7-Apr-2018

COLLABLOCATION
https://collablocation.shinyapps.io/home

Help and Data
for CNG Truck Stops in the US Southwest Application
https://collablocation.shinyapps.io/geodesign_cng_sw_2018

Here are some tips for users and explanations about data. These instructions are for users, not programmers. The explanations are organized according to the 5 tabs from right to left at the top of the **COLLABLOCATION** screen, which correspond to the typical geodesign workflow process.

If the iteration you are looking for in "Comparing to Other Groups" or "Spatial Comparison" is not showing up, please refersh the web page and try again.

1. **Main Tab.** The Main tab enable groups to locate a set of facilities and, in real time, evaluate their performance by various impact measures.
   - **Group Name, Stage, and Iteration.** Solutions are identified by the name of the group, the stage, and the iteration. "Stage" implies phase or round or step, so start with Stage 1. You can do several trials within a given stage, which we call "iterations."
     - Begin by choosing a short group name, e.g., GroupC or SunDevils.
     - If you are participating in a workshop, we strongly suggest that all group names start with a common workshop name, e.g., TRB18, to make it easy to identify other results from the same workshop. We recommend using an underscore between the workshop name and the group name. In this case, group names could be TRB18_GroupC and TRB18_SunDevils. Group names including workshop name are limited to 20 characters, including spaces.
     - A pop-up window will remind users to include the workshop name in their group name.
     - Users who are not part of a workshop can just enter a group name with no reference to a workshop name, e.g., Nikola_Tesla.
     - Both the stage and iteration boxes accept only numbers.
     - Using these inputs, **COLLABLOCATION** will automatically generate results named by GroupName_Stage s.i, where s and i are stage and iteration, e.g., TRB18_SunDevils_Stage 2.6, or NikolaTesla_Stage 1.4.
   - **Layers.** Each new layer you click on to visualize is layered on top of the previous layers. To see a hidden layer better, unclick it and reclick it. It will become the top layer.
     - **Existing CNG Stations.** These include 360 existing and planned, publicly available, CNG stations accessible by Class 8 trucks according to https://www.afdc.energy.gov/locator/stations/ as of December 26, 2017.
     - **Truck Stops.** These include diesel truck stops that do not currently have CNG pumps. Data are from AllStays Pro, https://www.allstays.com/DL/pro-promo-truck-stops.htm, as of April, 2017. These red dots are the candidate sites for locating new CNG truck stops.
     - **AADTT layers.** AADTT is annual average daily truck traffic by class of roads. Data are from the USDOT Freight Analysis Framework (FAF): https://ops.fhwa.dot.gov/freight/freight_analysis/faf/ for 2012. Arterial streets were not included, as there are too many and they would slow the platform down. Occasionally you may see gaps in the network where an arterial street would complete a connection (see Selected New CNG Stations tab for more detail).
     - **Truck fleet data.** We purchased data for Class 8 truck fleets for the four states through which I-10 runs plus Nevada. Data are for from RL Polk, now owned by IHS Markit: https://www.ihs.com/products/automotive-truck-commercial-vehicle-forecasts.html. Data are vehicles registered as of February, 2017 for model years 1990-2017. This layer is the basis of the Fleet coverage metric (see Selected New CNG Stations tab for more detail).
     - **Metro O-D Centroids.** These points were selected by us to represent the centers of metropolitan areas in the Freight Analysis Framework. These centroids serve as the origin and destination points for

generating inter-city freight routes between metropolitan areas for the path coverage performance metrics. They were placed at centrally located major highway intersections, considering truck traffic volumes and intermodal terminals (see Group Performance Measures for more detail).

- **Natural Gas Pipelines.** This layer shows natural gas pipelines in the Southwest from https://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/index.html as of May 3, 2017. Note: there are no performance measures associated with this layer.

- **Locating new stations.** The Truck Stops (red circles) layer must be turned on to be able to add new stations. Click on a red circle to add a marker. Click on a marker to delete it.
- **Base maps.** In the upper-right corner of the map is this symbol:  Click on it to choose a base map for the look and feel that you prefer, and highlight the I-10 by checking the box.
- **Zooming vs. Scrolling**. Scroll with the hand symbol (the default cursor) or click with the +/- buttons to zoom in/out. Depending on which layers you have turned on, you may see one or more map legends. Scrolling with the scroll bar may move these legends out of sight, whereas scrolling with the scroll bar will keep the legends visible on the screen. On the other hand, to see all of the commands located on the right side of the screen, you need to use the scroll bar to scroll down. Scroll back to the top to restore the map to full-screen size.
- **Network Distance (via Google Maps).** Hover over any red or green circle to see its station ID, then type the ID into one of the two boxes. Click Calculate to show the road travel distance according to Google® Maps. This is a real-time route calculation reflecting traffic conditions at the time.
- **Stations in Network Dist. Range (mi).** Hover any existing (green circle) or new station (red circle) to see its station ID and then type the ID in the box as an origin. Given a user-defined network distance range (e.g. 50 miles – 150 miles) by using the slider bar, click Calculate to highlight all stations (burgundy circles) within this distance range from the origin. The results are based on the actual road distance for the most likely truck route, based on the following assumptions:
  - Only stations within 3 miles of a complete Freight Analysis Framework (FAF) road network in the Southwest are considered.
  - In estimating the length of the most likely truck route, a penalty is applied to each road segment based on the National Highway System (NHS) categories (Table 1).
  - After the best route is estimated according to the penalized distances, the actual (non-penalized) distance of the shortest is computed and stored in a pre-generated matrix that is used by this distance tool.

Table 1. Distance penalties and associated NHS categories

Distance Penalty	National Highway System (NHS) Category
No penalty	Interstate Highway (NHS 1)
Distance x 1.1	Non-Interstate Strategic Highway Network (NHS 3)
Distance x 1.2	Other National Highway System (NHS 7) and Principal Arterial (NHS10)
Distance x 1.3	Other NHS categories (e.g. Approved Intermodal Connector (NHS 8))

For each pair of stations, Dijkstra's algorithm is applied to calculate the shortest route based on the penalized segment lengths. The penalized shortest paths generally are more reasonable and realistic routes for trucks to take between two stations than the actual shortest path. The road segments in the categories with the smaller penalty values—interstate highways and strategic highway network—generally have much higher AADTT, indicating that heavy-duty trucks drive most frequently on roads in these categories.

The following example illustrates that how the final network distance is calculated between stations (Figure 1). The path with the shortest penalized distance (solid, cyan line) is selected as the final path connecting the origin and destination. Furthermore, the actual distance of the penalized shortest path is used to construct the actual network distance matrix between any pair of stations. That said, if a user selected the origin in this example, the destination in Figure 1 would be highlighted if the user-defined distance range includes 220 miles—for example, if the user wanted to highlight stations 200-225 miles away, or 150-250 miles away.

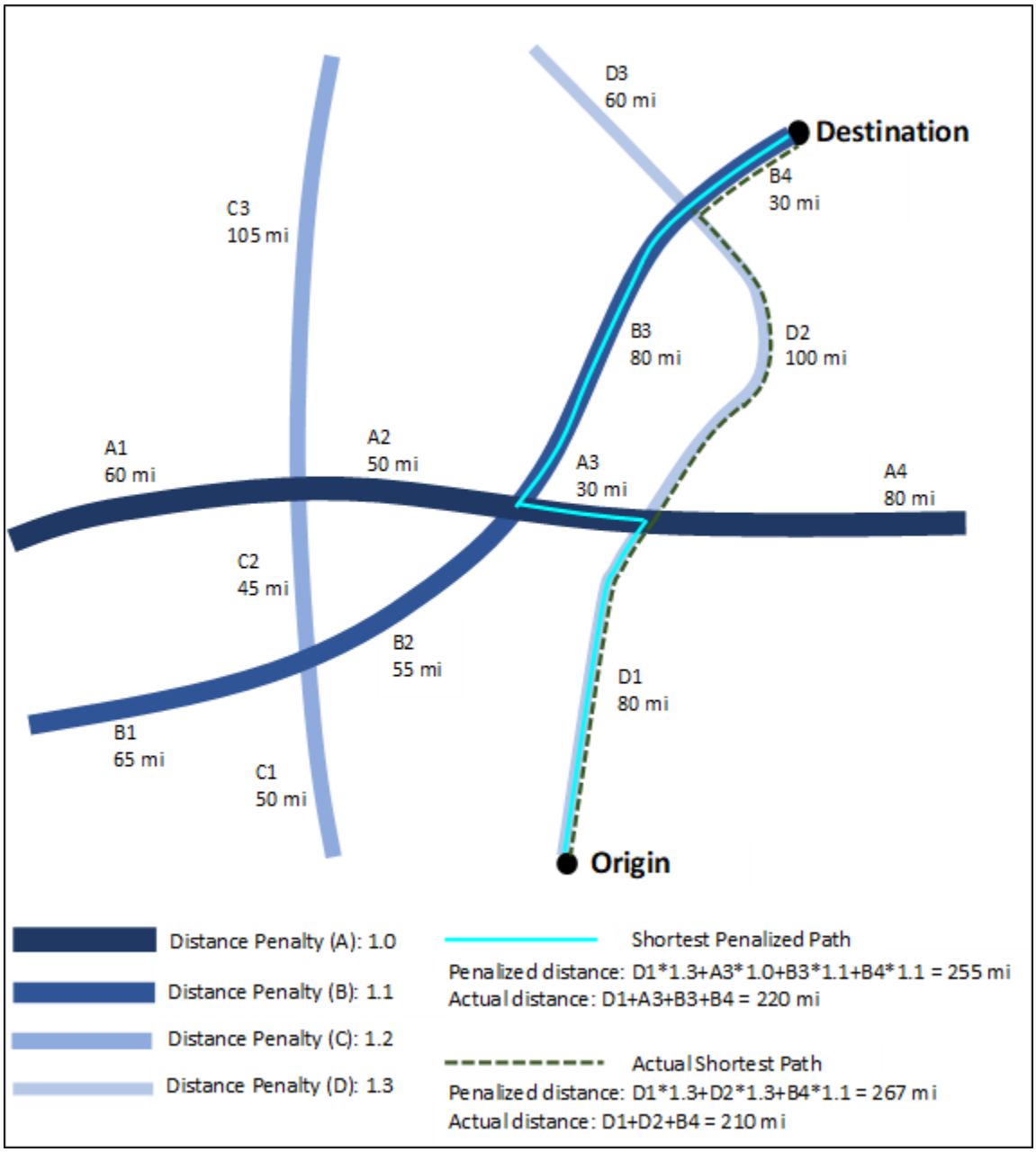

Figure 1. Network distance calculation for a pair of stations. The reported distance in this case will be the actual distance of the shortest penalized path: 220 miles.

The use of a pre-generated matrix of network distances in the distance range tool enables many workshop participants to simultaneously visualize a large number of network distances with no limits or delays or extra costs, based on reasonable assumptions for Class 8 trucks.

- **Driving Range.** This menu is for estimating whether the major truck freight flows between metropolitan areas can be completed given the existing CNG truck stops plus those that your group has picked. Enter a driving range, that is, the miles that a typical CNG truck can travel on a full tank. When choosing a driving range, consider that there are numerous original equipment manufacturers (OEMs), and that each OEM offers several different configurations of engine, trailer, and tank size. Also consider that the CNG pressure delivered at different stations may vary, and that terrain, wind, load, and detours can influence the actual driving range on a given trip. Choose a "safe" driving range with a built-in safety margin to minimize the chance that trucks will run out of fuel.
- **Show Coverage Gaps.** For a given set of existing and new stations, **COLLABLOCATION** can display network gaps where main routes between FAF metropolitan areas cannot be completed, given the driving range chosen by the

user. Gaps are highlighted anywhere the driving distance between available stations (existing or new) exceeds the assumed driving range. Gaps are displayed as straight lines, but the distances are based on network driving distances. For better visualization, users can show the gaps by quartile, ranked according to the O-D tonnage. For instance, the top quartile shows coverage gaps for the Top 80 O-D pairs with the largest tonnage.

- **Origin-Destination Path.** The drop-down menu lists the 323 O-D pairs between Metro O-D centroids of FAF regions. Select an O-D pair in the menu to display the associated driving truck route. The routes were generated as the shortest travel time paths between centroids. Travel times in hours are calculated from posted speed limits (miles/mph). Travel times, however, are adjusted to favor routing on highways in the national Strategic Highway Network. Specifically, for all roads not part of the Strategic Highway Network, speed limits are reduced by 50% to account for stop lights, stop signs, traffic, etc. This allows non-Strategic Highways to be used as necessary, but steers most O-D routes onto the Strategic Highway Network, consistent with their much higher AADTT levels.
- **Retrieve Previous Selections.** Users can add any set of stations previously chosen by any group, and then edit this selection by adding or removing stations. Click in the open window and scroll down to choose any previous solution. Previous solutions are organized into two categories: "Completed" solutions were evaluated successfully, while "Temporary" solutions also include solutions that were not evaluated, either because the user never clicked on Evaluate and Save, or the web page crashed or timed out. Users can select one or several previous set of stations at a time. Click **Add Previous Selections** to place the markers on the map. Click **Remove Previous Selections** to remove all markers from the map (note – this is different than the **Refresh** button, which reloads the entire web page).
- **Evaluate and Save.** This button submits the current station selections shown on the screen for instant evaluation by the three main performance metrics:
    - Coverage of local truck fleets in the same zip code
    - Coverage of nearby AADTT (estimated number of daily unique trucks within 3 miles)
    - Ability for trucks to complete round trips between major metropolitan areas given the assumed driving range and pre-generated main routes

  It also saves the solution for detailed analysis, for comparison to other solutions, or for building a new solution.
- **Refresh.** This button reloads the entire web page. Any solution showing at that time will be retrievable from the list of Temporary solutions.

2. **Selected New CNG Stations Tab.** This tab shows *individual station* information about *your group's* previous selections.
    - **Show X entries.** Use this command in the upper left corner to show 10, 25, 50, or 100 entries at a time. This is a useful feature because this list of stations can grow quite long because it lists every station chosen at every iteration of every stage. If you have included the same station in many solutions, it will be repeated in each group. Users may also wish to page through multiple pages (see bottom right corner).
    - **AADTT.** AADTT stands for Annual Average Daily Truck Traffic (see Main page for data source and specification). Our calculation is a rough estimate of the unique trucks passing near the station on a daily basis. This is a simple concept but difficult to estimate because a given truck could have been counted on multiple road segments as it drives on, to, and from a given highway to other highways and other road classes in the vicinity of the station. Our calculation of the number of unique trucks is based on the following assumptions:
        - Only highways within 3 miles of the station are counted.
        - Each highway segment between highway intersections is considered a separate "arc."
        - The AADTT method accounts for arcs neighboring the station and arcs within 3 miles of the station differently.
        - For the neighboring arc(s), each station is classified into one of two cases based on whether it is at a highway intersection or not:
            - Case 1: If a station is in the middle of an arc, the arc's AADTT is counted fully. In Figure 2, this is Arc A1.
            - Case 2: If a station is at a highway intersection, we add the AADTT of all four arcs connecting at the intersection and divide by two. The idea here is that a truck arriving at an intersection will

likely do one of three things: go straight through, turn left, or turn right. In all of these cases, the same truck would be counted in two different arc's AADTT. In Figure 2, the station is at the intersection of highways A and B, where arcs A1, A2, B1, and B2 meet.

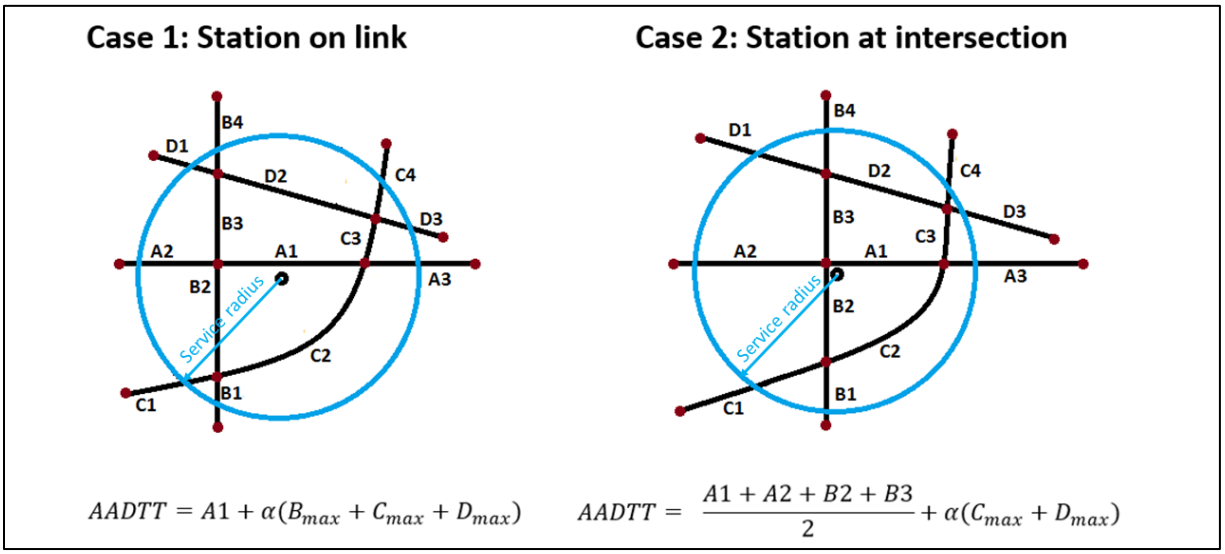

Figure 2. AADTT calculation for Case 1 (station between intersections) and Case 2 (station at intersection).

- For the other arcs in the 3-mile buffer area, the two cases are treated the same:
  - Identify all other non-adjacent highways in the 3-mile buffer around the station. In Figure 2/Case 1, the non-adjacent highways are B, C, and D. In Case 2, the non-adjacent highways are C and D.
  - Identify the segment with the maximum flow, e.g., the AADTT of arc C1, C2, or C3—whichever is largest.
  - Multiply the AADTT times α (we used α=0.5) and include it in the AADTT.
- In addition, in estimating the number of unique trucks driving in the station area, it is important to take the hierarchy of roads into account. Trucks generally use smaller roads as feeder road onto larger roads, but sometimes truck drivers must stay on the smaller roads because of the absence of larger roads. Table 2 illustrates how we operationalize this concept. Specifically, Table 2 lists which AADTT are counted based on which other road categories exist in the 3-mile buffer. For instance:
  - In Cases 1-4, both categories of roads in the Strategic Highway Network are found in the buffer area. Therefore, the AADTT on the non-Strategic Highway Network are not counted because their truck flows are assumed to feed onto the two higher-level types of roads, where they would already be counted.
  - In Cases 5-6 and 9-10, one of the two Strategic Highway Network categories is completely missing from the buffer area. Therefore, the AADTT on Other National Highway Systems roads because they may not feed onto the remaining category.
  - The smallest category of roads—Not on the National Highway System—are presumed to function as feeder roads in most cases, and are only counted in the complete absence of any Strategic Highway Network roads in the buffer area. See Cases 13 and 15.

While these assumptions are imperfect, the method is based on the simple idea that more trucks on more roads near a station indicate a higher potential for trucks to refuel there. For non-adjacent roads, it is unknown whether trucks are following routes that eventually go past the station, but if not, they have the potential to detour to the station to refuel. It is a reproducible metric using easy-to-obtain AADT data.

Table 2. Road categories counted towards the AADTT, depending on which combination of road categories are present in the station's 3-mile buffer area.

	Highway Categories that Exist in the 3-mile Buffer				Highway Categories Counted in the AADTT Calculation			
Case	Interstate Highways	Other Strategic Highway Network	Other National Highway System	Not on National Highway System	Interstate Highways	Other Strategic Highway Network	Other National Highway System	Not on National Highway System
1	Y	Y	Y	Y	Y	Y		
2	Y	Y	Y	N	Y	Y		
3	Y	Y	N	N	Y	Y		
4	Y	Y	N	Y	Y	Y		
5	Y	N	Y	Y	Y		Y	
6	Y	N	Y	N	Y		Y	
7	Y	N	N	Y	Y			
8	Y	N	N	N	Y			
9	N	Y	Y	Y		Y	Y	
10	N	Y	Y	N		Y	Y	
11	N	Y	N	Y		Y		
12	N	Y	N	N		Y		
13	N	N	Y	Y			Y	Y
14	N	N	Y	N			Y	
15	N	N	N	Y				Y

- **Fleet.** This is the number of Class 8 trucks registered to owners in the same zip code as the station. See main page for data source and specification. Data are based on DMV registration records, usually based on the company headquarters location, and are aggregated to zip codes. On the recommendation of IHS Markit, the data exclude fleets with over 2500 trucks, because these often represent the headquarters of large companies whose trucks are actually distributed across many different locations.

3. **Group Performance Measures by Stage Tab.** This tab also shows data *only for your group*, but *compares across different designs* you created. For each plan your group tested, data in this tab are aggregated over all stations chosen.
   - **Number of Stations.** This number refers to the number of *new* stations chosen.
   - **Total AADTT.** The sum of AADTT (unique trucks) estimated for all new stations selected.
   - **Average AADTT.** Total AADTT divided by the Number of Stations, indicating average performance per new station.
   - **Total Fleet.** The sum of trucks registered in the stations' zip code summed over all new stations selected.
   - **Average Fleet.** Total Fleet divided by the Number of Stations, indicating average performance per new station.
   - **Path Covered, KTons Covered, and TMiles Covered.** These three metrics are based on the entire set of open stations in your scenario. That is, it is based on the union of the set of existing and planned CNG stations and the set of new stations selected by your group. All three metrics are based on the O-D pair driving range analysis for major metropolitan areas in the FAF database. Numerous assumptions and steps go into these results.
     - FAF estimates flows to, from, and within major metropolitan areas, as well as for zones consisting of the "Rest of State."
     - For states with at least one metropolitan area, we ignored the Rest of State, because one cannot accurately estimate its origin or destination, which is especially problematic in large southwestern states.
     - Arkansas and New Mexico have no metro areas in the FAF database, so we used the Rest of State data centered on Little Rock and Albuquerque, the largest city in each state.

- For each origin-destination (O-D) city-to-city pair, we summed the flow volume for the two directions (e.g., Phoenix-Dallas + Dallas-Phoenix).
- The analysis considers a total of 323 city-to-city pairs in the FAF data for the 10 Southwest states.
- The routes were generated as the shortest travel time paths between Metro O-D Centroids. Travel times are based on posted speed limits (miles/mph), but are adjusted to favor routing on highways in the national Strategic Highway Network. Specifically, for roads not part of the Strategic Highway Network, speed limits are reduced by 50%. This allows non-Strategic Highways to be used as necessary, but steers most O-D routes onto the Strategic Highway Network, consistent with their much higher AADTT levels.
- Any existing CNG station or selected new station within 3 miles of each of these paths is considered to be along the route and able to refuel it.
- A route is "covered" or "feasible" if it is possible to travel from the either end point to the other and back without running out of fuel. Consistent with the scientific literature, the round trip is feasible if:
  - The distance between adjacent stations along the path is always less than or equal to the driving range.
  - The distance between either endpoint and the first station is less than or equal to half of the driving range. This would allow a truck to go from the last station on the route to the end point and back without running out of fuel.
- Given these data, assumptions, and analyses, the three related performance measures are:
  - **Path Covered.** The assumed driving range (a user input parameter) is listed for reference, followed by the number of feasible city pairs. All routes are weighted equally.
  - **KTons Covered.** With this metric, routes are weighted by the annual freight tonnage in 2015.
  - **TMILES Covered.** With this metric, routes are weighted by freight tonnage x distance, that is ton-miles, which are proportional to fuel consumption and emissions savings.

4. **Comparing to Other Groups Tab.** This tab provides *table and graph comparisons between groups*.
   - **Select Groups and Stages.** Click on the completed solutions you wish to compare. In the right margin, click on a + sign to see all iterations by a given group. Comparisons can be made across groups and stages. The tables and graph will automatically populate.
   - **Update the List.** Click here if you do not see the most recent iterations in the list.
   - **Update the Table.** Click this button if the table needs updating.
   - **X-Axis and Y-Axis Variables.** In the right-hand margin, possibly off screen, are two drop-down menus for setting the axes.
     - **Bar Graph.** For a bar graph, leave the X-axis as Group and Stage, and set the Y-axis to any single performance metric.
     - **Scatter Plot.** For a scatter (x,y) diagram, set the X and Y axes to different performance metrics to evaluate the tradeoffs between them and which solutions perform well on both.
   - **Download.** Both the table and graph can be downloaded for analysis or reporting purposes.

5. **Spatial Comparison Tab.** This tab can be used to compare *where different groups located stations*, and which locations were chosen by multiple groups.
   - **Map Layers.** Use the check boxes to visualize station, AADTT, and other map layers from the Main tab. Remember that the most recently added layers automatically go on top of the other layers. Turn layers on and off to move them to the top.
   - **Select Groups and Stages.** Click on a + symbol to open the list of iterations for any group(s). Check the boxes for completed solutions you wish to compare. Comparisons can be made across groups and stages.
   - **Update the List.** Click this button to update the list of available completed solutions.
   - **Visualize Points.** Click to display station locations for multiple solutions on the map.
   - **Remove Points**. Click to clear the map and start over.