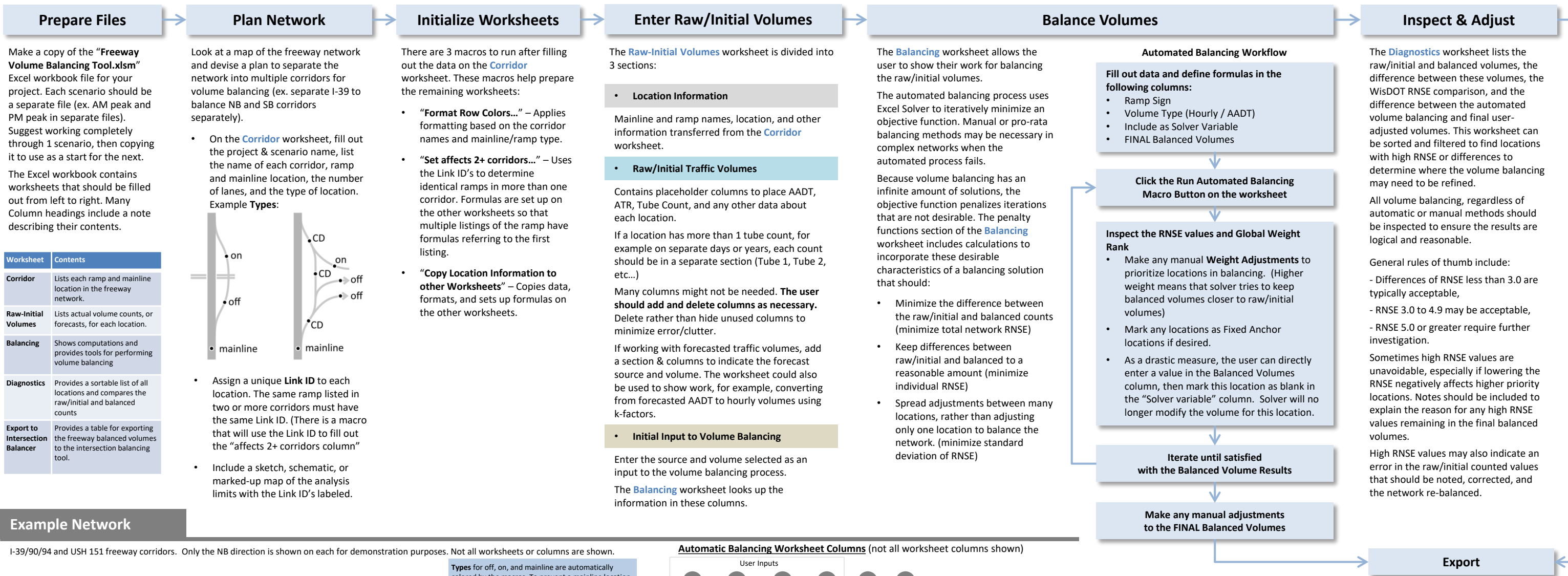


Freeway Volume Balancing Tool

Using the freeway volume balancing tool generally follows this workflow:

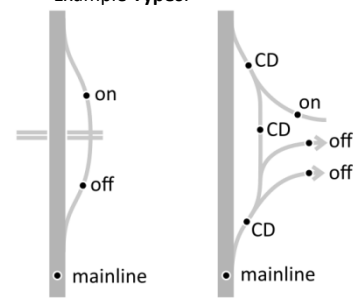


Prepare Files
Make a copy of the "Freeway Volume Balancing Tool.xlsm" Excel workbook file for your project. Each scenario should be a separate file (ex. AM peak and PM peak in separate files). Suggest working completely through 1 scenario, then copying it to use as a start for the next. The Excel workbook contains worksheets that should be filled out from left to right. Many Column headings include a note describing their contents.

Worksheet	Contents
Corridor	Lists each ramp and mainline location in the freeway network.
Raw-Initial Volumes	Lists actual volume counts, or forecasts, for each location.
Balancing	Shows computations and provides tools for performing volume balancing
Diagnostics	Provides a sortable list of all locations and compares the raw/initial and balanced counts
Export to Intersection Balancer	Provides a table for exporting the freeway balanced volumes to the intersection balancing tool.

Plan Network
Look at a map of the freeway network and devise a plan to separate the network into multiple corridors for volume balancing (ex. separate I-39 to balance NB and SB corridors separately).

- On the **Corridor** worksheet, fill out the project & scenario name, list the name of each corridor, ramp and mainline location, the number of lanes, and the type of location. Example **Types**:
 - Assign a unique **Link ID** to each location. The same ramp listed in two or more corridors must have the same Link ID. (There is a macro that will use the Link ID to fill out the "affects 2+ corridors" column"
 - Include a sketch, schematic, or marked-up map of the analysis limits with the Link ID's labeled.



Initialize Worksheets
There are 3 macros to run after filling out the data on the **Corridor** worksheet. These macros help prepare the remaining worksheets:

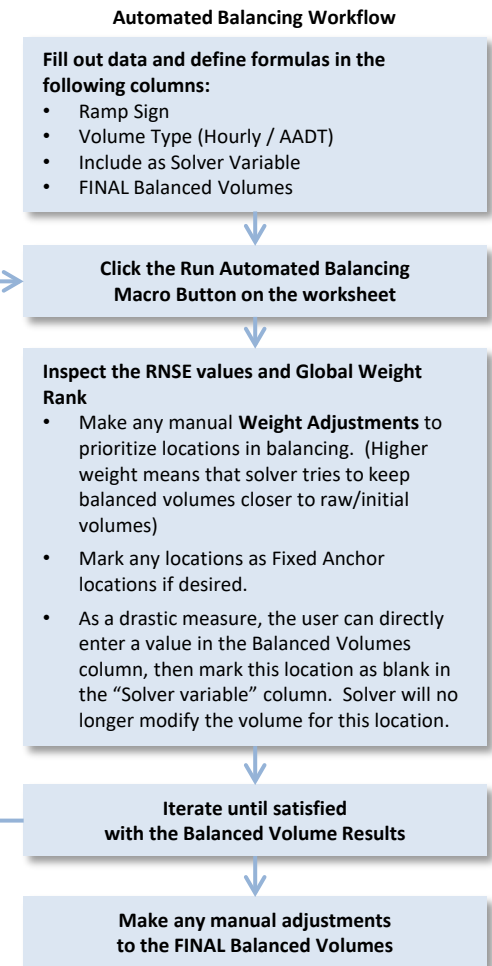
- "**Format Row Colors...**" – Applies formatting based on the corridor names and mainline/ramp type.
- "**Set affects 2+ corridors...**" – Uses the Link ID's to determine identical ramps in more than one corridor. Formulas are set up on the other worksheets so that multiple listings of the ramp have formulas referring to the first listing.
- "**Copy Location Information to other Worksheets**" – Copies data, formats, and sets up formulas on the other worksheets.

Enter Raw/Initial Volumes
The **Raw-Initial Volumes** worksheet is divided into 3 sections:

- Location Information**
Mainline and ramp names, location, and other information transferred from the **Corridor** worksheet.
- Raw/Initial Traffic Volumes**
Contains placeholder columns to place AADT, ATR, Tube Count, and any other data about each location. If a location has more than 1 tube count, for example on separate days or years, each count should be in a separate section (Tube 1, Tube 2, etc...) Many columns might not be needed. **The user should add and delete columns as necessary.** Delete rather than hide unused columns to minimize error/clutter. If working with forecasted traffic volumes, add a section & columns to indicate the forecast source and volume. The worksheet could also be used to show work, for example, converting from forecasted AADT to hourly volumes using k-factors.
- Initial Input to Volume Balancing**
Enter the source and volume selected as an input to the volume balancing process. The **Balancing** worksheet looks up the information in these columns.

Balance Volumes
The **Balancing** worksheet allows the user to show their work for balancing the raw/initial volumes. The automated balancing process uses Excel Solver to iteratively minimize an objective function. Manual or pro-rata balancing methods may be necessary in complex networks when the automated process fails. Because volume balancing has an infinite amount of solutions, the objective function penalizes iterations that are not desirable. The penalty functions section of the **Balancing** worksheet includes calculations to incorporate these desirable characteristics of a balancing solution that should:

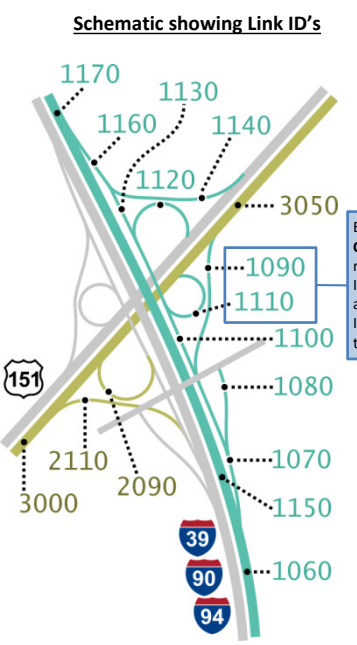
- Minimize the difference between the raw/initial and balanced counts (minimize total network RNSE)
- Keep differences between raw/initial and balanced to a reasonable amount (minimize individual RNSE)
- Spread adjustments between many locations, rather than adjusting only one location to balance the network. (minimize standard deviation of RNSE)



Inspect & Adjust
The **Diagnostics** worksheet lists the raw/initial and balanced volumes, the difference between these volumes, the WisDOT RNSE comparison, and the difference between the automated volume balancing and final user-adjusted volumes. This worksheet can be sorted and filtered to find locations with high RNSE or differences to determine where the volume balancing may need to be refined. All volume balancing, regardless of automatic or manual methods should be inspected to ensure the results are logical and reasonable. General rules of thumb include:
- Differences of RNSE less than 3.0 are typically acceptable,
- RNSE 3.0 to 4.9 may be acceptable,
- RNSE 5.0 or greater require further investigation. Sometimes high RNSE values are unavoidable, especially if lowering the RNSE negatively affects higher priority locations. Notes should be included to explain the reason for any high RNSE values remaining in the final balanced volumes. High RNSE values may also indicate an error in the raw/initial counted values that should be noted, corrected, and the network re-balanced.

Example Network

I-39/90/94 and USH 151 freeway corridors. Only the NB direction is shown on each for demonstration purposes. Not all worksheets or columns are shown.



Example ramps **Affecting 2+ Corridors** (1090, 1110). These ramps are listed first in the NB I-39/90/94 corridor, so they are marked primary on I-39/90/94, and secondary in the NB US 151 corridor.

Corridor Location Information

Types for off, on, and mainline are automatically colored by the macros. To prevent a mainline location from being colored, use Type "mainline." or "mainline " (using a dot or space after mainline)

Corridor	Corridor & Direction	Link ID	Affects 2+ Corridors?	Location Type	Location
NB I-39/90	NB I-39/90	1060		mainline	Badger to US 151
	NB I-39/90	1070		CD	off to US 151/High Crossing CD
	NB I-39/90	1080		off	CD: off to High Crossing
	NB I-39/90	1090	Primary	off	CD: off to NB US 151
	NB I-39/90	1100		CD	CD: b/n ramps
	NB I-39/90	1110	Primary	on	CD: on from NB US 151
	NB I-39/90	1120	Primary	off	CD: off to SB US 151
	NB I-39/90	1130		CD	CD: b/n ramps
	NB I-39/90	1140	Primary	on	CD: on from SB US 151
	NB I-39/90	1150		mainline.	b/n CD exit & CD entrance
NB I-39/90	1160		CD	on from CD	
NB US 151	NB US 151	3000		mainline	Frontage Rd to I-39/90/94
	NB US 151	2110	Secondary	off	off to SB I-39/90/94
	NB US 151	2090	Secondary	on	on from SB I-39/90/94
	NB US 151	1110	Secondary	off	off to NB I-39/90/94
	NB US 151	1090	Secondary	on	on from NB I-39/90/94
NB US 151	3050		mainline	I-39/90/94 to American Pkwy	

Automatic Balancing Worksheet Columns (not all worksheet columns shown)

User Inputs					
1	2	3	4	5	6
Raw/Initial Volume	FINAL Balanced Volumes	Include as a Solver Variable?	Weight Adjustment	Global Weight Rank	Capacity Weight
0	3650		1.00	54	0.00
1843	1970		1.00	11	0.46
541	470	TRUE	1.00	23	0.27
1469	1380	TRUE	1.00	4	0.73
0	120		1.00	54	0.00
102	70	TRUE	1.00	42	0.10
154	120	TRUE	1.00	42	0.10
0	70		1.00	54	0.00
171	130	TRUE	1.00	42	0.10
0	1680		1.00	54	0.00
0	200		1.00	54	0.00
1785	1880		3.00	2	0.30
753	820	TRUE	1.00	36	0.13
229	200		1.00	54	0.11
233	260		1.00	54	0.12
102	70		1.00	54	0.10
1469	1380		1.00	54	0.73
2177	2190		1.00	19	0.36

Column	Brief Description
1	Selected raw/initial volume used as a starting point for volume balancing. This volume is carried over from the Raw-Initial Volumes worksheet, so it will show 0 if no volume was selected.
2	Contains the balanced volume output from Solver and user adjustments. Only cells marked as TRUE in column #3 are changed by Solver. Formulas need to be manually entered in this column to compute the cumulative sum of the volumes for locations not marked TRUE.
3	For locations marked TRUE, Solver will change the number in the Balanced Volume column #2 at this location during its optimization process. These are typically ramp locations and the first location in a corridor.
4	User adjustments to the "importance," or weight that each location has within Solver. The adjustment should initially be 1.0. Inspect the Global Weight Rank column when adjusting to ensure that higher ranked locations are meaningful to the project and the user. See #5, Global Weight Rank.
5	Lists the rank of each location based on the Global Weight column. 1 = the location with the most weight. Solver will try to minimize the RNSE of higher ranked locations before minimizing the RNSE of lower ranked locations. Ranks 1-10 are highlighted.
6	Provides an estimated "importance" of the location based on the hourly volume per lane with respect to an assumed capacity of 2000 vph/ln. The value ranges from 0 to 1.0. The capacity weight gets multiplied by the user weight-adjustment to determine the global weight rank.

Export
If also balancing ramp terminal or other intersection, copy data from the **Export To Intersection Balancer** worksheet to the intersection balancing tool. Balancing freeways and intersections can be iterative. Intersection balancing may reveal information that requires re-balancing the freeways and vice-versa.