.6			14.9			5.8			74.8	
Green Ratio (*g/C*)		0.03			0.12			0.66			0.66	
Capacity (*c*), veh/h		36			183			1077			1095	
Volume-to-Capacity Ratio (*X*)		0.821			1.307			0.190			0.954	
Available Capacity (c_a), veh/h		57			183			1077			1095	
Back of Queue (*Q*), veh/ln (95th percentile)		2.0			22.4			3.3			35.6	
Queue Storage Ratio (*RQ*) (95th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		58.2			52.6			8.0			19.6	
Incremental Delay (d_2), s/veh		19.3			171.8			0.4			18.1	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		77.5			224.3			8.4			37.8	
Level of Service (LOS)		E			F			A			D	
Approach Delay, s/veh / LOS	77.5	E		224.3	F		8.4	A		37.8	D	
Intersection Delay, s/veh / LOS	64.0						E					

In addition to computing the LOS for the existing flagging operation, the LOS for a condition where the flagging operation did not exist during the holidays was also calculated using HCS 2010's TWSC module and shown in Table 6.

Table 6: LOS Report from HCS 2010 TWSC Module for the Existing Operations if No Flagging were Performed

Delay, Queue Length, and Level of Service								
Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LTR*	*LTR*		*LTR*			*LTR*	
v (veh/h)	*8*	*48*		*112*			*40*	
C (m) (veh/h)	*488*	*1328*		*70*			*192*	
v/c	*0.02*	*0.04*		*1.60*			*0.21*	
95% queue length	*0.05*	*0.11*		*9.62*			*0.76*	
Control Delay (s/veh)	*12.5*	*7.8*		*426.5*			*28.6*	
LOS	*B*	*A*		*F*			*D*	
Approach Delay (s/veh)	--	--	*426.5*			*28.6*		
Approach LOS	--	--	*F*			*D*		

<u>*Horseshoe Bend Congestion: Method and Results for Field Measurement Activities*</u>

The "floating-car" method was used on July 6, 2014 (the peak day of the 2014 Peak Season if things followed previous year's trends) to track and evaluate the northbound shockwave that some assume originated from the point where Horseshoe Bend dropped to 25 mph. (Church, 2014)

Prior to the start of July 6, 2014, the map in Figure 13 was created to have designated stopping points. A driver then was positioned just upstream of Horseshoe Bend's 35 MPH zone at the first monitoring location from about 9:30 AM Mountain Daylight Time until 4:45 PM and observed the traffic flow behavior. When the shockwave's congestion reached the monitoring location, the time was recorded on a data collection form (see Appendix 1). At 4:45, the driver then drove north, observing traffic conditions along the way. Several times along the drive, the southbound traffic would alternate between pockets of stand-still traffic and free-flowing traffic, with the largest (and also the last) stand-still group extending from the "Before Cascade Raft" location to somewhere past the "Gravel Bank at Cottonwood Creek." Stopping at the 9th designated location to record how long it took to reach that point, the floating car then followed the congestion, recording the times the shockwave reached a location and then driving to the next designated location. However, by 5:30 PM, the shockwave stopped advancing after traveling over 10.5 miles.

Reference Descriptions	Distance
Horseshoe Bend to Banks-55 Intersection	*15 Miles*
Boise to Horseshoe Bend	*27 Miles*
Boise to Banks-55 Intersection	*41 Miles*

Figure 13: Floating Car Method's Designated Location reference

Horseshoe Bend Congestion: Discussion

Although the shockwave standstill traffic did not reach the SH 55-Banks intersection, the data from the floating car observations suggests that it can and supports some of the observations by the SH 55-Banks intersection ITD foreman's as stated in the quote below:

> "*The traffic backs up on Hwy 55, all the way from Horseshoe Bend, due to several factors. The Banks Café is quite busy and traffic entering and leaving their parking area slows 55 traffic. Whitewater enthusiasts crossing the North Fork of the Payette river bridge in front of our maintenance shed contribute, as do vehicles entering and leaving the numerous turnouts along Hwy 55 south of Banks, particularly the little beach area about a half mile south of the café. Traffic may or may not have a short*

run at near highway speeds between the rafting takeout at Beehive Bend and the backed up traffic from the 25 MPH speed limit and turning traffic congestion in Horseshoe Bend, but usually traffic is backed up for several miles north of town, if not all the way to Banks." (Inwards, 2014)

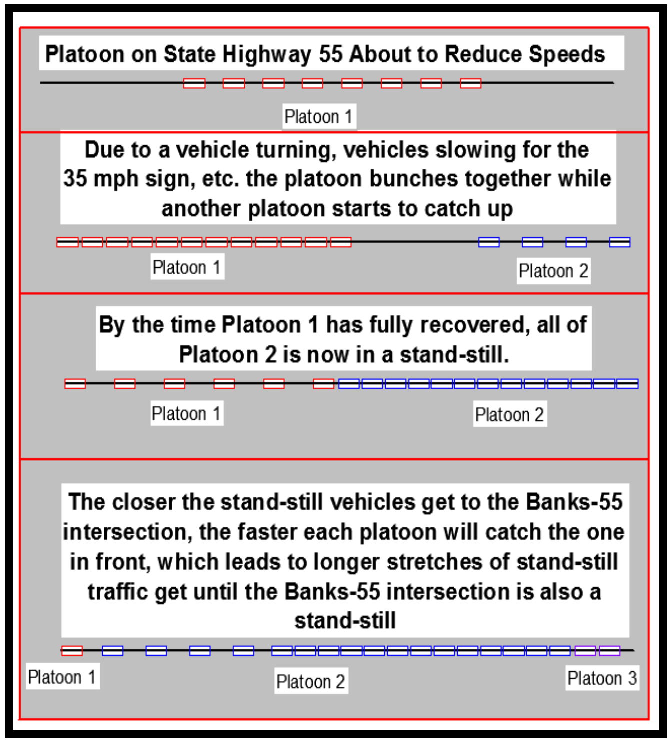


Figure 14: Graphical representation of how a shockwave could propagate the 15 miles from Horseshoe Bend to the SH 55-Banks intersection

The foreman assumed that it was through several factors including "vehicles entering and leaving the numerous turnouts along Hwy 55 south of Banks, particularly the little beach area about a half mile south of the Banks Café. Applying this more generally, the data suggests that the main shockwave is primarily due to vehicles slowing down and bunching up as diagramed in Figure 14. Since there is a reduced speed limit change when entering Horseshoe Bend, that location is consistently forcing vehicles to slow down and causing bunching. Combine that with the large platoons along SH-55 the bunching-induced shockwave can propagate as long as the rear-most part of the shockwave cannot disperse prior to the next large platoon arriving. Since July 6, 2014 had lower volumes than usual for the end of Independence Day weekend as is indicated in the flow rate comparison graph in Appendix 2, it is assumed that the "pockets" of traffic near highway speeds seen by the floating car driver would disappear to match the ITD foreman's observations.

One Lane Bridge: Vehicle Conflict

The east leg of the SH 55-Banks intersection is a one lane bridge, however, two directions of traffic are permitted on the bridge. Throughout the majority of the year, the low volumes provide enough gap between vehicles that conflicts are minor. However, during Memorial

Day and Independence day, the volumes increase because rafting company vans utilize that bridge for scheduled rafting pickups and dropoffs.

<u>One Lane Bridge: Pedestrian Conflicts</u>

On the south-east corner of the intersection, there is an open gravel area traveler's frequently use as a parking space when accessing the rafting launch area just southwest of the SH 55-Banks intersection. The problem with that arrangement is that in order to get to the launch area, pedestrians must cross SH-55 and then walk along the west leg's one lane bridge unprotected. Although only 5 to 10 pedestrians cross during peak holiday hours, it is a safety issue for both vehicle and pedestrians and the crossings can further complicate congestion at the intersection by forcing SH-55 drivers to slow down unexpectedly.

<u>Crashes</u>

If a crash takes place at the SH 55-Banks intersection, there are no easily accessible side routes to divert traffic to so reducing the number of crashes can reduce congestion. Since the Highway Safety Manual cannot only predict crashes based on existing conditions but also the recommended alternatives that are presented later, the safety performance function (SPF) used in the manual was calibrated to the SH 55-Banks intersection's historical crash data.

In the Highway Safety Manual, 1st Edition, the SPF for a four-leg stop-controlled intersection such as the SH 55-Banks intersection is calculated using the following function: (American Association of State Highway and Transportation Officials, 2010)

$$N_{spf\ 4ST} = \exp\left[-8.56 + 0.60 * \ln(AADT_{maj}) + 0.61 * \ln(AADT_{min})\right]$$

Where:

$N_{spf\ 4ST}$ = estimate of intersection-related predicted average crash frequency for base conditions for four-leg stop controlled intersections;

$AADT_{maj}$ = Annual Average Daily Traffic (AADT, vehicles per day) on the major road; and

$AADT_{min}$ = AADT (vehicles per day) on the minor road; and

To determine the $AADT_{maj}$ value at the SH 55-Banks intersection, an average of all ATR #182 and #184 monthly daily traffic values from Table 2 above was used and resulted in about 4,200 vehicles. Similarly, the average of ATR #183 values from Table 2 was used for $AADT_{min}$ and equaled about 1,700 vehicles. Inputting those values into the above SPF, the result is shown below:

$N_{spf\ 4ST}$ = exp [-8.56 + 0.60 * ln (4,200) + 0.61 * ln (1,700)] = 2.7 crashes per year

Typically, the predicted crashes above would be modified by standard Highway Safety Manual (HSM) crash modification factors (CMFs) for the four-leg stop controlled intersection. However, the four standard CMFs (skew, left and right turns, and lighting) do not apply or are not significant. That said, according to the Idaho 55 Central Draft Corridor Plan, there were four crashes at the intersection during 2010 to 2012 which is an average of 1.3 crashes per year. Therefore, it is assumed that in order to use the HSM method, a local calibration factor or CMF of 1.3 / 2.7 = 0.48 should be applied.

Assessment of Available Design Improvements

Once the sources of congestion were identified, each type of modification listed in the literature review was evaluated for fit. Then each one was sorted into two categories: "Recommended" and "Not Recommended." Below, the resultant sorting is shown along with pros and cons on how each recommended treatment addresses the SH 55-Banks intersection problem.

Recommended Treatments

✧ *Signalization of the Intersection*

Cost: Low to Medium

Primary Reasons for Being Recommended: This treatment is the primary recommendation for the SH 55-Banks intersection because of its adaptability to the existing intersection geometric layout. Also, the signal can be programed to aid traffic when needed (so more than just holidays) without affecting the existing traffic conditions the rest of the year by going into flashing mode

Effects on Intersection Safety: In HSM Volume 3's Table 14-7 (not shown in this report), it suggests that by installing a traffic signal, the existing number of crashes decreases by a factor of 0.56. Using the $N_{spf\ 4ST}$ of 2.7 crashes and local CMF of 0.48 developed in the "Summary of Findings for Existing Conditions" section above, the predicted number of crashes after installing a signal would be 2.7 * 0.48 * 0.56 = 0.76 crashes per year.

Signal Warrants: The intent of installing a signal is not to control traffic year-round but to only control it when traffic volumes induce large backups. Therefore, since the peak hour warrant, Warrant 3 in the Manual on Uniform Traffic Control Devices (MUTCD) 2009 Edition in Section 4C.04 paragraph 05, describes doing that when Warrant 3 is the only warrant met, no other warrant was verified in this report. (US Department of Transportation Federal Highway Administration, 2013)

With SH-55 having a posted speed limit exceeding 40 mph, Figure 4C-4 from the MUTCD (Figure 15 in this report) could be used to check if this warrant is met. Using the July 6, 2014 peak 15-min flow rates in Figure 12 multiplied to create hourly flow rates, the sum of the major street approaches (northbound and southbound) and the higher volume minor street approach (westbound) are 1360 vehicles per hour and 112 vehicles per hour respectively. Since any major street volume over 850 and a minor volume of about 110 vehicles per hour is over the "1 Lane & 1 Lane" threshold, as indicated by the dashed line approximately marking the higher volume minor street approach in Figure 15, this warrant is met.

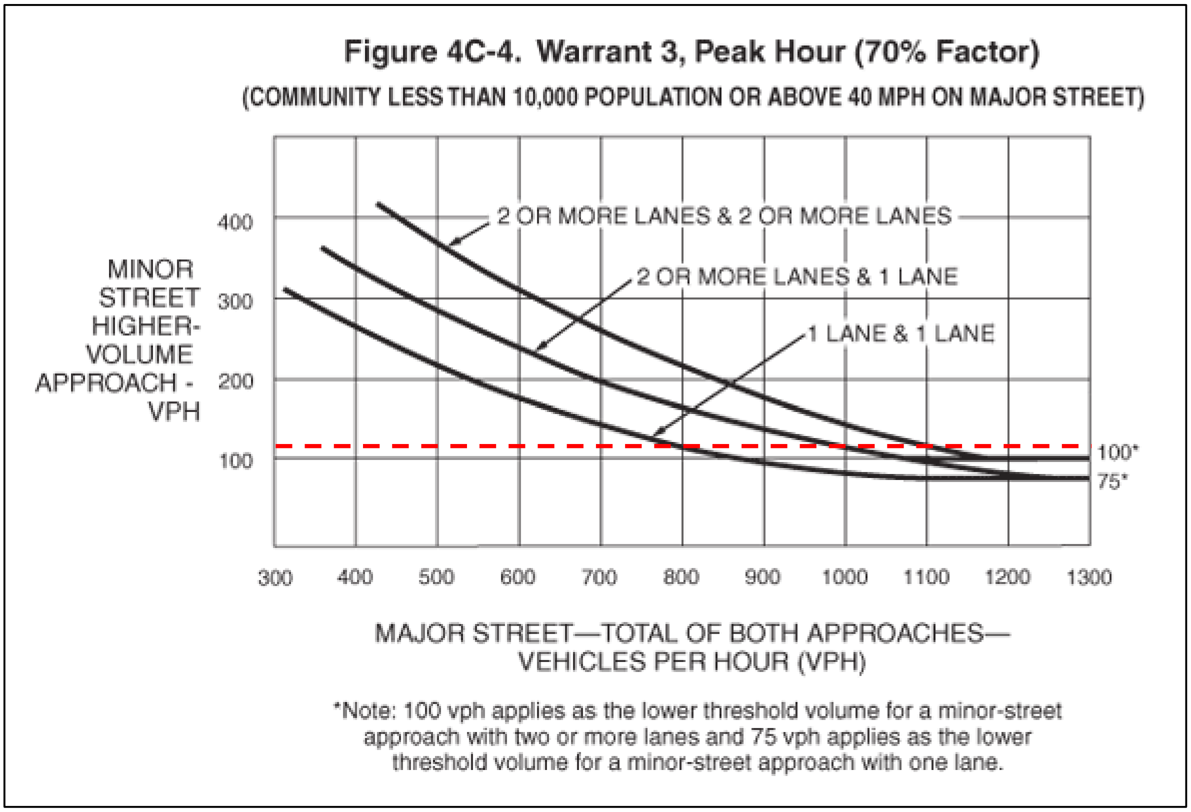


Figure 15: Figure 4C-4 from the MUTCD 2009 Edition, which is used to validate if signal warrant 3 is met.

Pro: This is in part due to the fact that signalized intersections are one of the most well documented treatments in the literature which reduces the difficulty of implementing one at the SH 55-Banks intersection. Also, since it is not based on a geometric adjustment, such as a roundabout, the timing can be adjusted in real-time to match traffic volumes as they fluctuate throughout the year to keep the intersection from dropping below the LOS shown in Table 7. For instance, optimized timing that alternates between the main line and the minor streets can take place on holidays or weekends with high volumes. Then, when there are low volumes on the minor roads during the majority of the year, the signal can be set to red and yellow flashing (yellow serving SH-55 and red for Banks-Lowman Road and Banks-Grade Way). Also, so that the transition between the two types of signalization could happen any time of the year, rather than just on the holidays, queue detectors could be placed on the minor approaches to identify when and automatically do the switch between the red-yellow-green mode and the yellow-red flashing mode.

There are other advantages to having a signal as well besides optimizing vehicle progression through the SH 55-Banks intersection. Signalizing the intersection could also help protect the pedestrians. Not only would the signalization protect pedestrians crossing SH-55 using pedestrian lights common on most signalized four-way intersections (shown in the intersection diagram below), but the issues with sharing the one-lane bridge between slow moving pedestrians and vehicles. Similar to a signalization used in Folsom, California (Weir, 2013), when a pedestrian pushes a button to cross the bridge, signal displays can prohibit turning into the bridge while the pedestrian crosses. That way, the signal can protect the pedestrian while other movements take place.

In addition to signalization, due to the existing space and minor cost of installment, it is also recommended that a left turn pocket be added to the Banks-Lowman road approach. That way, the right turn and through movements on the Banks-Lowman Road can more readily complete their movements compared to if those movements have to wait for the left turn vehicles to leave the through lane. Although such a lane only aids about 5% of the westbound vehicle movements, the lane can be achieved with relative low cost which makes the addition worthwhile to install.

Con: Although angled crashes would decrease, the expected rear end crashes would probably increase. To aid with that problem, an advanced “BE PREPARED TO STOP” flashing signal should be installed on SH-55 upstream from the intersection to alert drivers about the possibility of stopping at the intersection.

LOS If Treatment is Implemented: D

Table 7: Level of Service Report for the Signalization Treatment per HCS 2010 Software

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h		29			239			204			1045	
Adjusted Saturation Flow Rate (s), veh/h/ln		1374			1476			1588			1617	
Queue Service Time (g_s), s		2.6			18.8			0.0			43.9	
Cycle Queue Clearance Time (g_c), s		2.6			18.8			5.8			75.0	
Green Ratio (g/C)		0.03			0.19			0.66			0.66	
Capacity (c), veh/h		36			283			1074			1093	
Volume-to-Capacity Ratio (X)		0.821			0.845			0.190			0.955	
Available Capacity (c_a), veh/h		366			443			1074			1093	
Back of Queue (Q), veh/ln (95th percentile)		1.9			11.3			3.3			35.9	
Queue Storage Ratio (RQ) (95th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		58.2			46.8			8.1			19.8	
Incremental Delay (d_2), s/veh		15.5			5.0			0.4			18.4	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (d), s/veh		73.7			51.8			8.4			38.2	
Level of Service (LOS)		E			D			A			D	
Approach Delay, s/veh / LOS	73.7		E	51.8		D	8.4		A	38.2		D
Intersection Delay, s/veh / LOS	37.0						D					

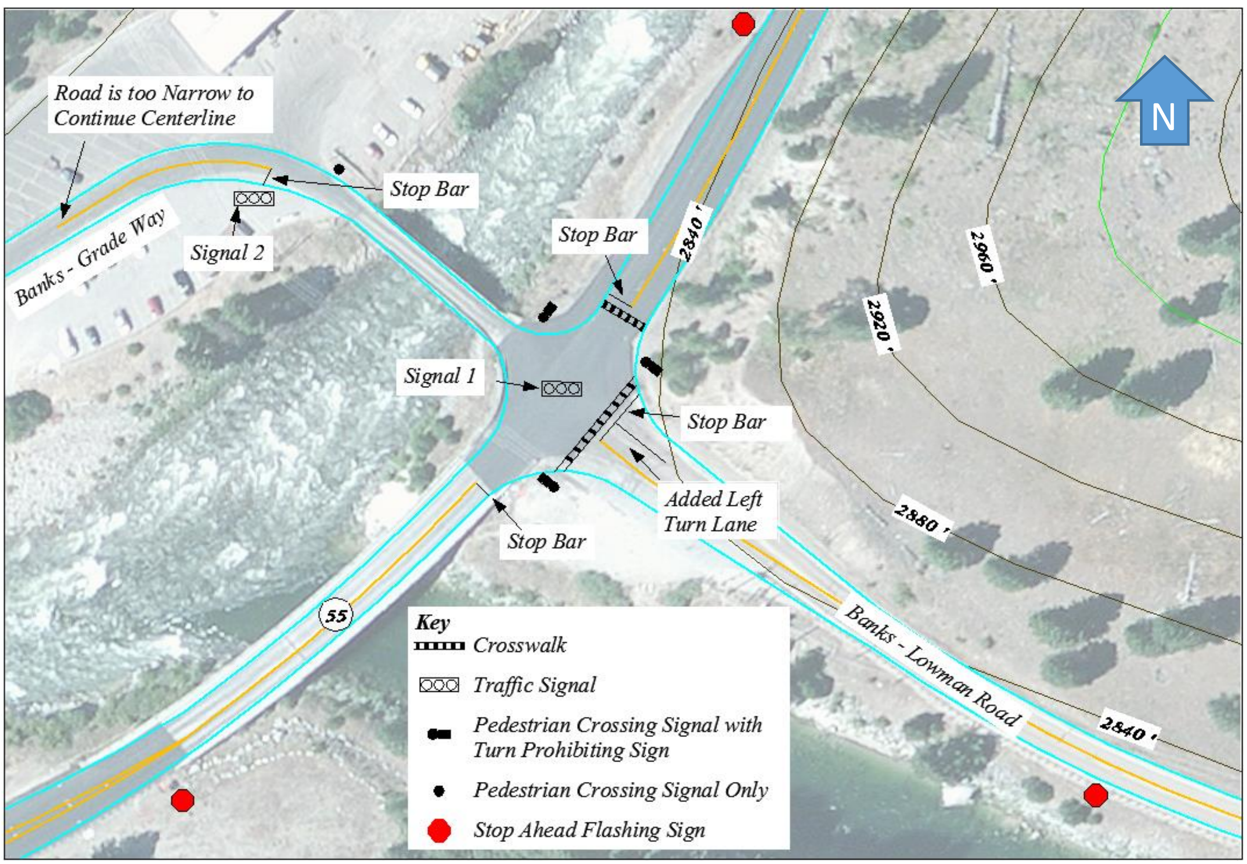


Figure 16: Conceptual Signalization Layout

✧ *Receiving Left Turn Bay*

Estimated Cost: Medium to High

Primary Reasons for Being Recommended: Although this treatment still has an LOS rating of "F" as shown in Table 8 it does decrease average delay when compared to the existing LOS if flaggers were not being deployed. This situation happens when the traffic volumes increase during a summer weekend outside of a holiday weekend. Adding a lane for the receiving lane also facilitates future expansion of SH-55.

Effects on Intersection Safety: Very limited research was discovered regarding the safety of this improvement. However, the Crash Modification Factors Clearinghouse did have a report that showed a CMF of 0.77 with a standard error of 0.19 which gives a range of 0.58 to 0.96. applying this to the SPF developed previously, the range of predicted crashes is 0.75 crashes to 1.24 crashes per year.

Pro: This is a treatment (also known as a Left Turn Acceleration Lane) used at the intersection of Main St. and Washington State Highway 26 on the south side of Othello, WA. Similar to a permitted left-turn through a median, westbound vehicles only interact with one direction at a time. The westbound-turning-southbound vehicle first crosses the northbound traffic into an added lane which allows the westbound-turning-southbound vehicle to sit protected in between the north and south bound traffic. Then, when there is a gap in the southbound traffic, the vehicle could enter the southbound lane.

Con: The greatest challenge to this treatment is that the bridge over S. Payette is only a few hundred feet south of the intersection. In order to avoid the cost of shifting the Bank-Low Hwy intersection further north or widening the bridge, a truck and trailer must be able to drive across the northbound lane and get completely into the middle lane before they get too close to the bridge. That said, in the Idaho 55 Central Draft Corridor Plan, it identified the South Fork Payette River Bridge as being "**Structurally Deficient**." Therefore, the cost to improve and widen the bridge may be connected to repairs to the bridge.

LOS If Treatment is Implemented: F

Table 8: Level of Service Report for the Receiving Left Turn Bay Treatment

Delay, Queue Length, and Level of Service								
Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	LTR	LTR		LTR			LTR	
v (veh/h)	8	48		112			40	
C (m) (veh/h)	488	1328		120			192	
v/c	0.02	0.04		0.93			0.21	
95% queue length	0.05	0.11		6.00			0.76	
Control Delay (s/veh)	12.5	7.8		133.2			28.6	
LOS	B	A		F			D	
Approach Delay (s/veh)	--	--	133.2			28.6		
Approach LOS	--	--	F			D		

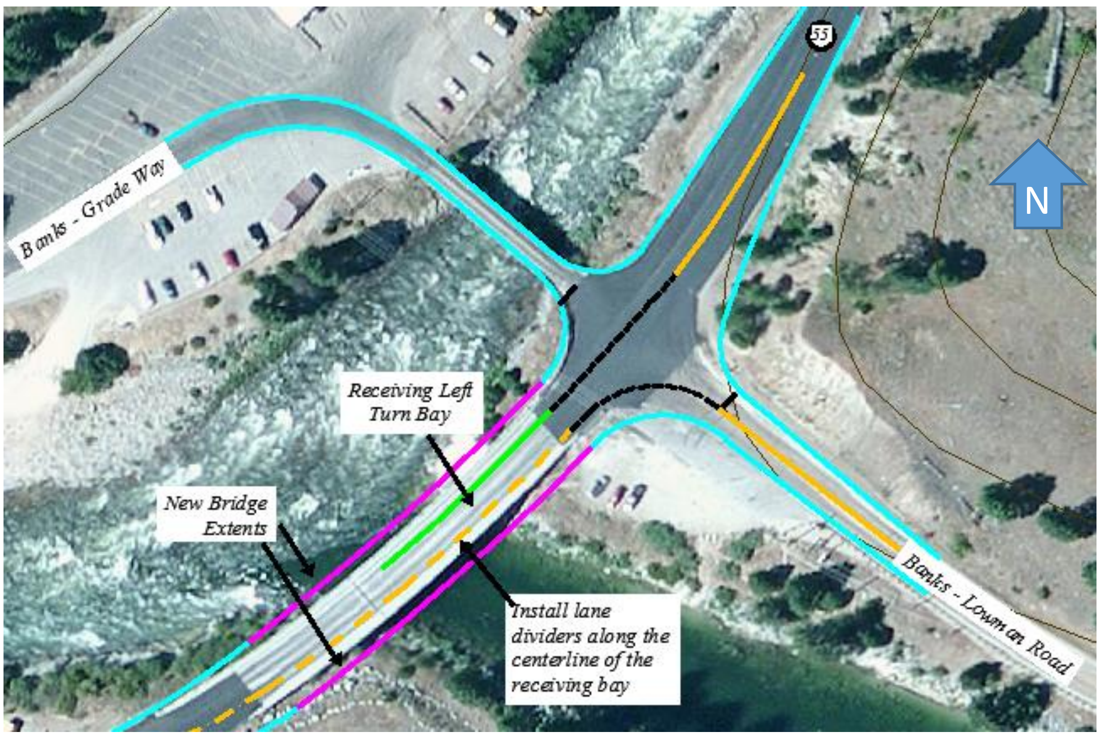


Figure 17: Example of a Left Turn Receiving Lane Projected Onto the SH 55-Banks Intersection

✧ *Roundabout*

Cost: High

Effects on Intersection Safety: In Table 14-4 of the HSM, the conversion of a rural, one lane intersection to a modern roundabout has a CMF of 0.29. Using the SPF developed previously, the new predicted crashes would become 0.4 crashes per year.

Pro: By installing a roundabout as shown in the figure below, both the left turn movement from Banks-Lowman Road and the through southbound movement on SH-55 could take place at the same time. Due to that principle, no approach would be subjected to more than a LOS C as shown in Table 9. (Washington State Department of Transportation, 2014b)

Con: There are two major opposing ideas for the roundabout recommendation. First, the congestion only takes place three months out of the year, but the roundabout will slow SH-55's traffic to at least 35 mph all year long. If the roundabout is being built to handle future growth in the area, then it may not be an issue, but the year-round change must be considered.

The other opponent to a roundabout is the construction cost. As shown in Figure 18 below, not only would the bridge have to be remodeled, a significant amount of excavation would need to be done in order to accommodate the roundabout. This cost however, can be warranted as a method to facilitate future growth and to improve safety.

LOS If Treatment is Implemented: C

Table 9: Level of Service Report for the Roundabout Treatment

Delay and Level of Service												
	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		*11.9*			*8.1*			*5.6*		*17.5*	*22.0*	
Lane LOS		*B*			*A*			*A*		*C*	*C*	
Lane 95% Queue		*0.3*			*1.3*			*0.8*		*5.2*	*7.0*	
Approach Delay, s/veh	*11.87*			*8.11*			*5.61*			*19.92*		
Approach LOS, s/veh	*B*			*A*			*A*			*C*		
Intersection Delay, s/veh	*15.98*											
Intersection LOS	*C*											

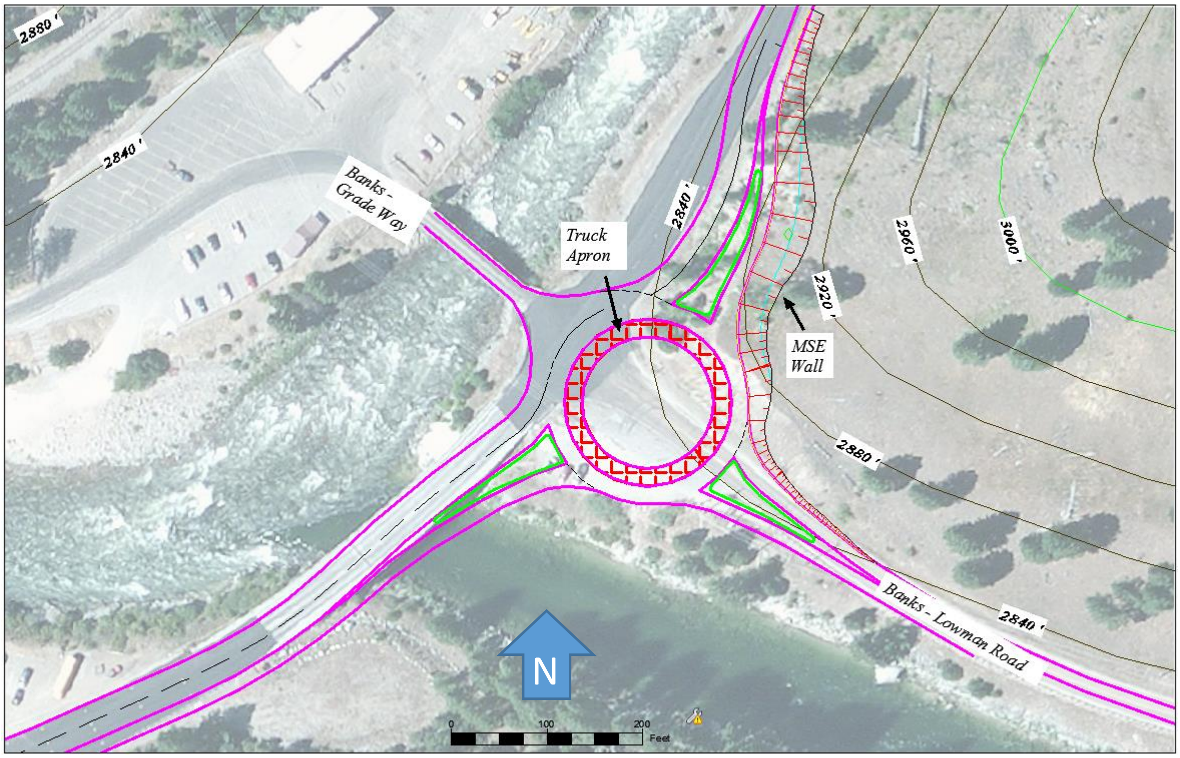


Figure 18: Preliminary Design of a Roundabout at the SH 55-Banks intersection

<u>*Reasoning On Why Other Treatments Were Not Selected*</u>

✧ *Continue Flagging the SH 55-Banks Intersection Only on Major Holidays*

During the 2014 field observations, the flagging crews used were untrained and thus there was a significant difference between the proposed signalization LOS and the LOS from flagging. However, even if it is later proven that the flagging is just as efficient as having a signal control traffic movements, peak volumes at this intersection do not always come at predictable times. Memorial Day and Labor Day peak volumes always happen on the predicted day, but Independence Day peak volumes do not. For instance, when Independence Day occurs in the middle of the week, past data has shown that the peak day varies between Sunday before Independence Day and the Sunday after, assuming the traffic volumes do not peak on both weekends. A signal can be traffic-actuated, but deploying flaggers cannot.

✧ *Additional Lanes*

This option was discredited because the geographical boundaries mentioned in the site description allow very little room to expand without expensive excavation. Also, since the holiday peak only takes place three times a year, this option could be viewed as "over-building" the road

✧ *J-Turn*

Although the J-turn would reduce the minimum acceptable gap, the geographical boundaries would either require detour northbound before vehicles performed a U-turn to be so long it would result in the same amount of delay, or the excavation cost to create a U-turn location closer would be extremely expensive.

✧ *Turn Pocket*

As the only improvement, adding either a left or right turn pocket to the Banks-Lowman Road approach would do very little to help with congestion. Only about 5% of the Banks-Lowman Road traffic volume makes a right turn so a right turn pocket would be underutilized with left turn vehicles frequently blocking past the pocket. In a similar manner, even a long left turn pocket would spill over into through lane which in turn would block the right and through traffic also making the improvement ineffective.

✧ *Grade Separation*

It is logical to assume that this would improve traffic flow to approximately the same LOS as the roundabout. However, the cost would be even larger than the expensive roundabout because a similar amount of excavation, if not more, would have to take place and that does not even account for the cost of all the environmental impacts it could have due to it touching the river.

✧ *Road Realignment*

For an intersection where both minor approaches experience high volumes, there is a possibility that realigning one or both of the minor roads so that both minor approaches intersect the main road at different locations. However, since the Banks-Grade Way approach has relatively low traffic volumes, the extra conflicts created by the Banks-Grade Way approach are negligible and this treatment was discredited.

✧ *Access Management*

Similar to the road realignment treatment, this option was discredited because there are not a lot of driveways or access points near this intersection that interfere with the flow of traffic through the SH 55-Banks intersection.

Chapter 4

Conclusions and Recommendations

Many rural highways experience a surge in traffic flow levels on “high-travel” days during national holidays. Due to the platooned nature of the high volume traffic on the main highway, vehicles on the minor approach attempting to turn onto the major highway are subjected to excessive delays. This research focused on alternative intersection treatments to alleviate congestion at rural intersections caused by increased traffic volume during high-travel days. The study documented the characteristics of holiday traffic at different locations in Idaho and presented possible measures that can be implemented to alleviate congestion resulting from holiday traffic at rural intersections. A case study focusing on the intersection of SH 55 and Banks-Lowman highway, an intersection that experiences high level of traffic volumes during summer national holidays, was presented. As part of the case study, field data and macroscopic and microscopic simulation were used to assess the impact of different measures to alleviate congestion at the intersection. The HSM was used to document the potential safety impact of each proposed treatments.

Traffic flow trends for the intersection were obtained from data collected through several automatic traffic counters continuously monitoring traffic near the intersection. In addition, field data was collected at the intersection during the 2014 Memorial Day and Independence Day weekends. From a trend analysis, three main sources that contribute to the excessive delay were identified as: 1) reduced number of acceptable gaps from the main highway as a result of high traffic volumes, 2) possible queue propagation from Horseshoe Bend, ID to the intersection being studied, and 3) conflicts arising from the one-lane bridge on the west approach in the intersection.

Three different intersection treatments were analyzed as part of the case study. They are: signalizing the intersection, installing a left-turn receiving bay, and installing a compact roundabout at the intersection. The results of the microscopic and macroscopic models for the existing conditions and alternative treatments showed that a roundabout provides the most efficient alternative from both an operational and safety point of view. The average delay at the intersection is reduced from 64 seconds per vehicle during flagging operations to 16 seconds per vehicle when a roundabout is installed. The average delay at the intersection with a fully actuated signal is 37 seconds per vehicle. A left-turn receiving lane can be very effective during times high traffic volumes when flaggers are not presented. The analysis showed that they can reduce the average delay for left turning vehicles from an average of 424 seconds per vehicles to 133 seconds per vehicle.

From a safety perspective, the expected average number of crashes per year will decrease from 1.30 crashes/year in the existing conditions to 0.40 crashes per year if a roundabout is installed. This value is 0.76 crashes per year if a fully actuated traffic signal is installed. A left-turn receiving lane will slightly reduce the expected average number of crashes at the intersection to 1.24 crashes/year.

While a compacted roundabout provided the best operational and safety benefits, the significant construction cost and its year-long effect on main highway traffic have made it the second recommended treatment option for the intersection. The relatively moderate cost of signalizing the intersection along with the fact that the actuated operation of the signal will only be operational if traffic flow levels exceed a certain threshold minimizing the impact on the main highway, made signalizing the intersection the preferred treatment for the intersection considered in the case study. It provides safe and efficient movement for both vehicular and pedestrian traffic. Specifically, the following recommendations are made:

- Install advanced “be prepared to stop” flashing signal on SH 55 upstream from the intersection to alert drivers about the possibility of stopping at the intersection.
- Operate the traffic signal in flashing mode all year unless the queue on Banks-Lowman Road exceeds a certain length. (MUTCD Section 4C.04.06)
- Widening the bridges that serve as legs in the intersection will lead to additional safety and operational improvements at the intersection.
- Widening the bridge over the South Fork Payette River on SH-55 to add a lane will allow for future long-term development and remove its the structural deficiencies. (ITD, Idaho 55 Central Draft Corridor Plan, 2014 a)
- Widening the bridge across the North Fork Payette River is recommended to remove the conflict created by the one-lane bridge and to allow for future expansion to the west and to improve the safety of pedestrian movement on the bridge.

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Appendix 1

Millage and Time Form for the Floating Car Method

Blank Form

Floating Car Driver: ______________ **Observation Date:** **July 06, 2014** **Start Time:** ______________

Stop #	Name/Description	Distance	Distance Traveled	Expected Travel Time		Time Traveled
				Time	Time Traveled	
0	35 mph sign	0	0.0	0	0	N/A
1	Rocky Road	0.8	0.8	1	1	
2	Near Bridge	0.4	1.2	1	2	
3	Porter Creek Road	0.9	2.1	1	3	
4	Hill Creek Road	1.2	3.3	2	5	
5	Before Cascade Raft	1.9	5.2	3	8	
6	After Cascade Raft	0.8	6.0	1	9	
7	After Beartown	0.9	6.9	2	11	
8	Gravel Bank at Cottonwood Creek	1.1	8.0	1	12	
9	Residential Pullout	1.2	9.2	1	13	
10	Off-Roading Pullout	1.5	10.7	2	15	
11	shoulder Pullout	1.2	11.9	2	17	
12	Off-Roading Pullout	1.1	13.0	1	18	
13	Banks	0.7	13.7	0.87	18.87	

*All distances are in units of miles and time is in units of minutes.

Completed Form

Floating Car Driver: Christopher Bacon **Observation Date:** **July 06, 2014** **Start Time: 11 AM**

Stop #	Name/Description	Distance	Distance Traveled	Expected Travel Time		Time Backup Reached Location
				Time	Time Traveled	
0	35 mph sign	0	0.0	0	0	Not Monitored
1	Rocky Road	0.8	0.8	1	1	14:30
2	Near Bridge	0.4	1.2	1	2	Arrived too Late
3	Porter Creek Road	0.9	2.1	1	3	Arrived too Late
4	Hill Creek Road	1.2	3.3	2	5	Arrived too Late
5	Before Cascade Raft	1.9	5.2	3	8	Arrived too Late
6	After Cascade Raft	0.8	6.0	1	9	Arrived too Late
7	After Beartown	0.9	6.9	2	11	Arrived too Late
8	Gravel Bank at Cottonwood Creek	1.1	8.0	1	12	Arrived too Late
9	Residential Pullout	1.2	9.2	1	13	17:07
10	Off-Roading Pullout	1.5	10.7	2	15	17:21
11	shoulder Pullout	1.2	11.9	2	17	N/A
12	Off-Roading Pullout	1.1	13.0	1	18	N/A
13	Banks	0.7	13.7	0.87	18.87	N/A

Note: All distances are in units of miles, Expected Travel Time is in units of minutes, and Time Backup Reached Location is in MDT.

Appendix 2

15-Day Independence Day Comparison:
Field Values vs ATR Volumes

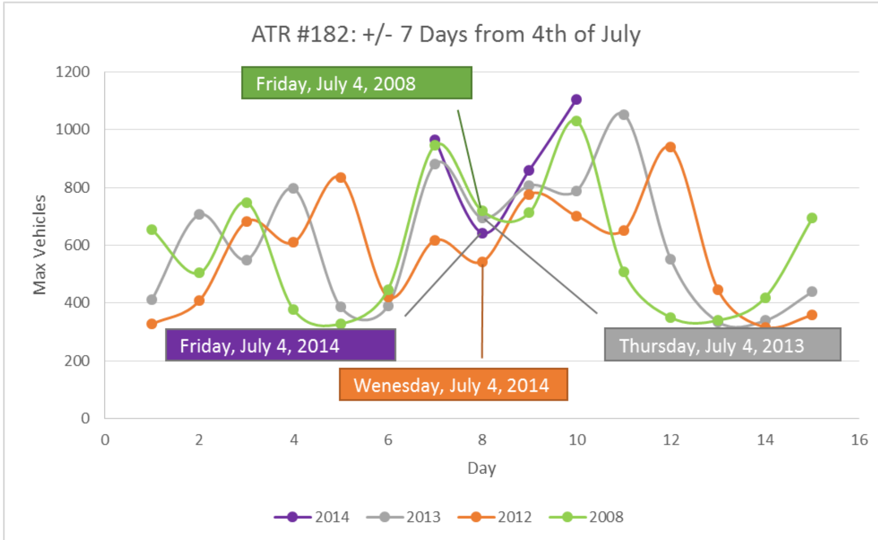

Figure 19: ATR #182's 15 Day Comparison with Field Test, Centered on July 4th

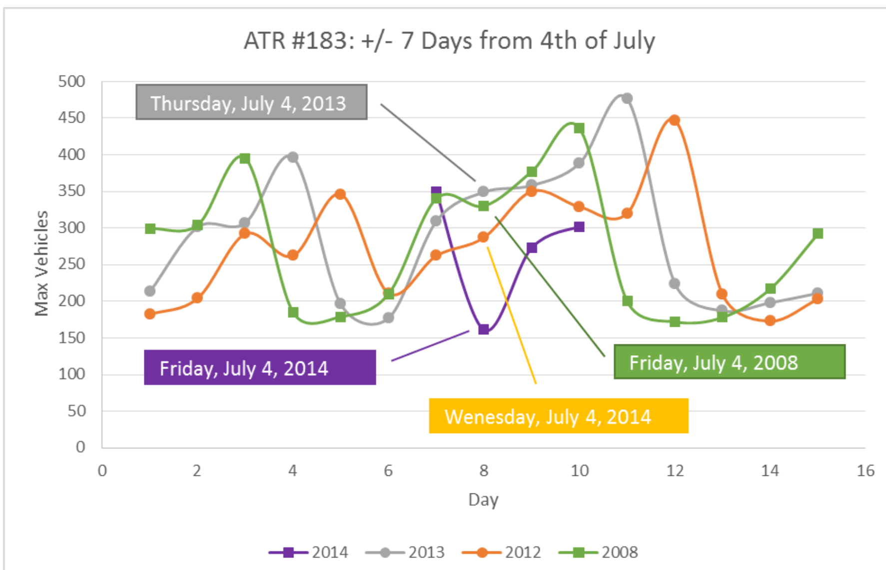

Figure 20: ATR #183's 15 Day Comparison with Field Test, Centered on July 4th

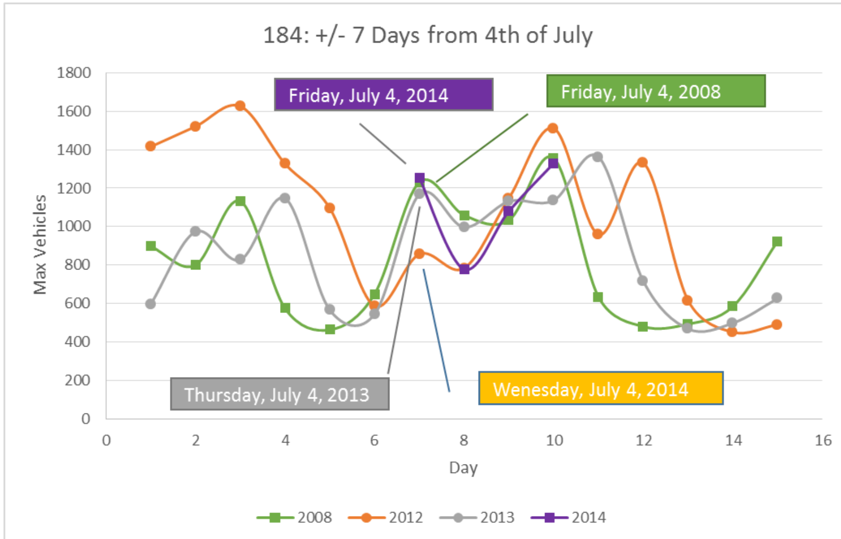

Figure 21: ATR #184's 15 Day Comparison with Field Test, Centered on July 4th