2018

NCHRP 25-50 RCAT

USERS GUIDE

INTRODUCTION..... 2

OVERVIEW OF THE RCAT METHODOLOGY..... 2

VISUALIZING THE MULTI-CRITERIA EVALUATION.....2

APPROACH.....3

THE RCAT MODEL APPROACH.....4

A. FORMULATE THE PROBLEM.....4

B. COLLECT THE DATA.....5

C. SETTING UP THE PRIORITIZATION TOOL AND DOWNLOAD.....7
THE DATA FROM THE FRA INVENTORY

D. PREPARING EACH OF THE 4 MODULE.....15

E. RUN THE RCAT MODEL - FINAL SCORE.....32

F. ANALYZE THE FINDINGS.....34

G. INTERPRET THE RESULTS.....36

H. RERUN THE MODEL TO DETERMINE SENSITIVITY.....36

INTRODUCTION

The Rail Crossing Assessment Tool (RCAT) was developed based on previous research, transportation agency input, professional guidelines and reports, and practical experience, which is described in detail in the NCHRP Project 25-50 Final Report. Users of the RCAT tool should be aware that a great deal of data collection and cleaning will be necessary; gaps exist in the FRA database that must be filled for the tool to function properly. Users should be technically competent (ability to conduct GIS analysis is preferred) and familiar with the corridors and locations that are being analyzed. Finally, it is recommended that corridor analyses be conducted under the same assumptions for the factors involved and not compared from analysis to analysis as assumptions for qualitative data may yield varying results from user to user.

RCAT has been developed under NCHRP project 25-50 in cooperation with, FHWA, FRA and AASHTO. RCAT is a multi-criteria assessment tool designed to help state and local officials prioritize at-grade railroad crossings within a corridor or region to evaluate and rank at-grade crossings for separation projects or other improvements.

This appendix explains how to use the programmed spreadsheet, which is built around the RCAT methodology. The programmed spreadsheet is intended to facilitate prioritization of rail crossings within a user defined rail corridor based on the RCAT methodology; however, Grade Crossing prioritization within a corridor can be implemented independently of the programmed RCAT spreadsheet using a variety of technological tools.

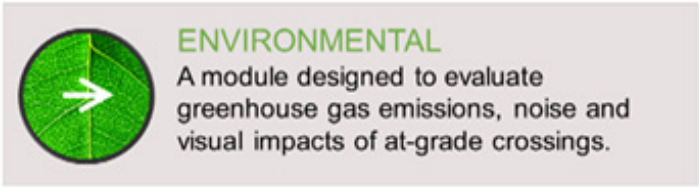
ORVIEW OF THE RCAT METHODOLOGY

VISUALIZING THE MULTI-CRITERIA EVALUATION TOOL

This research effort developed a programmed spreadsheet tool that state and local planners can use to assist their efforts at prioritizing at-grade crossing improvements. The evaluation tool consisting of four modules.

1. SAFETY: This module is a quantitative evaluation module that prioritizes at-grade crossing locations for separation or other improvements based largely on traditional safety criteria such as historical safety record of crossings, accident prediction, number of tracks, traffic levels, etc. This module includes information and links to resources for improving traffic count and other data. For instance, the American Association of State Highway and Transportation Officials (AASHTO) established a technology implementation group (TIG) that surveyed states and railroads on state-of-the-art grade crossing electronic document management systems. Links to this research, as well as links and information about low-cost techniques and technologies for improving the accuracy and timeliness of traffic counts or other key data elements, will be included.

2. ECONOMIC: This module is based on quantitative or monetized factors and safety savings and other qualitative economic factors. Quantitative factors include travel time savings for commuters, as well as commercial driver/freight savings. Qualitative economic factors include mobility improvements based upon density around the crossing and economic impacts on adjacent properties. The module is designed to allow users to select and weigh criteria based on data availability and desired level of analysis. This module may provide data that can be used to conduct a benefit-cost or an economic impact analyses to support grant and other funding applications.

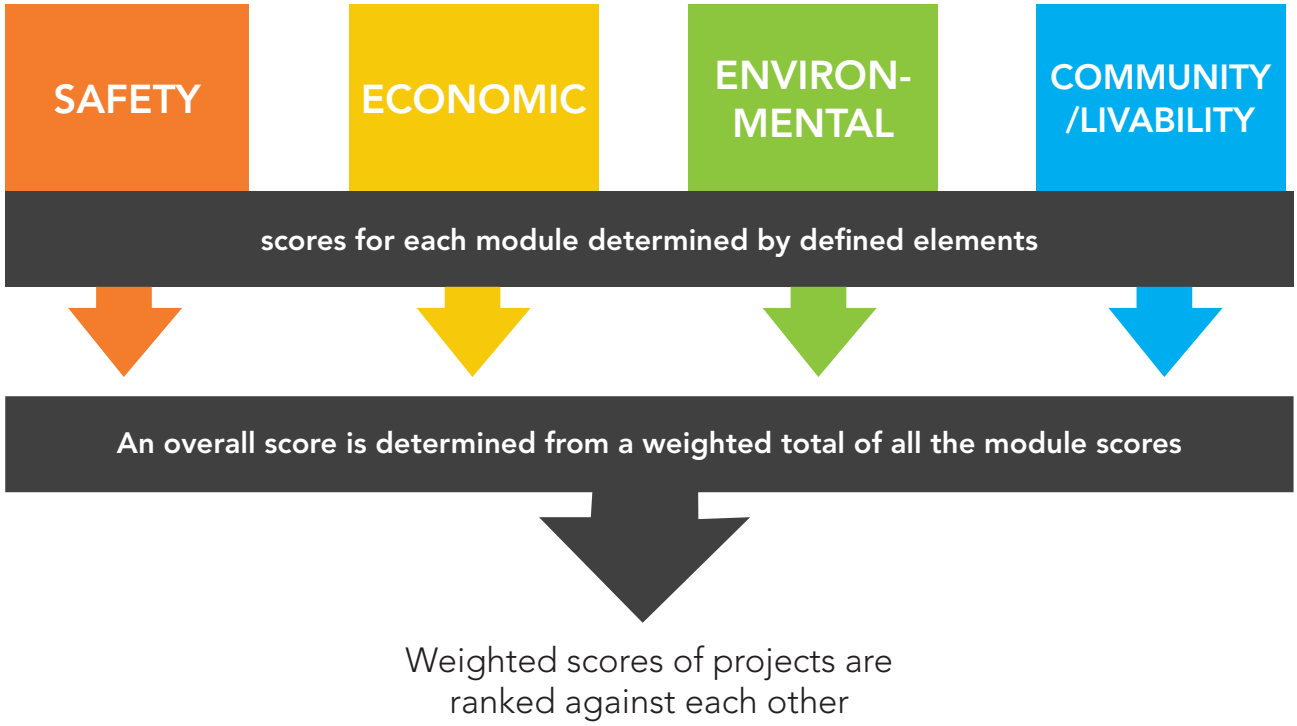


3. ENVIRONMENTAL: This module includes factors for greenhouse gas emissions, visual or audible environmental impacts, potential impacts to waterways and wetlands in the event of a cargo spill, etc.

4. COMMUNITY/LIVABILITY: This module incorporates quantitative risk factors such as number of hazardous cargo cars, residential population densities, fixed populations, transient populations, emergency service locations and routes, and local agency priorities.

The results of four modules are built upon defined elements that are weighted to produce a score for each respective Module. Each Module can be assigned an agency's weighting scheme by the user on the Final Score Tab. To assign a Module weight, the user can use the default weights given to each module in the Final Score Tab or assign their own weighting scheme to generate a Total Weighted Score for each project. Using the results of the Total Score (column O) found on the Final Score Tab, the individual project scores can be sorted by total score values.

Figure 1: Evaluation Methodology

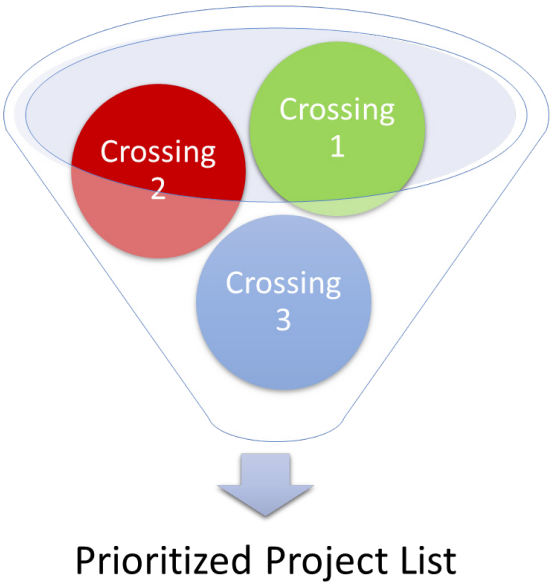


APPROACH

To make the best use of the programmed spreadsheet, it is recommended that the following five-step problem-model-analyze-interpret-rerun process can be used to prioritize Grade Crossings investment decisions within a defined rail corridor.

THE RCAT MODEL APPROACH

A. FORMULATE THE PROBLEM



Using the RCAT model can help support and inform your investment decision-making process. The problem to be solved using this model is: Which Rail crossing(s) within the rail corridor should be selected for public investment?

In this Step, the user formulates the question or questions that must be answered to make the investment decisions or recommendations.

It is recommended to frame the primary business question as follows:

What is the definition of the Rail Corridor to be evaluated? (For example: Milepost to Milepost within a Subdivision or all crossings on a subdivision within a City, County, etc.)[1]

Which rail crossings within the Corridor does the user want to evaluate for improvement? (All or a preselected short list of potential crossings within the Corridor)

What are the characteristics of the crossing and surrounding area?

How does the user want to weight the elements within each Module? How does the user want to weight the four Modules against each other?

B. COLLECT THE DATA

Once the Corridor is defined, the user must decide which crossings within the Corridor are to be selected for evaluation. Due to the amount of data available, the more tightly the Corridor definition is written, the easier it will be to parse the crossing data from the FRA crossing inventory database. Due to the amount of data available and the required user inputs per module, it is recommended that users take time to think about their agency's investment processes. For example, how many crossings does the agency want evaluated? (5, 10, 50, 100?). This decision should be based upon resource availability as each crossing evaluated has 23 elements that must be reviewed and an additional 22 elements that must be populated by the user. It is estimated that it takes 1-2 hours to complete the data collection and input for each crossing. This time estimate is based upon the need to start with the data available from the FRA Crossing Inventory database and then enhance this data by reviewing the available FRA data and then populating the specific elements in each of the four modules. This is accomplished by adding the additional user gathered information into each crossing record as needed in each of the four modules.

What is the locational component?

There are multiple locational components associated with the investment decision you are trying to address with this model. You must identify the corridor to be evaluated and which specific crossings on this corridor you want to be evaluated. A GIS map showing rail crossing location(s) will be helpful. You also need to identify the characteristics of the crossing and area around the crossings—determining what is located within a 1-mile area of each crossing. This determination involves assessing the population density, land use, public services, traffic and train volumes at the crossing as well as specific crossing characteristics.

What data do I need for the model?

To determine which crossing should be prioritized for investment, you will need several types of data:

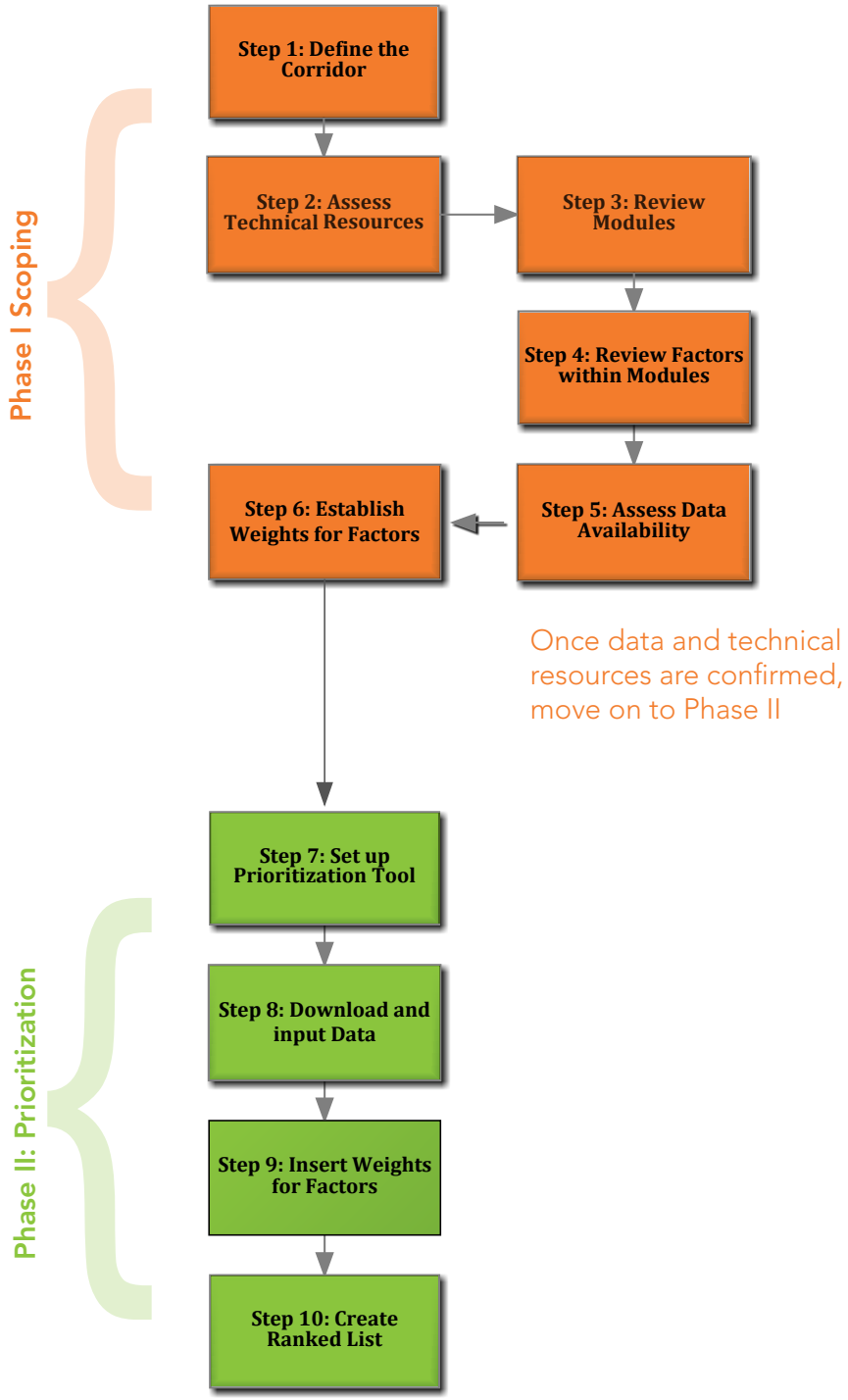
- A good definition of the Corridor, including Location, defined Railroad name, subdivision name, Mileposts on each end.
- FRA inventory data for each selected crossing.
- A satellite image or GIS map of the corridor with a 1-mile buffer around the corridor outlined on the map (This map can be generated with software or a hard copy of a local map.
- Local knowledge for the area and the crossings.

Where can I get the data I need?

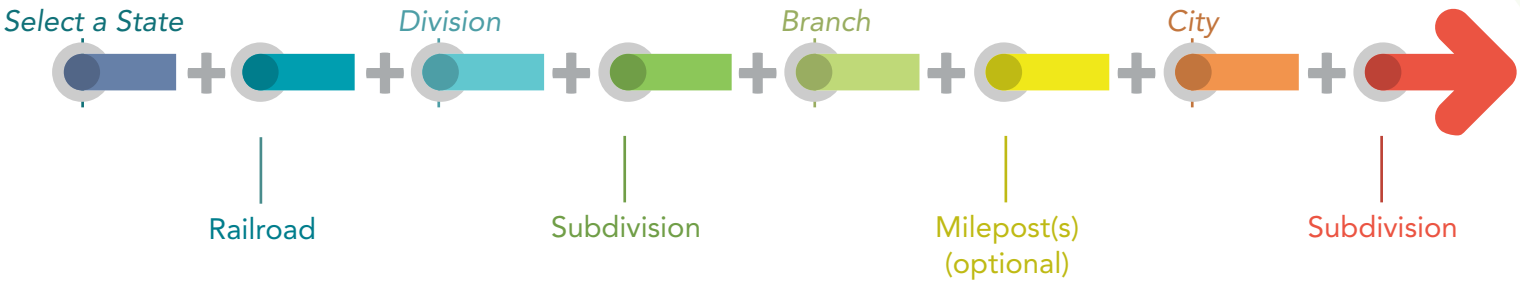
Location data exists in many forms within an organization. Your agency may have crossing and local information such as maps, open source data, Section 1130 project lists, etc. This type of location information can be displayed on a map to show relationships that were not visible before, such as distance between the crossings, the density and type of land use surrounding the crossing, how the crossing are dispersed along the corridor, and so on. ArcGIS Online may be a good tool to map the corridor as it includes population characteristics, road and rail locations, as well as additional information

[1] The Rail Corridor definition can be as large or small as the user chooses.

can be loaded onto different base maps such satellite imagery, street maps, etc.



C. SETTING UP THE PRIORITIZATION TOOL AND DOWNLOAD THE DATA FROM THE FRA INVENTORY



Once these criteria are selected, an available crossing list is produced. You can then select individual crossing id's to analize. Once these Crossings are selection and the Create Modules button is hit this will populate the four modules with the Data elements needed to populate the model include specific crossing data, including the locational components that you need for the evaluation within each module.

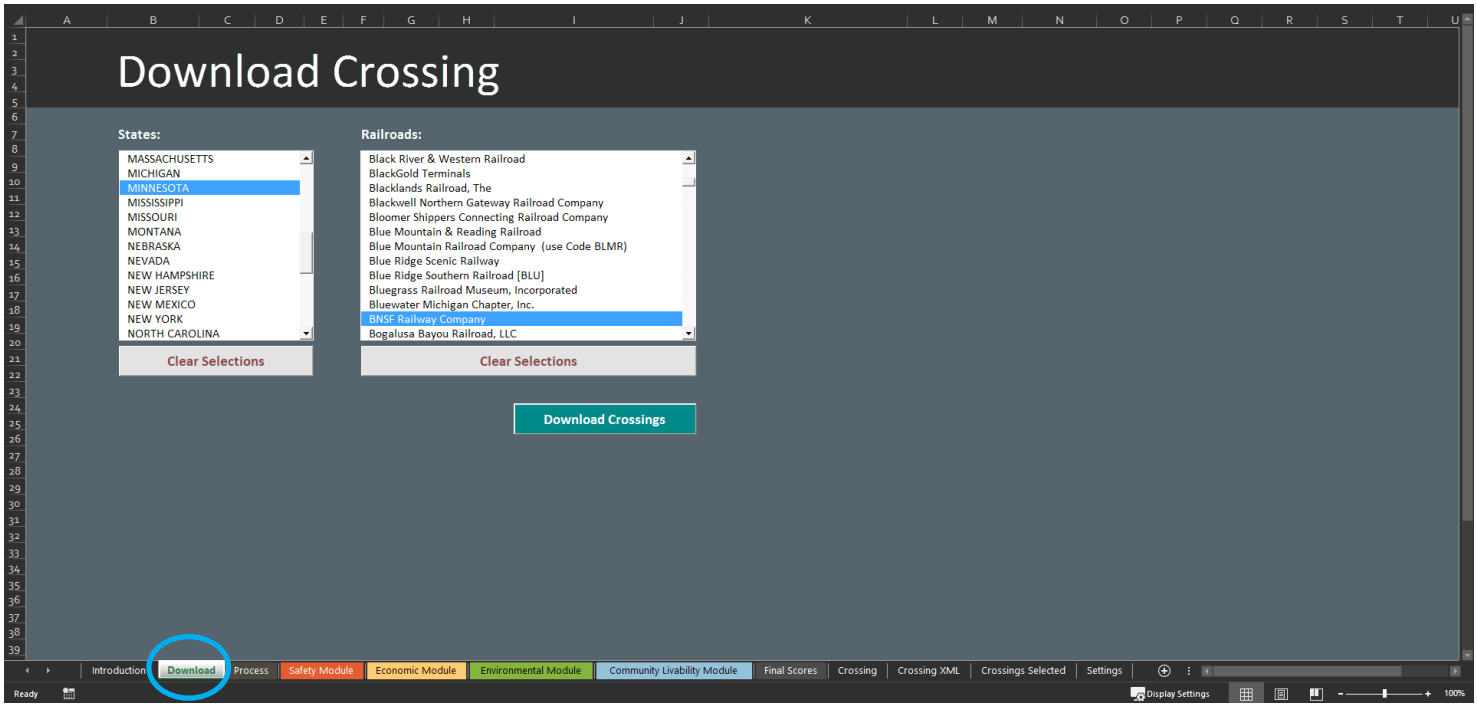
Download the Data into the RCAT Model

The next task is to model the solution or identify what is needed to answer the investment question. This task includes collecting and preparing data to be used in the RCAT model.

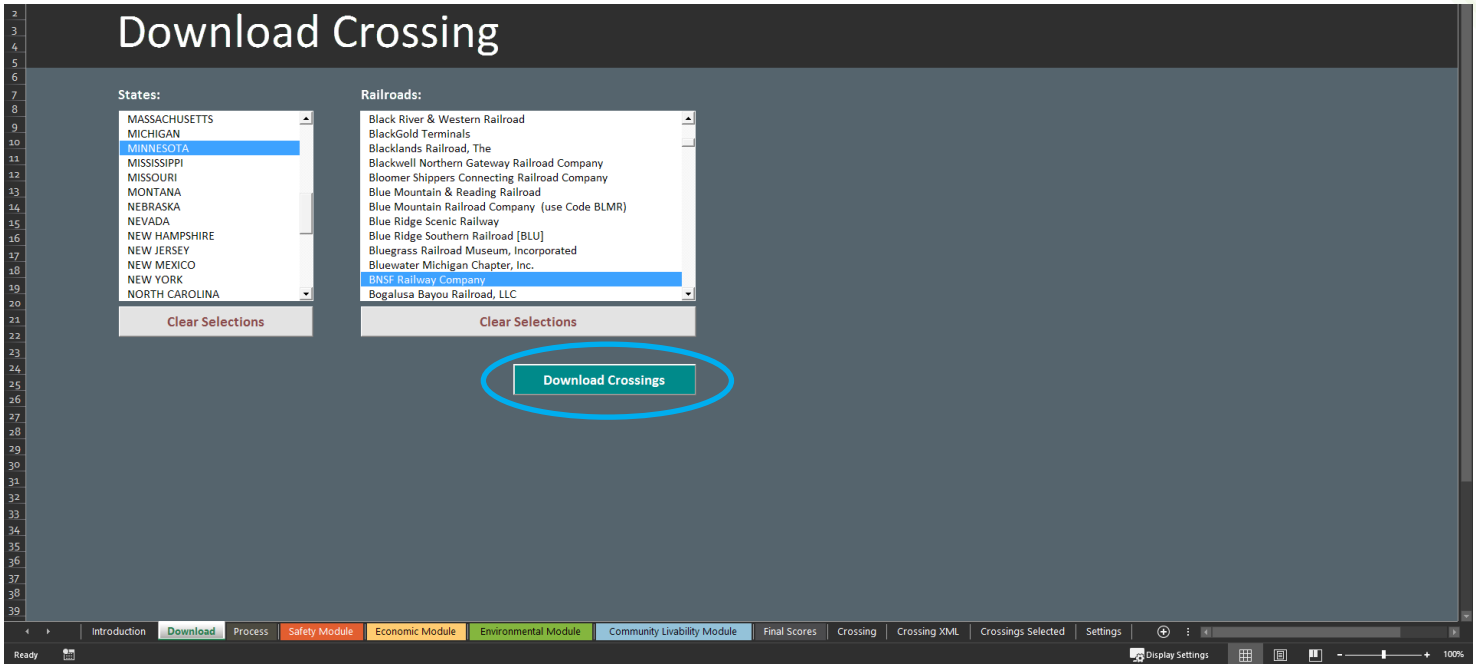
The Rail Corridor definition can be as large or small as the user chooses. The user must be able to define the corridor well enough to designate the Corridor boundaries. The user defined Corridor boundaries must then be turned into a decision tree so that the appropriate crossings can be selected for evaluation.

Step 1: Once the crossing data set is defined, the user can start the data collection needed to populate the model starting with the Download Tab. The RCAT programed spreadsheet allows the user to download the data for a specific state(s) from the FRA Crossing Inventory.

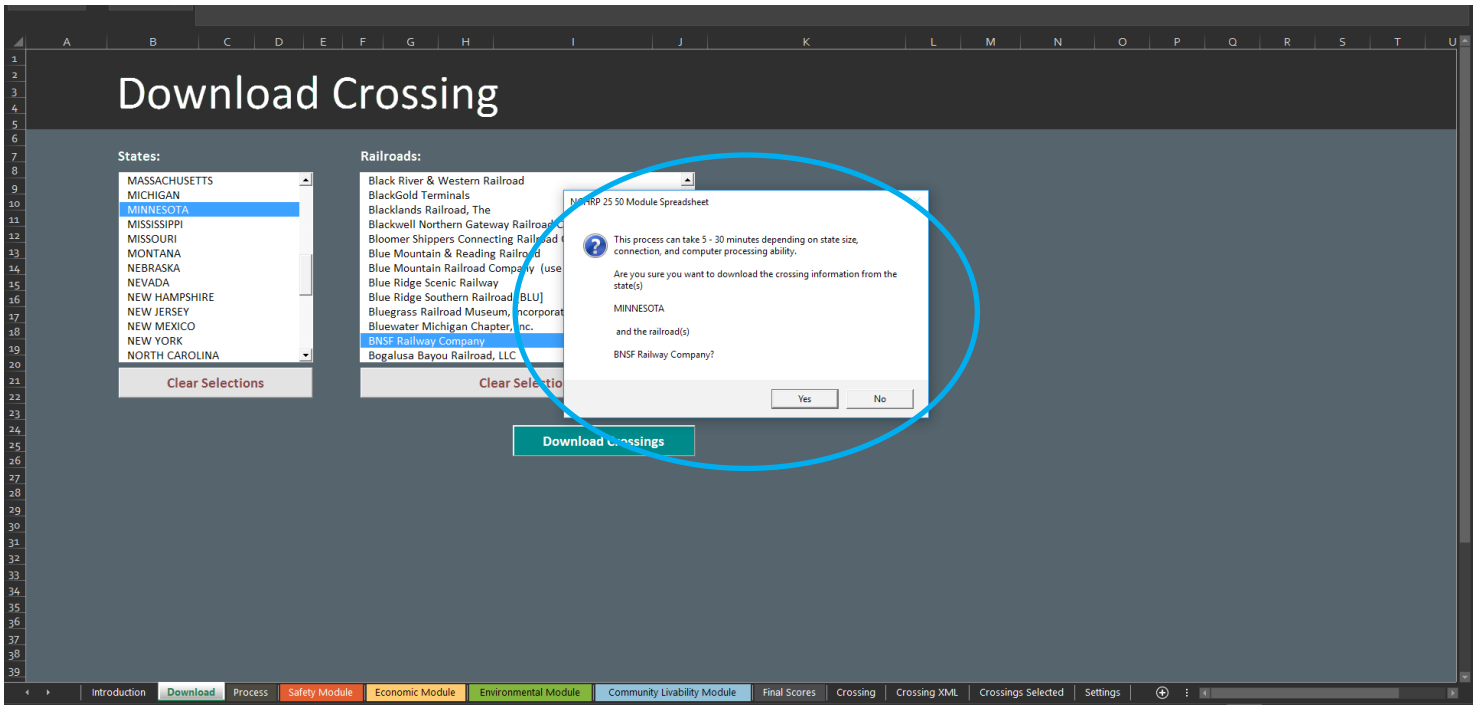
Step 2: On the Download Tab, the user selects the State(s) and the Railroads to be downloaded into the



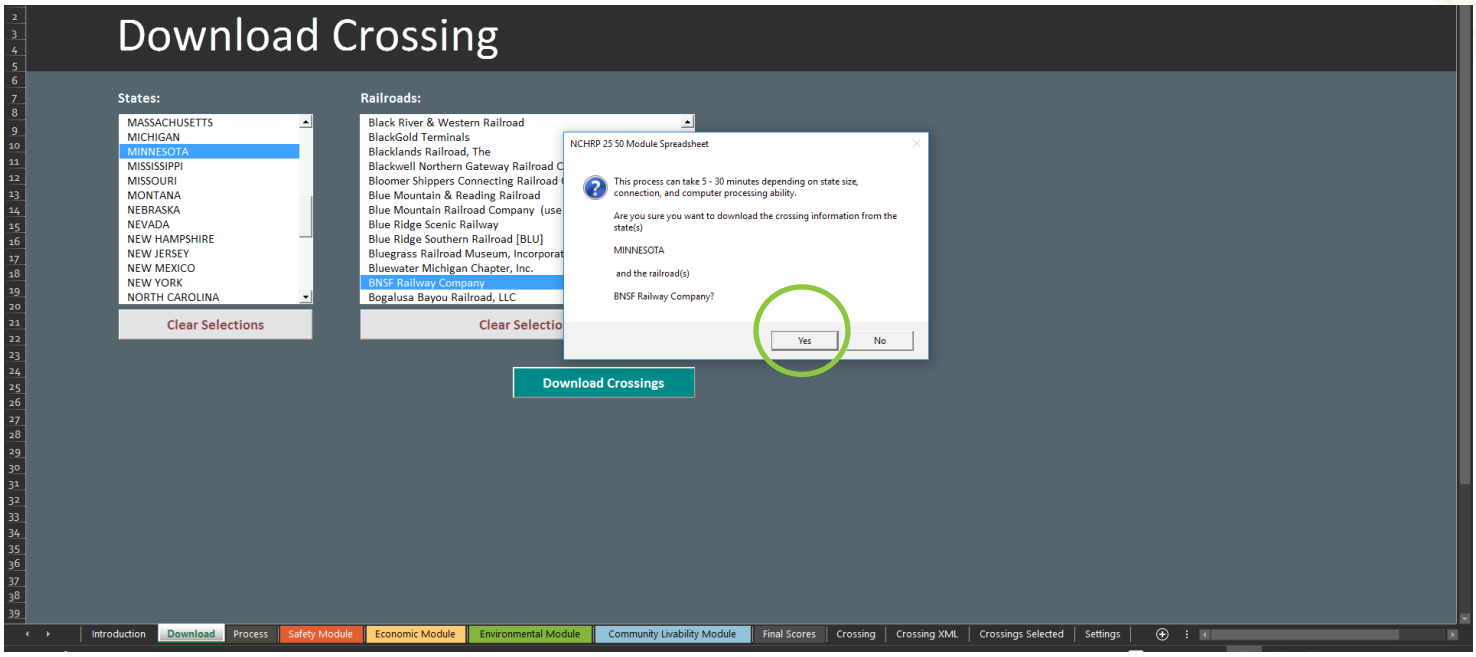
Crossing Tab. Hit the Download Crossing Button.



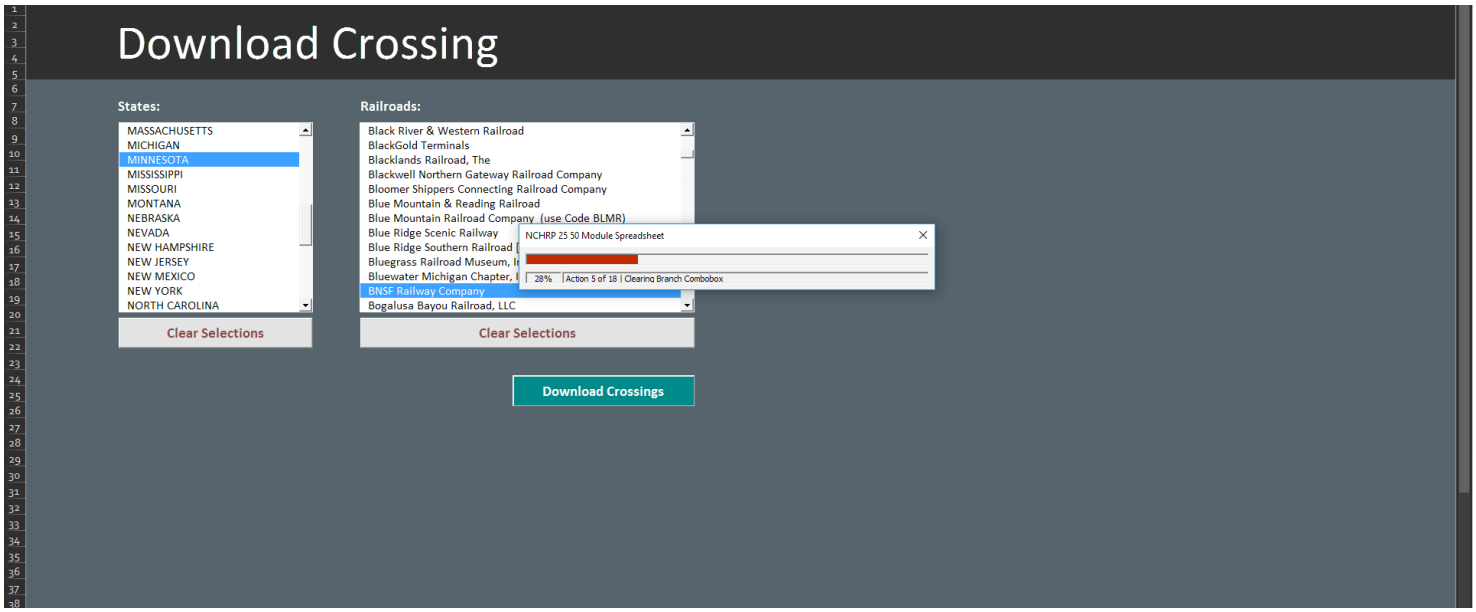
Note: once the user hits the Download Crossing Button, the user will get a message letting them know the download may take 5-30 minutes to download the data depending on the size of the state, the connection bandwidth and the computer's processing ability.



Step 3: Hit Yes and go get a cup of coffee.



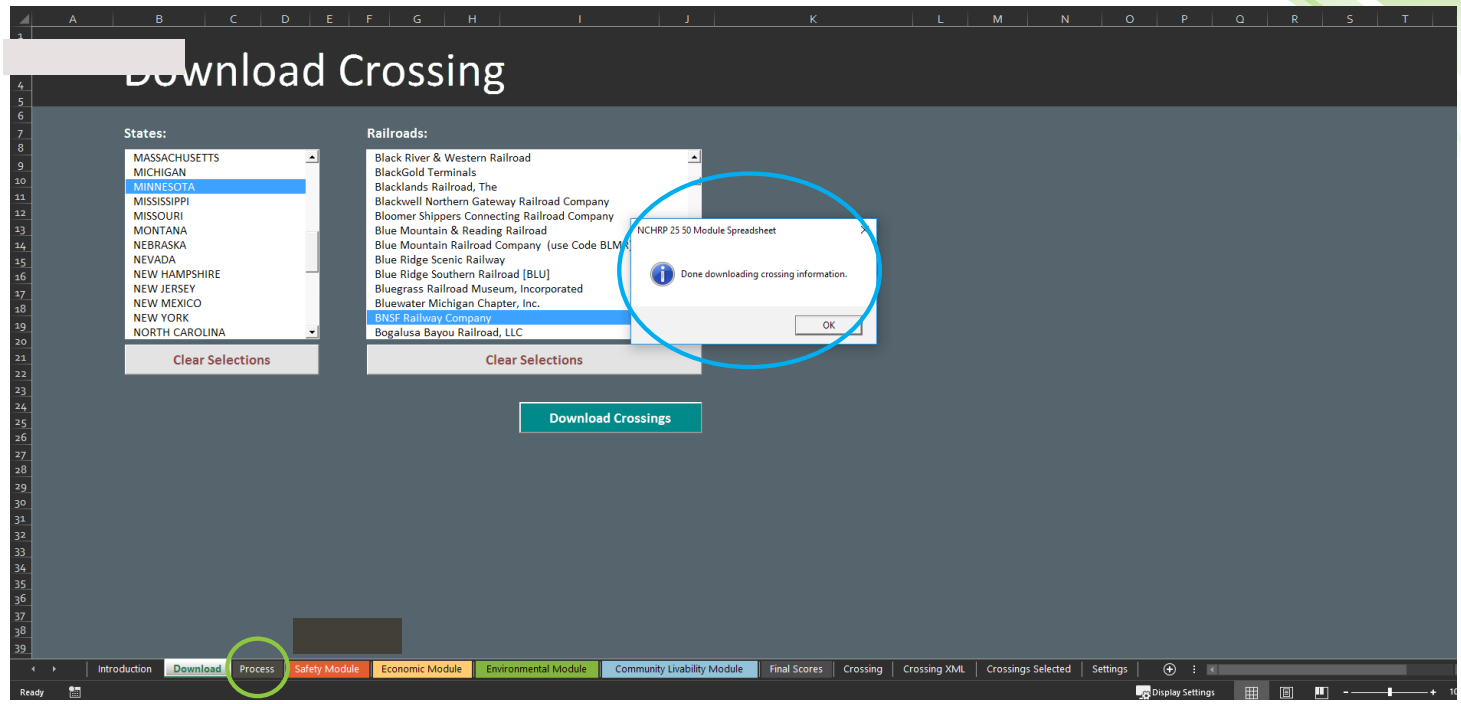
Step 4: The Download from the FRA database will begin, and you will see multiple progress bars as the Model downloads the data for the selected crossings and parses the data into the Crossings Tab.



Note: downloading and populating the RCAT spreadsheet with a State's crossing information can take time as the data is parsed and indexed as it is downloaded from the FRA website into the Crossings Tab in the model.

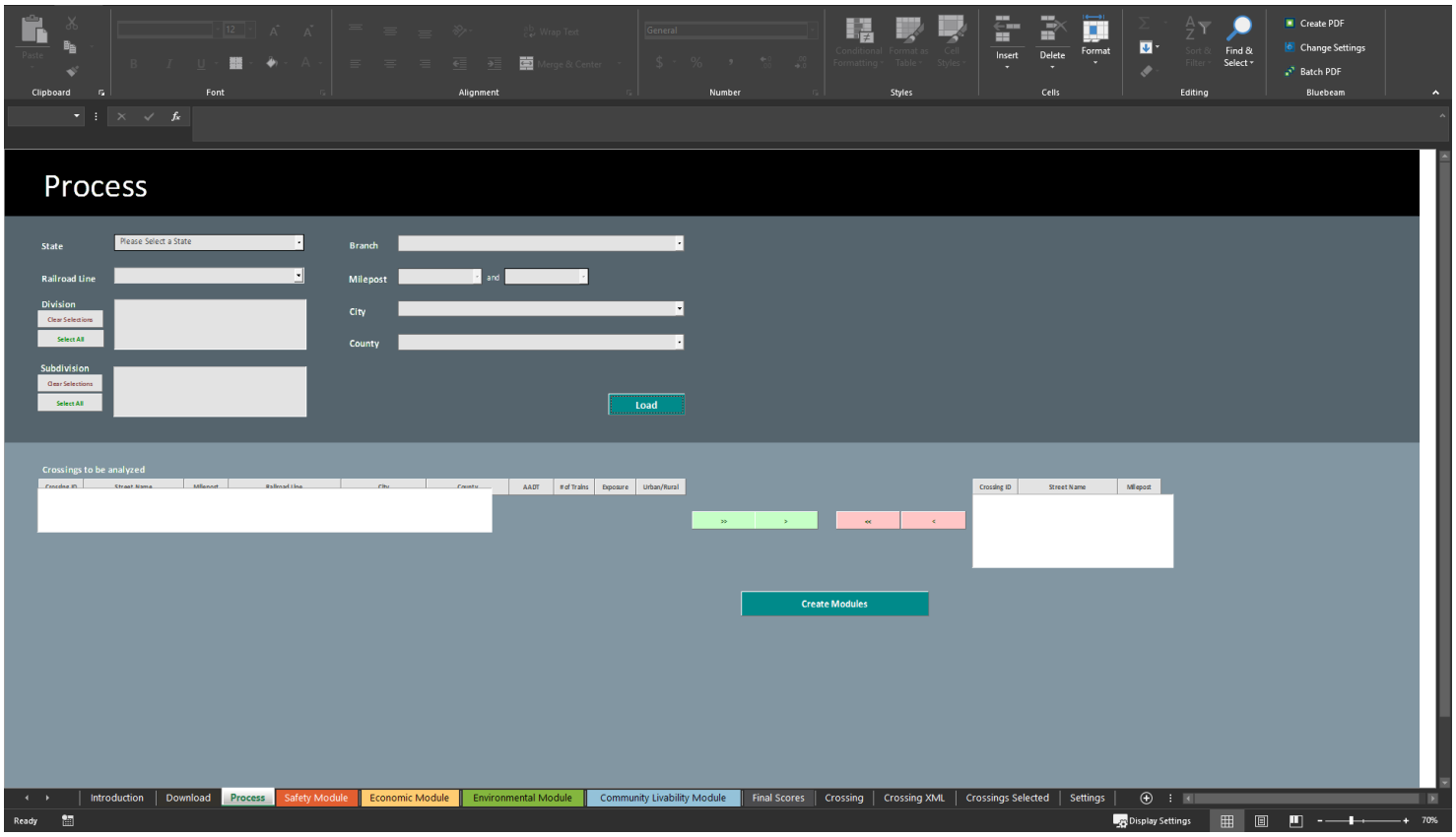
There are multiple steps that the local computer must process through. Be patient.

Step 5: When the local computer is done with the processing of the data and has completed placing the data into the Crossing Tab. A message stating "Done downloading crossing information" will appear on the screen.



Hit and Go to the Tab.

Step 6: The Tab



Step 6a: Complete the crossing selection using dropdown boxes in the Process Tab to pull the potential crossings from the FRA Crossing Inventory database that has been download into the Crossing Tab. Preprogramed dropdown boxes allow the user to refine the available data set to a manageable size for further manipulation. Once the which will then allow the user to start the data collection using FRA crossing inventory data.

Before the user can select the corridor data, it is best if the user has used the Tips and Tricks Instruction on how to prepare to use the RCAT model. In those instructions, it is suggested that the user downloads the FRA inventory sheets for each potential crossing. As highlighted on the example US DOT Crossing Inventory Form below.

U. S. DOT CROSSING INVENTORY FORM

DEPARTMENT OF TRANSPORTATION
FEDERAL RAILROAD ADMINISTRATION

OMB No. 2130-0017

Instructions for the initial reporting of the following types of new or previously unreported crossings: For public highway-rail grade crossings, complete the entire inventory Form. For private highway-rail grade crossings, complete the Header, Parts I and II, and the Submission Information section. For public pathway grade crossings (including pedestrian station grade crossings), complete the Header, Parts I and II, and the Submission Information section. For Private pathway grade crossings, complete the Header, Parts I and II, and the Submission Information section. For grade-separated highway-rail or pathway crossings (including pedestrian station crossings), complete the Header, Part I, and the Submission Information section. For changes to existing data, complete the Header, Part I Items 1-3, and the Submission Information section, in addition to the updated data fields. Note: For private crossings only, Part I Item 20 and Part III Item 2.K. are required unless otherwise noted. An asterisk * denotes an optional field.

A. Revision Date *(MM/DD/YYYY)* 04 / 28 / 2016

B. Reporting Agency ☒ Railroad ☐ Transit ☐ State ☐ Other

C. Reason for Update *(Select only one)* ☒ Change in Data ☐ New Crossing ☐ Closed ☐ No Train Traffic ☐ Quiet Zone Update ☐ Re-Open ☐ Date Change Only ☐ Change in Primary Operating RR ☐ Admin. Correction

D. DOT Crossing Inventory Number 062949V

Part I: Location and Classification Information

1. Primary Operating Railroad BNSF Railway Company [BNSF]

2. State MINNESOTA

3. County CLAY

4. City / Municipality ☒ In ☐ Near MOORHEAD

5. Street/Road Name & Block Number 11TH ST *(Street/Road Name)* | * *(Block Number)*

6. Highway Type & No. MSAS121

7. Do Other Railroads Operate a Separate Track at Crossing? ☐ Yes ☒ No
If Yes, Specify RR

8. Do Other Railroads Operate Over Your Track at Crossing? ☐ Yes ☒ No
If Yes, Specify RR

9. Railroad Division or Region ☐ None TWIN CITIES

10. Railroad Subdivision or District ☐ None K O

11. Branch or Line Name ☐ None E DILWRTH-MINOT

12. RR Milepost | 0006.389 | *(prefix)* | *(nnnn.nnn)* | *(suffix)*

13. Line Segment * 0026

14. Nearest RR Timetable Station * MOORHEAD JCT

15. Parent RR *(if applicable)* ☒ N/A

16. Crossing Owner *(if applicable)* ☐ N/A BNSF

17. Crossing Type ☒ Public ☐ Private

18. Crossing Purpose ☒ Highway ☐ Pathway, Ped. ☐ Station, Ped.

19. Crossing Position ☒ At Grade ☐ RR Under ☐ RR Over

20. Public Access *(if Private Crossing)* ☐ Yes ☐ No

21. Type of Train ☒ Freight ☐ Intercity Passenger ☐ Commuter ☐ Transit ☐ Shared Use Transit ☐ Tourist/Other

22. Average Passenger Train Count Per Day ☐ Less Than One Per Day ☐ Number Per Day 0

23. Type of Land Use ☐ Open Space ☐ Farm ☐ Residential ☒ Commercial ☐ Industrial ☐ Institutional ☐ Recreational ☐ RR Yard

24. Is there an Adjacent Crossing with a Separate Number? ☐ Yes ☒ No If Yes, Provide Crossing Number

25. Quiet Zone *(FRA provided)* ☐ No ☒ 24 Hr ☐ Partial ☐ Chicago Excused Date Established

26. HSR Corridor ID ☒ N/A

27. Latitude in decimal degrees *(WGS84 std: nn.nnnnnn)* 46.8745000

28. Longitude in decimal degrees *(WGS84 std: -nnn.nnnnnn)* -96.7625000

29. Lat/Long Source ☐ Actual ☒ Estimated

30.A. Railroad Use *

31.A. State Use * F0944E

30.B. Railroad Use *

31.B. State Use *

30.C. Railroad Use *

31.C. State Use *

30.D. Railroad Use *

31.D. State Use * NOE 2/25/2008

32.A. Narrative *(Railroad Use)* *

32.B. Narrative *(State Use)* *

33. Emergency Notification Telephone No. *(posted)* 800-832-5452

34. Railroad Contact *(Telephone No.)* 817-352-1549

35. State Contact *(Telephone No.)* 651-366-3667

Part II: Railroad Information

1. Estimated Number of Daily Train Movements

1.A. Total Day Thru Trains *(6 AM to 6 PM)* 34

1.B. Total Night Thru Trains *(6 PM to 6 AM)* 34

1.C. Total Switching Trains 0

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)* 2013

3. Speed of Train at Crossing
3.A. Maximum Timetable Speed *(mph)* 35
3.B. Typical Speed Range Over Crossing *(mph)* From 1 to 35

4. Type and Count of Tracks
Main 2 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

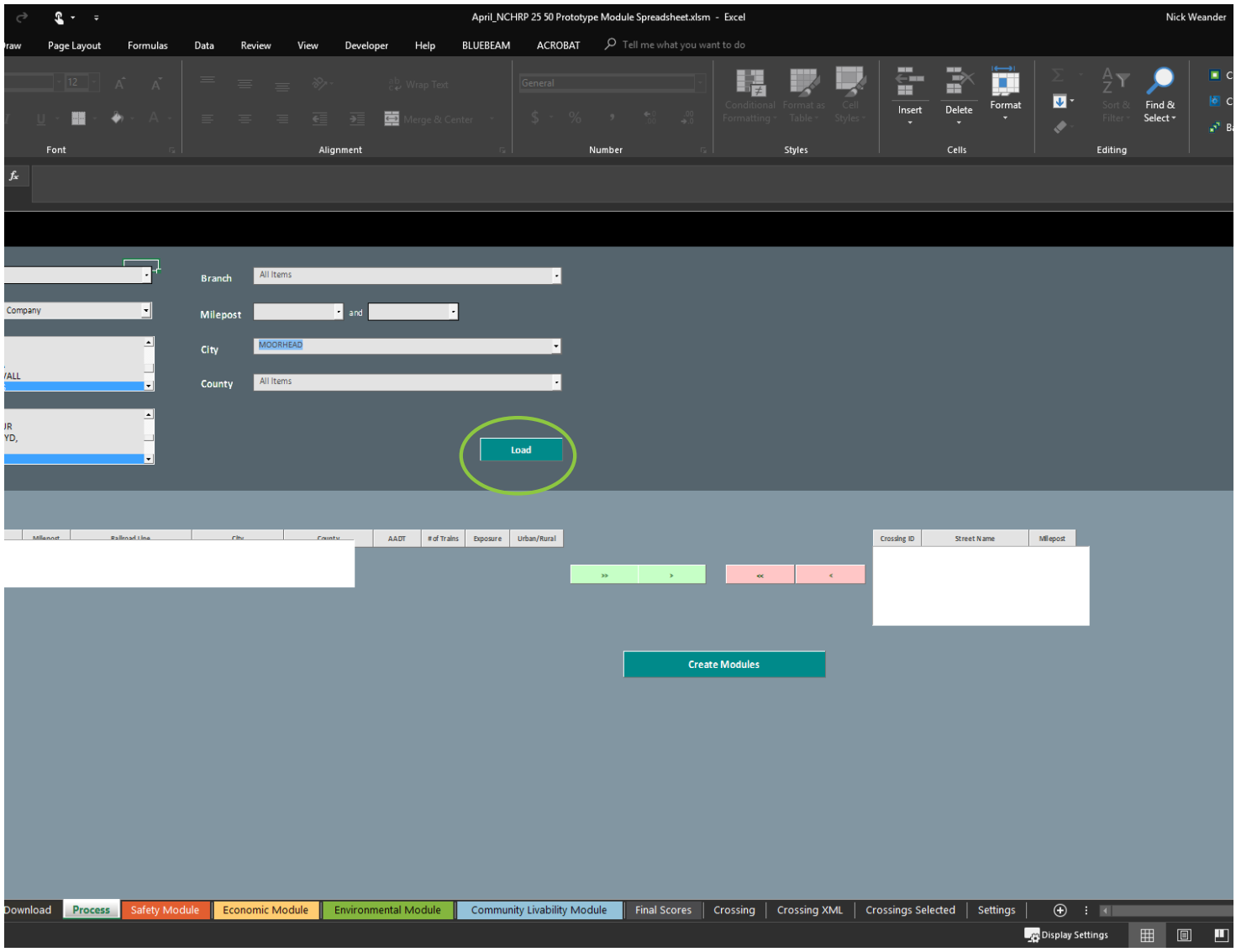
7.A. Event Recorder ☐ Yes ☐ No

7.B. Remote Health Monitoring ☐ Yes ☐ No

FORM FRA F 6180.71 (Rev. 3/15) OMB approval expires 3/31/2018 Page 1 OF 2

Using the FRA Inventory form, the user can find the following data that will help the user select the correct crossings specification from the dropdown boxes:

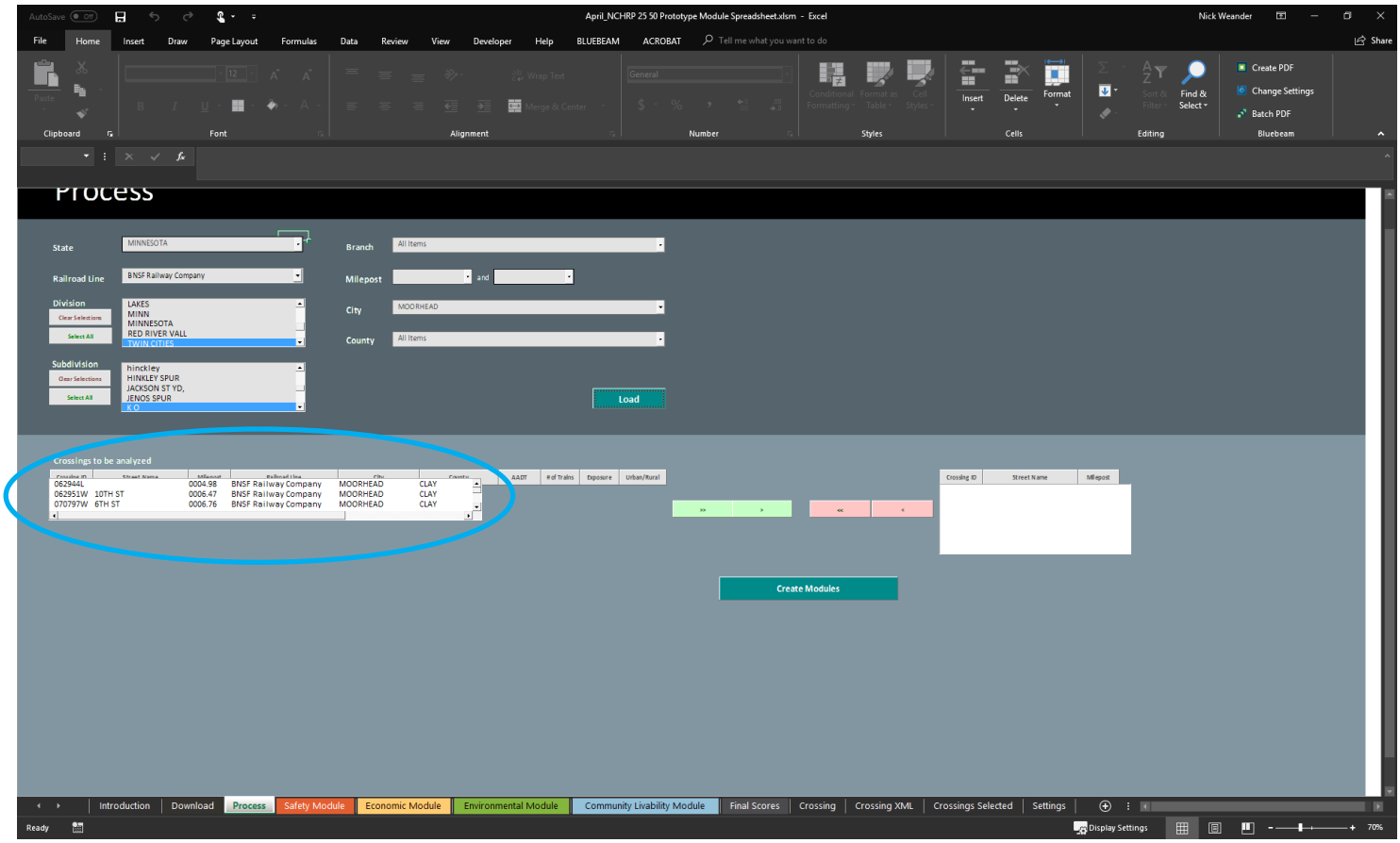
- State: (Example: Minnesota)
- Railroad Division: (Example: Twin Cities)
- Railroad Subdivision: (Example: KO)
- Branch Name: (Example: E Dilworth-Minot)
- Milepost: (this selection is optional)
- City: (Example: Moorhead)
- County: (Example: Clay)



Step 6b: Hit Load button.

The spreadsheet will load the crossing that match these specifications from the FRA databased downloaded into the local computer under the previous steps.

The Crossings to be analyzed box is now populated.



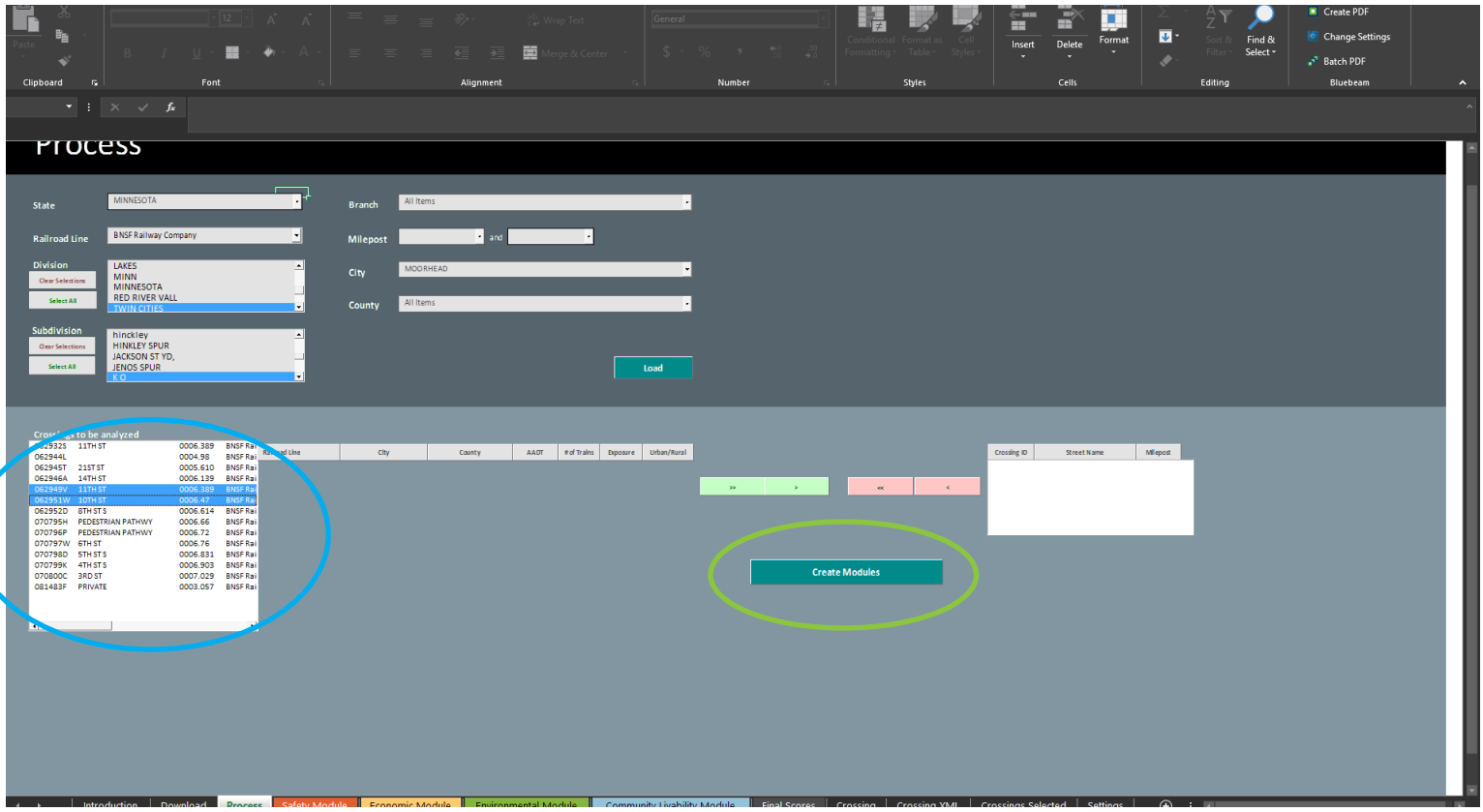
Step 6c: From this box, select the specific crossing to be analyzed within the Modules. The user may have to use the scroll bar to see all the available crossings as well as all the attributes for each crossing.

If the user is looking to analyze a long Corridor and wants to select high use crossings, the user can sort the available crossings by AADT. Another option is to sort the available crossings by Exposure Rates, Urban vs. Rural.

In the Tips and Tricks Instructions Sheet, the following information was gathered for the Example Corridor.

CrossingId	Railroad	County Name	CityName	Street	RrSubDiv	Branch	MilePost	RrDiv	Exposure
062952D	BNSF	CLAY	MOORHEAD	8TH ST S	K O	E DILWRTH-MINOT	0006.614	TWIN CITIES	788800
062932S	BNSF	CLAY	MOORHEAD	11TH ST	K O	E DILWRTH-MINOT	0006.389	TWIN CITIES	513400
062949V	BNSF	CLAY	MOORHEAD	11TH ST	K O	E DILWRTH-MINOT	0006.389	TWIN CITIES	285600
062946A	BNSF	CLAY	MOORHEAD	14TH ST	K O	E DILWRTH-MINOT	0006.139	TWIN CITIES	278800
070798D	BNSF	CLAY	MOORHEAD	5TH ST S	K O	E DILWRTH-MINOT	0006.831	TWIN CITIES	234600
070797W	BNSF	CLAY	MOORHEAD	6TH ST	K O	E DILWRTH-MINOT	0006.76	TWIN CITIES	167500
062951W	BNSF	CLAY	MOORHEAD	10TH ST	K O	E DILWRTH-MINOT	0006.47	TWIN CITIES	127300
070799K	BNSF	CLAY	MOORHEAD	4TH ST S	K O	E DILWRTH-MINOT	0006.903	TWIN CITIES	108800

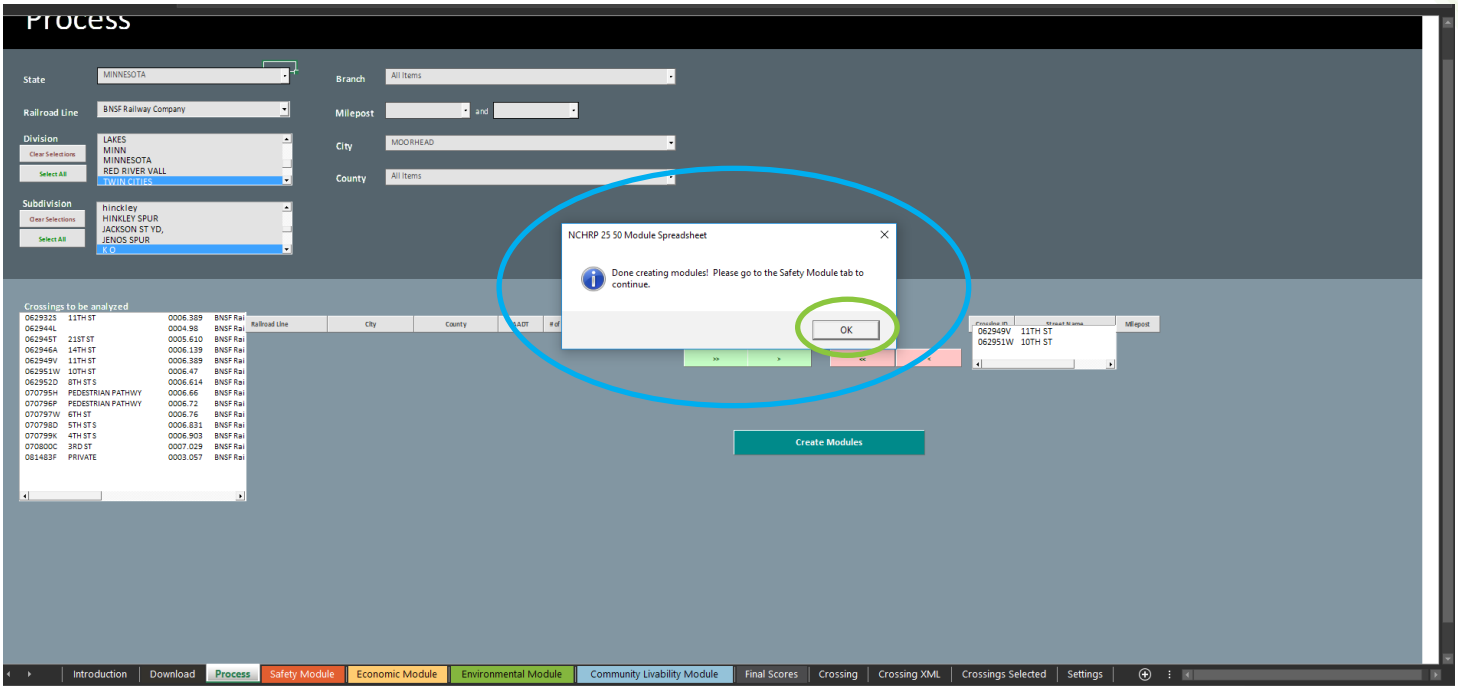
In this step, we will replicate the above list of crossings above into the model by selecting the crossing from the dropdown list. See Tips and Tricks for more details on the Example Project. If your crossings available for selection do not have all the crossing you want to analyze, check the FRA Crossing Inventory Sheets for the missing crossings to see which criteria is missing or incorrect. Then, rerun your selection criteria in the previous Step until all crossing are available for selection on the Process Tab.



Select the crossing(s) from Crossing to be analyzed drop down list. Use the green >> to move all to analyzed, or individually select a crossing by use the green > to move the specific crossing to the Selected list. If a crossing is moved to the bottom crossing list which shows the crossing selected, the pink < can be used to remove a specific crossing or the pink << can be used to remove all crossing and start the selection process again.

Step 7: Once, the user has confirmed the selection is correct, Hit the Create Modules button

The following message box will display.



Hit OK

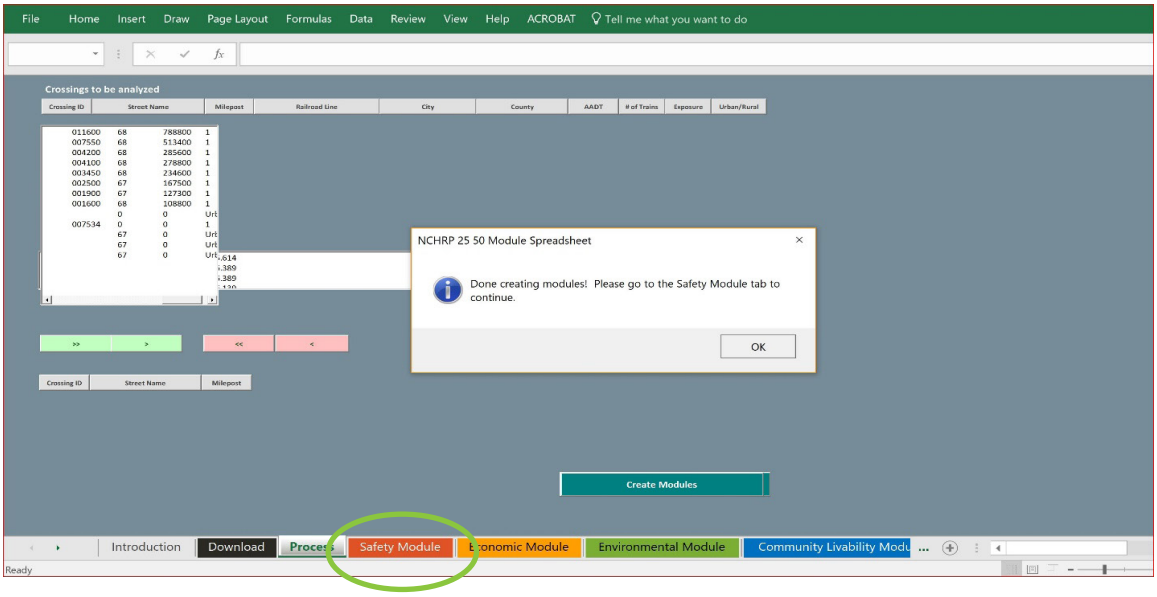
The user is now ready to go in and review each module.

D. PREPARING EACH OF THE 4 MODULES

The next step is to go into each module, check the downloaded data and input user required data elements

Let's start with the Safety Module

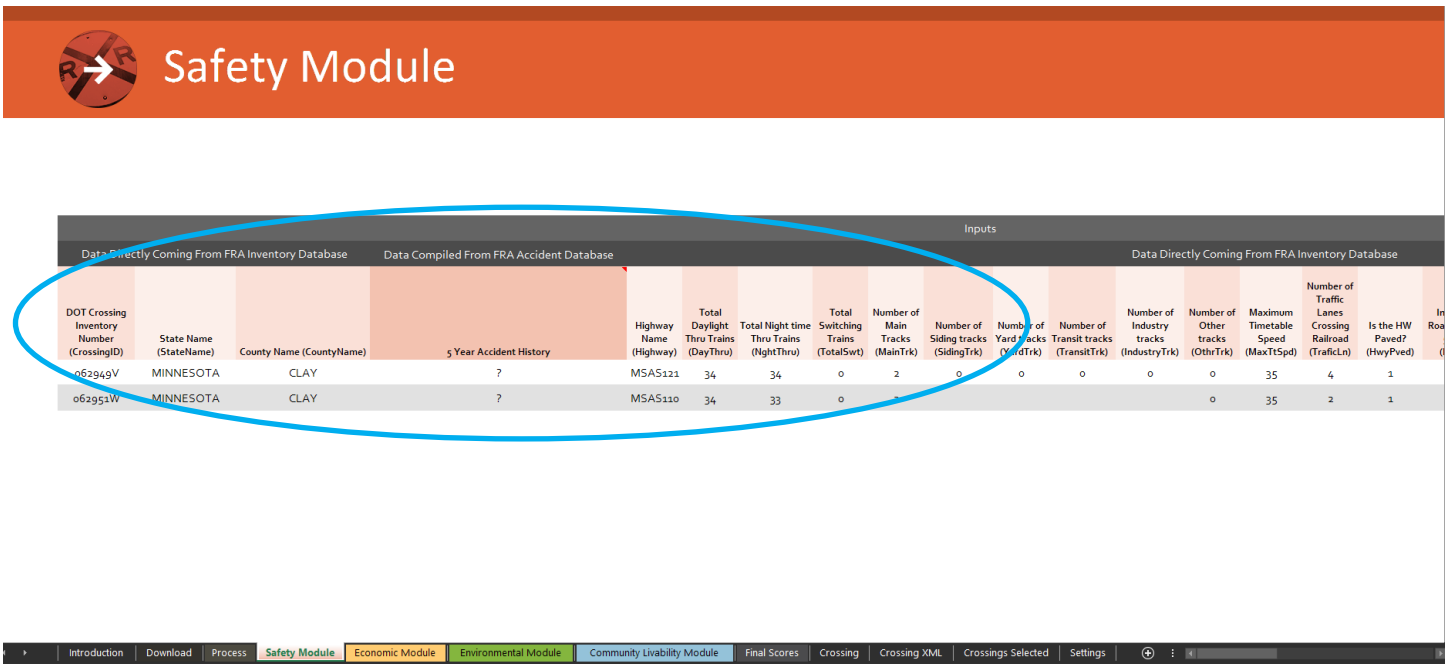
This module is a quantitative evaluation module that prioritizes at-grade crossing locations for separation or other improvements based largely on traditional safety criteria such as historical safety record of crossings, accident prediction, number of tracks, traffic levels, etc.



Click on the Safety Module Tab

Safety Module

Left side of Safety Module



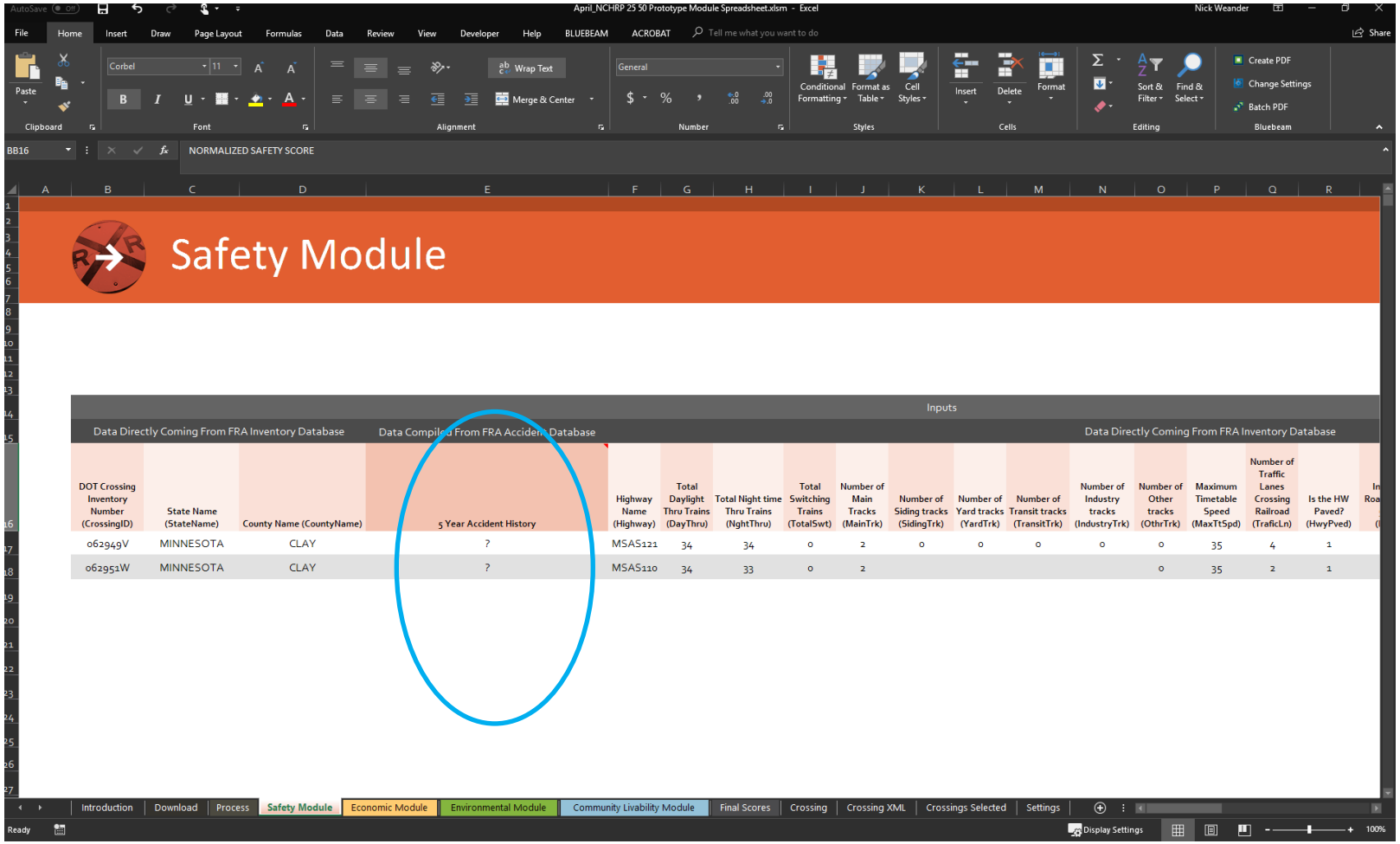
DOT Crossing Inventory Number (CrossingID)	State Name (StateName)	County Name (CountyName)	5 Year Accident History	Highway Name (Highway)	Total Daylight Thru Trains (DayThru)	Total Night time Thru Trains (NghtThru)	Total Switching Trains (TotalSwt)	Number of Main Tracks (MainTrk)	Number of Siding tracks (SidingTrk)	Number of Yard tracks (YardTrk)	Number of Transit tracks (TransitTrk)	Number of Industry tracks (IndustryTrk)	Number of Other tracks (OthrTrk)	Maximum Timetable Speed (MaxTtSpd)	Number of Traffic Lanes Crossing Railroad (TraficLn)	Is the HW Paved? (HwyPved)
062949V	MINNESOTA	CLAY	?	MSAS121	34	34	0	2	0	0	0	0	0	35	4	1
062951W	MINNESOTA	CLAY	?	MSAS110	34	33	0	[illegible]					0	35	2	1

Note: that based upon our criteria selected in the Download tab, only one of the four Grade Crossings in our Example Project has been processed. The user may have to review the individual FRA Crossing Inventory sheets for their defined corridor to determine why the anticipated crossings did not meet the user defined selection criteria.

Here are the 23 data elements that the download tab pulled from the FRA crossing inventory.

a. Double check that this information is current, if not update as appropriate.

b. Pull up the Public Highway-Rail Crossing Accident Report that was collected in the Tips and Tricks Instructions on how to prepare to use the model. Input the sum of accidents at each crossing for the last five years in the 5-year Accident History column. Query can be made at: http://safetydata.fra.dot.gov/webaps/default.aspx



DOT Crossing Inventory Number (CrossingID)	State Name (StateName)	County Name (CountyName)	5 Year Accident History	Highway Name (Highway)	Total Daylight Thru Trains (DayThru)	Total Night time Thru Trains (NghtThru)	Total Switching Trains (TotalSwt)	Number of Main Tracks (MainTrk)	Number of Siding tracks (SidingTrk)	Number of Yard tracks (YardTrk)	Number of Transit tracks (TransitTrk)	Number of Industry tracks (IndustryTrk)	Number of Other tracks (OthrTrk)	Maximum Timetable Speed (MaxTtSpd)	Number of Traffic Lanes Crossing Railroad (TraficLn)	Is the HW Paved? (HwyPved)
062949V	MINNESOTA	CLAY	?	MSAS121	34	34	0	2	0	0	0	0	0	35	4	1
062951W	MINNESOTA	CLAY	?	MSAS110	34	33	0	2					0	35	2	1

For the selected example crossings, none have experienced an accident in the last 5 years, so a zero (0) is inserted for all crossing in Column E

Safety Module

Inputs																	
Data Directly Coming From FRA Inventory Database			Data Compiled From FRA Accident Database										Data Directly Coming From FRA Inventory Database				
DOT Crossing Inventory Number (CrossingID)	State Name (StateName)	County Name (CountyName)	5 Year Accident History	Highway Name (Highway)	Total Daylight Thru Trains (DayThru)	Total Night time Thru Trains (NghtThru)	Total Switching Trains (TotalSwt)	Number of Main Tracks (MainTrk)	Number of Siding tracks (SidingTrk)	Number of Yard tracks (YardTrk)	Number of Transit tracks (TransitTrk)	Number of Industry tracks (IndustryTrk)	Number of Other tracks (OthrTrk)	Maximum Timetable Speed (MaxTtSpd)	Number of Traffic Lanes Crossing Railroad (TraficLn)	Is the HW Paved? (HwyPved)	In Roa (
062949V	MINNESOTA	CLAY	5	MSAS121	34	34	0	2	0	0	0	0	0	35	4	1	
062951W	MINNESOTA	CLAY	10	MSAS110	34	33	0	2					0	35	2	1	

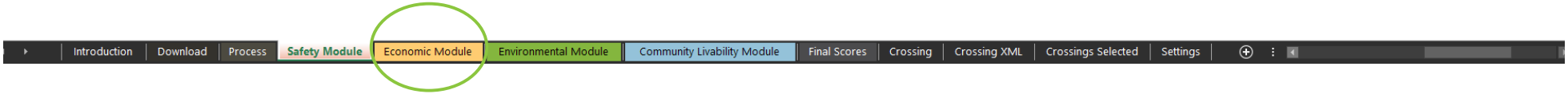
Hit the Enter key, The Safety Module will now calculate the Normalized Scores for this Module.

Calculated Values																						
Maximum Speed Factor MS	Highway Lanes Factor HL	Initial Collission prediction formula	Formula Weighing Factor	Zero Inflated Passive	Zero Inflated Flashing Lights	Zero Inflated Gates	AATT	Total Number of Tracks	USDOT Accident Prediction Value	Zero Inflated Negative Binomial Accident Prediction Value	Normalized value for angle of crossing	Normalized value for distance to nearby HW intersection	Normalized number of tracks	Normalized maximum timetaable train speed	Normalized highway speed	surface_index	Normalized value for surface	Site Related Adjustments	Safety Score	Min	Max	NORMALIZED SAFETY SCORE
1	1.53112078	0.19	4.126598	N/A	N/A	N/A	68	2	0.307630	N/A	0	-1	0.75	0.30	0.0	3	-0.5	-0.014400	0.293230	0.293230	0.449869	0.000
1	1.15257665	0.11	6.092097	N/A	N/A	N/A	67	2	0.467269	N/A	0	-0.5	0.75	0.30	0.0	4	-1	-0.017400	0.449869			10.000

Now, go to the Economic Module by clicking the Economic Module Tab

Calculated Values

Maximum Speed Factor MS	Highway Lanes Factor HL	Initial Collission prediction formula	Formula Weighing Factor	Zero Inflated Passive	Zero Inflated Flashing Lights	Zero Inflated Gates	AATT	Total Number of Tracks	USDOT Accident Prediction Value	Zero Inflated Negative Binomial Accident Prediction Value	Normalized value for angle of crossing	Normalized value for distance to nearby HW intersection	Normalized number of tracks	Normalized maximum timetaable train speed	Normalized highway speed	surface_index	Normalized value for surface	Site Related Adjustments	Safety Score	Min	Max	NORMALIZED SAFETY SCORE
1	1.53112078	0.19	4.126598	N/A	N/A	N/A	68	2	0.307630	N/A	0	-1	0.75	0.30	0.0	3	-0.5	-0.014400	0.293230	0.293230	0.449869	0.000
1	1.15257665	0.11	6.092097	N/A	N/A	N/A	67	2	0.467269	N/A	0	-0.5	0.75	0.30	0.0	4	-1	-0.017400	0.449869			10.000



ECONOMIC MODULE

Economic

This module is based on quantitative or monetized factors and safety savings and other qualitative economic factors. Quantitative factors include travel time savings for commuters, as well as commercial driver/freight savings. Qualitative economic factors include user observations on the improvement to mobility based upon the density of the area adjacent to the crossing and how the improvement will affect the economic returns of property near the crossing. The module is designed to allow users to select and weigh criteria based on data availability and desired level of analysis. This module includes data and level of analysis that may be helpful in the development of a benefit-cost or an economic impact analyses to support grant and other funding applications. Left side of Economic Module

Economic Module

b.

Default Values			
2.5	Medium	Yes	Low

Inputs														
Data Directly Coming from FRA Inventory Database				User Inputs										Ca
Crossing ID	Street/Highway	Percentage of Trucks (PctTruk)	AADT (Aadt)	Average cost of fuel per gallon	Land Use Density near Project (EC4)	Economic Losses (EC5)	Impacts to Land Use (EC6)	Supply Chain Savings (PctTruk) (EC7)	Vehicle operating and delay costs – Passenger vehicles (EC1)	Min	Max	Vehicle Operating C Passenger Vehicles		
062949V	11TH ST	5.00%	4200	$ 2.50	Medium	Yes	Low	1	$ 189,359	$ 84,403	$ 189,359	5.00		
062951W	[illegible]	5.00%	1900	$ 2.50	Medium	[illegible]	Low	1	$ 84,403			0.00		

a. c.

Introduction | Download | Process | Safety Module | Economic Module | Environmental Module | Community Livability Module | Final Scores | Crossing | Crossing XML | Crossings Selected | Settings

This module has four data elements that are pulled directly from the FRA Inventory Database.

Crossing ID, Street/ Highway, Percentage of Trucks and AADT.

a. Review the data to ensure it is current, update as needed.

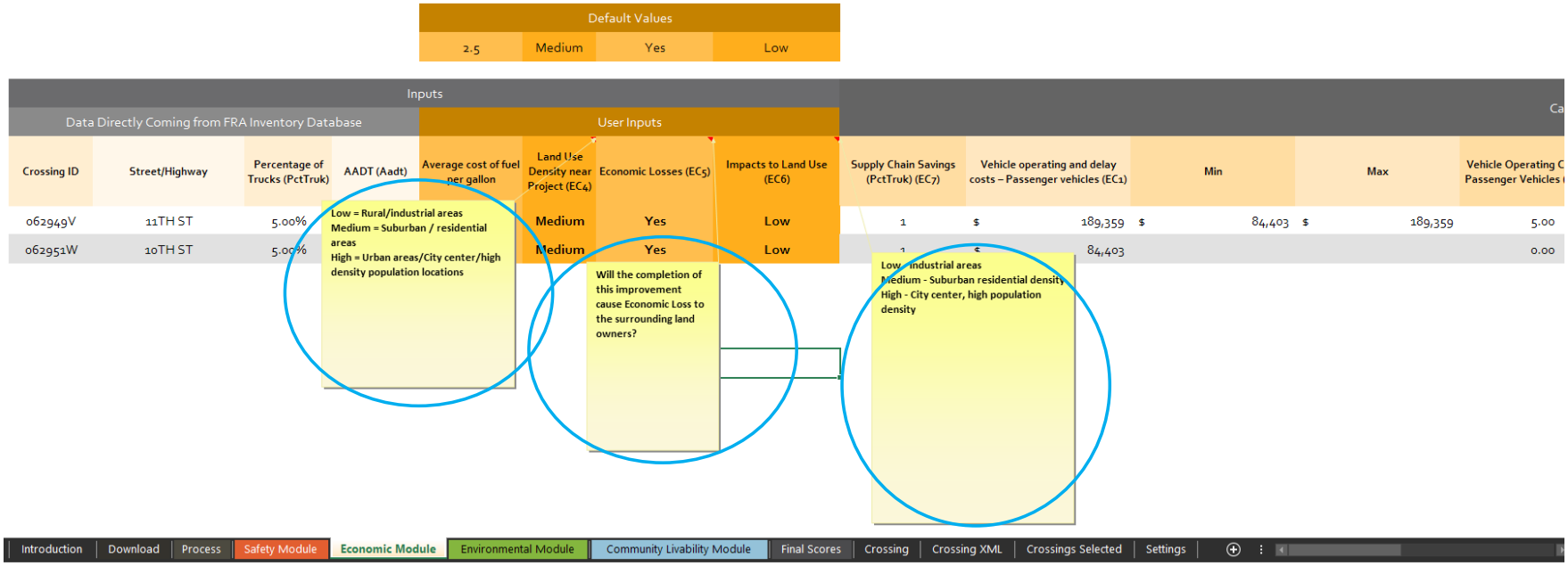
There are four elements that need users input, the designers have provided default values.

b. Review the default values and update as needed.

- Average cost of fuel per gallon- Fill in current fuel price per gallon
- Density near the Project (measures the improvement to mobility)- **Estimate the density near the project using the following scale:**
  - Low = Rural/industrial areas
  - Medium = Suburban / residential areas
  - High = Urban areas/City center/high density population locations
- Economic Loss due to project- **Will the completion of this improvement cause Economic Loss to the surrounding land owners?**
  - 1= Yes, 0= No
- Impacts on Land Use- **What Impact will the improvement to the Crossing have on the nearby land uses?**
  - 1= low (in industrial area)
  - 3= medium (suburban residential density
  - 5=Urban (city center, high population density)

c. Review each crossing and update the individual inputs as needed using the GIS maps collected in Tips and Tricks Section. Using the scales listed above. Note: Comments can be turned on as needed to see the ranges for each user input element

Each user will have their own definitions of subjective characterizations. In this Module, the user will have to decide on a definition for Economic Loss. As long as the user consistently applies their respective definitions the crossings will be ranked accordingly.



The example module has now been populated with updated Default Values and the maps of the individual crossing have reviewed.

Economic Module

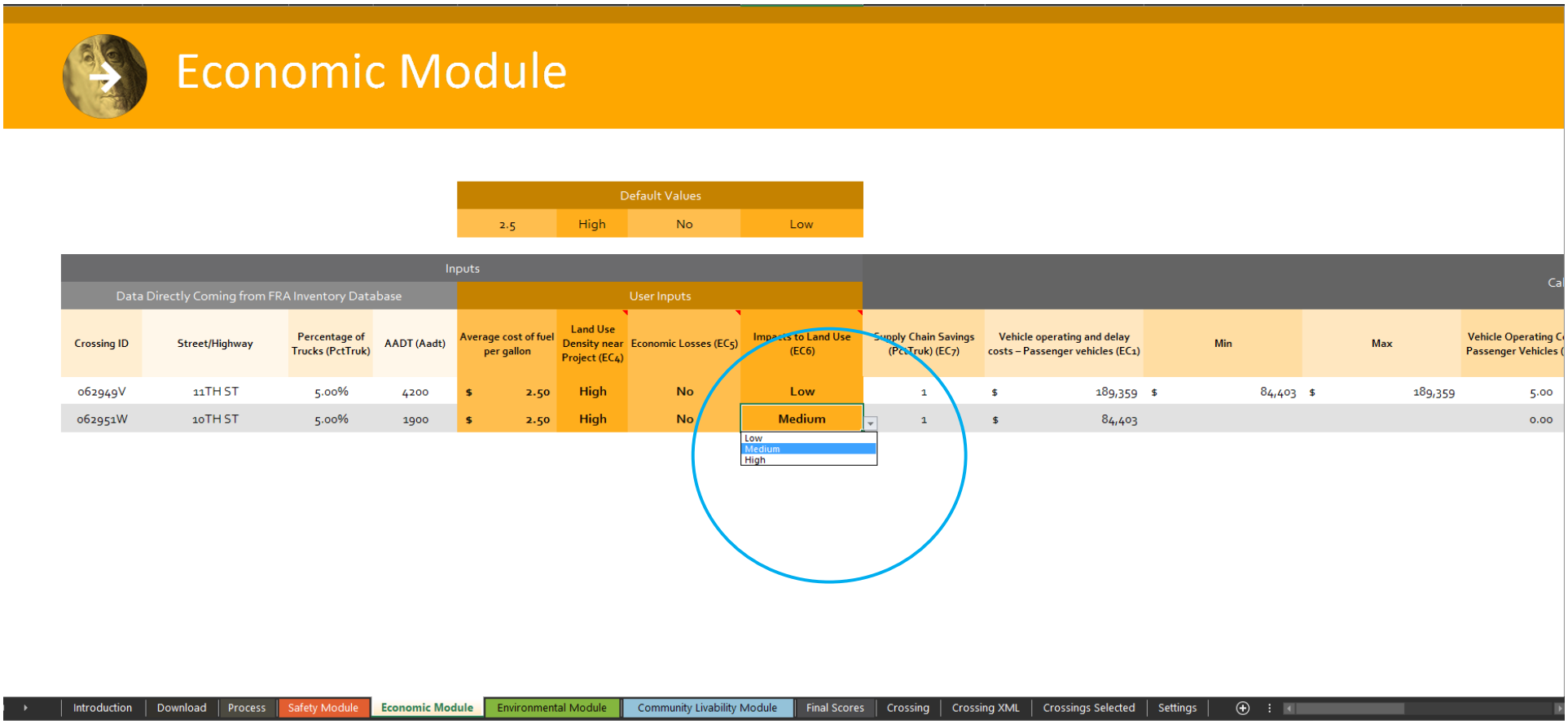
Default Values			
2.5	High	No	Low

Inputs									
Data Directly Coming from FRA Inventory Database				User Inputs					
Crossing ID	Street/Highway	Percentage of Trucks (PctTruk)	AADT (Aadt)	Average cost of fuel per gallon	Land Use Density near Project (EC4)	Economic Losses (EC5)	Impacts to Land Use (EC6)	Supply Chain Savings (PctTruk) (EC7)	Veh costs
062949V	11TH ST	5.00%	4200	$ 2.50	High	No	Low	1	$
062951W	10TH ST	5.00%	1900	$ 2.50	High	No	Low	1	$

Introduction | Download | Process | Safety Module | Economic Module | Environmental Module | Community Livability Module | Final Scores | Crossing | Crossing XM

Now, edit the individual crossing user input fields using the drop down boxed in each line next the field that needs to be changed.

Since all of these crossings are closed together most of the crossings the Default Values are acceptable and only a few require individual crossing updates. This will not be the norm for most corridors. Thus, double check the user input values before moving on.



Next Step is to review the weight Factors over in the upper right corner of the Tab. The Default is set to 1 for each of the Factors. The user should review their agency's investment criteria and adjust the Factor weights accordingly.

Economic Factors:

EC1: Vehicle operating cost/ delay – Passenger Vehicles Score (Column N)

EC2: Vehicle operating cost/ delay – Commercial Vehicles Score (Column R)

EC3: Not used

EC4: Density near project (Column G)

EC5: Economic Loss (Column H)

EC6: Impacts to Land Use (Column I)

EC7: Supply Chain Savings (Column J)

	User Defined
Factor for Vehicle operating cost/ delay – Passenger Vehicles (EC1)	1
Factor for Vehicle operating cost/ delay – Commercial Vehicles Score (EC2)	1
Factor for Density near project (EC4)	1
Factor for Economic Loss (EC5)	1
Factor for Impacts to Land Use (EC6)	1
Supply Chain Savings (EC7)	1

Weighting of Economic Factors:

The Weights are set to a default of 1.

The user can change the weights by replacing the "1" with another weight to give a Factor more or less weight compared to the other factors. Once the weights are entered, Hit enter.

The Scores for the Economic Module will be Normalized automatically once the user has completed updating the User Defined Weight Factors.

Calculated Values										
Min	Max	Vehicle Operating Cost/Delay - Passenger Vehicles (EC1) Score	Vehicle operating and delay costs – Commercial vehicles (EC2)	Min	Max	Vehicle operating cost/delay and accident cost – Commercial vehicles (EC2) Score	Score for Economic Factors			Normalized Score for Economic Factors
$ 84,403	$ 189,359	5.00	$ 18,106	$ 8,070	$ 18,106	$ 5	22.00	Min	14.0	10.00
		0.00	$ 8,070			$ -	14.00	Max	22.0	0.00
								Range	8.0	

Introduction | Download | Process | Safety Module | Economic Module | Environmental Module | Community Livability Module | Final Scores | Crossing | Crossing XML | Crossings Selected | Settings

This model is complete. The user can move on to the Environmental Tab

ENVIRONMENTAL MODULE

ENVIRO -MENTAL

This module includes factors for greenhouse gas emissions, visual or audible environmental impacts, potential impacts to waterways and wetlands in the event of a cargo spill, etc.

Left side of Environmental Module

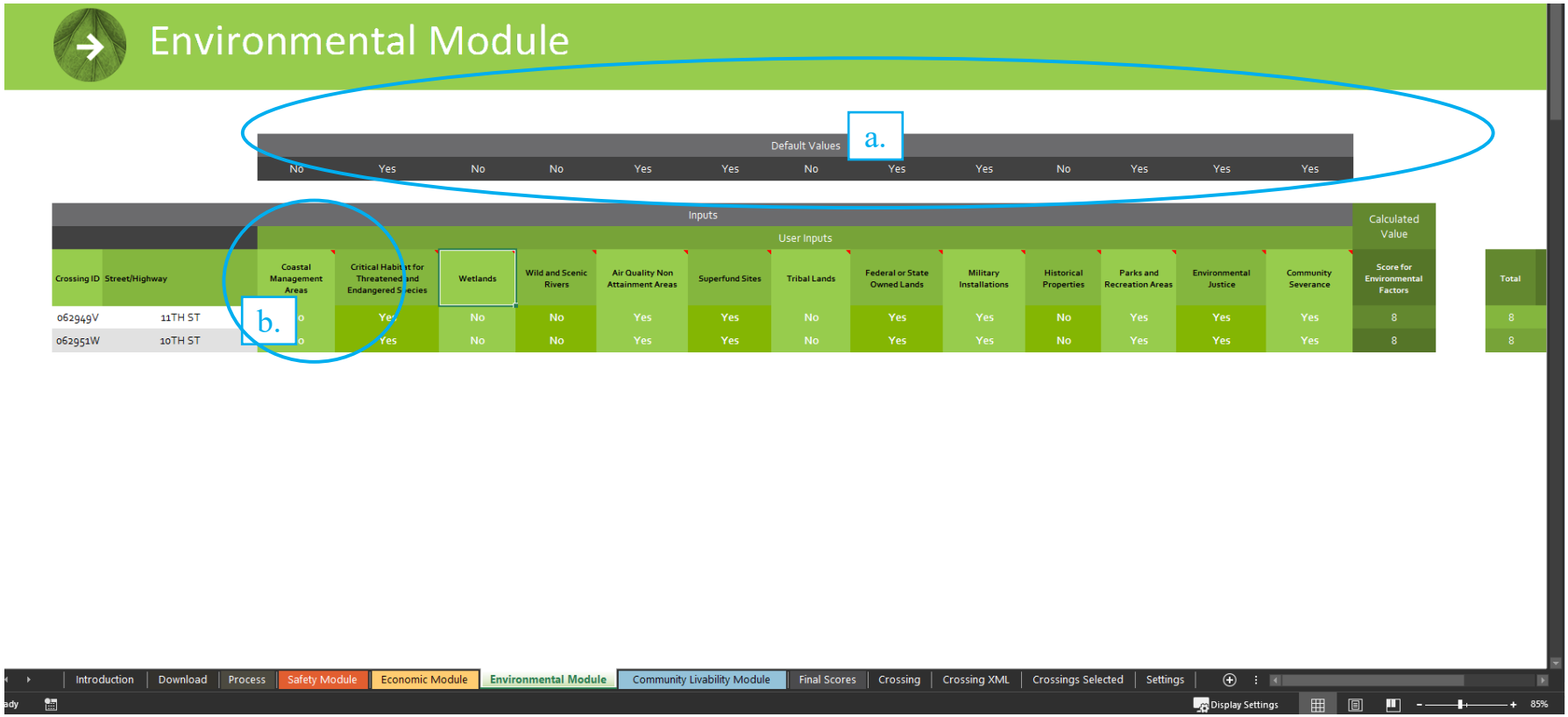
Environmental Module

		Coastal Management Areas	Critical Habitat for Threatened and Endangered Species	Wetlands	Wild and Scenic Rivers	Air Quality Non Attainment Areas	Superfund Sites	Tribal Lands	Federal or State Owned Lands	Military Installations	Historical Properties	Parks and Recreation Areas	Environmental Justice	Comm Sever
Default Values		No	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Ye
Inputs		User Inputs												
Crossing ID	Street/Highway													
062949V	11TH ST	No	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Ye
062951W	10TH ST	No	Yes	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Ye

Introduction | Download | Process | Safety Module | Economic Module | Environmental Module | Community Livability Module | Final Scores | Crossing | Crossing XML | Crossings Selected | Settings

Display Settings 100%

In the Environmental Module there are 13 Subjective elements that the User must populate. To help in this process a set of default values are provide as a starting point shown as circle a below. For this module, the user will need maps of the crossings to determine the characteristics for each factor. As in the Economic Module, comments are available showing the input choices, shown in circle b.

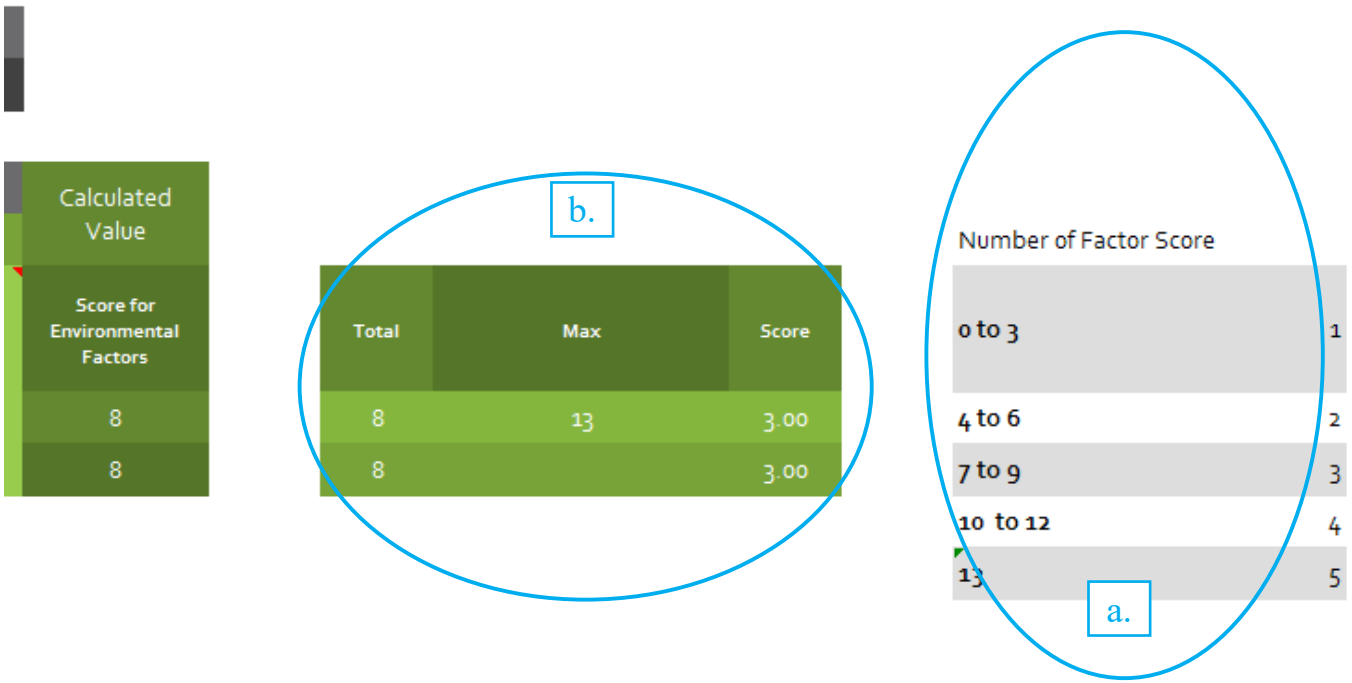


As in the Economic Module, review the corridor map and set the Default Values in circle a.

- Coastal Management Areas:
  - Yes, for Presence of a Coastal Management Area (CMA) within a 1-mile buffer zone of the crossings
  - No, if does not apply

- **Critical Habitat for Threatened and Endangered Species:**
  - Yes
  - No
- **Wetland-Is the project within 1 mile of a wetlands?**
  - Yes
  - No
- **Wild and Scenic Rivers- Is the project within a 1 mile of a wild or scenic river?**
  - Yes
  - No
- **Air Quality Non- Obtainment Zone- Is the project in a Non-Obtainment Zone?**
  - Yes
  - No
- **Superfund Site- Is the project either in or within 1 mile of a Superfund site?**
  - Yes
  - No
- **Tribal Lands- Is the project either in or within 1 mile of Tribal lands?**
  - Yes
  - No
- **Federal or State Owned Land- Is the project on Federal or State owned land?**
  - Yes
  - No
- **Military Installation – Is the project on a Military Installation?**
  - Yes
  - No
- **Historic Property- Is the project within 1 mile of a Historic Property?**
  - Yes
  - No
- **Parks and Recreational Area- Is a park or recreational area within the 1-mile buffer of the project?**
  - Yes
  - No
- **Environmental Justice – Is there a Presence of a high ratio of low-income and/or minority population within the 1-mile buffer?**
  - Yes
  - No
- **Community Severance- Would this project if completed sever the community?**
  - Yes
  - No

Right hand side of Environmental Module



For the Environmental Module, once the 13 Factors are assigned a "Yes" or "No". The Module will calculate the total number of Factors affected and place a score in the Score for Environmental Factors Column (Column Q) indicated in circle a above. Using this score, the model will normalize the score for each crossing as indicated in circle b in the diagram above.

In the Environmental module, the weight factor scores are set by the number of factors that have a "Yes". No user updates are needed for the weights in this module.

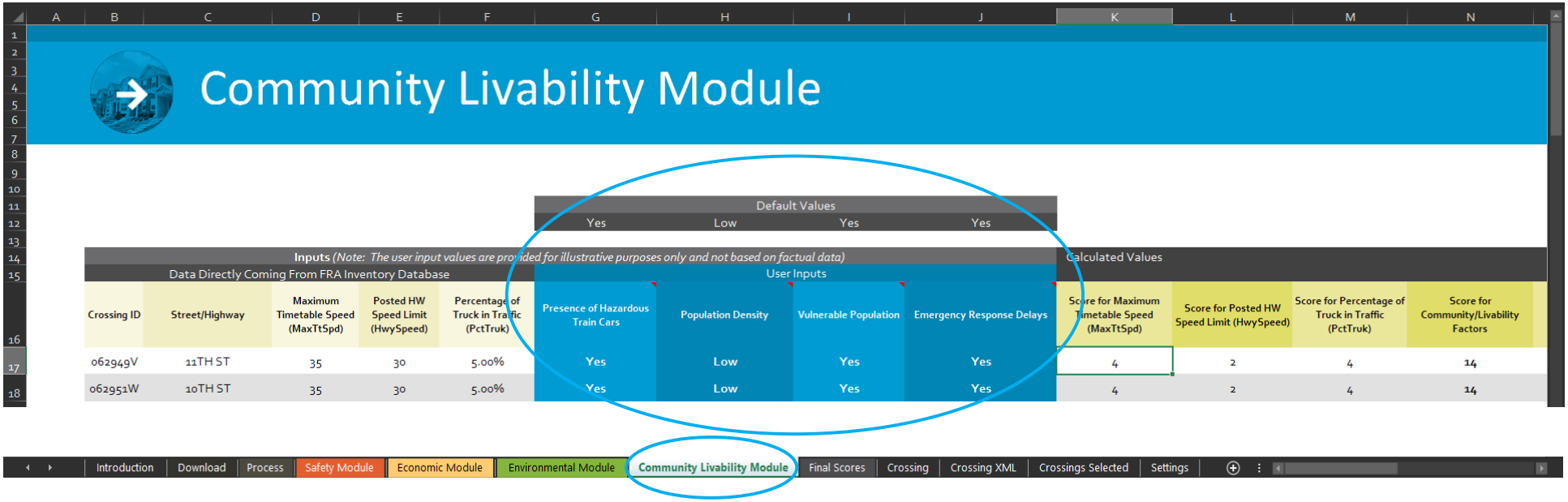
After completing the Environmental Module, the user can click the Community Livability Module Tab

COMMUNITY/LIVABILITY

COMMUNITY/ LIVABILITY

This module incorporates quantitative risk factors such as number of hazardous cargo cars, residential population densities, fixed populations, transient populations, emergency service locations and routes, and local agency priorities.

In this Module, there are four data elements that are pre-populated from the FRA database, remember to check this data for accuracy.



Community Livability Module

					Default Values			
					Yes	Low	Yes	Yes

Inputs *(Note: The user input values are provided for illustrative purposes only and not based on factual data)*

Data Directly Coming From FRA Inventory Database					User Inputs				Calculated Values			
Crossing ID	Street/Highway	Maximum Timetable Speed (MaxTtSpd)	Posted HW Speed Limit (HwySpeed)	Percentage of Truck in Traffic (PctTruk)	Presence of Hazardous Train Cars	Population Density	Vulnerable Population	Emergency Response Delays	Score for Maximum Timetable Speed (MaxTtSpd)	Score for Posted HW Speed Limit (HwySpeed)	Score for Percentage of Truck in Traffic (PctTruk)	Score for Community/Livability Factors
062949V	11TH ST	35	30	5.00%	Yes	Low	Yes	Yes	4	2	4	14
062951W	10TH ST	35	30	5.00%	Yes	Low	Yes	Yes	4	2	4	14

Introduction | Download | Process | Safety Module | Economic Module | Environmental Module | Community Livability Module | Final Scores | Crossing | Crossing XML | Crossings Selected | Settings

As seen in the previous Modules, there is a User Input Section with Default Value per filled in.

User Elements Include:

- Presence of Hazardous Train Cars- Do are there Hazardous Materials on the trains that pass through this crossing?
  - Yes
  - No
- Population Density:
  - Low = Rural/industrial areas

- Medium = Suburban / residential areas
- High = Urban areas/City center/high density population locations

- Vulnerable Populations – Are there vulnerable populations ((senior living, hospitals, schools or prisons) within the ½ mile buffer?
  - Yes
  - No
- Emergency Response Delays- Is there presence of police station, fire station or hospital within 1 mile of crossing without access to a grade separated crossing within a mile?
  - Yes
  - No

Remember to:

a. Check the Default Values and update as needed.

b. Review the individual crossing factors to ensure that the default values represent this crossing, if not update.

In this module, there are four Calculated Values:

- Score for Maximum Timetable Speed (MaxTtSpd)
- Score for Posted HW Speed Limit (HwySpeed)
- Score for Percentage of Truck in Traffic (PctTruk)
- Total

Weights can be changed for seven factors:

Factor for Speed Limit	**1**
Factor for Maximum TT Train Speed	1
Factor for % truck in traffic	**1**
Factor for Presence of Hazardous Train Cars	1
Factor for Population Density	**1**
Factor for Vulnerable Population	1
Factor for Emergency Response Delays	**1**

The Score for Community/Livability Factors is a calculation based upon of the weights of each of the seven factor times the relevant score of those factors.

The Community / Livability Score is than normalized in Column R.

The model will calculate a Total Score for the Community Livability Module using the user defined weights and will Normalize the crossing scores as shown below in the circle.

nity Livability Module

		Default Values			
		Yes	Low	Yes	Yes

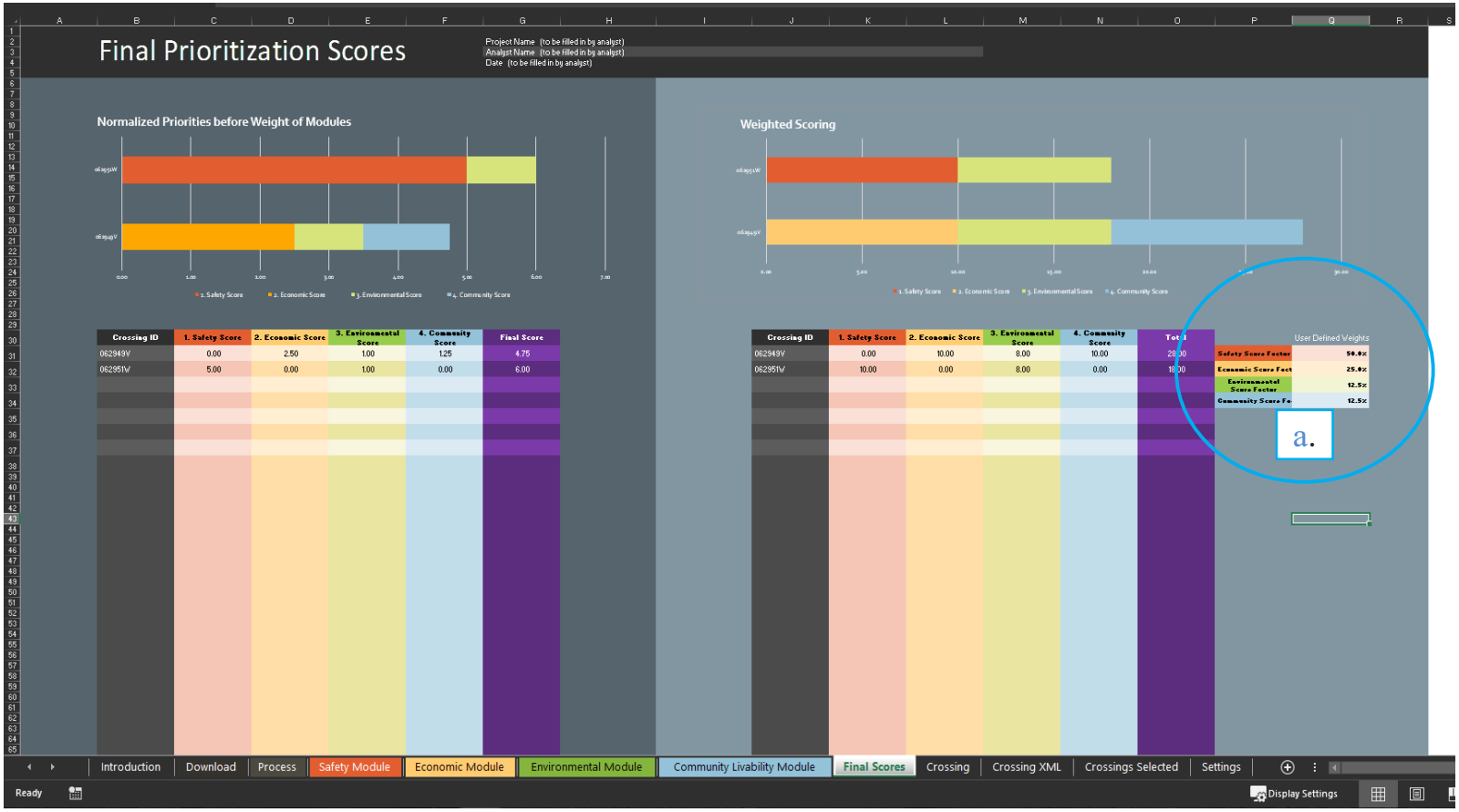
The user input values are provided for illustrative purposes only and not based on factual data)

entory Database		User Inputs				Calculated Values						
Posted HW Speed Limit (HwySpeed)	Percentage of Truck in Traffic (PctTruk)	Presence of Hazardous Train Cars	Population Density	Vulnerable Population	Emergency Response Delays	Score for Maximum Timetable Speed (MaxTtSpd)	Score for Posted HW Speed Limit (HwySpeed)	Score for Percentage of Truck in Traffic (PctTruk)	Score for Community/Livability Factors			Normalized Score for Community/Livability Factor
30	5.00%	Yes	Low	Yes	Yes	4	2	4	14	Min	13	10.00
30	5.00%	Yes	Low	No	Yes	4	2	4	13	Max	14	0.00
										Range	1	

Introduction | Download | Process | Safety Module | Economic Module | Environmental Module | Community Livability Module | Final Scores | Crossing | Crossing XML | Crossings Selected | Settings

When the user has double checked all of the data elements and weights, the user can move to the FINAL Score Tab.

E. RUN THE RCAT MODEL – FINAL SCORE



Before the user reviews the final scoring for the Model, the user should to do a final review of the default weights for each factor within the four modules.

Remember the weights selected for each factor in each module can be used to customize the model to provide the information that reflects the user's agency priorities. Take time to think about the weights, to make sure that the results of this Model will be useful in making the investment criteria investment recommendations based upon the local community's priorities.

Finally look at the default weight given to each module on the right side of the Final Score Tab. The researchers have provided default weights for each of the modules that can easily be edited by the user to reflect local priorities See circle a above.

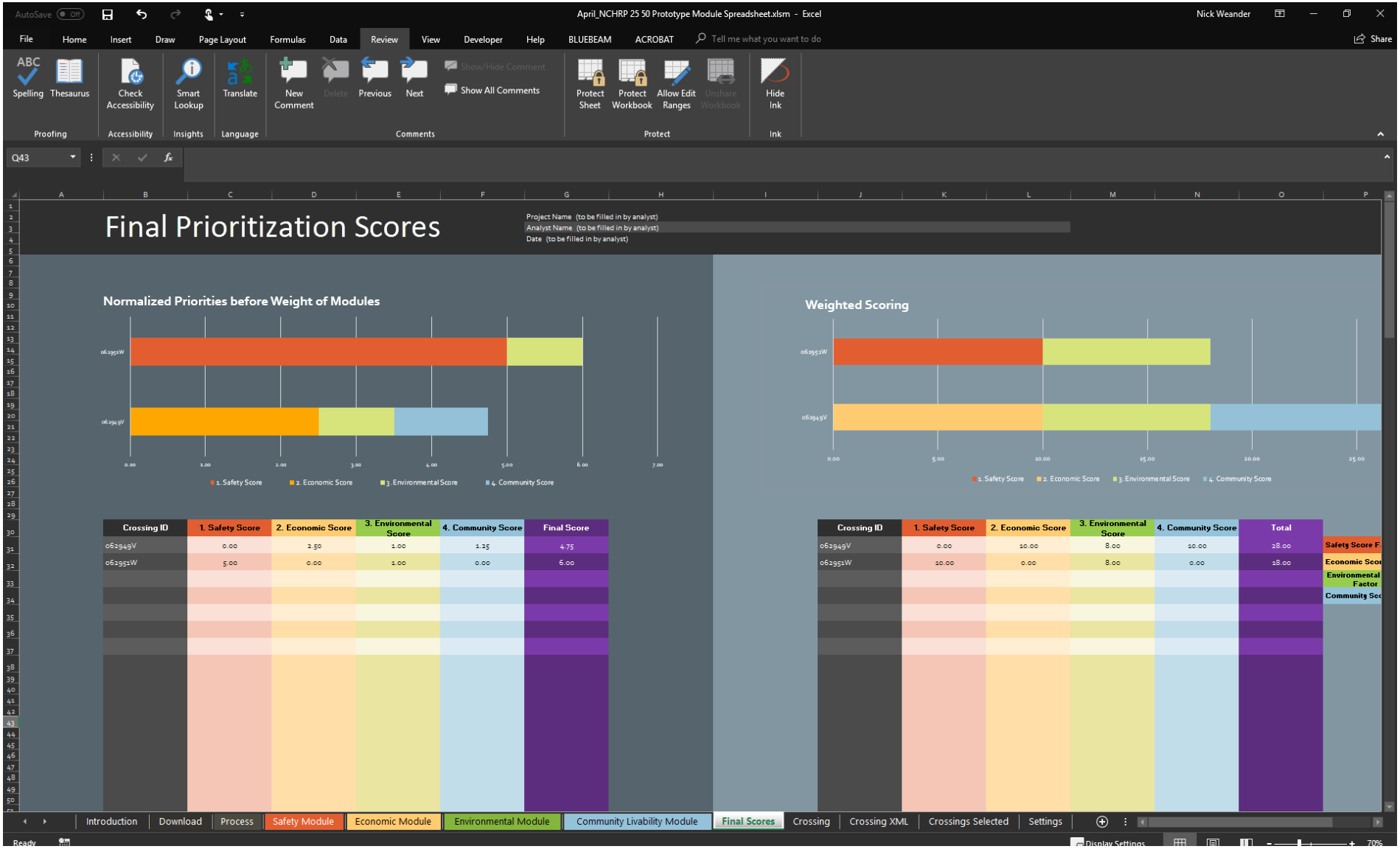
Zoom in of Circle a

	User Defined Weights
Safety Score Factor	50.0%
Economic Score Factor	25.0%
Environmental Score Factor	12.5%
Community Score Factor	12.5%

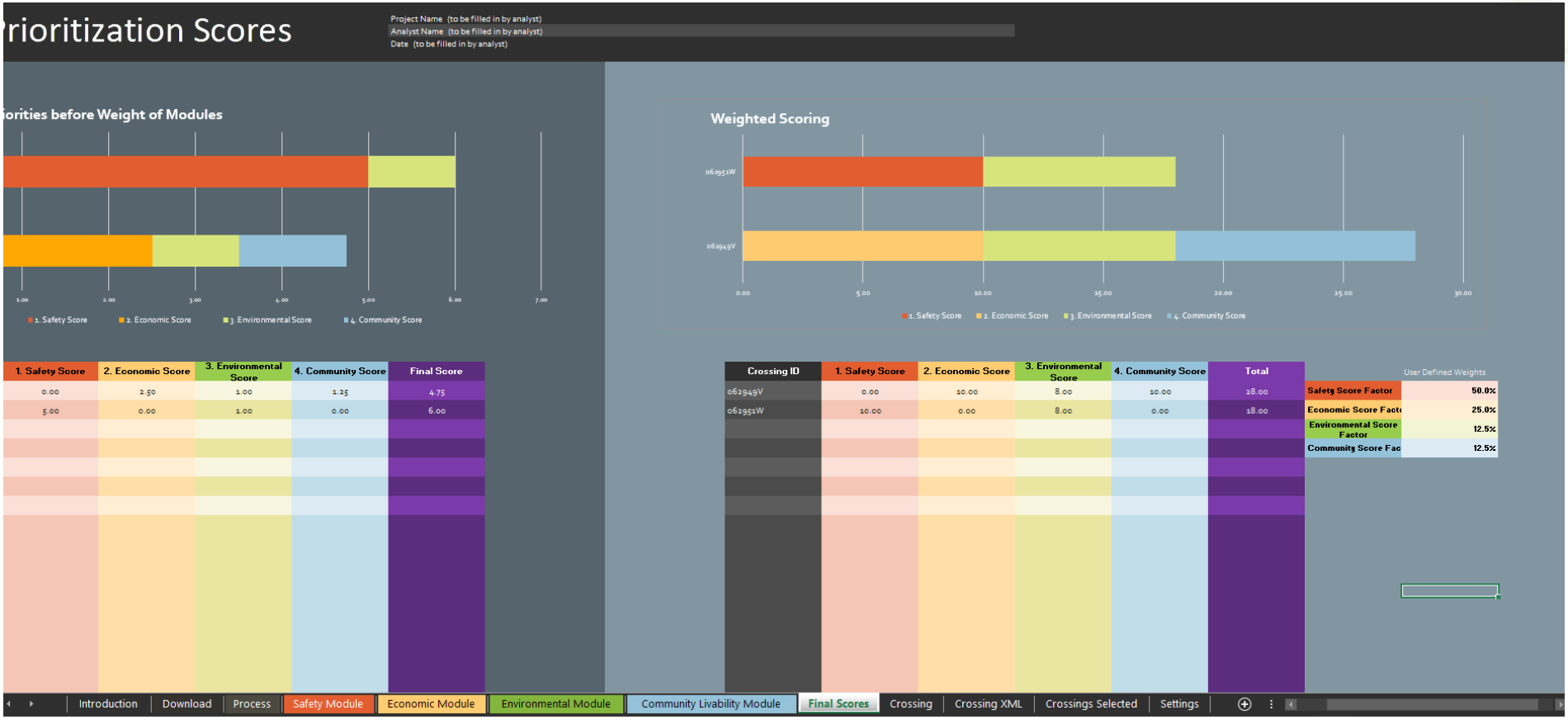
Now you are ready to look at the graphs and Analyze the Findings.

F. ANALYZE THE FINDINGS

The display below shows the left graph within the Final Score Tab. This shows the Normalized Scores before the user assigned weights for each module .



The right graph shows the normalized scores for each crossing after the module weight have been utilized.



Using the findings from the model based upon the user defined elements and data collected in the previous phases, analyze the results of the model. Ask yourself:

- Does the ranking make sense based upon what you know of the crossings within your selected Corridor?
- Did I use the right weighting factors?
- Did I have all the data I needed to perform the analysis?

If you answered "yes" to all of these questions move on to step 6, if not, go back to the data collection phase and change your weights or collect more data to expand the analysis.

G. INTERPRET THE RESULTS

After you perform the analysis and examine the findings, you may discover that you have more questions. You can use the previous phased approach of this decision-making workflow as an iterative process to help you review and interpret information and inform decision making.

H. RERUN THE MODEL TO DETERMINE SENSITIVITY

To test the sensitivity of the weighting scheme you choose to use in the model, you may want rerun the model using a different scheme. To do this, name and save your first programmed spreadsheet, name and save your second version, then modify your weights and rerun the model to see how the ranking change. You may want to do these reruns using multiple weighting methods to test the sensitivity of the weighting scheme and give your decision makers an analysis of the decision criteria for their review.

THE RCAT MODEL CALCULATIONS

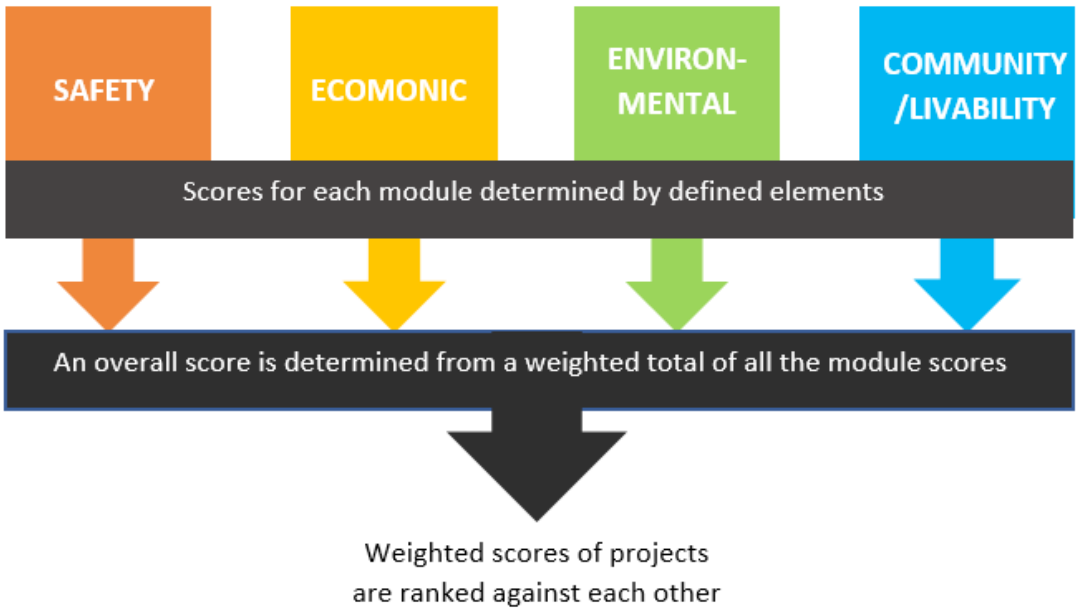
The programmed spreadsheet includes worksheets for all steps and modules in the RCAT. The figure below shows the relationship of these steps schematically. Users are encouraged to read through the Final Report/ Guidebook?) prior to using this tool.

In the programmed spreadsheet, the steps are arranged in order from left to right as individual worksheet tabs. In general, users should go through these steps in sequential order; however, it may be necessary to revisit Step X: Select Factors and Step Y: Select Variables based on data availability and technical resources.

EVALUATION MODULES

Four modules were proposed and approved as the basis for the evaluation factors used in project investment decisions. An examination of project impacts as they relate to safety, economics, environmental impacts and social (community livability) factors are reviewed in this section.

Based upon the conceptual design, the Olsson team developed an excel model to test these factors against the corridors that will be selected by the project



panel from the Case Study Beta-Test Corridors identified in Chapter 5 of the Final Report. The following sub-sections describe each of the four modules and present the formulas used to calculate the elements of each module.

SAFETY FACTORS

SAFETY

A module providing tools and resources to evaluate safety benefits and costs associated with at-grade crossings.

The objective of the safety module is to compute a safety score for each crossing and quantitatively rank them. A quantitative method was developed to prioritize grade crossings along a corridor for grade separation.

The safety score is composed of two components:

$$Safety\ Score = k_1 * (Accident\ Prediction\ Value) + k_2 * (Site\ Related\ Adjustments)$$

The first component of the safety module, *Accident Prediction Value* considers the predicted accident frequency for a location. The second component Site Related Adjustments is dependent upon factors related to each road-railroad crossing site. Each of these components are weighted using the multipliers k_1 and k_2 to reflect the relative importance of each component. Default values for k_1 and k_2 are 1.

The widely accepted USDOT accident prediction formula was used to estimate the expected frequency of accidents. The USDOT model was selected due to its acceptance among practitioners and familiarity of the users with the model. The results from the accident prediction formula can be used to rank the crossings but it merely predicts the likelihood of a collision occurring over a given period. This formula doesn't consider accident severity.

The research team explored if the site related variables identified thru the literature review could be used in the prioritization of grade-crossing with respect to safety. These variables were used to apply adjustments to the base USDOT accident prediction value for each crossing.

The adjustments applied are shown in the following equation:

$$\begin{aligned} &Adjusted\ USDOT\ Accident\ Prediction\ Value\ for\ Xing \\ &\quad = USDOT\ Accident\ Prediction\ Value \\ &\quad + \sum_{i=1}^{n} w_i * Normalized\ value\ of\ variable\ used\ for\ correction_i \end{aligned}$$

Where w_i is the weight for each of the n variables used in the correction.

While using a severity scale of 5 for fatal accidents, 3 for injury accidents and 1 for PDO accidents, the research concluded that:

- For crossings with gates, Maximum Timetable Train Speed, Distance to Nearby Highway Intersection and Crossing Surface improved the USDOT accident prediction values;
- For crossings with flashing lights, the variables Maximum Timetable Train Speed, Posted Highway Speed and Crossing Surface improved the USDOT accident prediction values;
- For crossings with crossbucks, the variables Maximum Timetable Train Speed, Crossing Angle and Crossing Surface could improve accident prediction values.

The tables below show the corrective variables identified, their normalized values and weight to be applied to compute the safety score.

Maximum Timetable Train Speed	<=10	0.1	0.017
	10-20	0.2	
	20-30	0.3	
	30-40	0.4	
	40-50	0.5	
	50-60	0.6	
	60-70	0.7	
	>70	0.8	
Distance to Nearby HW Intersection	<75	1	0.017
	75-200	0.5	
	200-500	-0.5	
	>500	-1	
Crossing Surface	Unconsolidated	1	0.011
	Timber	0.5	
	Asphalt	0	
	Rubber	-0.5	
	Concrete	-1	

Maximum Timetable Train Speed	<=10	0.1	0.047
	10-20	0.2	
	20-30	0.3	
	30-40	0.4	
	40-50	0.5	
	50-60	0.6	
	60-70	0.7	
	>70	0.8	
Posted Highway Speed	<=20	-2	0.005
	20-30	-1	
	30-40	0	
	40-50	1	
	50-60	2	
Crossing Surface	Unconsolidated	1	0.005
	Timber	0.5	
	Asphalt	0	
	Rubber	-0.5	
	Concrete	-1	

Maximum Timetable Train Speed	<=10	0.1	0.047
	10-20	0.2	
	20-30	0.3	
	30-40	0.4	
	40-50	0.5	
	50-60	0.6	
	60-70	0.7	
	>70	0.8	
Crossing Angle	< 60	-0.25	0.005
	>=60	0.5	
Crossing Surface	Unconsolidated	1	0.001
	Timber	0.5	
	Asphalt	0	
	Rubber	-0.5	
	Concrete	-1	

Safety Score Equation Applied to the RCAT

The safety score developed for RCAT uses the adjusted USDOT accident prediction model described above.

The safety score equation applied in RCAT for ranking crossings is shown below.

Safety Score for Crossings with Gates

$$\begin{aligned} Safety\ Score = {} & USDOT\ Accident\ Prediction\ Value \\ & +0.017 * Normalized\ Value\ for\ Maximum\ Timetable\ Train\ Speed \\ & +0.017 * Normalized\ Value\ for\ Distance\ to\ Nearby\ HW\ Intersection \\ & +0.011 * Normalized\ Value\ for\ Crossing\ Surface \end{aligned}$$

Safety Score for Crossings with Flashing Lights

$$\begin{aligned} Safety\ Score = {} & USDOT\ Accident\ Prediction\ Value \\ & +0.047 * Normalized\ Value\ for\ Maximum\ Timetable\ Train\ Speed \\ & +0.005 * Normalized\ Value\ for\ Posted\ HW\ Speed\ Limit \\ & +0.005 * Normalized\ Value\ for\ Crossing\ Surface \end{aligned}$$

Safety Score for Crossings with Crossbucks

$$\begin{aligned} Safety\ Score = {} & USDOT\ Accident\ Prediction\ Value \\ & +0.047 * Normalized\ Value\ for\ Maximum\ Timetable\ Train\ Speed \\ & +0.005 * Normalized\ Value\ for\ Crossing\ Angle \\ & +0.001 * Normalized\ Value\ for\ Crossing\ Surface \end{aligned}$$

ECONOMIC IMPACT FACTORS

ECONOMIC
A module providing tools and resources for assessing non-safety costs and benefits as travel time savings.

Development of the Prioritization Method and Analysis Tool

This section identifies the quantitative and qualitative factors required to prepare an analysis and prioritization method for the Economic Module. The Economic Module presents key criteria recommended to be incorporated into crossing improvement decisions based on previous research and stakeholder input.

Initial criteria incorporate economic factors such as the value of time savings to commuters and commercial vehicle drivers, supply chain savings, and impacts to land-use and economic development opportunities.

These factors are further broken down into two categories: quantitative and qualitative. The factors that can be calculated fit into the quantitative category. Those factors that are more challenging to calculate, have been placed in the qualitative category.

Quantitative Economic Factors:

The quantitative economic factors have been developed based upon guidance USDOT has given in recent competitive funding opportunities. These factors can be calculated using directions given by USDOT in their TIGER and INFRA Benefit Cost Analysis Guidance. In recent USDOT guidance from the TIGER and INFRA BCA Resource Guide, standard values are given for numerous public benefits related to long-term outcomes from the investment.

These standard factors include:

- Value of Statistical Life
- Value of Injuries
- Value of Property Damage Only Crashes
- Value of Travel Time
- Value of Emissions
- Social Cost of Carbon

Many of these standard factors can be applied to the economic module. In addition, five additional factors were offered for consideration. The following five factors were originally identified for inclusion in the economic module:

1. Vehicle operating cost/delay and accident cost – Passenger vehicles
2. Vehicle operating cost/delay and accident cost – Commercial vehicles
3. Crossing operating cost/life cycle cost
4. Construction cost of improvements
5. Economic Losses – positive or neg.

In completing the research of this project this list was refined to the following

6. Passenger Vehicle operating cost & delay cost
7. Commercial Vehicle operating cost & delay cost
8. Density near the Project-Low, Medium or High
9. Economic Losses – positive or neg.

Economic Factors	Determination of Factor
EC 1-Vehicle operating cost/delay cost – Passenger vehicles- EIS / BCA	Calculation –see formulas below.
EC2- Vehicle operating cost/delay cost – Commercial vehicles –EIS/ BCA	Calculation –see formulas below.
EC3-Improvement Cost - Removed from the model due to observations during beta testing	Engineering Estimates
EC4- Density near the Project	User Observation based upon location of crossing
EC5- Economic Losses – positive or neg.	User Observation based upon location of crossing

It is recommended that a set of standard monetized values be selected as default values for Crossing operating cost/ life cycle costs and Construction Costs. The default values can be selected by the user when

there is not any better local information available. This method will provide a basis to compare competing projects when project specific information is not available. Table 4-7 displays the calculation for each factor

Economic Factor	Calculation
Vehicle operating cost + delay cost - Passenger vehicles (EC1)	A. Vehicle delay cost in travel time savings: • Number of Passenger Vehicles (AADT less the # of trucks) *(av. delay (2.5 min) /60 minutes per hour) * average hourly all-purpose local travel ($13.00/ hr for local travel in Tiger FY 2016 guidance) B. Operating cost defined as Idling fuel costs: • Fuel savings due to Reduction of idling time in minutes * AADT/60 minutes per hour to convert to total hours of idling per day. • Total gallons saved by reduction of idling= hours of idling *1.5 gallons per hour • Total fuel savings =Total gallons saved * average cost of fuel per gallon
Vehicle operating cost + delay costs - Commercial vehicles (EC2)	C. Vehicle delay cost in travel time savings: • Number of Commercial Vehicles (AADT * % of trucks) *(av. delay (2.5 min) /60 minutes per hour) * average hourly truck drivers ($26.68/ hr for truck drivers in Tiger FY 2016 guidance) D. Operating cost defined as Idling fuel costs: • Fuel savings due to Reduction of idling time in minutes * AADT/60 minutes per hour to convert to total hours of idling per day. • Total gallons saved by reduction of idling= hours of idling *1.5 gallons per hour • Total fuel savings =Total gallons saved * average cost of fuel per gallon

Qualitative Economic Factors

Additional qualitative factors such as impact on land use, economic development opportunities, and supply chain savings can be derived from data collected for the visual amenity factor and crossing inventory.

The visual amenity factor in the Environmental Module estimates the intensity of development around the crossing. Factors to analyze the intensity of land use density adjacent to the crossing location are shown in Table 4-8. This data can be used to help determine inputs into the value to the local area of improved mobility at the crossing.

Intensity of Density	
Improved mobility near project (EC4) Low = Rural/industrial areas Medium = Suburban / residential areas High = Urban areas/City center/high density population locations	Review adjacent land use, make observation on Density The final score will calculate using 1= low,3=Medium, or 5 =High

Economic Loss	
Will the completion of this improvement cause Economic Loss to the surrounding land owners? EC5: Yes or No	Review adjacent land use and make an observation on whether the improvement will have a positive or negative effect on the property / property value. No= No loss to land owners Yes= Loss to land owners, if improvement made
Impacts to Land Use- EC6 1= low (in industrial area) 3= medium (suburban residential density 5=Urban (city center, high population density)	User Observation based upon looking at adjacent land use Rank 1 low-5 High
Supply Chain Savings – EC7 1= low (less than 6% truck traffic) 2= 6% to less than 11% 3= medium (11 to less than 16% truck traffic) 4=16% to less 26% 5= High (26% or more truck traffic)	FRA Crossing Inventory Trucks as a Percent of AADT

The concept for the Impacts to Land Use factor is that an improvement to the crossing in an industrial area, may not add much value to adjacent property, but should increase the mobility and safety of all stakeholders. Whereas in an urban setting, the addition of a grade separation should add value to the nearby property and opportunities for economic development due to the increased mobility and safety provided by such an improvement.

Supply chain savings can be an evaluated qualitatively based upon the percentage of trucks that are using the crossing as an estimate of the operational saving has already been calculated in EC2.

ENVIRONMENTAL FACTORS

Environmental stewardship and consideration of environmental impacts in the decision-making process has a long history in transportation planning. The enactment of the National Environmental Policy Act on January 1, 1970 required all projects utilizing federal-aid funding to undergo an environmental review in order to document and understand the impacts of a potential project on the environment. For the purpose of this project, the environment has been categorized into three areas: natural, built, and social.

Potential Environmental Factors

The natural environment encompasses the living flora and fauna as well as the naturally occurring geologic features that constitute the complex ecosystem aside from that which has been molded by humans. The built environment includes the communities, neighborhoods, historical artifacts and other features of the human-shaped world. Finally, the social environment constitutes the factors that describe the living conditions and characteristics of the population that resides in the built environment.

The identified factors for each subgroup are contained in the list below:

- Natural Environment
  - Costal Management Areas

  - Critical Habitat for Threatened and Endangered Species
  - Wetlands
  - Wild and Scenic Rivers
  - Air Quality Non-Attainment Areas
  - Superfund Sites
- Built Environment
  - Tribal Lands
  - Federal or State-Owned Lands
  - Military Installations
  - Historical Properties
  - Parks and Recreation Areas
- Social Environment
  - Environmental Justice
  - Community Severance

Methodology

Qualifying the value of an environmental factor can be extraordinarily difficult and contentious. To a certain extent, society places varying levels of importance upon the natural, built and social environment. The value an individual agency places upon the critical habitat of an endangered species may vary as compared to the societal value of a historical property or the potential severance of a community. To remove the ambiguity of the social value of an environmental good, a simple toggle approach is utilized for each of the above factors, Yes, or No (i.e. a 1 or 0). For the Total Score the number of factors are summed. The Total Score for each improvement is then Normalized within the Improvements being analyzed.

To help in the determination of each factor:

The corridor should be mapped and the location of known environmental variables mapped adjacent to the project locations. A buffer of 1 mile is proposed in order to provide local connection to the potential project. The presence of a sensitive environmental factor inside the project buffer should be noted as a 1 inside the excel module. If no environmental factor is located inside the project buffer, a 0 should be used.

Based upon the 13 environmental factors, the following scores may be assigned:

- 0-3 factors affected: 1 (low) ranking
- 4-6 factors affected: 2 ranking
- 7-9 factors affected: 3 (moderate) ranking
- 10-12 factors affected: 4 ranking
- 13 factors: 5 (high) ranking

Each of the factors is discussed in detail below.

Natural Environment

Coastal Management Areas

Coastal Management Areas (CMA) area locations that were established under the Coastal Zone Management Act of 1972 (CZMA). These locations have been established in order to preserve, protect, develop and where possible, to restore or enhance the resources of the nation's coastal zone. Zones begin at the shoreline and

extend inland to locations that have direct and significant impact on coastal waters. Additional lands held by the Federal Government are included in these zones unless otherwise noted. CMA location information can be found here: https://data.noaa.gov/dataset/coastal-zone-management-act-boundary-for-the-united-states-and-us-territories-as-of-decemb-2013 Corridors that may impact a Costal Management Area would yield a score of 1. Corridors outside a CMA would yield a score of 0.

Critical Habitat for Threatened and Endangered Species

Threatened and endangered species will vary from location to location. Reference lists for each project location should be developed with Natural Resource Agencies for each state/location. Locations of critical habitat can then be identified and be mapped to be used in the buffer analysis. The presence of critical habitat would yield a score of 1. No critical habitat would yield a score of 0.

Wetlands

Buffer map of project location and location of known wetlands. Impacts to the wetland areas may be determined through examination of the proposed scope of the grade separation project. In states/locations where wetland banking is allowed an assessment of the impact/cost as compared to the project cost can be determined to develop a ratio. A more qualitative assessment may utilize a No Impact or Impact scoring system. For this example, it is proposed that the presence of wetlands inside the buffer yield a score of 1 and the absence yield a 0.

Wild and Scenic Rivers

Wild and scenic rivers are federally designated pristine habitat designated by the Wild and Scenic Rivers Act of 1968. These waterways are oriented to preserve the natural, cultural and recreation value of the riverine system for future generations. Consultation with the National Park Service to identify Wild and Scenic Rivers via https://www.nps.gov/ncrc/programs/rtca/nri/index.html. The project buffer will be used to identify locations that may impact Wild and Scenic Rivers. For this example, it is proposed that the presence of a wild, scenic or recreational river inside the buffer yield a score of 1 and the absence yield a 0.

Air Quality Non-Attainment Areas

Corridors located inside areas that are not in attainment of the National Ambient Air Quality Standards (NAAQS) may require additional analysis and/or other project activities or amenities be included during the development of a grade separation project. The US Environmental Protection Agency (EPA) maintains the listing of areas currently designated as non-attainment for air quality standards on their website: https://www3.epa.gov/airquality/greenbook/. Project locations should be identified within these areas and tabulated based upon a 1 for a location inside a non-attainment area and a 0 for areas in attainment of air quality standards.

Superfund Sites

Areas with substantial pollution, requiring large scale clean-up activities have been identified by the EPA as focus areas for making a visible and lasting difference in communities in response to environmental emergencies, oil spills and other natural disasters. The location of superfund sites can be found here: https://www.epa.gov/superfund/search-superfund-sites-where-you-live Project locations should be identified within these areas and tabulated based upon a 1 for a location inside a superfund cleanup site and a 0 for areas that are not inside a superfund site.

Built Environment

Tribal Lands

The lands controlled by the indigenous tribes inside the United States require additional care and coordination when projects are located within their boundaries. The US Department of the Interior's Bureau of Indian Affairs (BIA) administers works with the recognized tribes to administer tribal property. Additional information on tribal lands can be obtained here: http://www.bia.gov/yourland/index.htm. Project locations should be identified within these areas and tabulated based upon a 1 for a location that impacts tribal lands and a 0 for locations that do not.

Federal or State-Owned Lands

The relevant state Departments of Transportation in partnership with the local Federal Highway Division Office will be able to determine the location of state or federally owned land within the project area. As these locations require additional consultation and may be protected, their presence should be noted during the initial screening process. Locations should be identified within the one-mile project buffer and scored 1 for locations with federal or state-owned lands and a 0 for project locations without federal of state owned lands.

Military Installations

Similar to federal or state-owned lands, military installations provide an additional layer of complexity. In addition to being federally or state owned, the site may be a historical property or contain locations with unexploded ordnance. Military installations can be found here: https://www.nps.gov/nagpra/DOCUMENTS/BasesMilitaryMAP.htm. Locations should be identified within the one-mile project buffer and scored 1 for locations adjacent to military installations and a 0 for project locations without military installations.

Historical Properties

The National Park Service maintains the National Register of Historic Places. Historical properties provide societal benefits that are difficult to quantify and cannot be replaced. Project corridors should be overlaid with locations of historic places from the register (available here: https://www.nps.gov/nr/research/index.htm). It should be noted that records have not be digitized for Arkansas, Illinois, Massachusetts, Michigan, Missouri, North Carolina, New York, Pennsylvania, Ohio, Texas and Virginia. It is necessary to consult with a state's historic preservation officer in order to identify locations that may not be available through the national register due to their restricted status. The presence of historical properties inside the corridor buffer should be scored 1 whereas the absence should be scored as 0.

Parks and Recreation Areas

Other locations that can be used by the public as parks or recreation areas should also be identified during the mapping and corridor buffer process. These locations may be protected under Section 4f of the Department of Transportation Act of 1966. As specific impacts are not readily available to be assessed in the preliminary screening for projects. The location of parks and recreation areas should be noted as a 1 in the excel portal. The absence of parks and or recreation areas within the project buffer should be noted as 0.

Social Environment

Environmental Justice Populations

Executive Order 12898 protects low-income populations from disproportionately high and adverse human health and environmental effects during the development of federal-aid transportation projects and programs. Low-income populations can be mapped according to census geography. For each location, areas with high low-income population should be identified within the project buffer. Presence of a high ratio of low-income population within the project buffer would yield a 1 whereas the absence would yield a 0.

Community Severance

An assessment of the cultural communities that exist within a jurisdiction should be undertaken to identify when potential grade separation decisions may close existing crossings that provide access to essential goods, services or community locations such as churches and other gathering places. A visual assessment may be conducted based upon demographic and social information available through the US Census Bureau and online mapping services such as Google Earth. The potential for community severance should be scored as a 1 whereas the absence would yield a score of 0.

COMMUNITY LIVABILITY FACTORS

COMMUNITY/LIVABILITY
This module is designed to assess factors impacting neighborhoods, community services and local priorities.

Livability is a concept that while not new, is increasingly being integrated in to the transportation planning process. In recent years, FHWA has started a Livability Initiative: http://www.fhwa.dot.gov/livability/ and in partnership with HUD, DOT and EPA, FHWA also sponsors an interagency Partnership for Sustainable Communities: https://www.sustainablecommunities.gov/

FHWA defines livability as:

> *Livability is about tying the quality and location of transportation facilities to broader opportunities such as access to good jobs, affordable housing, quality schools, and safer streets and roads. The FHWA supports livable communities through funding transportation related projects and sponsoring activities like Context Sensitive Solutions and public involvement that help, enable people to live closer to jobs, save households time and money, and reduce pollution.*

Under this definition, livability factors to consider for grade separations would be those factors related to safety, time savings, access to work and emissions.

In a research paper produced for FHWA about the role of FHWA programs in livability, other definitions of livability are also offered. Some livability definitions focus on the ability to access goods and services without having to use motorized transport. More broadly however, some organizations define livability as part of a community's overall character:

American Association of State Highway and Transportation Officials (AASHTO): *The Washington State Department of Transportation suggests that a "livable future" requires a balance of three key societal goals: vibrant communities, vital economy, and sustainable environment—all goals for which good transportation is essential…AASHTO's 'livability' objective is to use transportation investments to improve the standard of living, the environment, and quality of life for all communities, rural, suburban, and urban… providing more transportation choices for families, by walking, biking, and transit;….driving is also a legitimate transportation choice (AASHTO, 2010).*

American Institute of Architects: *In the quest to improve conditions in urban, suburban, and rural communities, citizens are becoming ever more engaged…One common thread that allows an effective discussion of such issues…is the shared interest among all stakeholders in the creation, conservation, or enhancement of a community's particular character. This character evolves from the weaving together of many elements to create a sense of comfort, function, and attractive appearance (AIA, 20015).*

AARP: *(Beyond 50.05 – A Report to the Nation on Livable Communities: Creating Environments for Successful Aging). "A livable community is one that has affordable and appropriate housing, supportive community features and services, and adequate mobility options, which together facilitate personal independence and the engagement of residents in civic and social life." (AARP, 2005, pp 4).*

Potential Community Livability Variables

One thing for certain is that the term "livable community" is evolving. Generally, the phrase livable community includes the principles of safety and security, communities that encourage citizens to be engaged, and, from a strictly transportation standpoint, communities that do not require motorized transport to access goods and services. The term livable community is also often used as an ancillary means for describing *quality of life*.

Within the other three evaluation categories being address by NCHRP 25-50 research; 1) Safety, 2) Economics and 3) Environment, many elements that contribute to livability, e.g. safety and access to jobs are already covered. The livability evaluation category in this context can should be viewed as factors that affect the security of citizenry, without being directly involved in a train accident/collision. These suggested factors are:

> **1.Risk of Derailment/Release of Hazardous Materials (HazMat):** "*Since 1980 the U.S. railroad derailment rate has declined from 8.98 derailments per million train miles, to 1.63 in 2014, an 82% reduction.*" (Liu, Saat, & Barkan, 2015, pp 2). While derailment statistics have dramatically improved over the past several decades, a single derailment involving the release of hazmat can have tragic consequences, as was the case in Lac-Megantic, Quebec in 2013. While Lac-Megantic tragedy was not related to an at grade road-railroad crossing, recent research conducted by UI-UC Rail Transportation and Engineering Center (RailTEC) found: *"that 22.6% of all grade crossing incidents involved a train carrying hazardous materials."* (Chadwick, et. al., 2013 pp 13). The research also notes however that grade crossing incidents involving a hazardous materials release are rare; a total of 30 release events involving at grade crossing incidents over a 20-year period. Further, statistics suggest that the likelihood of a hazmat release is highly dependent upon a derailment event: *The likelihood of release also appears dependent on derailment, as 0.641% of all derailments result in release and 0.063% of all non-derailments result in release.* (Chadwick, et. al., 2013 pp 14).

The safety evaluation category addresses primarily crashes and incidents between a train and an automobile, bike or pedestrian. *"Traditionally, highway departments prioritize upgrading grade crossings with the highest risk of an accident, but do not account for the likelihood of a train derailment."* (Chadwick, et. al., 2013, pp 3). The safety evaluation category does not consider the impact on citizens resulting from train related incidents at crossings that result in explosions or the release of a hazardous substances. RailTEC research has also identified factors that contribute to derailments; and, while a predictive model is still being formulated, the researchers have identified several conditions that contribute to train derailments: 1) track class, 2) method of operation (signaled or non-signaled) and 2) traffic density. The research conducted by Rail TEC drew the following conclusions: (Liu, Saat, & Barkan, 2015, pp 9)

- The higher the FRA track class, the lower the train derailment rate
- Signaled track has a lower derailment rate than non-signaled track
- Track with higher density has a lower derailment rate

However, the authors of this train derailment research note that the analysis focused only on derailments and excluded other types of train accidents such as grade crossing incidents. (Liu, Saat, & Barkan, 2015, pp 3). The research by Chadwick, Saat, Dick and Barkan which focused specifically on derailment occurrence at grade crossings, identified three variables with predictive value for identifying grade crossings and derailment risk, as well as easily obtainable proxy variables (Chadwick, et. al., 2013).

Table 4-10 Derailment/Crossing Variables

Incident specific variable	Crossing specific variable
Vehicle Speed	Highway Speed Limit
Train Speed	Posted Timetable Speed
Large Vehicle Involvement	Percent Truck Traffic Annual Average Daily Truck Traffic (AADT)

While the research noted above suggests conditions that contribute to train derailments at grade crossings, other research has examined the potential impact of a derailment on the safety and security of resident populations near a crossing if hazardous materials are present:

a. Population Density: In 2014 the Minnesota Legislature directed the Minnesota Department of Transportation to study the issue of at grade crossings and the movement of crude by rail through Minnesota: *The study focuses on prioritizing risks, while also reducing potential collisions by improving the overall safety of each grade crossing... This study is different because it expands the conventional evaluation scope to include the risk to adjacent residents and workers. The study shifts the focus to an area and population-based risk assessment, rather than just an accident prediction assessment."* (MnDOT, 2014, pp 9). MnDOT used satellite imagery and GIS to delineate buffer zones around at grade crossings to examine the potential populations endangered by a hazardous materials release or explosion.

b. Vulnerable Populations: The MnDOT effort also made an attempt to identify "fixed vulnerable populations such as hospitals, nursing home and prisons and transient vulnerable populations such as schools." (MnDOT, 2014, pp 10). The presence of hospitals, senior care facilities, schools and prisons can also be identified via GIS applications.

2. Emergency Response Delays Safety evaluations of at grade crossings typically do not address the impact of trains blocking a crossing on timely response by emergency vehicles responding to a crisis. Recently the City of Chicago identified a series of grade crossings frequently used by emergency vehicles which have been identified as "911 Critical Grade Crossings." In 2005, SAFETEA-LU directed the FRA to examine and report the impacts of blocked highways due to at grade crossing on emergency response providers. The study found that there is no national data collection effort to identify or quantify blocked crossings or emergency response delays. However, the study identified several factors that contribute to traffic delays at grade crossings: 1) Moving trains and train length, 2) Stopped trains, and 3) Operational problems. The FRA report concluded:

> *"The impacts on communities from delayed response due to blocked crossings, while sometimes severe, are less than the impacts of traffic delays and congestion caused by blocked crossings. Another way to look at it would be to say that in places where blocked crossings are seen as a problem – to traffic, to safety and to emergency response – emergency response delays may help to justify a grade separation or other major expenditure, but such delays are unlikely, by themselves, to justify major remediation measures except in special cases."*

Since 2001, the National Fire Protection Association has published NFPA 1710 which establishes a baseline against which emergency response units across the U.S. measure their performance. In general, the so called "Gold Standard" for emergency response is that the first unit should arrive within eight minutes 90 percent of the time (NFPA, 2010).

Scoring Community Livability Factors

Based on the review of literature, The table below suggests a preliminary scoring methodology for including community livability factors in the evaluation of road-rail grade separation projects.

Risk of Derailment Factors	Data Value	Data Source	Comments

Highway Vehicle Speed (Proxy variable = posted speed limit)	10 – 85 mph	State DOT or local road authority	65+ mph = Score 10 55-60 mph = Score 8 45 - 50 mph = Score 6 35 - 40 mph = Score 4 <35 mph =Score 2
Train Speed	Maximum Timetable Speed (MaxTtSpd)	FRA*	Train speed which is a FRA inventory data field. The following maximum speeds are for freight trains: 64 mph or more = Score 10 <64 mph = Score 8 <50 mph = Score 6 <40 mph = Score 4 <35 mph = Score 2 Should this be < 26?
Large vehicle exposure	Percent of trucks in traffic	State DOT or local road authority	20% or more = Score 10 15-19% = Score 8 10 – 14% = Score 6 5 – 9% = Score 4 <5% = Score 0
Exposure to HazMat from Incident	**Data Value**	**Data Source**	**Comments**
Presence of Hazardous Train Cars Are there trains carrying Hazardous Materials moving through the crossing?	Cars per day	railroad / observation	Railroads must report hazardous material train volumes of more than 1 million gallons to state emergency management officials, but that information may not be shared with local officials. HazMat cars/tankers must be placarded to identify the nature of the contents. Observations or the use of camera technologies can be used to collect and analyze HazMat volumes. Yes= 1 No = 0
Population Density	population/sq. mi.	GIS	Measured within 1 square mile of crossing Low =1 Medium = 3 High = 5
Vulnerable populations	hospitals, senior living, schools, prisons	GIS	Measured within 1 square mile of crossing Yes=1 No=0
Emergency Response Delays	Presence of police station, fire station or hospital within 1 mile of crossing without access to a grade separated crossing	EMS Services	Measured within 1 square mile of crossing Yes= 1 No=0