Wisconsin Rapids
Feasibility Study Report

Prepared For:

City of Wisconsin Rapids
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Executive Summary

The City of Wisconsin Rapids, with a population of over 19,000, has historically struggled with some thirteen at-grade rail crossings including those along the Route 13 highway corridor due to slow moving or stopped Wisconsin Central (CN) trains (map below). The excessive grade crossing blockages affecting some 35,000 vehicles per day on average and the associated horn noise has forced the City to initiate a feasibility study to determined potential solutions.

The City has hired the team of Patrick Engineering & LinqThingz to evaluate and Identify the origins of the problem (Task 1-3) and find alternatives and solutions (Tasks 4-6).

After an extensive study, it was determined that to serve the communities' best needs the following elements are recommended:

- Implementing the Predictive Mobility system would prevent a significant portion of congestion and safety problems for the crossings in the city.
- Construction of a Grade separation at Grand Avenue would improve safety and eliminate conflicts at the crossing and provide alternative routes for auto traffic.
- Quite Zone improvement will reduce noise problems through much of the corridor.

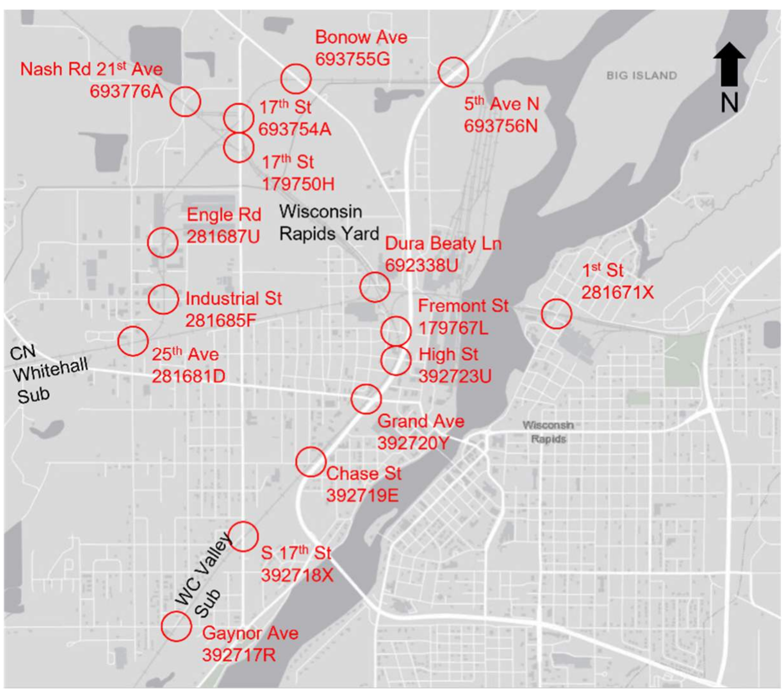

Figure 1: Wisconsin Rapids Site Map

Background

Wisconsin Rapids (City) has experienced delays due to train traffic along the Wisconsin Central (CN), Valley Sub corridor through the City much of it parallel to State Highway 13. The Corridor in consideration stretches from mile post (MP) 47.88 at Gaynor Avenue to the south, to MP 50.81 at 5th Avenue to the north. In this corridor, there are nine (9) at grade crossings, the CN Wisconsin Rapids Yard, General Chemical, and an additional storage siding of two (2) tracks.

Increasing freight rail traffic has plagued communities for decades with increased congestion, delays, noise, and safety consequences. Wisconsin Rapids experiences 1,500-minute backups multiple times a day, frequent complaints about noise and a plethora of rail congestion related issues. There is a history of searching for solutions including a rail relocation initiative back in 2000 (https://www.federalregister.gov/documents/2000/08/30/00-22034/wisconsin-central-ltd-and-fox-valley-and-western-ltd-joint-relocation-project-exemption-wisconsin).

Freight railroads offer benefits to municipal economic development and are a key factor in attracting manufacturing businesses to the area because of the following.

- One intermodal train carries as much freight as 270 trucks. If the goods railroads move were to instead move over highways, those highways would be choked with additional traffic.
- Freight railroads are 3-4 times as fuel-efficient as trucks.
- Moving freight by rail results in a reduction of around 75% in greenhouse gas emissions.
- Railroads account for around 40% of long-distance freight volume by weight, but only 1.9% of transport-related greenhouse gas emissions.

Deliverable Tasks for the Study

1. Investigation
2. Define
3. Alternatives
4. Funding
5. Implementation
6. Recommendation

TASK 1: Investigate, review and inventory at-grade railroad crossings, road characteristics, etc.

Road Traffic in Wisconsin Rapids

The major road traffic through Wisconsin Rapids via Hwy 51/54 is not affected directly by rail traffic because of the grade separation near Forest Hill Cemetery. However, there is a significant amount of east-west traffic from Hwy 54 that crosses the tracks via W Grand Avenue. The rail does have a significant effect on traffic on Hwy 13, 73, and 34 along the north-south rail (Valley subdivision) in town. There is significant rail and road traffic on Bonow (Hwy F) on the north side of town. There are a total of fifteen (15) grade crossings in the City of Wisconsin Rapids. Of this 15, there are thirteen (13) At Grade Crossings with AADT greater than 500 vehicles per day for a daily traffic flow at grade crossing of totaling more than 35,000 AADT.

Rail Traffic In Wisconsin Rapids

The crossing with the biggest impact is at W Grand Avenue with an AADT of 11,900 in the vicinity of the rail crossing. STH 13 is parallel to a set of tracks and the rail crossing at W Grand Av has not only an impact on traffic turning onto W Grand, but also traffic that gets backed up due to the turn lane traffic queues.

The team compared rail traffic from FRA reports, previous Wisconsin Rapids Study and current study using LinqThingz's TrainLinq. The sensors have been installed at W Grand Ave, Gaynor Ave., 17th St and Bonow Rd. A summary of rail traffic from this study is illustrated below. A more complete analysis is found in Appendix B.

	Data Period (days)	Time (minutes)	Average Speed (MPH)	Vehicle Blocked Per Day	Vehicle Delay / Year (hrs)
Grand	14	535	10	327	8516
Gaynor	14	189	12	34	969
Bonow	8	873	7	189	10264
17th	8	285	6	28	942

Figure 2: Summary of Rail Traffic From Sensors placed near crossings.

Here is a summary of rail traffic characteristics in Wisconsin Rapids

- The railroad in Wisconsin Rapids, owned by Wisconsin Central Ltd (CN), serve predominantly regional freight customers and are not on a major freight line.
- The largest amount of road traffic impact is a Grand Avenue.
- The largest amount of rail traffic is at Bonow.
- Crossings are blocked for an average of 8 minutes.
- At times, crossings can be blocked for over 1 hour.
- 740,000+ vehicles are delayed per year at all crossings.
- 99,000+ hours are spent a year waiting at the total of all crossings.
- Crossings at Gaynor and Grand are blocked simultaneously only 0.11% of the time.
- Crossings at Bonow and 17th are blocked simultaneously only 0.48% of the time.
- Most of the time spent with crossings blocked is the result of switching-type operations.
- Over 50% of the delay times caused are the result from the trains stopped on the tracks.
- The most rail-related accidents have occurred at the crossing on 1st St.
- The most rail-related fatalities have occurred at the crossing on Grand.

Approximately 8,000 people are employed in Wisconsin Rapids and the primary source of transportation is by automobile. The average work commute time in the city is 22 minutes. However, trains blocking crossings can increase this by 1 to 60 minutes. The community survey shows that many people in the community have been late for work, school, meetings, and other activities due to blocked crossings. Over 60% have experience delays of more than 20 minutes.

There is a range of wages in the Wisconsin Rapids area, and it is geographically separated. The west side of town below highway 73 is marked by an area where the average wage is $36,000 per year. This is certified Opportunity Zone (see Appendix A).

TASK 2: Define concerns and issues.

There are multiple stakeholders in the city and multiple governing bodies that oversee highway traffic and railroads. The stakeholders include citizens, businesses including the railroads, city leaders, fire/rescue, public safety, DPW, State DOT, State DNR, Federal Agencies including USDOT, FHWA and FRA, and other federal agencies including DHS and EPA.

The Mayor of Wisconsin Rapids has expressed concern with congestion and the times when multiple crossings are blocked simultaneously making it difficult or impossible to overcome long crossing blockages. However, current data shows that 99% of time there is a southerly alternate route in addition to an alternate route between Grand and Gaynor or Grand and Bonow.

The Fire Department is challenged during emergency operations daily. There are two fire stations in Wisconsin Rapids to mitigate some delays of the crossings that bisect the city. Even with the measure in place, rescues are hampered at rail crossings 6 to 12 times a year. Anticipating which crossings is open or closed is a daily struggle. Getting to the scene is one problem for emergency crews. Getting to the hospital is another. There is one hospital on the east side of the tracks and there is potential that getting to the hospital may be delayed by blocked crossings.

The Director of Community Development for the City of Wisconsin Rapids points out that the WEDC regularly queries communities regarding assets like rail access. Rail access is a key driver for some manufacturers and suppliers. Future opportunity for economic growth is available in Rapids East Commerce Center. Companies like Metalco have taken advantage of access to rail and land to grow their business in this area of the city.

There is only one hospital in Wisconsin Rapids, and it is on the east side of the north-south rail. Rail blockages with no obvious alternate paths could mean life or death when associated with heart attack, stroke, or traumatic injury patients. The cost of care associated with emergency transport doubles approximately every 4 minutes (as noted above blockages in this city can extend past 20 minutes).

The citizens of Wisconsin Rapids have great concerns about congestion, safety, noise, and some minor concerns regarding other issues (see Appendix F community survey results).

Issue 1: Congestion

The public survey (see Appendix F) identified congestion as the number one concern with over 95% of respondents. We reviewed data for 13 crossings in Wisconsin Rapids and have provided a preliminary cost impact on the community due to congestion. The data includes FRA information about rail traffic and accident reports, data from previous Wisconsin Rapids studies, current data from sensor systems used in this study and external references.

The current study contains the most detailed and comprehensive data regarding rail traffic at grade crossings. The detailed data at Grand, Gaynor, Bonow and 17th are contained in Appendix B. A comprehensive analysis at all 13 crossings is contained in Appendix F. This analysis considers impacts due to delays and blocked crossings. The complete list of assumptions is provided. The metrics for analysis include Carbon Cost (pollution), excess fuel usage, citizen productivity and logistics productivity. A separate safety analysis is in the following section.

Congestion Impact at Grade Crossings	
AADT(vehicles)	33,960.00
Carbon Cost ($)	$22,031.58
Fuel ($/yr)	$198,326.40
Citizen Costs ($/yr)	$1,804,770.24
Supply Chain Costs ($/yr)	$3,476,909.70
Total	$5,502,037.92

Figure 3: Congestion impact with cost estimates for 13 busiest crossings in Wisconsin Rapids

With the data provided by the City, observations made in the field, and data collected, there are two (2) determining factors that result in the congestion: The measured speeds of "Through Trains" and "Switching Movements".

The first issue observed is the speed of through trains through the corridor. While on site, a coal train was observed moving through town at a very slow speed. This train caused a delay at Grand Ave for more than 13 minutes. During this time, traffic began to back up in the northbound (NB) left turn lane of STH 13, blocking one of the NB through lanes. This study only collected delay statistics at Grand, Gaynor, Bonow and 17th. The typical mile-long freight trains are likely to block Grand, Chase, and High street simultaneously due to their proximity. However, the distances between Grand/Gaynor (1.4 miles), Grand/Bonow (1.9 mi), an Bonow/Gaynor (3.3 miles) are large enough to give over 99% probability of at least one alternate path.

According to the data collected between October 24th to November 5th (see below), there were forty-seven (47) through trains crossing Grand Ave with an average speed of 4.40 mph. These trains caused a total of 254 minutes of delay. Of the forty-seven (47) trains, 70% of the through train delays was caused by fifteen (15) of the trains for an average of 11.88 minutes. Currently there is a slow order in place between the CN Wisconsin Rapids Limits of MP 43-51 due to switching movements and tight curves in those limits. CN does believe this slow order could be lifted in the future.

The second issue observed is the switching movements being done by CN in the area. The switching movements are being done at the CN Wisconsin Rapids Yard, the siding between Chase Ave and 17th St, and servicing General Chemical. At Grand Ave, thirty-four (34) switching movements were recorded for a total delay of 69.27 minutes. However, there were three (3) instances that accounted for 42.88 minutes.

	GRAND AVENUE 10/24 – 11/5					
	Count	Total Delays	Average Delays	Average Speed	Count Percent	Delay Percent
NB LONG DELAYS	8	110.68	13.84	2.46	10%	34%
SB LONG DELAYS	7	67.57	9.65	3.60	9%	21%
NB SHORT DELAYS	15	26.68	1.78	4.78	19%	8%
SB SHORT DELAYS	16	49.98	3.12	4.04	20%	15%
SWITCHING LONG DELAYS	3	42.88	14.29	2.85	4%	13%
SWITCHING SHORT DELAYS	31	26.38	0.85	4.80	39%	8%
TOTAL	80	324.18	4.05	3.75	100%	100%

Issue 2: Safety

Safety was the second most important aspect of grade crossings based on the responses from the community survey (Appendix D). The safety concerns are broken into two categories. Impacts on emergency response due to blocked crossings and accidents at grade crossings.

The impacts on emergency vehicles are difficult to measure, however. These vehicles experience the same type and length of delays as do citizens and logistic companies. There are two fire houses constructed, one on each side the valley subdivision, to mitigate issues regarding blocked crossings. However, even with two fire houses, emergency vehicles are blocked at crossings 6 to 12 times a year. The community survey provides several accounts of this. Typical response times are targeted at 4 minutes. A crossing blocking an emergency crew from a traumatic injury victim or a burning building could mean life or death. There are examples of this at https://www.LinqThingz.com/Milwaukee. In addition, there is one hospital in Wisconsin Rapids, and it is on the east side of the tracks.

The other aspect of safety is accidents. Over the past ten years there have been 33 accidents at rail crossing resulting in property damage, injuries and/or death. A more complete analysis is in Appendix X. The return on investment is based on comprehensive causality numbers and statistics created by the insurance industry.

	Events	Cost	Sub Total
Crashes	33	N/A	
No Injuries	28	52700	$1,475,600.00
Injuries	22	345000	$7,590,000.00
Deaths	1	11449000	$11,449,000.00
Total			$20,514,600.00
Average per Year			$2,051,460.00

Figure 4: Safety impact with cost estimates for 13 busiest crossings in Wisconsin Rapids

Issue 3: Noise

Noise was the third issue that is met with concern according to the community survey in Appendix F. Under the Train Horn Rule (49 CFR Part 222), locomotive engineers must begin to sound train horns at least 15 seconds, and no more than 20 seconds, in advance of all public grade crossings. The sound level is between 96 and 110 decibels. The area around the crossings includes residential, commercial, and industrial areas. These horns can be heard for many miles and are a substantial nuisance for residents living near the tracks. There is a second corridor in the Wisconsin Rapids area that serves the industries along 17th Street and 25th Street northwest of the Grand Ave crossing. Rail traffic runs at all times of the day.

Issue 4: Pollution

Idling extra time at crossings produces pollution that adds to the carbon footprint. It is of least concern to citizens but there are several fundings and grants available to reduce carbon footprints.

Public Poll Summary:

Ten questions were asked in an online survey regarding grade crossings with a response from over 1000 citizens.

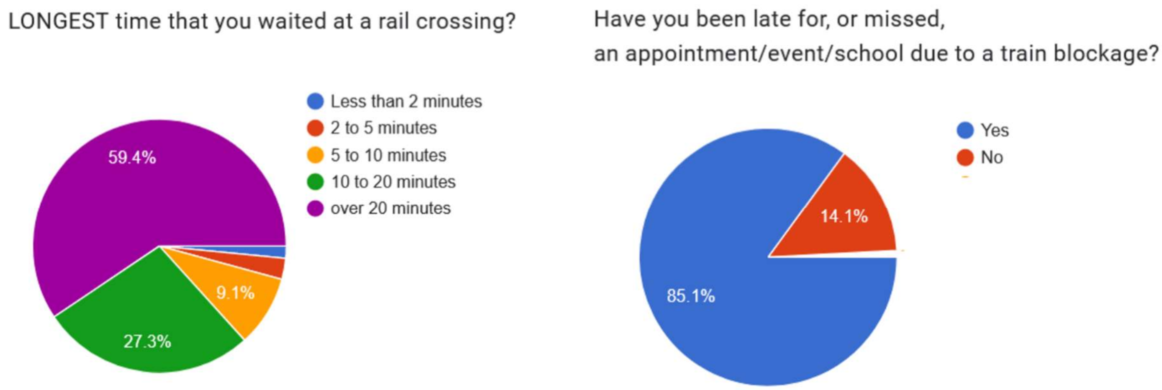

Figure 5: Two of the ten questions from public survey in Appendix F.

TASK 3: Identify and compare alternatives to address those concerns.

There are multiple ways to improve the issues outlined in Task 2: (1) Increasing the speed of the through trains; (2) route optimization and ITS solutions; (3) intersection modification; (4) track relocation; (5) grade separation; and (6) Quiet Zone.

Alternate 1: Increasing Speed of through trains

The CN timetable shows that the maximum speed for trains on the Valley Sub is forty (40) mph. However, there is a slow order in place through the yard limits (MP 43-51) of 5 mph. This slow order affects every crossing in the corridor. Sensors used in this study shows the average speed (at open/closing) at Grand and Gaynor as 10 mph and 12 mph respectively. Increasing the train speed through the corridor will only have an impactful effect on the through trains. Most of the switching movements over the crossings would not be affected by this change.

One possible solution would be to work with CN and see if there are ways to change operations to improve issues that limit speed through the yard limits and to modify switching movements to avoid the extended blocking of crossings. This alternative would require CN Coordination.

Pros	Cons
Cuts all delays by through trains significantly	Unknown Causes
Potentially limited amount of work required	May not affect switching movement delays

Alternate 2: Route Optimization and ITS solutions

The alternative routing analysis in Appendix C shows that the crossings at Grand and Gaynor are simultaneously blocked only 0.11% of the time. This means that there is an alternate route with 99% probability for success. Similarly, alternate routing at Bonow and 17th show that these intersections are simultaneously blocked 0.48% of the time. Predictive Mobility works by giving advanced warning, typically 2 to 7 minutes, so that road traffic does not intersect with rail traffic. For example an ambulance moving from the west on Grand/25th St could take either 17th St /Hwy 34 (4 minutes) or continue on Grand to Hwy 13 (4 minutes) to reach the hospital on the east side of the river. If notified, in advance of reaching 17th and Grand, the ambulance would add no extra time to the trip, while avoiding a potential 20 minute wait at Grand. The fastest time to get from the west end of the city and across the tracks is about 4 minutes. Based on the overlap between blocked crossings (Appendix C) there is an alternate route taking no more 7 minutes from anywhere on the west side 99% of the time. This is a maximum 3 minute penalty to avoid and average blockage penalty of 8 minutes or up to over 20 minutes.

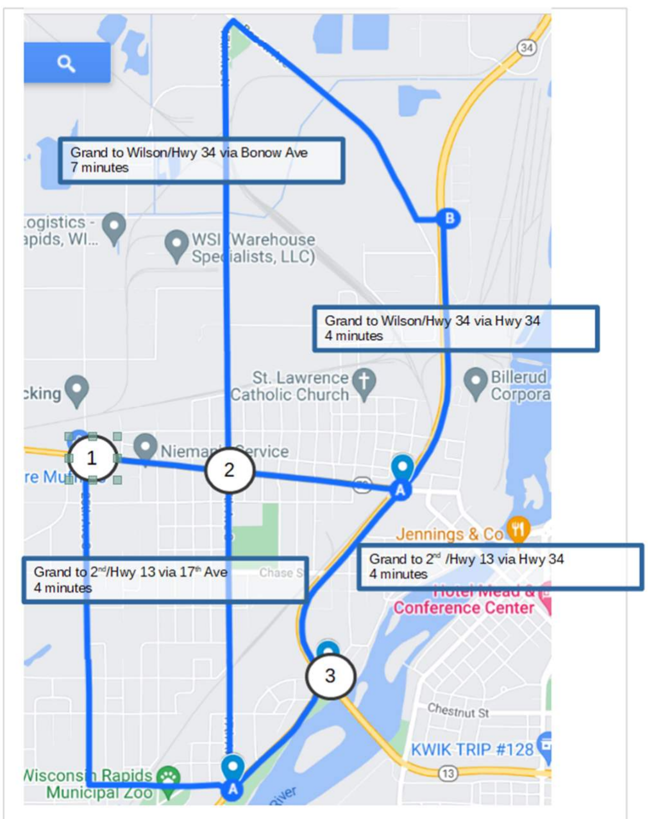

Figure 6: Example Alternate Route: Consider ambulance traveling from (1) to (3). Alternate routes from (2) to (3) take same amount of time but can avoid 20+ minute wait with advance warning given at (1) when one of the crossings is blocked.

Predictive Mobility works by placing an array of sensors within vicinity of rail but outside rail right of way. Sensors contain RADAR, LIDAR, IR, Camera, Magnetometer, Audio, Radio all within a single enclosure for fast Machine Learning processing to identify location, speed, direction, and length of trains. This information is communicated from multiple sensors to LinqThingz cloud where it is stored, and another Machine Learning engine processes the data to predict when crossings are and will be closed/open. This information is communicated to users via mobile application, web applications, fixed message signage with notifications, variable message signs and cloud applications. It is expected that the information from these sensors can be available to major navigation and connected vehicle companies by 2025.

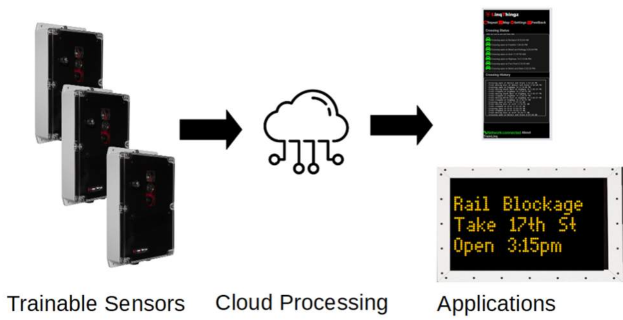

Figure 7: Predictive Mobility uses sensor data and machine learning to provide advanced warning of blocked crossing to digital applications and dynamic road-side signs.

Pros	Cons
Rerouting can eliminate congestion for over 95% of crossing incidents for all 13 crossings in Wisconsin Rapids	Very long or multiple trains in a queue may block all crossings
It can be implemented with only approval from the City to install Sensors on City Property	Increases Auto traffic on roads where high volumes are not regular
It can be implemented in a matter of months	
It is much lower cost than many construction solutions	
It provides a pathway to support future transportation such as computer aided dispatch, transportation management, navigation, and connected/autonomous vehicle platforms	

Alternate 3: Intersection Modification

When the crossing at Grand Ave is being blocked for an extended period due to a train, the NB traffic on STH 13 begins to back up due to the left turn lane queuing up. Currently, the left turn lane extends approximately 170’ from the stop bar before the taper into the NB traffic lane. Extending the left turn lane to increase the capacity would allow for NB traffic to flow even when the crossing is being blocked. Without affecting the mall entrance, the left turn lane can be extended around 200’. The existing east curb could be relocated east to align with the curb line at the Grand Avenue intersection widening the south approach. This should have no effect on the sidewalk, but would result in storm sewer, light poles, and other utility modifications. The existing medians would need to be modified to channelize traffic and extend the left turn lane south. The left turn lane of the SB traffic would not be affected, and no modification to Grand Avenue. A full traffic study would need to be done to determine how much the left turn lane would need to be extended.

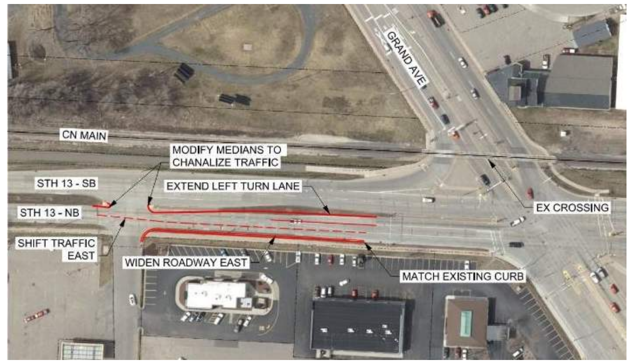

Figure 8: Potential intersection Modifications

Pros	Cons
Minimum impact on surrounding area	Doesn't change delays at the crossings
Constructable with active traffic	

Alternate 4: Track Relocation

In this option, all through train traffic would be rerouted on a Wisconsin Rapids Bypass. The goal of this option would be reducing the number of trains moving through the city and to speed up trains that are not stopping in the CN Wisconsin Rapids Yard, since the yard will be avoided. The existing track would remain after the bypass construction allowing CN to maintain access to the siding and General Chemical.

Option 1: Relocation along City West Edge

South of Seneca Rd the track curves along the river. In the relocation option, a power turnout would be installed south of this curve. From there, the proposed alignment would run north along the west edge of the city. On the north end, the new alignment reverse curves and ties into another proposed turnout west of the Grand Avenue bridge. For this alignment, three new grade crossings would need to be installed at Seneca Road, Gaynor Avenue, and George Road. The crossings should be constructed in a way that would allow for a quiet zone to be established once the corridor is constructed. Additionally, there would need to be four (4) small bridges or large culverts installed where the track would go over existing creeks. The alignment would match the 40-mph maximum speed the current timetable allows. Additional track improvements may also be needed through the industrial area between 17th and 25th Avenue east of where the alignment would tie in to accommodate the increase in train traffic and to maintain the train speeds.

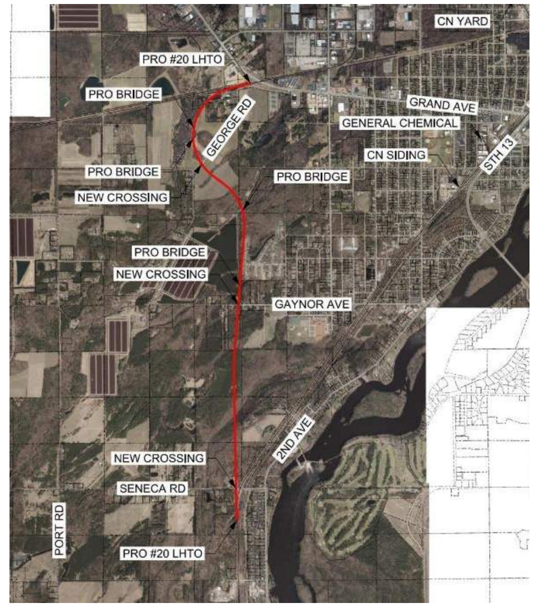

Figure 9: Potential track relocation

Pros	Cons
Relocates train traffic away from populated area	Property Acquisition
Through Trains avoid CN Wisconsin Rapids Yard	3 New crossings created
Build to allow a Quiet Zone	3 Bridges over creeks and rivers
Provide location for proposed industry expansion	Increase Train Traffic in Industrial area between 17th and 25th St
	Potential Wetland Impacts
	Maintains Switching Movements at Hwy 13 Corridor to serve industry and out of CN Wisconsin Rapids Yard

Option 2: Relocation along County lands

This option would relocate the train traffic west of the city on county lands. West of the Kimball Avenue crossing a power turnout would be installed. The proposed corridor would run northeast from this location. On the north end, another turnout would be installed west of the Ridge Road crossing. For this alignment, three (3) new crossings would need to be constructed at WI-54, Seneca Road, and Marsh Road. Additional private crossings may be needed based on the alignment and private lands the new track would bisect. The crossings should be constructed in a way that would allow for a quiet zone to be established once the corridor is constructed. Additionally, four (4) small bridges or large culverts would need to be installed where the track would go over existing creeks. The alignment would match the 40-mph max speed the current timetable allows. Additional track improvements may also be needed through the industrial area between 17th and 25th Avenue east of where the alignment would tie in to accommodate the increase in train traffic and to maintain the train speeds.

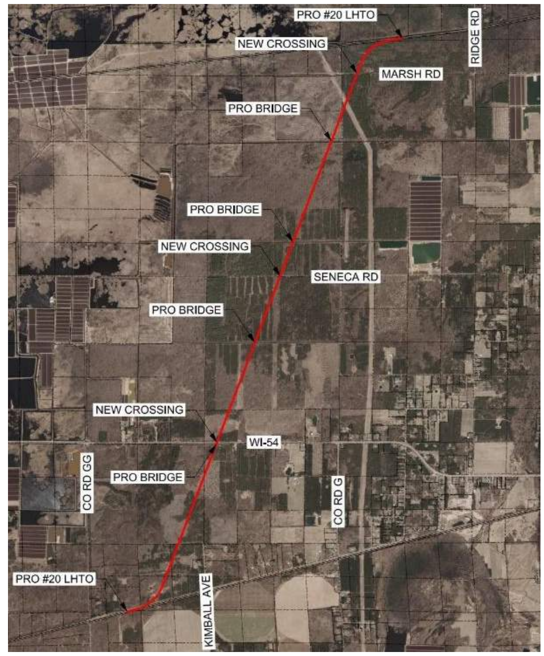

Figure 10: Potential track relocation

Pros	Cons
Relocates train traffic away from populated area	Property Acquisition
Through Trains avoid CN Wisconsin Rapids Yard	3 New crossings created
Build to allow a Quiet Zone	4 Bridges over creeks and rivers
Provide location for proposed industry expansion	Increase Train Traffic in Industrial area between 17th and 25th St
	Potential Wetland Impacts
	Maintains Switching Movements at Hwy 13 Corridor to serve industry and out of CN Wisconsin Rapids Yard

Alternate 5: Grade Separation

To alleviate all delays and safety concerns at Grand Ave, the only option would be to construct a grade separation. This would also provide an alternative route for traffic being blocked by trains at adjacent crossings. The traffic flow at Grand Av is 11900 AADT of the 35000 AADT city wide. A grade crossing at Grand Av. would likely solve more than 30% of the existing crossing-related traffic flow problems for the west side of Wisconsin Rapids given existing flow patterns. These patterns would likely shift during and after construction.

Option 1: New Overpass

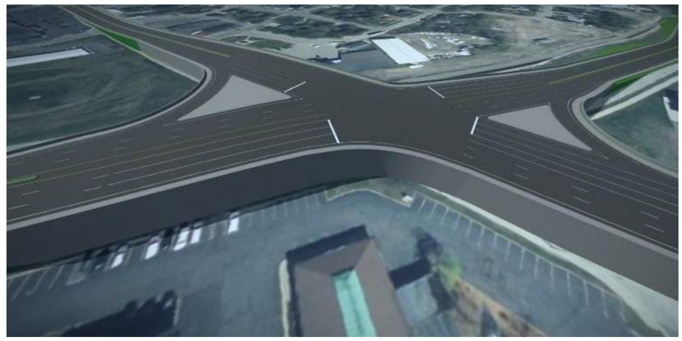

Figure 11: New grade separation overpass

This option would be to elevate Grand Ave over the tracks. The vertical clearance required by CN at a bridge is 23’-0” in the state of Wisconsin. A large amount of fill material would be imported for the project and retaining walls would be built to support the elevated road. The Grand Ave raise would stretch from the 6th Avenue / Jackson Street intersection to the east to the 10th Avenue intersection to the West. To accommodate the raise in the road, the parking lot entrance east of the STH 13 Intersection would need to be closed. The intersection at 9th Avenue west of the crossing would be cul-de-saced due to the raise in the road and to maintain access to the Family Natural Foods. Along STH 13, the road raise would stretch from the beginning of the NB left turn lane of the High St crossing to the north, to north of the Hale Street intersection to the south. The parking lot entrance south of Subway would need to be closed to accommodate the raise in the road. The entire intersection of Grand Ave and STH 13 would be raised to maintain current traffic patterns and volumes. A traffic study should be done to optimize the new intersection geometry as part of the planning/design process. The surrounding sidewalks would need to be raised with the road to maintain pedestrian access throughout the corridor. On the west side of the tracks, there is a line of overhead wires that would need to be relocated or modified to allow for the elevated road. The track alignment would not require any adjustment during or after construction. There would need to be a study of buried electrical, data, gas, and other underground assets.

Pros	Cons
Eliminates all Delays at Grand Ave	Large Earthwork Fill
Improves safety	Overhead Electric relocation on West Approach
Provides alternate route for adjacent crossings when blocked	Mall entrance closing
No track modification	Eliminate intersection with 9th Ave
Qualifies corridor for a Quiet Zone	Would require a Roadway Shoofly
	Aesthetics for local Business

Option 2: New Underpass

Figure 12: New grade separation underpass

This option would be to lower Grand Ave under the tracks. The vertical clearance required by WisDOT at a bridge is 14'-9" minimum. To lower the roads, there would need to be a large amount of excavation completed and hauled off site. Retaining walls would need to be installed along the limits of excavation. The Grand Ave excavation would stretch from west of the 6th Avenue / Jackson Street intersection to the east and west of the 9th Avenue intersection to the west. To accommodate lowering Grand Ave, the parking lot entrance east of the STH 13 Intersection would need to be closed. The Intersection at 9th Avenue and the 9th Avenue approach can be modified to maintain the road access. Along STH 13, the excavation would stretch from the parking lot entrance south of the Grand Ave intersection to the south, to south of the NB left turn lane at the High St intersection to the north. Small modifications may be required at the parking lot entrance along STH 13 to accommodate the excavation. When excavating the road, all underground utilizes will need to be relocated. A track shoofly would need to be constructed to maintain train traffic during the construction process.

Pros	Cons
Eliminates all Delays at Grand Ave	Large Earthwork Cut
Improves Safety	Underground storm sewer, water mains, electric and other utility relocation, and modification
Provides alternate route for adjacent crossings when blocked	Retaining Walls
Qualifies corridor for a Quiet Zone	Mall entrance closing
Aesthetics for local business	Road and Track Shoofly
Raising track can help optimize excavation costs	Underpass creates drainage low spot

Alternate 6 Quiet Zone

There are two corridors in Wisconsin Rapids that can be considered for a Quiet Zone. The first corridor is along the Wisconsin Central, Valley Sub. The second corridor is along the Wisconsin Central, Whitehall Sub.

Quiet Zone 1 – Valley Sub

The Quiet Zone would consist of nine (9) crossings along the WC Valley Subdivision beginning at Gaynor Avenue running North to 5th Avenue North.

QZ: Valley Sub			
US DOT Crossing ID Number	**Railroad**	**Street or Highway Name**	**MP**
392717R	WC	Gaynor Avenue	47.88
392718X	WC	S 17th Street	48.30
392719E	WC	Chase Street	48.83
392720Y	WC	Grand Avenue	49.23
392723U	WC	High Street	49.45
179767L	WC	Fremont Street	49.58
692338U	WC	Dura Beauty Lane	49.81
693755G	WC	Bonow Ave	50.51
693756N	WC	5th Avenue North	50.81

Before a quiet zone could be considered, all public crossings in the limits are required to have gates installed. This would mean Gaynor Ave, S 17th St, and Fremont St would need to have gates installed at the crossings.

To qualify for a quiet zone, the Quiet Zone Risk Index (QZRI) would need to be below the Nationwide Significant Rist Threshold (NSRT) of 15,488.00. Based on the FRA Quiet Zone Calculator, the current configuration of the crossings has a QZRI of 16,842.87, which does not qualify for a quiet zone. To lower the QZRI, there are multiple improvement options the City could implement. The only crossing with any safety measures currently is Grand Ave. The existing medians do not qualify for a full Supplementary Safety Measure (SSM) due to the proximity with STH 13. The medians for this study would be considered as an Alternative Safety Measure (ASM).

Option 1: Grade Separating Grand Ave

This option would be to implement Alternate 4 described above. Installing a Grade Separation will reduce the QZRI for the whole corridor to 13,282.82. This is lower than the NSRT which would qualify the exiting corridor for a Quiet Zone.

Option 2: Improvement at Bonow Ave

In this option, 100 ft of a Kwik Curb or equivalent raised median that would qualify as a SSM would be installed on both approaches of the crossing. This improvement would reduce the QZRI to 15,123.44, qualifying the corridor for a Quiet Zone.

Option 3: Installing Improvements at Gaynor and S 17th St.

In this option, while the gates are also being installed, Kwik Curb or equivalent raised medians would be installed at Gaynor Street and s 17th Street. Due to intersecting streets near each crossing, Carey St at 17th St and 21st Ave at Gaynor St, a full SSM would not be possible. However, installing the Kwik Curb or an equivalent raised median to the limits of the intersections should qualify as an ASM. Installing both improvements would reduce the QZRI to 14,894.24, qualifying the corridor for a Quiet Zone.

Quiet Zone 2 – Whitehall Sub

The Quiet Zone will consist of six (6) crossings along the WC Whitehall Subdivision beginning at Nash Road/21St St running south to 25th Avenue.

QZ: Whitehall Sub			
US DOT Crossing ID Number	**Railroad**	**Street or Highway Name**	**MP**
693776A	WC	Nash Road 21st Avenue	50.00
693754A	WC	17th Street North	50.80
179750H	WC	17th Street North	96.15
281687U	WC	Engel Road	96.54
281685F	WC	Industrial Street	97.05
281681D	WC	25th Avenue	97.34

To create this quiet zone, gates would need to be installed at all the included crossings. To qualify for a quiet zone, the Quiet Zone Risk Index (QZRI) needs to be below the Nationwide Significant Risk Threshold (NSRT) of 15,488.00. Based on the FRA Quiet Zone Calculator, the current configuration of the crossings has a QZRI of 7,896.60, which is lower than the NSRT of 15,488.00. This means the corridor will qualify for a quiet zone once all the gates have been installed.

Alternate 7 Relocating Business to East Commerce Center

There is a push to fully utilize Wisconsin Rapids East Commerce Center and its rail hub. There are multiple economic development grants, and loans that would benefit a company that is currently on the west end and connected to the valley subdivision; to move to the East Commerce Center. One example company would be General Chemical. If the move expanded operations and employment then economic development money could be used on the new facility, Rail elimination grants could be used to remove the rail spur. The facility, which is located in a certified opportunity zone could be replaced with housing or other businesses that qualify.

TASK 4: Identify costs, grant funding

The alternatives analyzed in TASK 3 can have vastly different costs and sources for funding. Quiet zone, Grade Separations, and Rail Relocation solutions impact initial and ongoing costs to both the city, state, federal government, and the railroad and are typically funded through a variety of grants, local funds, and railroad budgets. Alternate routing, depending on jurisdiction, impact initial and ongoing costs to both the city, state and federal government but have small requirement or impact on rail companies. Alternate routing solutions are typically funded through a variety of federal, state grants and local municipal budgets. Technology solutions have cost impacts directly to the municipality and require little responsibility from state, federal, and railroad sources. These technology solutions, however, can be funded by a variety of local, state, federal grants. The study will include grant opportunities including but not limited to:

- CMAQ - Congestion Mitigation and Air Quality Improvement Program
- ARPA America Rescue Plan Act
- Bipartisan Infrastructure Investment
- Section 130 Federal Highway Administration's (FHWA) Highway Safety Improvement Program (HSIP)
- CRISI Grant
- Carbon Reduction-related grants
- Grants related to underserved communities for Variable Message Signage
- Wisconsin General Transportation Fund grants
- Alternative/Sustainable funding sources

These grants include traditional transportation grants as per alternative 1,2,3 and 5. The technology solutions also can be funded by communication grants (for the communication infrastructure), and inclusiveness grants (for variable message signage for community members without mobile devices). In addition, this information can be sold to citizens, logistics companies, emergency services, mapping companies, etc. and secure commercial sponsorship. Thus, the technology solution can be sustainable with only minor long-term costs to the community, state, federal and rail stakeholders. We will analyze costs and sources of support and funding for the various solution alternatives.

Below is a table of the cost estimate in 2022 dollars, for each of the alternates listed above and characteristics that would fall under federal, state, and third-party funding.

ALTERNATE	DESCRIPTION	ESTIMATED UNIT COST	FUNDING OPTIONS
ALTERNATE 1	Increasing Speed of Through Trains	N/A	CN operation improvement, Signal Improvements, Carbon Reduction
ALTERNATE 2-1	Minimum Proof of Concept at a Single crossing	$52,000	Crossing Improvement, Technology Innovation, Carbon Reduction, Underserved communities, Commercial Sponsorship
ALTERNATE 2-2	Minimum Digital-Only City-wide solution	$217,200	Crossing Improvement, Technology Innovation, Carbon Reduction, Underserved communities, Commercial Sponsorship
ALTERNATE 2-3	Value-Based City-wide solution with Active Signage	$375,000	Crossing Improvement, Technology Innovation, Carbon Reduction, Underserved communities, Commercial Sponsorship
ALTERNATE 3	Intersection Modification	$1,000,000	Carbon Reduction
ALTERNATE 4-1	Track Relocation - City West Edge	$27,800,000	CN Operation Improvement, Safety Improvements, Carbon Reduction
ALTERNATE 4-2	Track Relocation - County Lands	$34,500,000	CN Operation Improvement, Safety Improvements, Carbon Reduction
ALTERNATE 5-1	Grade Separation - Railroad Under	$32,600,000	Safety Improvements, Grade Separation, Carbon Reduction, CN Operation Improvement
ALTERNATE 5-2	Grade Separation - Railroad Over	$33,600,000	Safety Improvements, Grade Separation, Carbon Reduction, CN Operation Improvement
ALTERNATE 6-1	QZ Option 1 - Grade Separation Grand Ave	$37,800,000	Quiet Zone, Safety Improvements, Grade Separation, Signal Improvements
ALTERNATE 6-2	QZ Option 2 - Improvement at Bonow Ave	$2,900,000	Quiet Zone, Safety Improvements, Signal Improvements
ALTERNATE 6-3	QZ Option 3 - Improvements at Gaynor and s 17th St	$2,900,000	Quiet Zone, Safety Improvements, Signal Improvements
ALTERNATE 6-4	Whitehall Sub Quiet Zone	$5,400,000	Quiet Zone, Safety Improvements, Signal Improvements
ALTERNATE 7	Relocated Rail Intensive Businesses to East Commerce Center	$?	WEDC grants and loans, SBA grants and Loans, Other miscellaneous Economic development incentives. Rail operation support.

See Appendix G for detailed estimates.

TASK 5: Implementation of alternatives.

The implementation process for each alternative is different.

The City would need to work with CN to determine the improvements required to increase the train speed through the city and discuss operations to prevent CN switching movements from blocking multiple crossings at the same time preventing easy alternative routes for traffic.

ITS, Predictive Mobility and alternate routing can be taken in steps and starts with a pilot project with sensors at all target crossings. There is an installation process with fixed or variable message signage and a roll out process for digital solutions that include mobile applications and cloud application integration. Community communication is an important part of this process.

The intersection modification at Grand Avenue along STH 13 project would involve the City performing an engineering study. There would need to be a traffic study performed to determine the improvements required to alleviate the traffic backups caused by the train blocking the crossing. The traffic study, engineering design, and construction process could be completed in two (2) years. During the construction process, the road would need to remain open to allow for traffic to continue.

The track relocation process would require CN coordination, public outreach, and engineering to determine the new track alignment. The City would need to work with the county and the project would require property acquisition. The engineering, property acquisition, and construction process would take multiple years before the new track could be operational.

The grade separation project would require engineering for the road alignment and the structures. A shoofly for the track and road would need to be designed to maintain train and roadway traffic operations during the construction process.

To implement a Quiet Zone, the city would need to complete a study to determine the improvements required to have the corridor qualify for a Quiet Zone. There would need to be a diagnostic site meeting with the involved parties, after which a Notice of Intent (NOI) package would be sent to the FRA. After 60 days and the safety improvements have been completed, a Notice of Establishment (NOE) from the City will need to be submitted to the FRA for final approval.

TASK 6: Recommendation

There are multiple solutions to the issues Wisconsin Rapids is experiencing. To substantially improve the City's traffic flow, Wisconsin Rapids should pursue a combination of the listed solutions. The solutions that we would recommend pursuing would be to work with CN to determine any operational changes including train speeds and switching movements, constructing a grade separation at Grand Ave, and implementation of Predictive Mobility. Working with CN to modify the current operations could help speed up trains through the corridor limiting the delay of each through train and modify switching movements to prevent multiple crossings being blocked for an extended period. The only way to eliminate all train delays at a single crossing would be to construct a grade separation. There are fifteen (15) at grade crossings in the city, a grade separation should be constructed at the crossing with the biggest impact. While Bonow seems to have the highest blockage time, Grand Avenue has the greatest impact based on the large AADT, centered in the city, proximity to other crossings, and impacts to traffic on STH 13. A grade separation at Grand Avenue will also help in the implementation of a Quiet Zone in the corridor. For all the other crossings in the City, message boards can be installed informing drivers of crossings being blocked to help guide drivers across the tracks avoiding trains in the area.

The teams' following recommendations have been generated based on the comprehensive analysis of the City's characteristics, rail traffic and road traffic.

These recommendations are as follows:

- Pursue steps to construct grade separation (underpass/overpass) at Grand Avenue that will start with a more detailed traffic and construction study.
    - NEXT STEP: Begin the process of detail traffic and construction analysis which Patrick Engineering can assist with.
- Pursue implementation of Predictive Mobility system that can help solve the problem at all 15 crossing in a matter of months while the longer-term, multi-year, multi-step grade separation projects is in motion.
    - NEXT STEP: Deploy pilot Predictive Mobility System.
- Pursue the implementation of a Quiet Zone in the city.
    - NEXT STEP: Begin the process of crossing analysis and determine improvements required for a Quiet Zone, which Patrick Engineering can assist with.

Appendix A

Wisconsin Rapids Characteristics

AADT from Wisconsin Department of Transportation

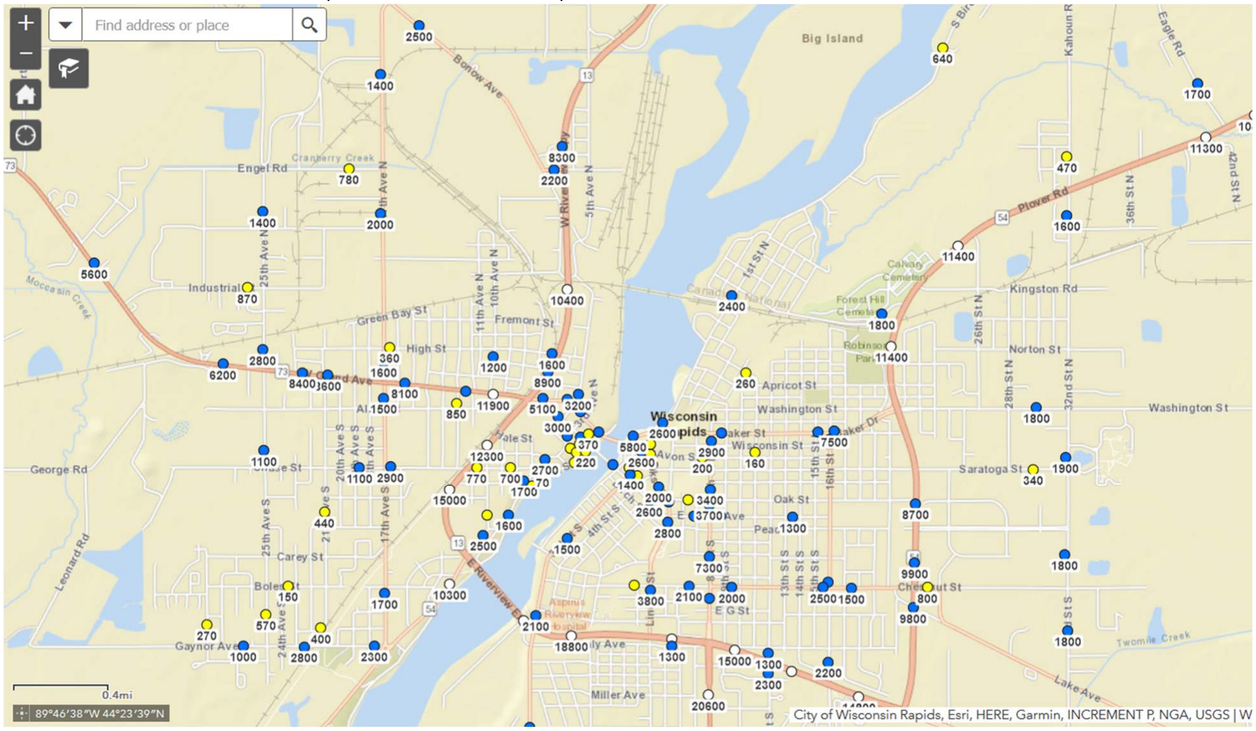

Figure A-1: AADT map of Wisconsin Rapids

Wisconsin Rapids GIS showing properties, floodplain, and hunting grounds.

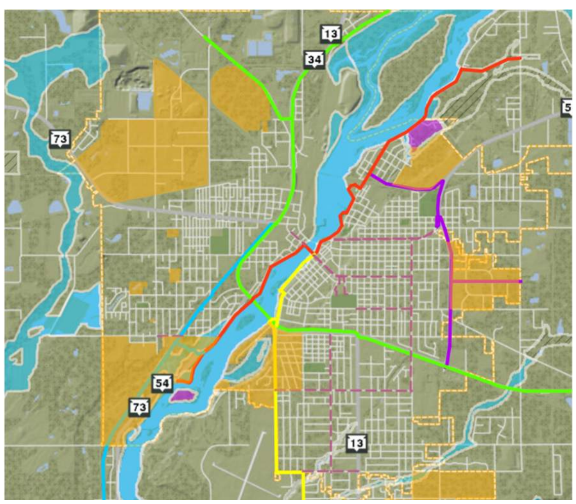

Figure A-2: Flood plains, hunting grounds and parks

Wisconsin Department of Natural Resources Wetland Inventory

The Wisconsin Wetland Inventory was established in 1978 to help protect wetlands. The DNR completed the initial inventory in 1984 after being directed to map the state's wetlands. There are special permits and limits on activities and construction around wetlands.

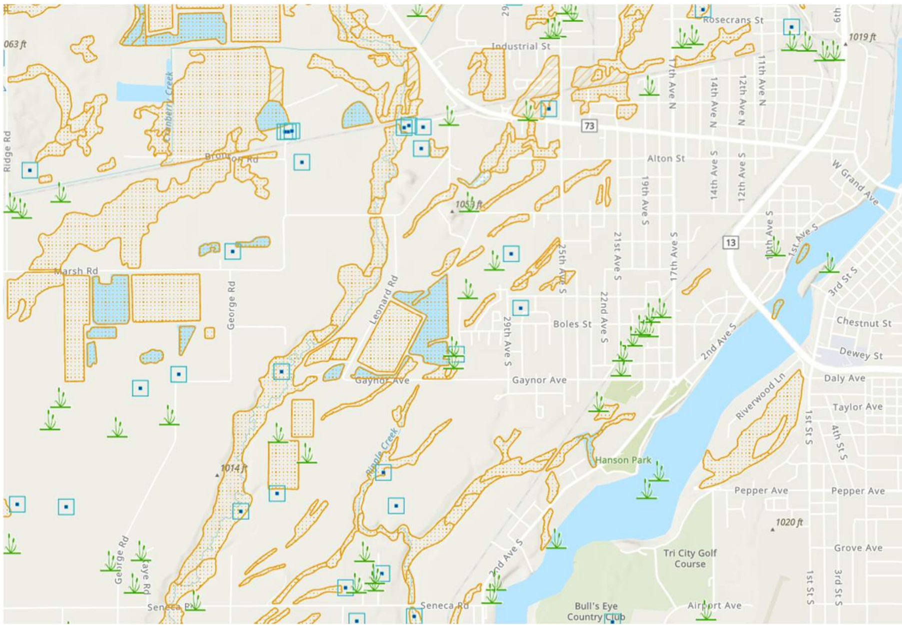

Figure A-3: Location of protected wetlands in Wisconsin Rapids

Demographics and Opportunity Zones

The economy of Wisconsin Rapids, WI employs about 8,000 people. The largest industries in Wisconsin Rapids, WI are Health Care & Social Assistance (1,580 people), Manufacturing (1,455 people), and Retail Trade (1,011 people), and the highest paying industries are Utilities ($69,688), Public Administration ($45,466), and Construction ($45,391). The median household income for this Opportunity Zone is approximately $36,000. The city of Wisconsin Rapids, Wisconsin has 1 designated Opportunity Zone. In total these Opportunity Zones have a population of approximately 3,700. That represents 21% of the city's total population of 18,000. 14.7% of the population for whom poverty status is determined in Wisconsin Rapids, WI (2.53k out of 17.2k people) live below the poverty line, a number that is higher than the national average of 12.8%. The largest demographic living in poverty are Females 25 - 34, followed by Females 18 - 24 and then Females 75+.

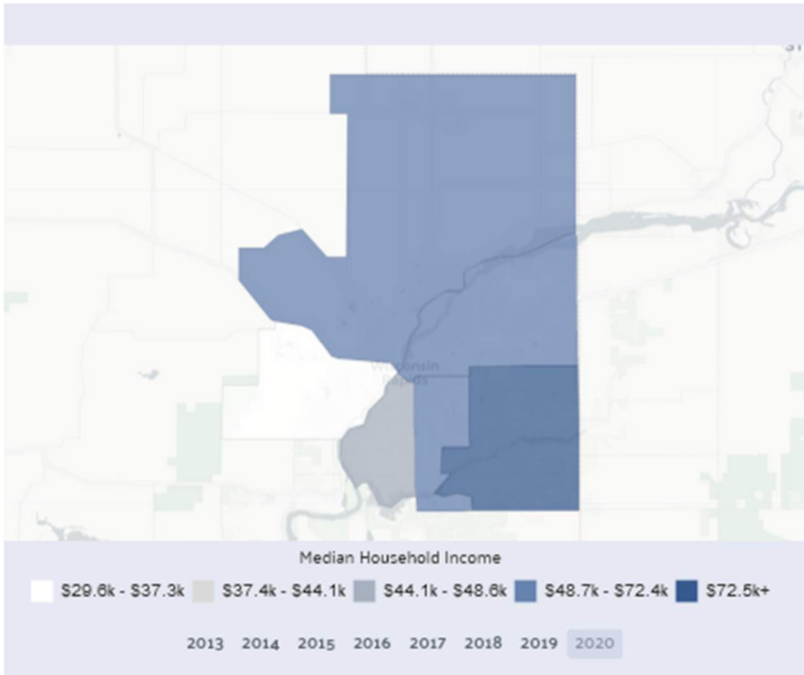

Figure A-4: Median Household Income by Location

Using averages, employees in Wisconsin Rapids, WI have a shorter commute time (22.4 minutes) than the normal US worker (26.9 minutes). Additionally, 2.57% of the workforce in Wisconsin Rapids, WI have "super commutes" in excess of 90 minutes.

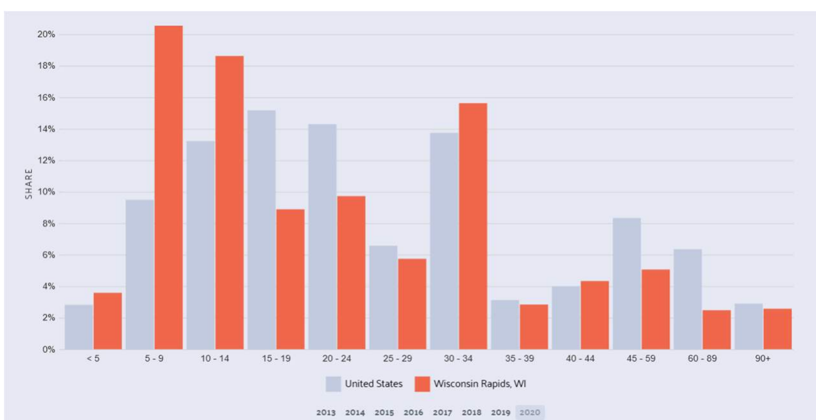

Figure A-5: Commute Time Histogram

Wisconsin Rapids Economic Development (with rail)

The Director of Community Development noted that rail is a key feature of the economic development draw to the City of Wisconsin Rapids. This Certified Site comprises 51 acres in the southeastern corner of the Rapids East Commerce Center, located just off State Highway 54. There is a Canadian National rail line that runs 1,200 feet north of the site, and an airport about 40 miles away.

https://inwisconsin.com/wp-content/uploads/2017/10/Wisconsin-Rapids1.pdf

Rail Access (if applicable) – not required • feasibility of service (if site is to be marketed as rail-served)	• A Canadian National rail line runs ~1,200 ft north of the site • There is an industrial spur in place to users on the western end of the R.E.C.C., but it currently terminates to the west of 48th St. at the Energy Composites Corporation • City owns the right-of-way that could be used to create a rail loop and provide access across the southern boundary of the site

Figure A-6: Excerpt from Rapids East Commerce Center brochure.

Appendix B-1

Rail Crossing Data
Grand Avenue

There are three primary sources of rail data for this report. 1) FRA rail inventory and accident data, 2) Previous Wisconsin Rapids Studies. 3) Data collected from sensors and observations from this study.

Sensors and Data Collection

LinqThingz Trainable Sensor Platform and Future as a Service SaaS platform was used to collect and analyze data in Wisconsin Rapids. The “Trainable Sensor Platform” (TSP) is not named for it use in rail. Rather, it describes a system that is a heterogeneous array of sensors including LIDAR, RADAR, Magnetometer, IR, Camera, Audio, RF feed into a neural network and streamed to the cloud. The on-board neural network can be programmed remotely in real-time and repurposed for a variety of USE CASES. The TSP also has an array of environment sensors (Temperature, Humidity, Barometric Pressure, and GPS location). LinqThingz Future as a Service (FaaS) SaaS system collects data from an array of TSP device plus other third party sensors. This data is streamed real-time through Machine Learning algorithms that combine data to differentiate rail traffic from other objects and determine the location, direction, speed, and length of trains. This information is stream to mobile applications, cloud integration (navigation programs, computer-aided dispatch, connected vehicles) and stores the data in a cloud data cluster for post analysis. The data that appears in this report is post analysis of data stored in the LinqThingz cloud.

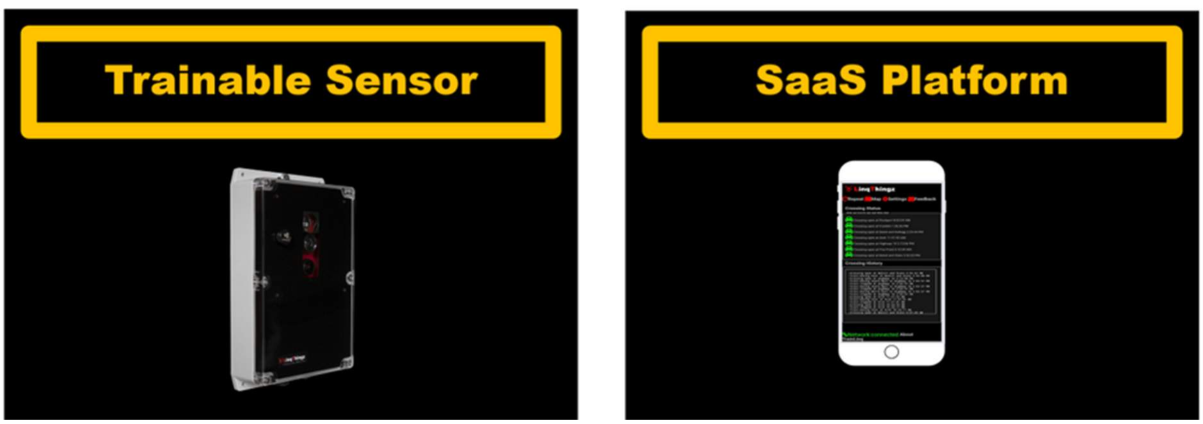

Figure B1-1: LinqThingz Trainable Sensor and SaaS Platform

LinqThingz Trainable Sensor Platform and Future as a Service SaaS platform was used to collect and analyze data in Wisconsin Rapids.

Typical, for rail applications, LinqThingz TSP sensors are usually poll mounted. However, for the purposes of rail studies the sensors are mounted on trailers that can easily moved from location to location.

Figure B1-2: Trainable Sensor Platform Mobile Sensor System

LinqThingz Trainable Sensor Platform configured as Mobile Sensor System using LinqThingz Future as a Service SaaS platform was used to collect and analyze data in Wisconsin Rapids

	Data Period (days)	Time (minutes)	Average Speed (MPH)	Vehicle Blocked Per Day	Vehicle Delay / Year (hrs)
Grand	14	535	10	327	8516
Gaynor	14	189	12	34	969
Bonow	8	873	7	189	10264
17th	8	285	6	28	942

Figure B1-3: Summary of Rail Traffic From Sensors placed near crossings.

Rail Crossing Data Grand Av.

Grand Avenue is the highest road traffic in Wisconsin Rapids with 11,600 AADT according WisDOT. The summary data appears in Figure B-3.

SUMMARY Grand		
Test Start (UTC)	'2022-10-23 00:00:00'	
Test End (UTC)	'2022-11-06 00:00:00'	
Test Duration	14	days
Total Close Time	554.02	minutes
Average Close Time	4.33	minutes
Most Frequent Wait Time	8	minutes
Maximum Close Time	24.67	minutes
Average Speed at Close	10.88	MPH
Average Speed at Open	8.80	MPH
Close Time per day	40	minutes
Trains per day	18	trains
AADT	11600	vehicles
Vehicles blocked per day	319	vehicles
Vehicle blocked hours per year	8398	hours

Figure B1-4: Summary of Information at Grand Ave

Freight Rail traffic is unlike commuter rail traffic and occurs and what appears to be pseudorandom time intervals and crossing blockage lengths.

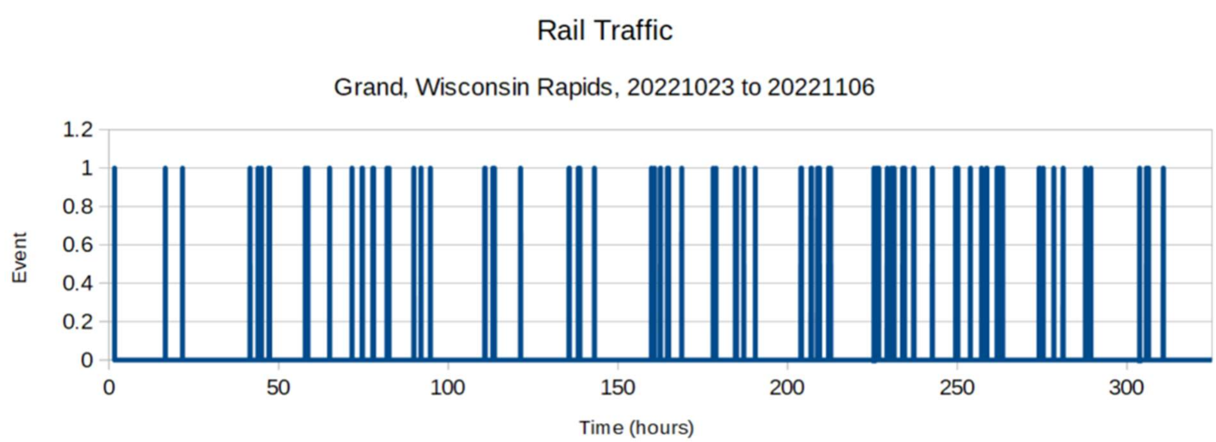

Figure B1-5: Rail Crossing Events at Grand Ave

Freight rail traffic has irregular frequency and length of blockage.

By contrast, highway traffic feature a more recurring volume tied to the time of day. Figure B1-6 illustrates the traffic peaks that occur during day-time hours. The zero-traffic totals for the first 120 hours depicts the lack of traffic when Grand Avenue was closed for construction.

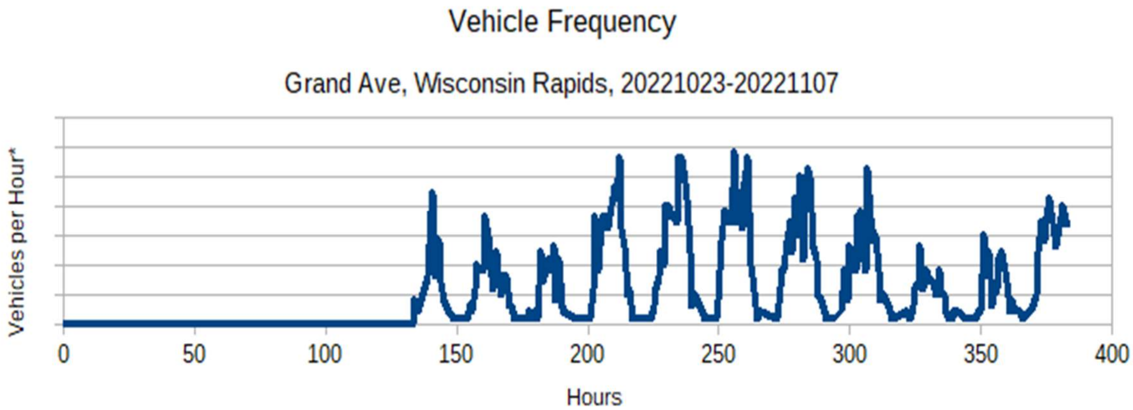

Figure B1-6: Vehicle Traffic at Grand Ave

Grand Avenue sees peak road traffic all daylight hours. Traffic is large throughout the middle of the day illustrating a large amount of commercial and through traffic. Note that the traffic is zero during the road closure at the beginning of the study.

It insightful to analyze the frequency of occurrence of crossing blockages. A histogram of crossing blockage is illustrated in Figure B1-7. The first cluster of blockages under 5 minutes is from train engines, short switching trains and maintenance vehicles. The peak around 9 minutes is from longer freight trains. The average block time occurs around 4.5 minutes. There are few actual blockage for this length of time.

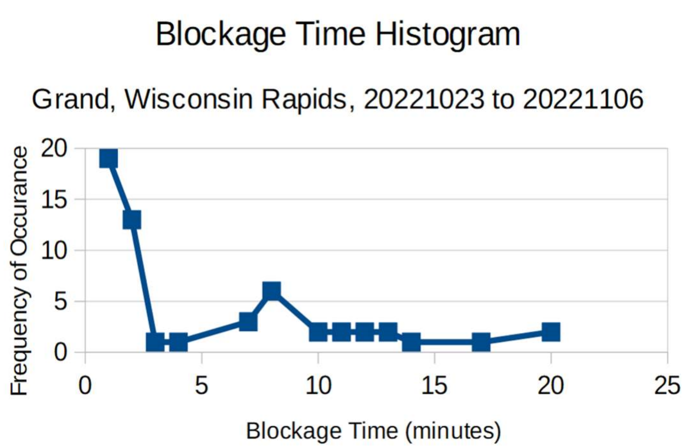

Figure B1-7: Histogram showing frequency of delay lengths

A more insightful measure is the time at crossing versus the block time. This is calculated by multiplying the blockage time with the frequency of blockage. A histogram of this measure is illustrated in figure

B1-8. Here the peak occurs around 8 minutes. This shows that the most frequently experienced delay is 8 minutes at this crossing.

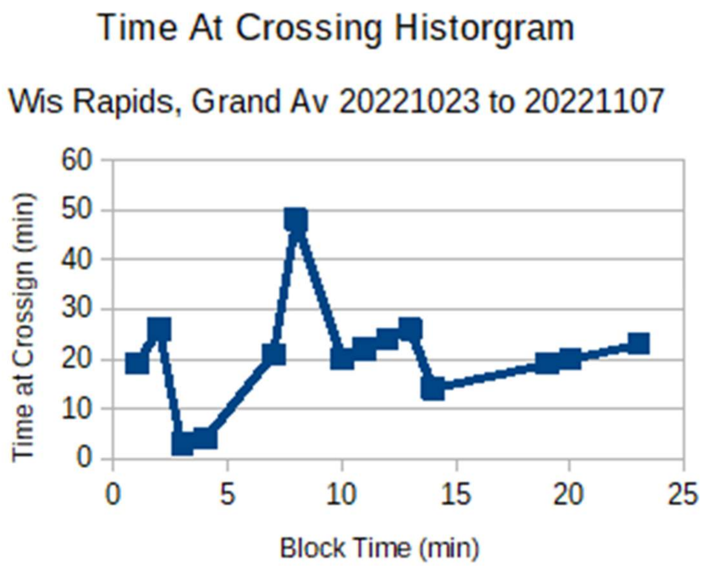

Figure B1-8: Histogram showing the accumulate blockage time per length of blockage

In the figure above most time is spend being delayed at 8-minute crossing blockages.

The histograms in figures B1-7 and B1-8 also illustrate that there is a significant amount of rail blockages exceeding 8 minutes. More than half of the time waiting at crossings occur for more than ten minutes. Insight into the anatomy of these long delay times can be seen in figure B-9. The train approaches the crossings with varying speed, then stops at the crossings, then eventually speeds up and leaves the crossings. The yellow curve is the presence signal indicating that train is occupying the crossing and the orange is raw RADAR data. The actual train speed can be obtained by multiplying the RADAR signal value by 1.89 for this sensor and crossing combination. The large peaks before and after the train blockage is road traffic being picked up by the RADAR. A key advantage of LinqThingz TSP is the heterogeneous sensor and neural network that differentiates rail and road traffic with very few false positive and false negatives.

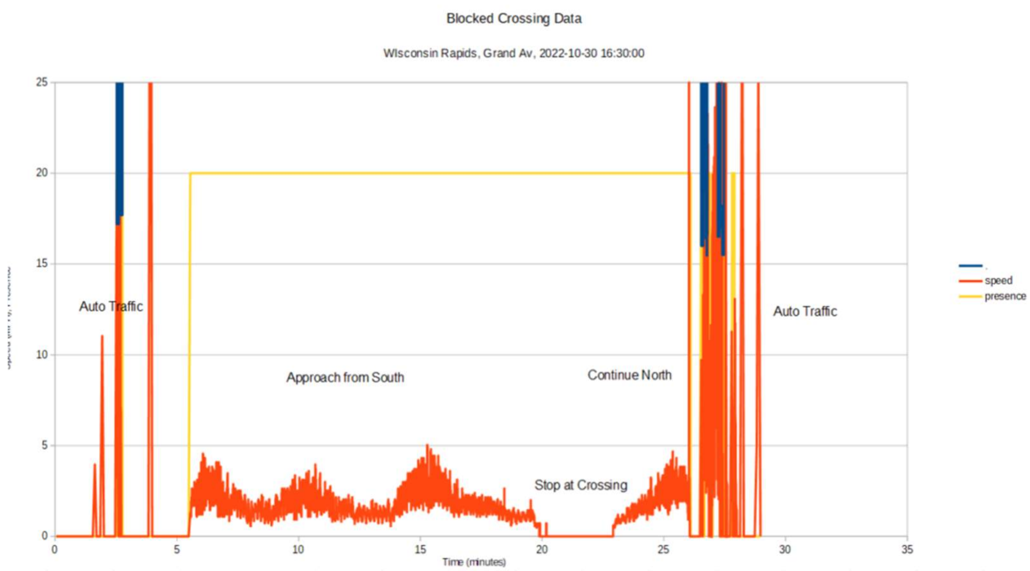

Figure B1-9: Typical long blocking event involving switching and stopped trains

Another useful metric in understanding rail traffic at the crossing is the zero-speed histogram. This measures the total time for each length of the time that the train is stopped. The most frequently occurs at 8 minutes.

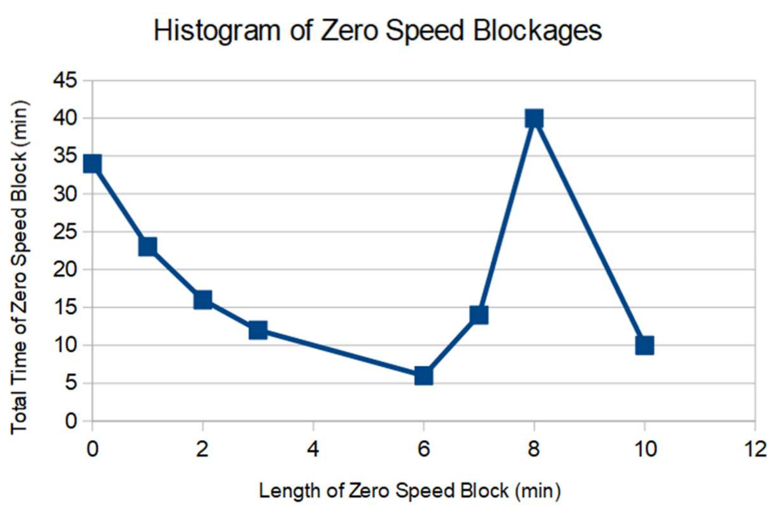

Figure B1-10: Histogram of Zero Speed Blockages

Zero Speed Blockages account for more than 50% of the blockage time at Grand Av.

PATRICK

LinqThingz Predictive Mobility

It is useful to compare our detailed data to the summary data on the FRA Freight Rail Crossing Inventory. The FRA data shows 6 through trains and 14 switching trains each data for a total of 20 trains. The LinqThingz sensor show 18 trains. As an average over time these two numbers are in good agreement.

Part II: Railroad Information

1. Estimated Number of Daily Train Movements

1.A. Total Day Thru Trains *(6 AM to 6 PM)*	1.B. Total Night Thru Trains *(6 PM to 6 AM)*	1.C. Total Switching Trains	1.D. Total Transit Trains	1.E. Check if Less Than One Movement Per Day ☐ How many trains per week? ______
4	2	14	0	

2. Year of Train Count Data *(YYYY)*: 2016

3. Speed of Train at Crossing
3.A. Maximum Timetable Speed *(mph)*: 40
3.B. Typical Speed Range Over Crossing *(mph)* From 1 to 25

4. Type and Count of Tracks
Main 1 Siding 0 Yard 0 Transit 0 Industry 0

5. Train Detection *(Main Track only)*
☒ Constant Warning Time ☐ Motion Detection ☐AFO ☐ PTC ☐ DC ☐ Other ☐ None

6. Is Track Signaled? ☒ Yes ☐ No
7.A. Event Recorder ☐ Yes ☒ No
7.B. Remote Health Monitoring ☐ Yes ☒ No

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Figure B1-11: Excerpt from Grand Ave FRA Crossing Inventory

The congestion impact uses the Average Annual Daily Traffic and the amount of time highway traffic is stopped per year to calculate the extra Carbon Pollution, Fuel Usage, Citizen Productivity, and Logistics Productivity as illustrated in figure B-13.

11600	AADT
9	minutes blockage are the type of delay most time is spent waiting
29	minutes is the longest delay measured in the study
21	minutes is the average time the crossing blocked each day
8870	minutes is the average time the crossing blocked each year
657	ton of pollution from waiting
2444	Dollars of excess fuel usage
31766	Dollars of citizens productivity
153943	Dollars of logistics productivity

Figure B1-12: Congestion Impact at Grand Ave

Another useful analysis is the queue size analysis. It uses a the AADT and the average length between stopped vehicles (queue unit) to calculate queue size. The Day-time multiple accounts for the higher volume compared to annual average during daytime hours and the Rush-hour multiple accounts for the higher volume at rush hour.

Assumptions

AADT	11600
Queue Unit (ft)	25
Day Time Multiplier	2
Rush Hour Multiplie	3
Max Queue (ft)	5280

Calculations

		Queue(ft)		
Delay Time (min)	Vehicles(#)	Average	Daytime	Rush Hour
1	8.1	201	403	604
2	16.1	403	806	1208
3	24.2	604	1208	1813
4	32.2	806	1611	2417
5	40.3	1007	2014	3021
6	48.3	1208	2417	3625
7	56.4	1410	2819	4229
8	64.4	1611	3222	4833
9	72.5	1813	3625	5280
10	80.6	2014	4028	5280
11	88.6	2215	4431	5280
12	96.7	2417	4833	5280
13	104.7	2618	5236	5280
14	112.8	2819	5280	5280
15	120.8	3021	5280	5280
16	128.9	3222	5280	5280
17	136.9	3424	5280	5280
18	145.0	3625	5280	5280
19	153.1	3826	5280	5280
20	161.1	4028	5280	5280
21	169.2	4229	5280	5280
22	177.2	4431	5280	5280
23	185.3	4632	5280	5280
24	193.3	4833	5280	5280
25	201.4	5035	5280	5280

Figure B1-13: Queue analysis for Grand Ave

Appendix B-2

Rail Crossing Data
Bonow Avenue

The crossing at Bonow seems to have nearly double block time compared to Grand Av. However, the number of vehicles blocked per year is only about 20% larger the Grand due to the higher AADT at Grand.

SUMMARY Bonow		
Test Start (UTC)	'2022-12-29 00:00:00'	
Test End (UTC)	'2023-01-06 00:00:00'	
Test Duration	8	days
Total Close Time	872.88	minutes
Average Close Time	8.99	minutes
Maximum Close Time	72.63	minutes
Most Frequent Wait Time	10	minutes
Average Speed at Close	9.22	MPH
Average Speed at Open	4.50	MPH
Close Time per day	109	minutes
Trains per day	12	trains
AADT	2500	vehicles
Vehicles blocked per day	189	vehicles
Vehicle blocked hours per year	10364	hours

Figure B2-1: Summary of rail traffic information at Bonow Ave

The FRA inventory reports a total of 12 trains a day with 6 being through and 6 being switching. LinqThings sensors also report 12 trains each day. However, as illustrated in Figure B3, LinqThingz data depicts over 75% switching trains compared to 50% reported by FRA. LinqThingz defines switching trains as trains that stop for more than one minute at crossing.

Part II: Railroad Information

1. Estimated Number of Daily Train Movements				
1.A. Total Day Thru Trains *(6 AM to 6 PM)* 4	1.B. Total Night Thru Trains *(6 PM to 6 AM)* 2	1.C. Total Switching Trains 6	1.D. Total Transit Trains 0	1.E. Check if Less Than One Movement Per Day ☐ How many trains per week? ____

2. Year of Train Count Data *(YYYY)*	3. Speed of Train at Crossing
2016	3.A. Maximum Timetable Speed *(mph)* 40 3.B. Typical Speed Range Over Crossing *(mph)* From 1 to 25

4. Type and Count of Tracks

Main 1 Siding 0 Yard 0 Transit 0 Industry 0

5. Train Detection *(Main Track only)*

☒ Constant Warning Time ☐ Motion Detection ☐ AFO ☐ PTC ☐ DC ☐ Other ☐ None

6. Is Track Signaled?	7.A. Event Recorder	7.B. Remote Health Monitoring
☒ Yes ☐ No	☐ Yes ☒ No	☐ Yes ☒ No

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Figure B2-2: Excerpt from Bonow Ave FRA Crossing Inventory

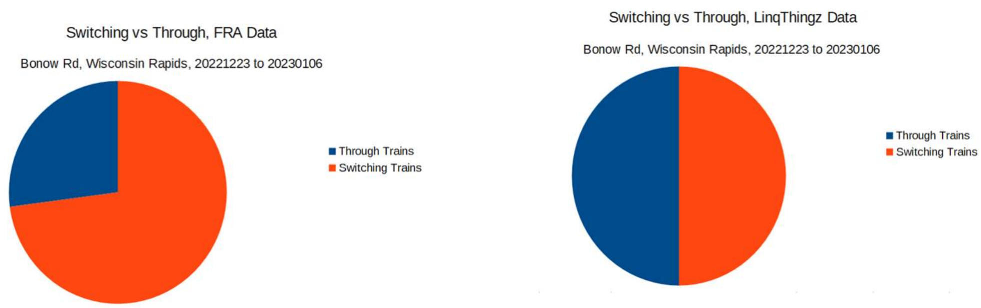

Figure B2-3: FRA Crossing Inventory Switching vs Through Trains at Bonow Ave

The time plot of rail traffic at Bonow illustrates the same pseudo-random behavior and typical freight rail traffic.

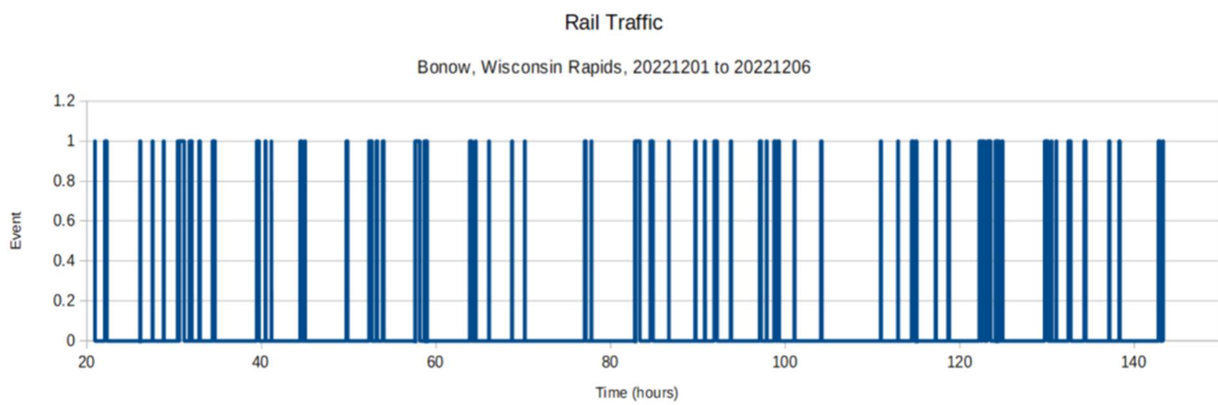

Figure B2-4: Rail Traffic at Bonow Ave

The time spent per block time show a peak around ten minutes and a larger quantify of long block times that Grand. This illustrates a higher amount of switching traffic.

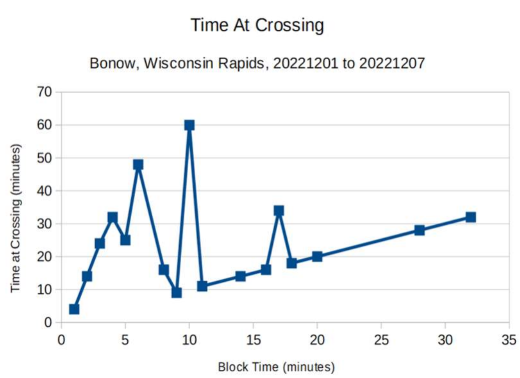

Figure B2-5: Total time spent for each delay time

Appendix B-3

Rail Crossing Data
Gaynor Street

The rail and road traffic are both substantially less that Grand Avenue and the yearly amount of time vehicles wait at the crossing is 1/10 that of Bonow Av.

SUMMARY Gaynor		
Test Start (UTC)	'2022-10-23 00:00:00'	
Test End (UTC)	'2022-11-06 00:00:00'	
Test Duration	14	days
Total Close Time	246.57	minutes
Average Close Time	4.92	minutes
Maximum Close Time	28.40	minutes
Most Frequent Wait Time	7	minutes
Average Speed at Close	14.53	MPH
Average Speed at Open	8.78	MPH
Close Time per day	18	minutes
Trains per day	4	trains
AADT	2800	vehicles
Vehicles blocked per day	34	vehicles
Vehicle blocked hours per year	1025	hours

Figure B3-1: Summary information from LinqThingz sensor

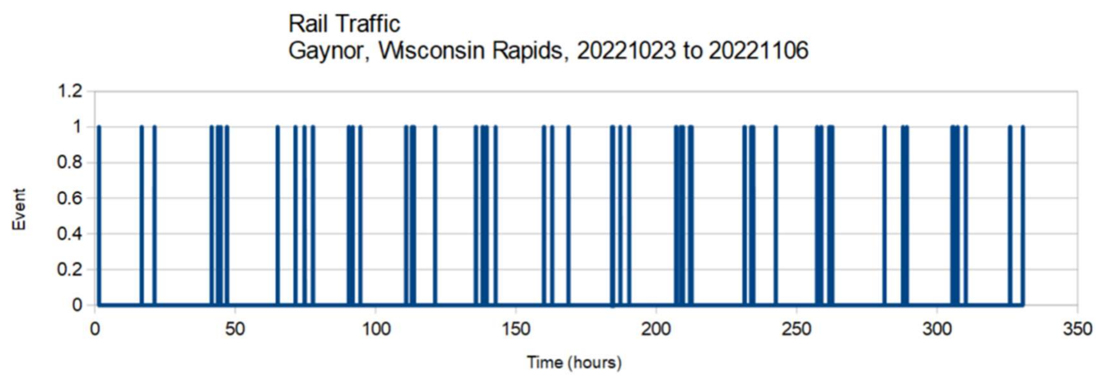

Figure B3-2: Rail traffic at Gaynor Ave

The time series data for Gaynor illustrates the typical behavior. The time series data for road traffic illustrates that the road traffic is primary and the two rush hours that suggests this traffic is primarily local commuter traffic.

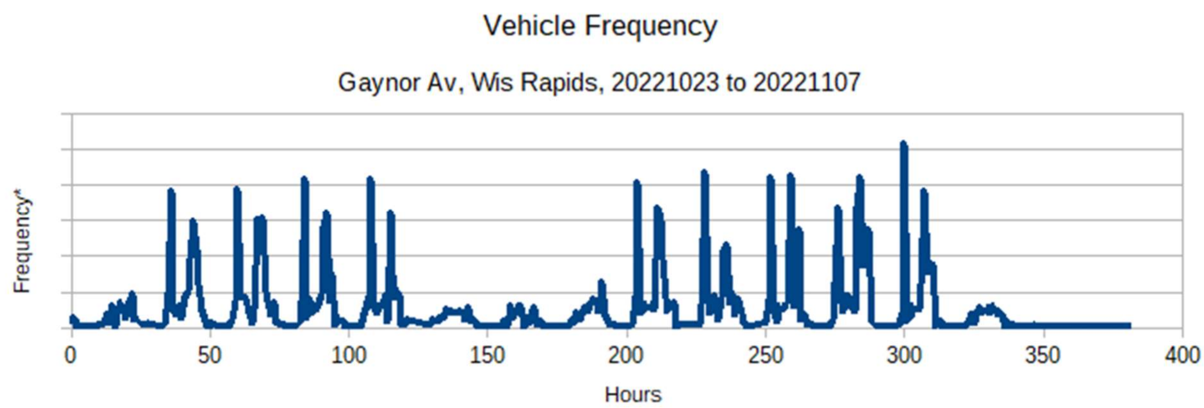

Figure B3-3: Road Traffic at Gaynor Ave

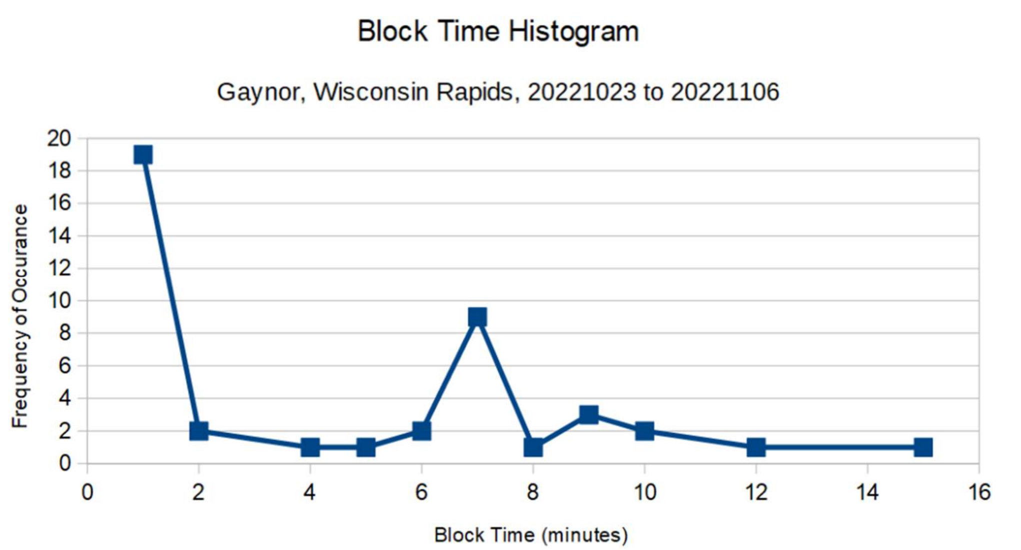

Figure B3-4: Rail traffic histogram

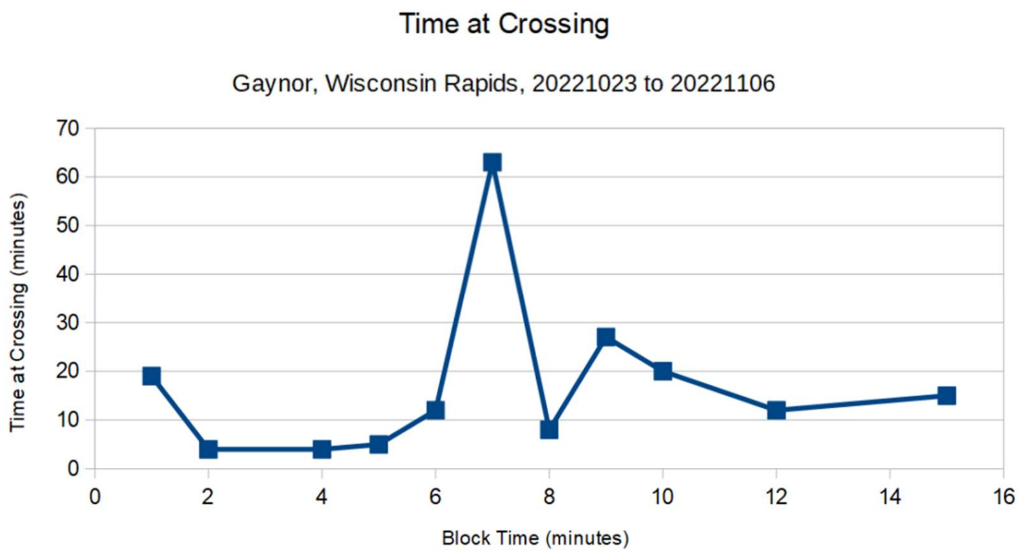

Figure B3-5: Time spent at crossing

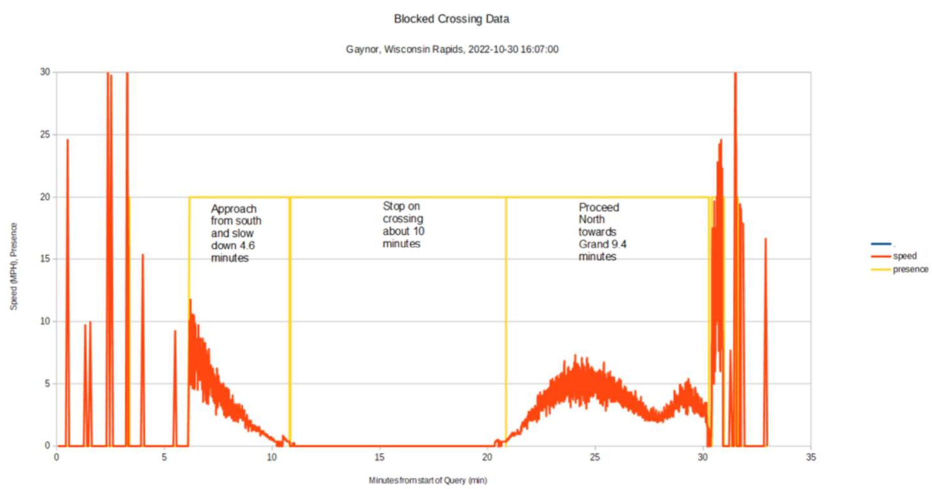

Figure B3-6: Typical long blocking event due to switching and stopped trains

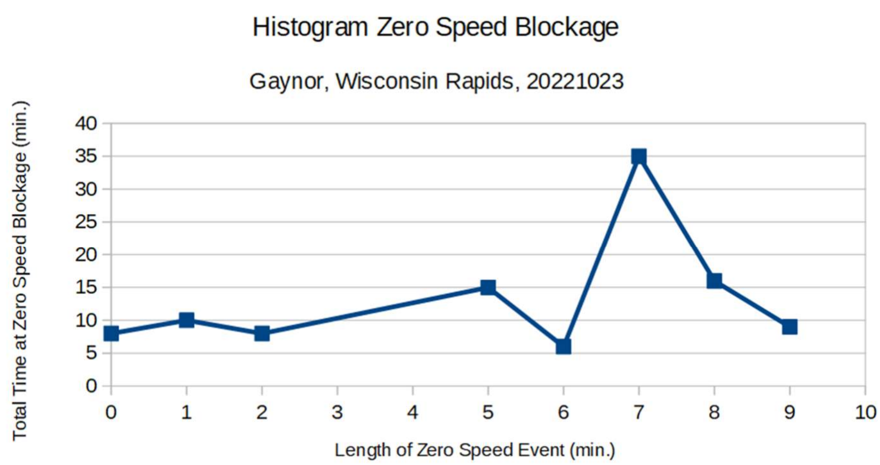

Figure B3-7: Time spent at zero-speed switching events.

The FRA inventory reports 10 trains per day. The sensor data collected on-site suggests more like only 4 trains a day.

Part II: Railroad Information				
1. Estimated Number of Daily Train Movements				
1.A. Total Day Thru Trains *(6 AM to 6 PM)* 4	1.B. Total Night Thru Trains *(6 PM to 6 AM)* 2	1.C. Total Switching Trains 4	1.D. Total Transit Trains 0	1.E. Check if Less Than One Movement Per Day ☐ How many trains per week? ______
2. Year of Train Count Data *(YYYY)* 2016	3. Speed of Train at Crossing 3.A. Maximum Timetable Speed *(mph)* 40 3.B. Typical Speed Range Over Crossing *(mph)* From 1 to 25			
4. Type and Count of Tracks Main 1 Siding 0 Yard 0 Transit 0 Industry 0				
5. Train Detection *(Main Track only)* ☐ Constant Warning Time ☒ Motion Detection ☐AFO ☐ PTC ☐ DC ☐ Other ☐ None				
6. Is Track Signaled? ☒ Yes ☐ No	7.A. Event Recorder ☐ Yes ☒ No	7.B. Remote Health Monitoring ☐ Yes ☒ No		

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Figure B3-8: Excerpt of Gaynor Ave FRA Crossing Inventory

Appendix B-4

Rail Crossing Data
17th Street

SUMMARY 17th Public Road Crossing		
Test Start (UTC)	'2022-12-29 00:00:00'	
Test End (UTC)	'2023-01-06 00:00:00'	
Test Duration	14	days
Total Close Time	284.89	minutes
Average Close Time	6.14	minutes
Maximum Close Time	22.25	minutes
Most Frequent Block Time	<5	minutes
Average Speed at Close	6.55	MPH
Average Speed at Open	4.51	MPH
Close Time per day	20	minutes
Trains per day	4	trains
AADT	2000	vehicles
Vehicles blocked per day	28	vehicles
Vehicle blocked hours per year	1055	hours

Figure B4-1: Summary information for 17th St

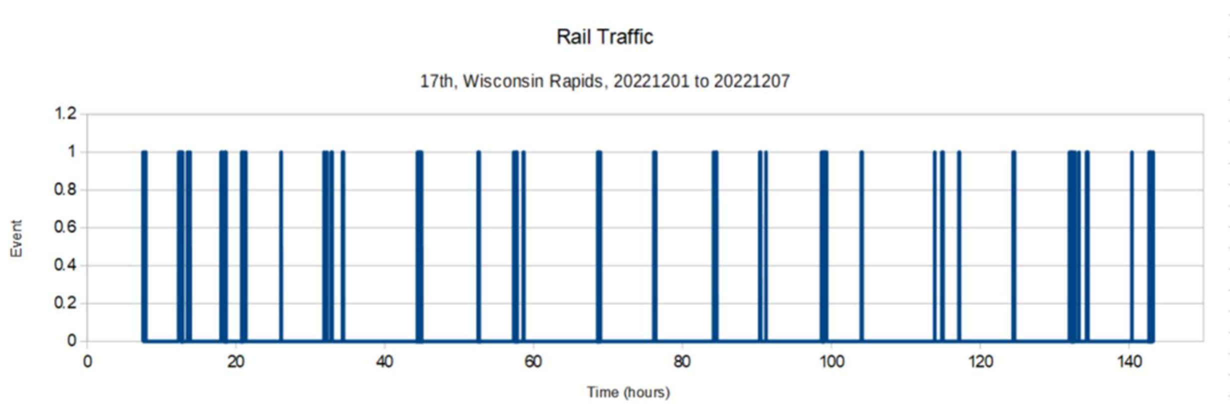

Figure B4-2: Rail Traffic at 17th St

The volume of block time at 17th St is, like Gaynor, a tenth of the block time at Bonow Ave. The FRA reports 8 switching trains a day. LinqThingz sensors report 4 trains a day. The LinqThingz data would suggest that the trains are primarily through trains. However, the FRA data suggests that the trains are entirely switching trains. This suggests some change in railroad operations. There are multiple tracks and sidings at 17th. More data would need to be collected at this “Criss-cross” to better understand traffic.

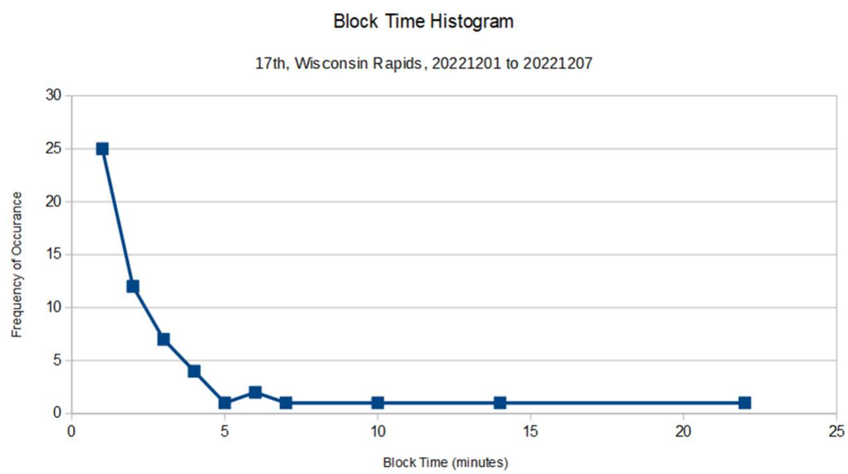

Figure B4-3: Histogram of block times

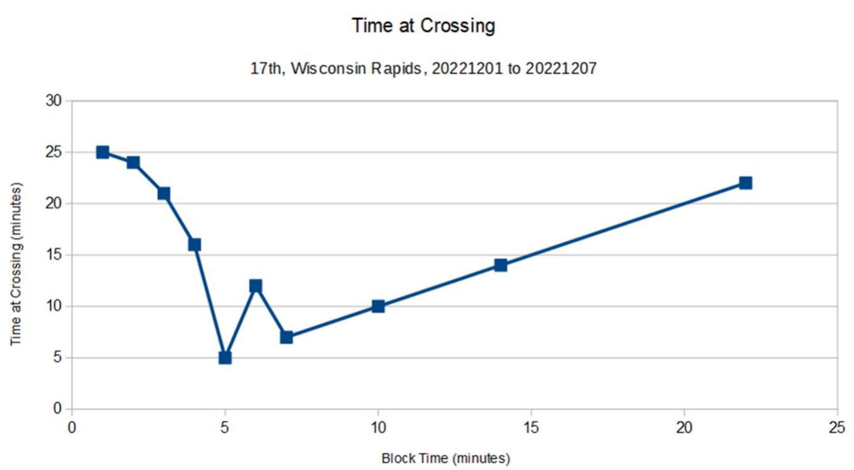

Figure B4-4: Histogram of time at crossing

Part II: Railroad Information

1. Estimated Number of Daily Train Movements

1.A. Total Day Thru Trains *(6 AM to 6 PM)*	1.B. Total Night Thru Trains *(6 PM to 6 AM)*	1.C. Total Switching Trains	1.D. Total Transit Trains	1.E. Check if Less Than One Movement Per Day ☐ How many trains per week? ______
0	0	8	0	

2. Year of Train Count Data *(YYYY)*	3. Speed of Train at Crossing
2016	3.A. Maximum Timetable Speed *(mph)* 10 3.B. Typical Speed Range Over Crossing *(mph)* From 1 to 10

4. Type and Count of Tracks

Main 0 Siding 0 Yard 0 Transit 0 Industry 1

5. Train Detection *(Main Track only)*

☐ Constant Warning Time ☒ Motion Detection ☐AFO ☐ PTC ☐ DC ☐ Other ☐ None

6. Is Track Signaled?	7.A. Event Recorder	7.B. Remote Health Monitoring
☒ Yes ☐ No	☐ Yes ☒ No	☐ Yes ☒ No

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Figure B4-5: Excerpt from 17th St FRA Crossing Inventory

Appendix C

Alternate Route Analysis

Predictive Mobility works by giving advanced warning, typically 2 to 7 minutes IN ADVANCE, so that road traffic does not intersect with rail traffic. For example, an ambulance moving from the west on Grand/25th St could take either 17^{th} St /Hwy 34 (4 minutes) or continue on Grand to Hwy 13 (4 minutes) to reach the hospital on the east side of the river. If notified, in advance of reaching 17^{th} and Grand, the ambulance would add no extra time to the trip, while avoiding a potential 20 minute wait at Grand. The fastest time to get from the west end of the city and across the tracks is about 4 minutes. Based on the overlap between blocked crossings (Appendix C) there is an alternate route taking no more 7 minutes from anywhere on the west side 99% of the time. This is a maximum 3 minute penalty to avoid and average blockage penalty of 8 minutes or up to over 20 minutes.

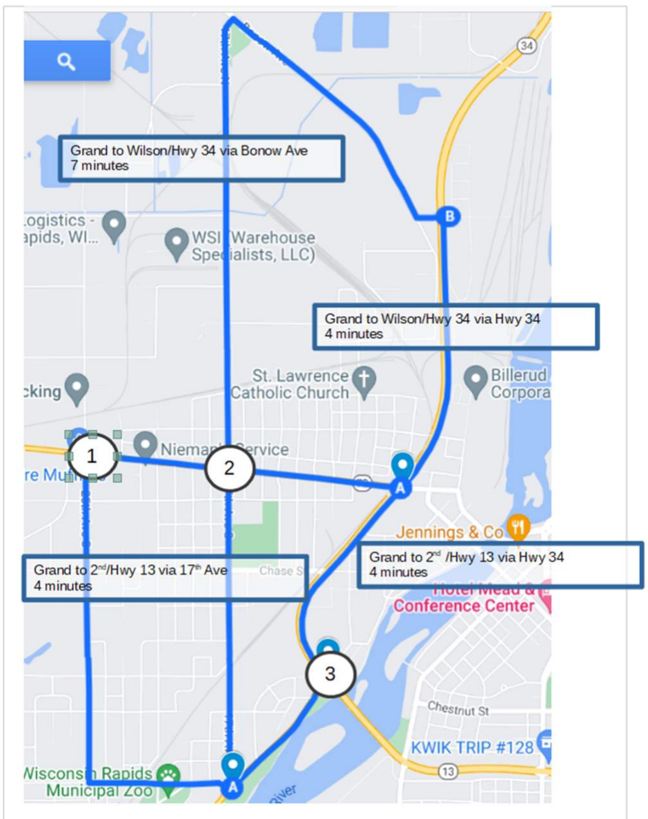

Figure C-1: Example Alternate Route

Consider ambulance traveling from (1) to (3). Alternate routes from (2) to (3) take same amount of time but can avoid 20+ minute wait with advance warning given at (1) when one of the crossings is blocked.

Predictive Mobility works by placing an array of sensors within vicinity of rail but outside rail right of way. Sensors contain RADAR, LIDAR, IR, Camera, Magnetometer, Audio, Radio all within a single enclosure for fast Machine Learning processing to identify location, speed, direction, and length of trains. This information is communicated from multiple sensors to LinqThingz cloud where it is stored, and another Machine Learning engine processes the data to predict when crossings are and will be closed/open. This information is communicated to users via mobile application, web applications, fixed message signage with notifications, variable message signs and cloud applications. It is expected that the information from these sensors can be available to major navigation and connected vehicle companies by 2025.

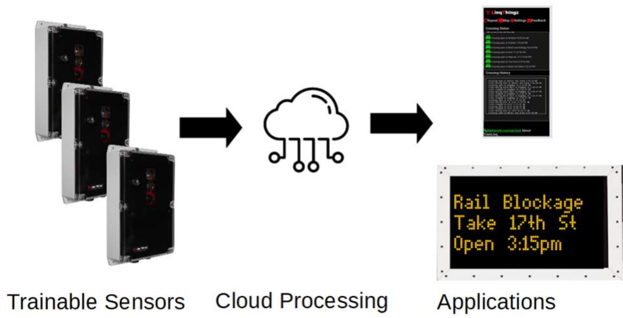

Figure C-2: Predictive Mobility Process

Predictive Mobility uses sensor data and machine learning to provide advanced warning of blocked crossing to digital applications and dynamic road-side signs.

There must be routes, without train traffic available for alternate routing to be effective and allow auto traffic to avoid blocked crossing. LinqThingz performs a special overlap analysis to determine these routes. Data queries are run to compare time when crossings are simultaneously blocked. Then mapping programs are used to determine alternate routes that have a minimal time penalty. The alternative routing analysis below shows that the crossings at Grand and Gaynor are simultaneously blocked only 0.11% of the time. This means that there is an alternate route with 99% probability for success. Similarly, alternate routing at Bonow and 17th show that these intersections are simultaneously blocked 0.48% of the time.

SUMMARY Bonow to 17th Road Crossing		
Test Start (UTC)	'2022-12-29 00:00:00'	
Test End (UTC)	'2023-01-06 00:00:00'	
Test Duration	8	days
Total Overlap Time	96.05	minutes
Min Overlap Time	0.51	minutes
Average Overlap Time	3.43	minutes
Max Overlap Time	10.68	minutes
Minimum Gap	2.26	minutes
Average Gap	5.01	minutes
Maximum Gap	9.53	minutes
Separation Distance	1991	ft
Separation Distance	0.377	mile
Average Station to Station	4.51	MPH
Max Station to Station	10.03	MPH
Total Crossing Close Time	872.88	minutes
Percent Block Time	4.33%	
Percent Overlap of Block Time	11.00%	
Percent of Possible Travel Time	0.48%	

Figure C-3: Summary Bonow Ave to 17th Ave Crossing

Example Alternate Routes

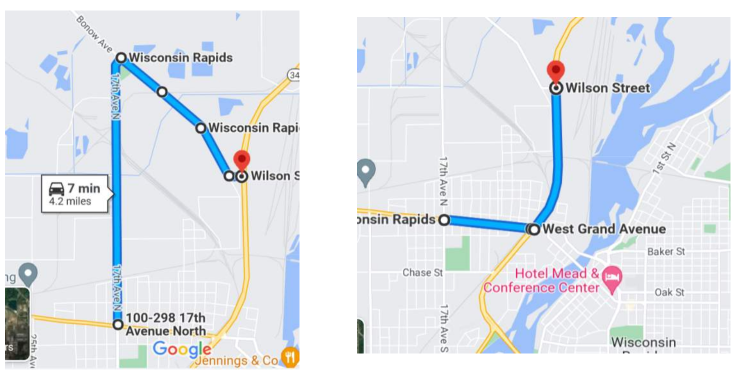

Figure C-4: Example routes from North Hwy 13 to the intersection of 17th and Grand. The two routes differ by 3 minutes. However, advanced routing could save over 20 minutes of block time.

Bonow and 17th

Bonow Avenue Southeast bound traffic, entering the city limits, takes about 1.2 minutes (5000 ft) to reach either the crossing heading straight on Bonow Avenue or turning right on 17th Avenue. The sensor configuration in the illustration below would provide 4 to 6 minutes advance warning about congestion and therefore provides amble re-routing time for this driving use case for a Variable Message Sign [V] located at the city limits on Bonow Ave (County F).

Bonow Avenue Northwest bound traffic, entering from State Highway 13 takes about 1 minutes (4000 ft) to reach the crossing on Bonow Av. The sensor configuration in the illustration below would provide 4 to 6 minutes advance warning about congestion and therefore provides amble re-routing time for this driving use case for a Variable Message Sign [V] located at the at the entrance of Bonow Ave (County F) off State Highway 13.

17th Avenue Northbound traffic, entering from State Highway 73 (Grand Avenue) takes about 2.4 minutes (5280 ft) to reach the crossings at 17th Avenue south of Nash. The sensor configuration in the illustration below would provide 4 to 6 minutes advance warning about congestion and therefore provides amble re-routing time for this driving use case for a Variable Message Sign [V] located at State Highway 73 (Grand Avenue) .

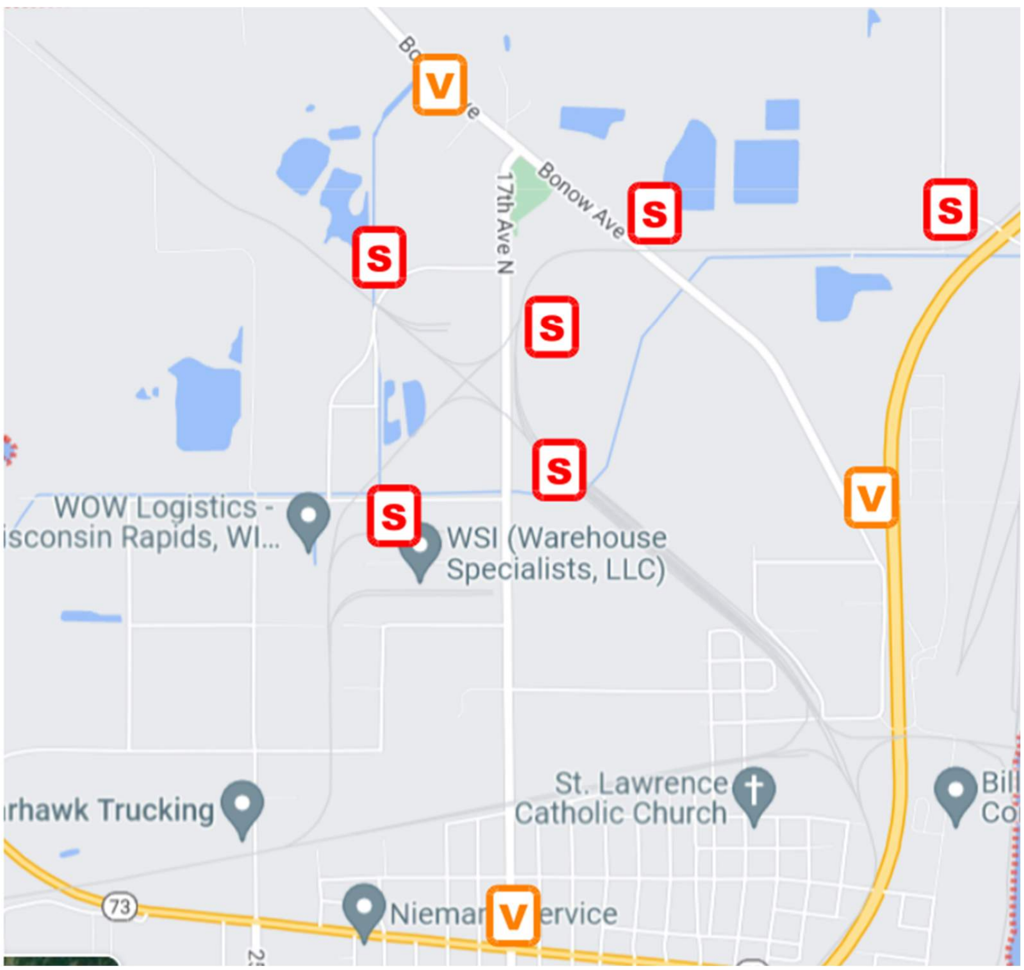

Figure C-5: Sensor and Variable Message Sign Locations

Sensor [S] located at crossings above could give 4-6 minute advance warning of blocked crossing. Variable Message Signage [V] would provide ample alternate route warning information to auto traffic on Bonow Ave and 17th Avenues.

Overlap Analysis Grand and Gaynor

SUMMARY Grand to Gaynor Road Crossing		
Test Start (UTC)	'2022-10-23 00:00:00'	
Test End (UTC)	'2022-11-06 00:00:00'	
Test Duration	14	days
Total Overlap Time	22.13	minutes
Min Overlap Time	0.33	minutes
Average Overlap Time	1.70	minutes
Max Overlap Time	4.93	minutes
Minimum Gap	4.79	minutes
Average Gap	9.27	minutes
Maximum Gap	22.39	minutes
Separation Distance	7180.8	ft
Separation Distance	1.360	mile
Average Station to Station	8.80	MPH
Max Station to Station	17.03	MPH
Total Crossing Close Time	536	minutes
Percent total Close Time	2.66%	
Percent Overlap Time	4.13%	
Percent of possible travel time	0.11%	

Figure C-6: Summary Grand to Gaynor Road Crossing

Example Alternate Routes

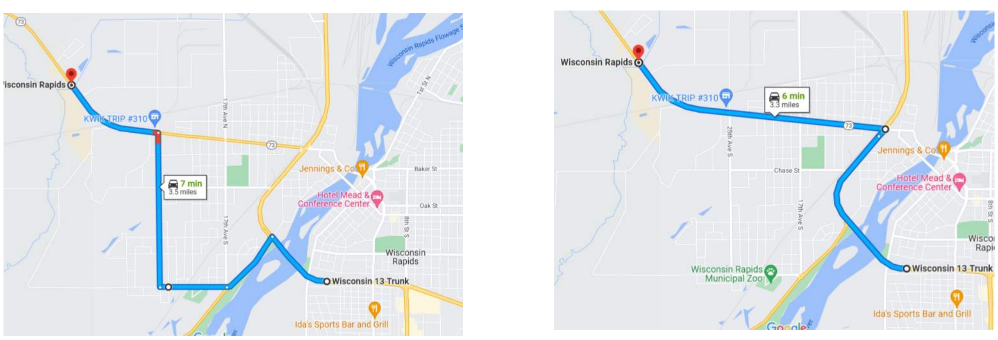

Figure C-7: Example routes from west Wisconsin Rapids to Hospital, with only a 1 minute difference in travel time, though could be taken with advance warning of whether the crossing will be blocked at Gaynor or Grand.

High Street through Gaynor

Grand Avenue Eastbound traffic, entering the city limits, takes about 2 to 4 minutes (8800 ft) to reach either the crossing heading straight or 1 to 2 minutes if approaching from 17th Avenue. The sensor configuration in the illustration below would provide 3 to 4 minutes advance warning about rail traffic approaching from the North and 2 to 8 minutes for rail traffic approaching from the South. The sensor configuration in the illustration below would provide amble re-routing time for this driving use case for a Variable Message Sign [V] located on State Highway 73 (Grand Avenue) .

West bound traffic, entering at W Grand Avenue, Jackson St, Baker St, and1st St takes about 2 to 3 minutes (3600 ft) to reach the crossing at W Grand Avenue. The sensor configuration in the illustration below would provide 3 to 4 minutes advance warning about rail traffic approaching from the North and 2 to 12 minutes for rail traffic approaching from the South. The sensor configuration in the illustration below would provide amble re-routing time for this driving use case for a Variable Message Sign [V] located on Jackson St, Baker St, and1st Streets.

North/West bound traffic, entering a State Highway 13 (MIA/POW Highway) takes about 2 to 3 minutes to reach crossing (1.0 to 1.2 miles depending if destination is Gaynor, Chase or W Grand Avenue) . The sensor configuration in the illustration below would provide 3 to 4 minutes advance warning about rail traffic approaching from the North and 2 to 12 minutes for rail traffic approaching from the South. The sensor configuration in the illustration below would provide amble re-routing time for this driving use case for a Variable Message Sign [V] located on State Highway 13 (MIA/POW Highway).

Northbound traffic, approaching on State Highway 73 takes between 2 and 5 minutes, depending on what westbound connection across the rail may be the destination. The sensor configuration in the illustration below would provide 3 to 4 minutes advance warning about rail traffic approaching from the North and 2 to 12 minutes for rail traffic approaching from the South. The sensor configuration in the illustration below would provide amble re-routing time for this driving use case for a Variable Message Sign [V] located on State Highway 73.

Southbound traffic, approaching on State Highway 13, takes less than a minute to get to the crossings starting a High Street, the high volume W Grand Avenue, and a few more minutes, depending on traffic signals, to reach Chase, 17th and Gaynor. The sensor configuration in the illustration below would provide 3 to 4 minutes advance warning about rail traffic approaching from the North and 2 to 12 minutes for rail traffic approaching from the South. The sensor configuration in the illustration below would provide amble re-routing time for this driving use case for a Variable Message Sign [V] located on State Highway 13/73.

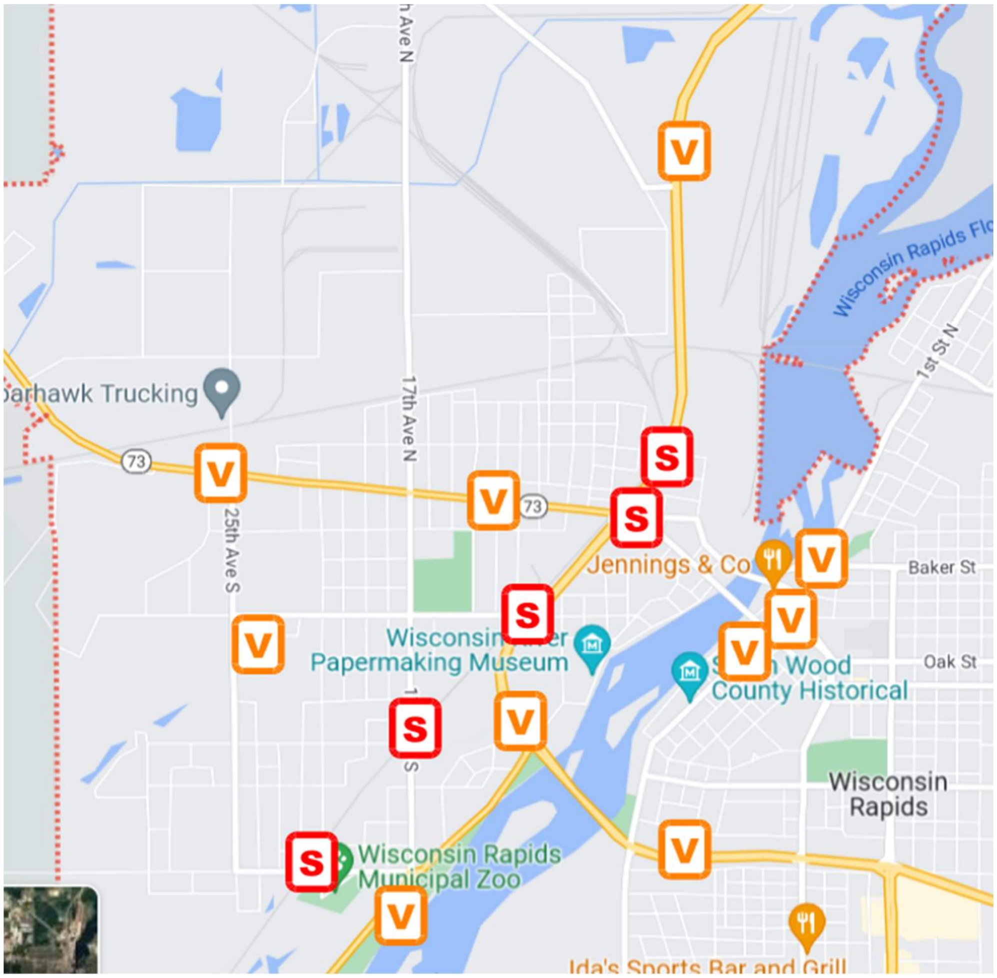

Figure C-7: Sensor and Variable Message Signage Locations

Sensor [S] located at crossings above could give 4-6 minute advance warning of blocked crossing. Variable Message Signage [V] would provide ample alternate route warning information to auto traffic on at-grade crossing ranging from Gaynor to High Street.

Predictive mobility works by placing sensors on municipal or private property and outside the railroad Right of Way. The multiple sensor data described about is streamed to a collection of data centers for processing. It is then delivered to various types of communication mechanisms to provide ADVANCED WARNING of block crossing to enable highway traffic to avoid ending up at a crossing that I blocked.

Figure C-8: Sensor Equipment

The round trip time between sensor and applications is typically between 20 and 40 milliseconds. For critical applications, this time can be decrease with special network configuration. The information is relayed to other cloud connected application like navigation, dispatch and connected vehicles via cloud application programming interface. It can be directly accessed by users like citizens and emergency crews via a mobile application. Finally, all citizens can benefit from this information when integrated to beacons and variable message signage.

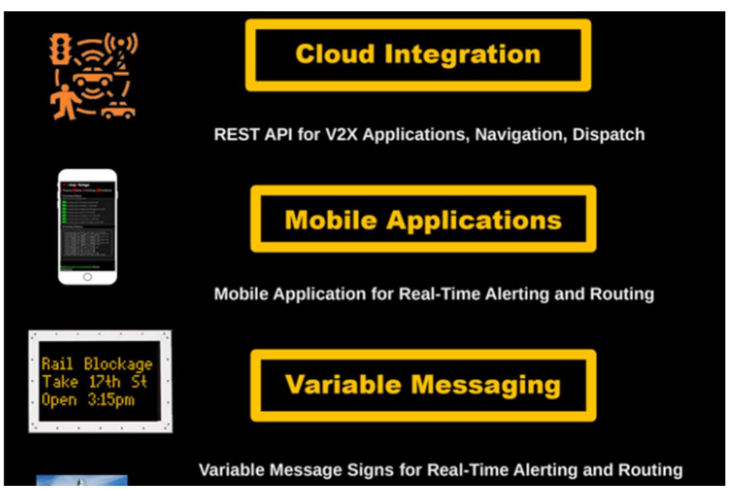

Figure C-9: Notification Options

Appendix D

Safety Economics

It is impossible to assess the personal and potential catastrophic physical, mental and emotional impact of an accident. However, insurance companies have long been experts and defining the economic impacts of accidents. In this section we review accident information for crossings in the city as recording the in the FRA accident report database and then attach these comprehensive insurance number. The purpose is to assess economic impact and ultimately define return on investment for safety improvements.

Accidents

According to the FRA accident reporting site (https://safetydata.fra.dot.gov/OfficeofSafety/PublicSite/Crossing/Crossing.aspx). There were 40 incidents, 29 injuries and 5 fatalities at grade crossings in Wood County between 2013 and 2022. In Wisconsin Rapids there where 33 incidents, 1 death, 22 injuries according to FRA reports from 2013 to 2022. The most recent fatality in Wisconsin Rapids was at Grand Ave in 2014 with a driver disregarded signals to avoid waiting at the crossing. The largest number of accidents (11) occurred at 1st Street and the second largest number of accidents (6) at Engel during this time frame.

Average Comprehensive Cost by Injury Severity, 2020

Death	$11,449,000
Disabling	$1,252,000
Evident	$345,000
Possible injury	$160,000
No injury observed	$52,700

Figure D-1: Comprehensive Costs per injury severity from NSC injury facts

	Events	Cost	Sub Total
Crashes	33	N/A	
No Injuries	28	52700	$1,475,600.00
Injuries	22	345000	$7,590,000.00
Deaths	1	11449000	$11,449,000.00
Total			$20,514,600.00
Average per Year			$2,051,460.00

Figure D-2: Comprehensive cost impacts from rail incidents in Wisconsin Rapids 2013 to 2022

Archived reports are located at:

Emergency Response

There are two Fire Houses in Wisconsin Rapids located on each side of Valley Sub corridor Rail to comply with NIST and NFPA requirements. However, according to the Fire Chief, there are still 6 to 12 times each year that Fire Response is blocked at a crossing. There is only one Hospital in Wisconsin Rapids and it is located on the east side of the track.

Appendix E

Congestion Economics

The public survey showed that congestion is the top concern regarding rail crossings in Wisconsin Rapids. We reviewed data for 13 crossings in Wisconsin Rapids and have provided a preliminary cost impact on the community due to congestion. The economic analysis includes impact from traffic congestion. The impact due to safety concerns is included in the next appendix. The congestion information combines AADT numbers from WisDOT and average blocking statistics collected by LinqThingz sensors.

ASSUMPTIONS	
Blocked	6.00%
Minimum Detour	1.00
Maximum Detour	5.00
Average Wait (min)	8.00
Through Time (min)	0.50
Op cost per mile ($)	3.25
Responses per year	3,976.00
carbon (g) per gal	8887
gal per min	0.00833
carbon cost ($/ton)	50
Citizen Delay Value ($/hr)	26
Logistics Delay Value ($/hr)	187
percent logistic traffic	30.00%
Citizen Delay Value ($/hr)	26
Logistics Delay Value ($/hr)	187
percent logistic traffic	30.00%
Dollar per Gallon	4
Work Days Per Year	260
population affected	18738

Figure E-1: Congestion Impact Assumptions

Crossing	AADT(vehicles)	Carbon Cost ($)	Fuel ($/yr)	Citizen Costs ($/yr)	Supply Chain Costs ($/yr)
Grand Av	11,900.00	$7,720	$69,496.00	$632,414	$1,218,352
Gaynor	2,800.00	$1,817	$16,352.00	$148,803	$286,671
17th Av Northern Crossing	1,700.00	$1,103	$9,928.00	$90,345	$174,050
17th Av Middle Crossing	1,700.00	$1,103	$9,928.00	$90,345	$174,050
Chase	2,900.00	$1,881	$16,936.00	$154,118	$296,909
High St	1,600.00	$1,038	$9,344.00	$85,030	$163,812
Fremont	0.00	$0	$0.00	$0	$0
1st St	2,400.00	$1,557	$14,016.00	$127,546	$245,718
25th Ave	2,800.00	$1,817	$16,352.00	$148,803	$286,671
Industrial St	870.00	$564	$5,080.80	$46,235	$89,073
Engel	780.00	$506	$4,555.20	$41,452	$79,858
17th av Southern Crossing	2,000.00	$1,298	$11,680.00	$106,288	$204,765
Bonow	2,500.00	$1,622	$14,600.00	$132,860	$255,956
	AADT(vehicles)	Carbon Cost ($)	Fuel ($/yr)	Citizen Costs ($/yr)	Supply Chain Costs ($/yr)
Total	33,950.00	$22,025.10	$198,268.00	$1,804,238.80	$3,475,885.88

Figure E-2: Calculations

PATRICK

LinqThingz Predictive Mobility

Appendix F

Public Survey

PATRICK

LinqThingz
Predictive Mobility

Ninety-Eight percent of the Wisconsin Rapids Community agrees with the importance of rail and truck traffic to the region.

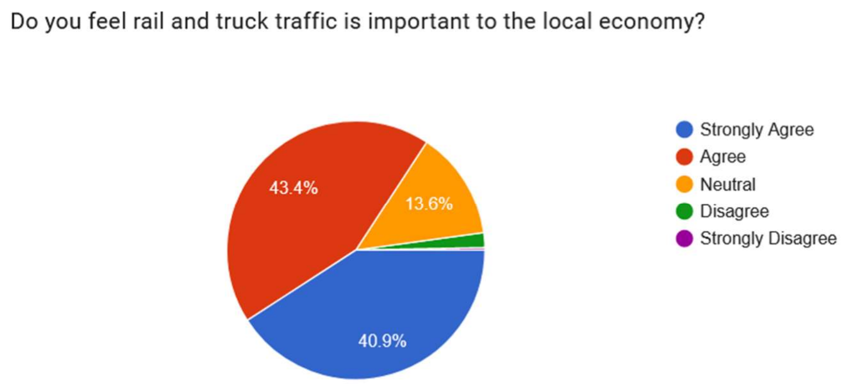

Figure F-1: Rail and Trunk Importance

Community understands importance of rail to local economy (Wisconsin Rapids Survey see below)

The impact of rail crossing blockages is a great concern to the citizens with over 1000 participants in the online survey.

A public survey was created and made available to the public at: https://forms.gle/VMUkcrCUZjdBacip7

955 citizens responded as of December 8, 2022.

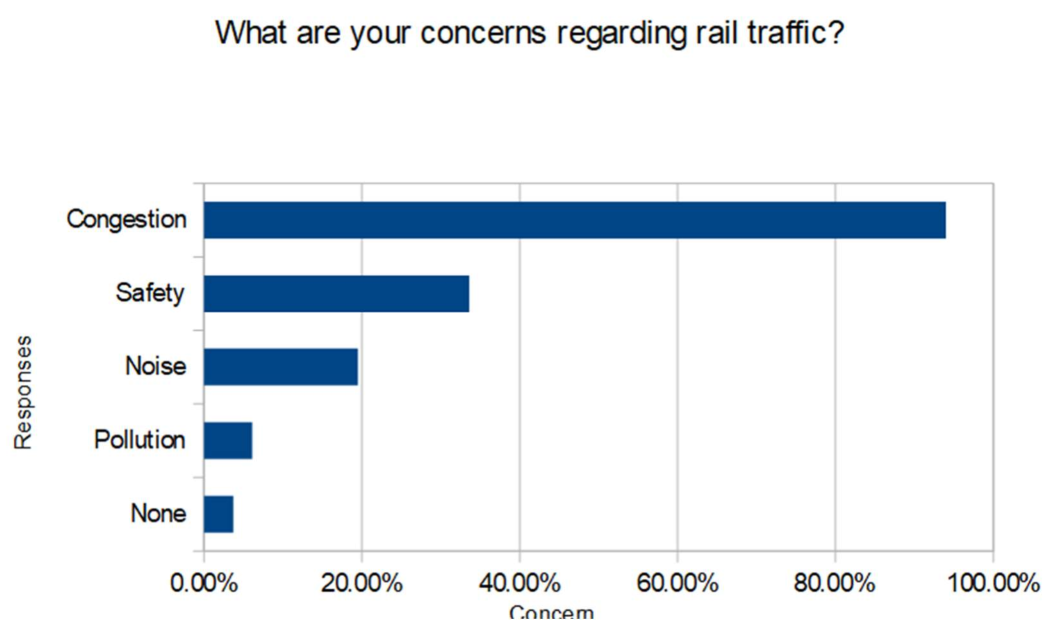

Figure F-2: Concerns regarding Rail Traffic

Rail congestion is a concern for 95% of the survey respondents followed by safety, noise and pollution.

In the past 30 days. How many times have you been stopped by blocked rail crossing?

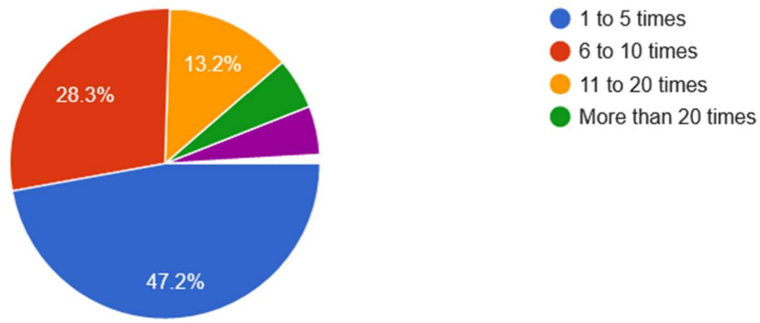

Figure F-3: Delay Frequency

95% of the community respondent have been blocked by rail traffic in the past 30 days.

What is the LONGEST time that you waited at a rail crossing?

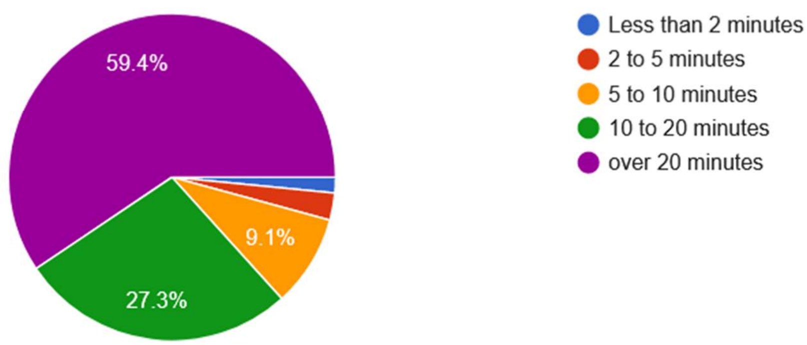

Figure F-4: Longest Delay

Almost 60% of the community respondent have been experience blockages over 20 minutes in the past 30 days.

What is the TYPICAL time that you wait at rail crossing?

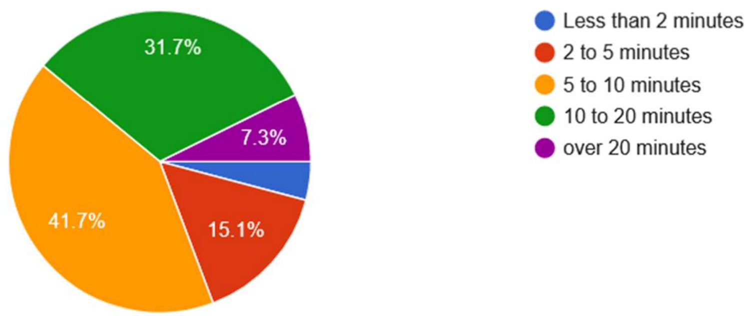

Figure F-5: Typical Delay Time

Almost 75% of the community wait at a crossing is between 5 and 20 minutes.

Have you been late for, or missed,
an appointment/event/school due to a train blockage?

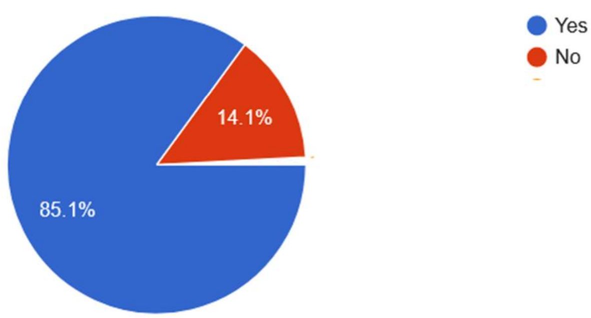

Figure F-6: Delay Impacts

85% of the community have missed important appointments due to blocked crossings

When approaching an intersection blocked by a train, have you turned around, used neighborhood streets or tried to beat the train to an unblocked at-grade crossing to avoid being delayed?

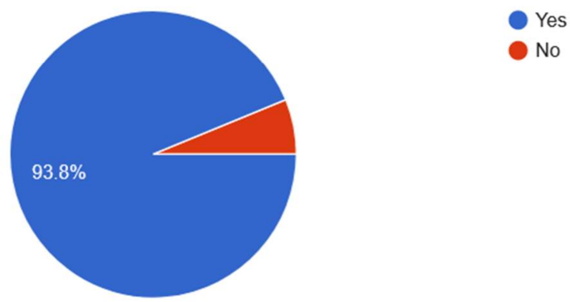

Figure F-7: Avoiding Blocked Crossing

Almost 95% of the community engages in dangerous safety behavior to avoid blocked crossings. Standard safety measures do not address this behavior issue that causes over 70% of grade crossing fatalities according to the FRA.

Have you altered travel plans due to rail crossing (i.e., left early or later, took a different route, etc.)?

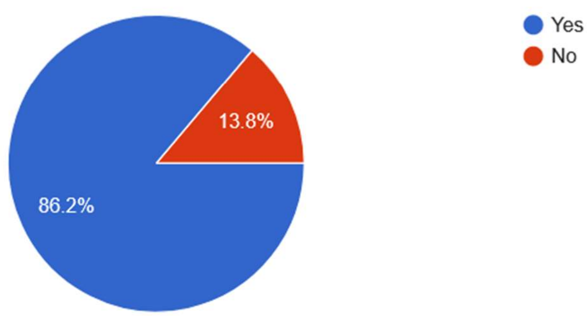

Figure F-8: Altered Travel Plans

More than 85% change travel plans to address rail crossings. However, no one has information about when they will be delayed or for how long. The crossings are blocked only about 6% of the time. So 85% of the time citizens alter their plans even though there is a 94% chance that they will not be blocked at a crossing.

What transportation do you use most?

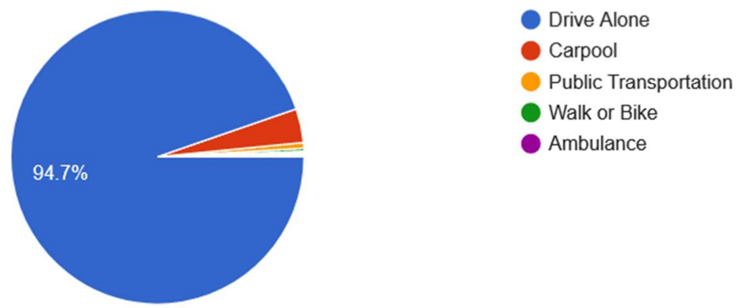

Figure F-9: Transportation Type

95% if the impact is people driving their own vehicle.

What cities do you travel in and encounter rail delays?

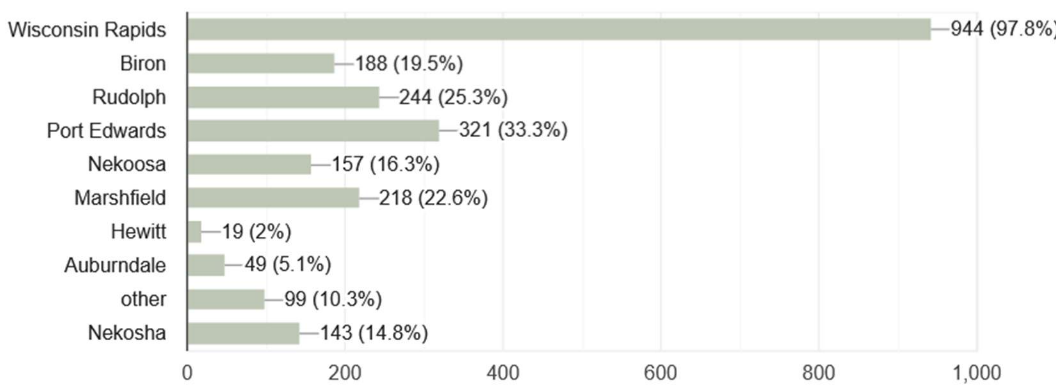

Figure F-10: Rail delay in Cities

Wisconsin Rapids residents also experience the congestion problems in neighboring communities (note Nekosha and Nekoosa are the same due to typo in original survey so Nekoosa total is 300 [31.1%]).

Appendix G

Cost Analysis

Budgetary Quote 20220202_01 Predictive Mobility System Wisconsin Rapids.

LinqThingz Predictive Mobility System can give up to 10 minutes advanced warning of blocked rail crossings. **Advanced warning** and **Alternate routing** ensures highway users do not cross rail tracks while train is using the same track. The reduces congestion, safety, pollution and improves the standard of living of a city with significant freight rail presence.

Sensors are mounted on existing or new poles on municipal property outside of railroad Right of Way. The sensors can be powered by continuous 120VAC, Solar or Intermittent 120VAC. The sensors can connect to a network via fiber, cellular or special radio interfaces.

The advanced warning and routing information is provide to customer via Mobile Application, Connection to other 3rd party navigation, dispatch or connected vehicles services or by network-controlled roadside active signage.

There are many combinations of technology configurations that can be customized to suite city needs. Individual pricing is included on next page.

Example 1: Minimum Proof of concept at a single crossing ($52,000)

This example includes 16 solar/cellular powered trainable sensor modules mounted on existing light or traffic poles. Free use of Android/Apple mobile application and one free cloud notification feed to navigation, dispatch of other service (fees may apply to that service). One year warranty and three years network connectivity included.

Example 2: Minimum Digital-Only City-wide solution ($217,200)

This example includes sixteen solar/cellular powered trainable sensor modules mounted on existing light or traffic poles and assumed 8 new pole installations. Augmented sensor modules on 4 devices to address complex rail yard/road traffic on 17th. Free use of Android/Apple mobile application and one free cloud notification feed to navigation, dispatch of other service (fees may apply to that service). One year warranty and three years network connectivity included.

Example 3: Value-Based City-wide solution with Active Signage ($375,000).

This example include sixteen solar/cellular powered trainable sensor modules mounted on existing light or traffic poles and assumed 8 new pole installations. Augmented sensor modules on 4 devices to address complex rail yard/road traffic on 17th. An assortment of beacon and variable message signage to address traffic needs of arterial, connector and local roads. Free use of Android/Apple mobile application and one free cloud notification feed to navigation, dispatch of other service (fees may apply to that service). One year warranty and three years network connectivity included.

TAPCO is the exclusive distributor for Wisconsin. LinqThingz products can be purchased through TAPCO using a variety of existing contract vehicles including OMNIA cooperative purchasing and GSA.

Budgetary Pricing for Predictive Mobility System

Trainable Sensor Modules	$7,500	$7,500
3 years mobile connectivity	$3,600	$3,600
Opt Solar/Cellular Integration box	$1,500	$1,500
Opt pole with helical anchor (if not installing on existing pole)		$2,200
Pole Install (if not installing on existing pole)		$2,100
Total	**$12,600**	**$16,900**
Customer Mobile App Support (3 Yr)	Included	
Cloud Data Feed for CAD (3 Yr)	Included	

Highway Signage Options

Option 1	Price
Solar powered (Dual 85W), Dual Beacon, sign, pole with helical anchor, cabinet with contact closure	$5,500
Installation estimate for option 1 (assuming at least 5 installs)	$2,100
Total	**7800**
Option 2	
AC powered, Dual Beacon, sign, pole, cabinet w/contact closure	$4,500
Installation estimate option 2 (assuming at least 5 installs)	2100 per pole
(For 120v power installed into existing MB up to 50', includes conduit and wire)	$1,800
Total	**$6,800**
Option 3	
24"x24" custom Blank out sign, contact closure activation, AC powered including pole	$7,500
installation option 3 (assuming at least 5 installs	$2,100 per pole
(For 120v power installed into existing MB up to 50', includes conduit and wire)	$1,800
Total	**$9,800**
Option 4,	
4'x8' custom Blank out sign, contact closure activation, AC powered including poles	$22,000
installation option 4	$6,000
Total	**$28,000**
Option 5	
24"x18" Variable message sign, AC power including pole	$12,000
installation option 5	2100 per pole
For 120v power installed into existing MB up to 50', includes conduit and wire)	$1,800
Total	**$14,100**
Option 6	
4'x10' Variable message sign, AC power (1 year lead time)	$40,000
2 mounting posts	$12,000
installation option 6	$2,000
Total	**$54,000**
Option 7, Full matrix large portable message trailer (solar powered) - PURCHASE	**$22,000**

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	Alternate 3 - Extend NB LT Lane				
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Clearing and Grubbing, Remove Topsoil,	SY	$10	200	$2,000
11	Pavement and Removal	SY	$10	200	$2,000
12	Install Asphalt Pavement and Agg Base	SY	$50	200	$10,000
13	Install Curb and Gutter	LF	$50	750	$37,500
16	Utility Cost	LS	$500,000	1	$500,000
17	Soft Costs (25%)	LS		1	$140,000
18	Contingency (40%)	LS		1	$280,000
				Total	$1,000,000

Note: The quantities presented here are for major items only, are an estimate based on aerial and GIS information, are for guidance only and do not represent every item necessary for complete construction. This opinion of probable construction cost is based on Patrick Engineering's ("PEI's") best judgement and experiences and has been prepared to provide guidance, to aid in decision making, and should only be used for an order of magnitude level analysis. This is not a bid, or a quote, or a cost estimate to perform work. Items, quantities, and unit costs are based on information available at this time not detailed final

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	Alternate 4-1: Track Relocation - City West Edge					
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Clearing and Grubbing, Remove Topsoil, Respread	SY	$10	78,000	$780,000
2	Property Acquisition	AC	$5,000	33	$165,000
3	Sub Ballast (12" road base stone section), Including	CY	$50	13,000	$650,000
4	Furnish and Install No. 20 Turnout Wood Tie Power 136RE	EA	$500,000	2	$1,000,000
5	Furnish, Construct and Install new track including ballast, 136 RE jointed rail and timber ties.	TF	$250	14,000	$3,500,000
6	Signal Costs for New Corridor	TF	$250	14,000	$3,500,000
7	Bridge	EA	$1,000,000	3	$3,000,000
8	Install New Crossing	EA	$750,000	3	$2,250,000
9	Utility Cost	LS	$1,000,000	1	$1,000,000
10	Soft Costs (25%)	LS		1	$3,970,000
11	Contingency (40%)	LS		1	$7,930,000
				Total	$27,800,000

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	Alternate 4-2: Track Relocation - County lands				
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Clearing and Grubbing, Remove Topsoil, Respread	SY	$10	145,000	$1,450,000
2	Property Acquisition	AC	$5,000	60	$300,000
3	Sub Ballast (12" road base stone section), Including Access Roadway	CY	$50	24,000	$1,200,000
4	Furnish and Install No. 20 Turnout Wood Tie Hand Throw 136RE	EA	$500,000	2	$1,000,000
5	Furnish, Construct and Install new track including ballast, 136 RE jointed rail and timber ties.	TF	$250	26,000	$6,500,000
	Signal Costs for New Corridor	TF	$250	26,000	$6,500,000
6	Bridge	EA	$1,000,000	1	$1,000,000
7	Install New Crossing	EA	$750,000	1	$750,000
8	Utility Cost	LS	$1,000,000	1	$1,000,000
9	Soft Costs (25%)	LS		1	$4,930,000
10	Contingency (40%)	LS		1	$9,860,000
				Total	$34,500,000

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	Alternate 5-1: Grade Separation - Railroad Under				
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Embankment (Fill)	CY	$10	650,000	$6,500,000
2	Bridge	EA	$1,000,000	1	$1,000,000
3	Install New Crossing	EA	$750,000		$0
4	Pavement and Removal	SY	$10	30000	$300,000
5	Install Asphalt Pavement and Agg Base	SY	$50	30000	$1,500,000
6	Install Curb and Gutter	LF	$50	4500	$225,000
7	Retaining Wall	SSF	$190	45000	$8,550,000
8	Utility Cost	LS	$500,000	1	$500,000
9	Soft Costs (25%)	LS		1	$4,650,000
10	Contingency (40%)	LS		1	$9,290,000
	Total				$32,600,000

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	Alternate 5-2: Grade Separation - Railroad Over				
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Earthwork (Cut)	CY	$5	400,000	$2,000,000
2	Furnish, Construct and Install new track including ballast, 136 RE jointed rail and timber ties.	TF	$250	2,000	$500,000
3	Pavement and Removal	SY	$10	25000	$250,000
4	Install Asphalt Pavement and Agg Base	SY	$50	25000	$1,250,000
5	Install Curb and Gutter	LF	$50	4200	$210,000
6	Pump Station	EA	$1,000,000	1	$1,000,000
7	Railroad Bridge	EA	$5,000,000	1	$5,000,000
8	Retaining Wall	SSF	$190	42000	$7,980,000
9	Utility Cost	LS	$1,000,000	1	$1,000,000
10	Soft Costs (25%)	LS		1	$4,800,000
11	Contingency (40%)	LS		1	$9,600,000
				Total	$33,600,000

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	Alternate 6-1: Quiet Zone Option 1 - Grade Separate Grand Ave				
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Traffic Control and Protection	LS	$3,500	8	$28,000
2	Quiet Zone Pedestrian Signage	EA	$600	14	$8,400
3	Quiet Zone Crossing Signage	EA	$600	24	$14,400
4	Update Pavement Markings	LS	$3,500	8	$28,000
5	Grade Separate Grand Ave	LS	$20,000,000	1	$20,000,000
6	Crossing Gates	EA	$250,000	6	$1,500,000
10	Soft Costs (25%)	LS		1	$5,400,000
11	Contingency (40%)	LS		1	$10,800,000
				Total	$37,800,000

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	Alternate 6-2: Quiet Zone Option 2 - Improvements at Borow Avenue				
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Traffic Control and Protection	LS	$3,500	9	$31,500
2	Quiet Zone Pedestrian Signage	EA	$600	18	$10,800
3	Quiet Zone Crossing Signage	EA	$600	28	$16,800
4	Update Pavement Markings	LS	$3,500	9	$31,500
5	200 LF Quick Curb for Full SSM	LS	$17,000	1	$17,000
6	Crossing Gates	EA	$250,000	6	$1,500,000
10	Soft Costs (25%)	LS		1	$410,000
11	Contingency (40%)	LS		1	$810,000
				Total	$2,900,000

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	Alternate 6-3: Quiet Zone Option 2 - Improvements at Gaynor and 17th St				
Item Number	**Item Description**	**Units**	**Estimated Unit Cost**	**Estimated Quantity**	**Estimated Cost**
1	Traffic Control and Protection	LS	$3,500	9	$31,500
2	Quiet Zone Pedestrian Signage	EA	$600	18	$10,800
3	Quiet Zone Crossing Signage	EA	$600	28	$16,800
4	Update Pavement Markings	LS	$3,500	9	$31,500
5	120 LF Quick Curb for Full SSM	LS	$11,500	1	$11,500
6	120 LF Quick Curb for Full SSM	LS	$11,500	1	$11,500
7	Crossing Gates	EA	$250,000	6	$1,500,000
8	Soft Costs (25%)	LS		1	$410,000
9	Contingency (40%)	LS		1	$810,000
				Total	$2,900,000

Note: The quantities presented here are for major items only, are an estimate based on aerial and GIS information, are for guidance only and do not represent every item necessary for complete construction. This opinion of probable construction cost is based on Patrick Engineering's ("PEI's") best judgement and experiences and has been prepared to provide guidance, to aid in decision making, and should only be used for an order of magnitude level analysis. This is not a bid, or a quote, or a cost estimate to perform work. Items, quantities,

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	Alternate 6-4: Whitehall Sub Quiet Zone				
Item Number	Item Description	Units	Estimated Unit Cost	Estimated Quantity	Estimated Cost
1	Traffic Control and Protection	LS	$3,500	6	$21,000
2	Quiet Zone Crossing Signage	EA	$600	12	$7,200
3	Update Pavement Markings	LS	$3,500	6	$21,000
4	Crossing Gates	EA	$250,000	12	$3,000,000
5	Soft Costs (25%)	LS		1	$770,000
6	Contingency (40%)	LS		1	$1,530,000
				Total	$5,400,000

Note: The quantities presented here are for major items only, are an estimate based on aerial and GIS information, are for guidance only and do not represent every item necessary for complete construction. This opinion of probable construction cost is based on Patrick Engineering's ("PEI's") best judgement and experiences and has been prepared to provide guidance, to aid in decision making, and should only be used for an order of magnitude level analysis. This is not a bid, or a quote, or a cost estimate to perform work.