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U.S. Department of Transportation

Federal Highway Administration

GETTING STARTED GUIDE

TRAFFIC NOISE MODEL 3.2

FHWA-HEP-24-012

FEDERAL HIGHWAY ADMINISTRATION
OFFICE OF NATURAL ENVIRONMENT
Washington, D.C.

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13. ABSTRACT (Maximum 200 words)

The Federal Highway Administration (FHWA) with the assistance of the Volpe Center Acoustics Facility finalized the Traffic Noise Model (TNM®) version 3.2. This step-by-step guide introduces users to some of the basic concepts in highway-related noise modeling by using TNM 3.2. It provides detailed steps to create a basic project with two roadways, a stationary and a non-stationary equipment object, two receivers, a building row and one perturbable barrier. This guide supplements the information found in the Help Menu inside TNM 3.2.

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SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
oz	ounces	28.35	grams	g
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
mL	milliliters	0.034	fluid ounces	fl oz
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
g	grams	0.035	ounces	oz
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	Kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

CONTENTS

PURPOSE

This guide introduces some of the basic concepts in highway-related noise modeling by using TNM 3.2. It includes detailed steps to create a basic project with two roadways, a stationary and a non-stationary equipment object, two receivers, a building row, and one perturbable barrier.

This guide will walk you through the steps to:

- Set application defaults
- Create a new project
- Understand the main areas of the interface
- Add TNM objects to the project
- Compute noise levels and view reports for barrier input heights
- Use the **Barrier Analysis** tool

Note that this walkthrough is not an exhaustive review of all capabilities in TNM. Additional details can be found by searching appropriate areas of the **Help Menu** inside TNM 3.2.

Please contact TNMHelp@dot.gov for assistance with TNM. A playlist of short tutorial videos that demonstrate how to accomplish basic tasks in TNM 3.0 and 3.1 can be found on the FHWA YouTube channel at: https://www.youtube.com/playlist?list=PL5_sm9g9d4T3naH9knm5E6SZUpmI_QD3y. These tasks are performed similarly in TNM 3.2. New videos for TNM 3.2 will be added periodically.

Setting Default Application Settings

To start, we want to set some default settings to apply to all new projects. After launching TNM 3.2, go to the **Settings** tab in the **Toolbar** and select **Application Settings** to input default settings. This will open a new dialog box where project defaults can be entered. Details on the purpose and options for each input in the dialog box can be found in the **Help Menu**. Enter preferred default information for each field. Click the **Save Settings** button to apply these default settings. FIGURE 1 shows example default inputs.

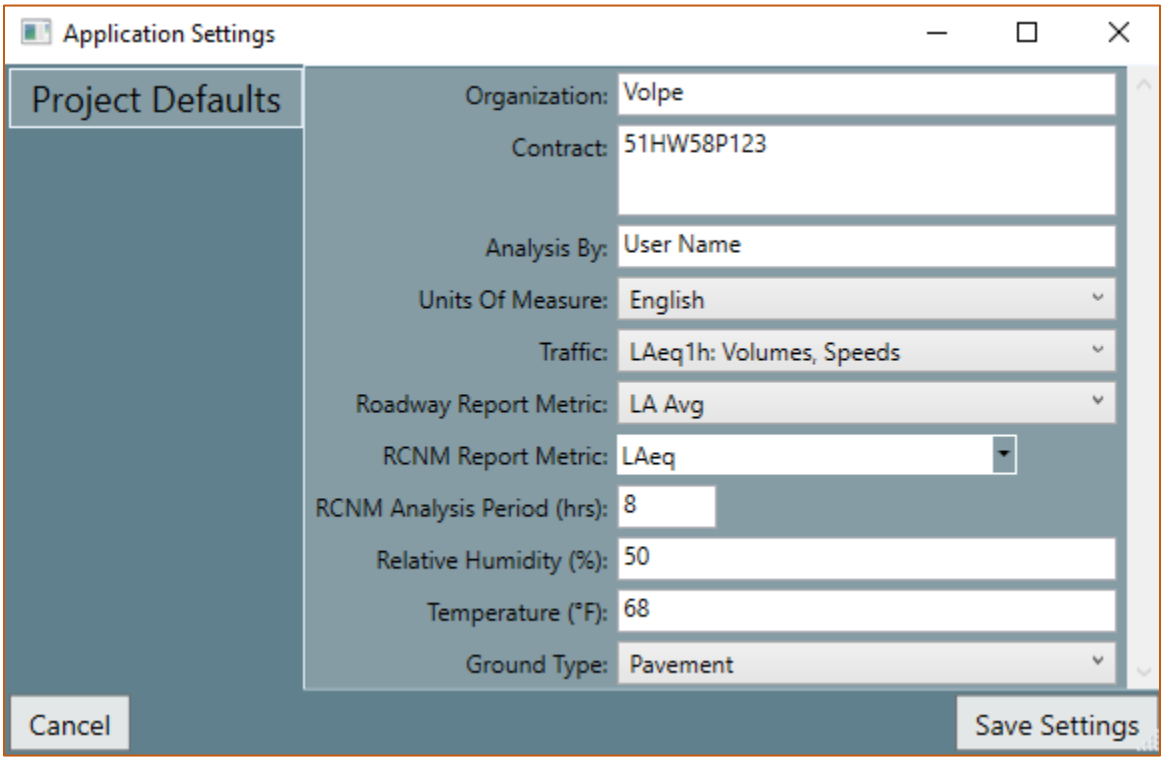


Figure 1 *Application Settings dialog box*

CREATING A NEW PROJECT

Once default settings are saved, we can create a new project that will inherit these settings. Click on the **File** tab in the **Toolbar**. Select **New Project**. The **New Project** dialog box will open, as shown in **FIGURE 2**. The inputs in this window apply only to the new project. The first three fields, **Organization**, **Contract** and **Analysis By**, allow entry of general data about the project. The next field, **Type**, allows you to select between three options: **Cartesian**, **Geographic** and **Projected**. You should use **Cartesian** when the input coordinate data are in orthogonal coordinates without any reference to a particular projection. This will enable options in the **Project Settings** fields (**Category**, **System** and **Units**) that are appropriate for studies in either English or Metric units without projection data. You should use **Geographic** or **Projected** Types when your data are in spherical coordinates, e.g., latitude, longitude, and elevation (for **Geographic**) or derived from projections that are designed to minimize map deformations near a particular location (for **Projected**). Note that all settings in this dialog box apart from the **Projection Settings** can be changed after the initial creation of the project. More details on the purpose and options for each input in the dialog box can be found in the **Help Menu**. For this example, enter the options shown in **FIGURE 2** and then click the **Create** button.

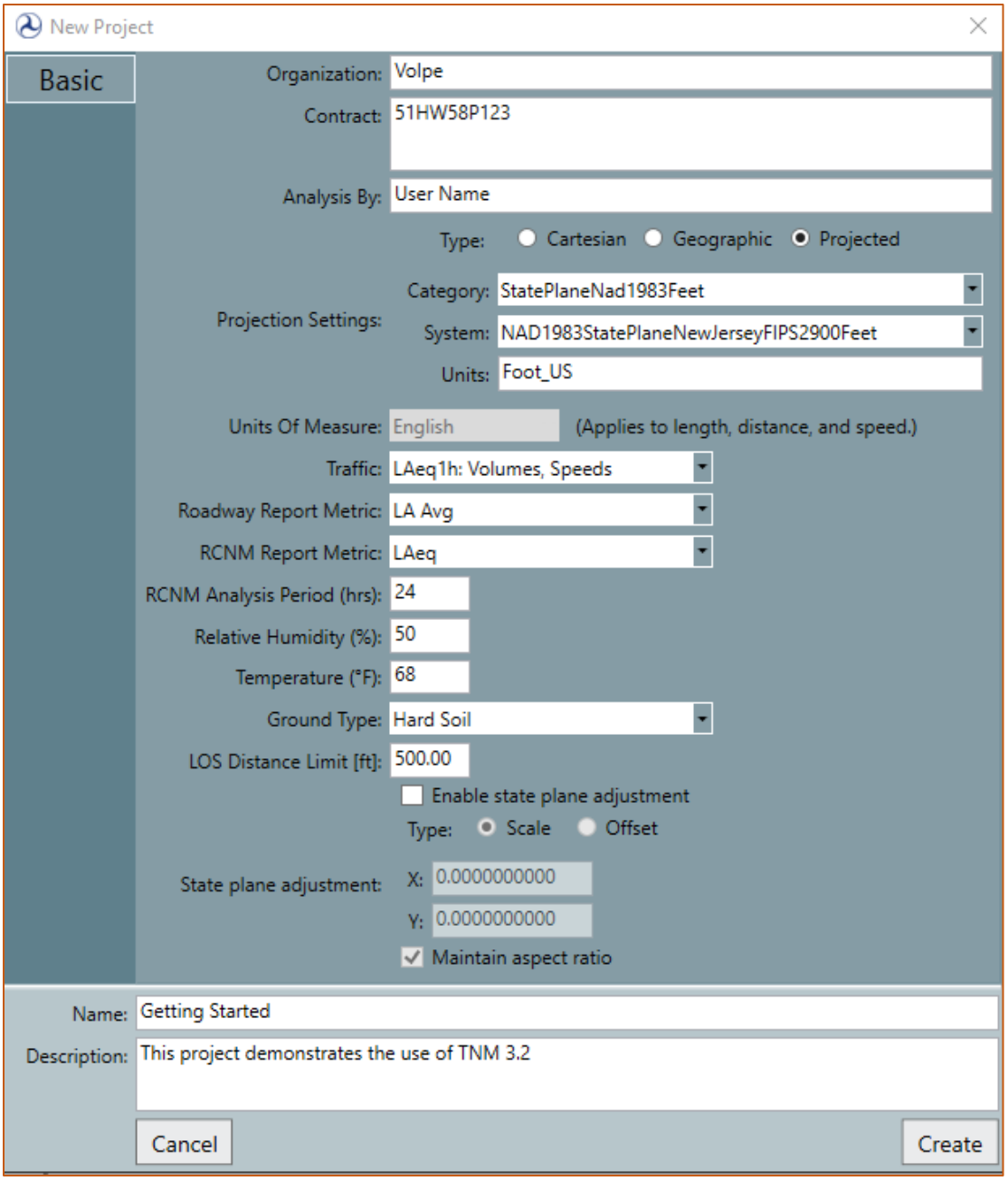


***Figure 2** New Project dialog box*

Save the project by clicking on the **File** tab in the left corner of the ribbon menu at the top of the screen. Select **Save Project As** in the File menu, shown in **FIGURE 3**. A file wizard will appear for you to input the desired file directory and name.

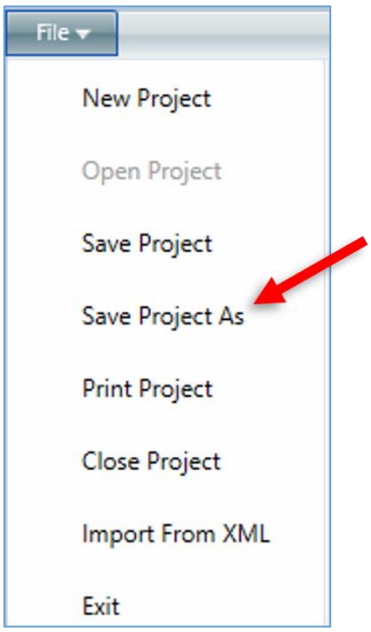


Figure 3 *File tab menu with Save Project As annotated*

The default **Homepage** will open. There are five main areas in the TNM application, annotated on the screenshot in **FIGURE 4**:

1. **Toolbar** (contains the File, Edit/Modify, View, Settings, Calculate, Barrier Analysis, Contours, Reports, Tools, and Help tabs)
2. **Legend Pane**
3. **View Pane** (contains the Plan Builder, 3D View, Section View, and Report View tabs)
4. **Edit Pane** (contains the Edit, Search, and Geocode tabs)
5. **Object Details Pane** (contains the Receivers, Barriers, Roadways, Equipment, Terrain Lines, Building Rows, Tree Zones, Ground Zones, Contour Zones, User Defined Vehicles, Output, Project Information, Roadways Results, Equipment Results, and Validation Results tabs).

We will show some example uses of each application area next. Further details on each pane can be found in the **Help Menu**.

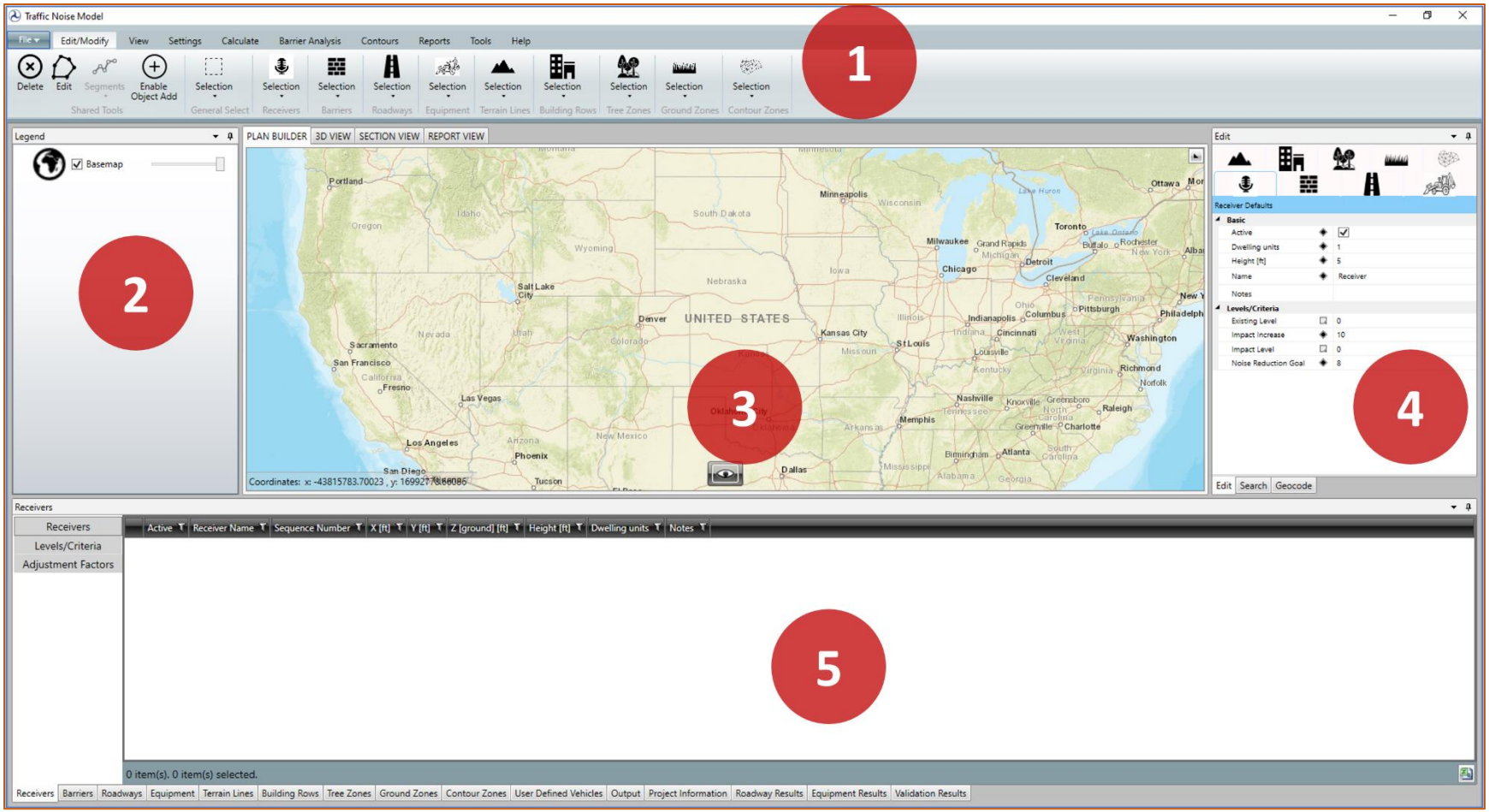


Figure 4 *Default project view, annotated to show each section*[1]

[1] Note that the size and position of the main areas annotated in **Figure 4** is the default. We will leave their configuration as is for this exercise. See the Section 2.1 of the **Help Menu** for instructions on how to manipulate the windows.

INPUTTING AND REVIEWING OBJECTS – ROADWAY NOISE ANALYSIS

TOOLBAR – EDIT MODIFY TAB

(*The **Toolbar** is found at the top of the application and is used to perform various functions in TNM. You can minimize or maximize the toolbar by right clicking and selecting **Minimize the Ribbon**. **Toolbar** details can be found in the **Help Menu**.*)

To start adding TNM objects to the project, press "D" on the keyboard or go to the **Edit/Modify** tab in the **Toolbar** and click on the **Enable Object Add button**. Using either method will highlight the Enable Object Add button, as shown in FIGURE 5.

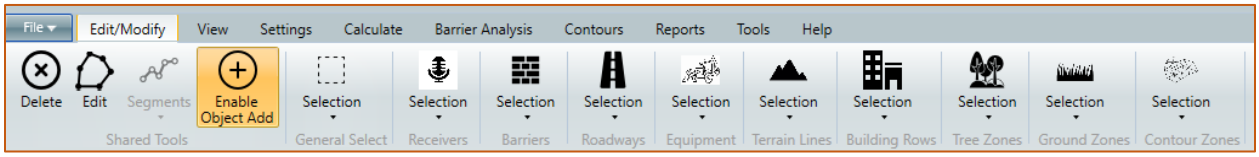


***Figure 5** Toolbar – Edit/Modify tab with Enable Object Add toggled on*

EDIT PANE

(*The **Edit Pane** is found on the right side of the application below the **Toolbar.** This pane contains settings for object defaults that are applied when creating new objects. The **Edit Pane** also allows you to select an object type to add to the project. More details on the **Edit Pane** can be found in the **Help Menu**.*)

Select the **Roadway** icon at the top of the **Edit Pane** to add a roadway to the project. When selected, it will be outlined in blue, as shown in FIGURE 6. Leave the default values as is, for now. These can be changed later when adding additional roadways. Note that when conducting precise noise analyses, several roadway lanes can be easily digitized at once using the Multi-Lane tool. Instructions on doing so can be found in Section 6.3.2 of the **Help Menu**.

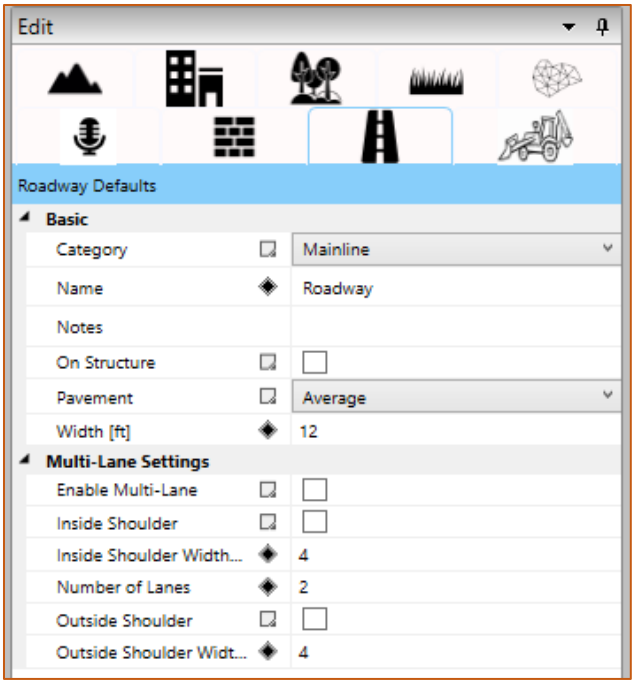


Figure 6 *Edit Pane Roadway Defaults window*

VIEW PANE

(*The **View Pane** displays the map and associated map data using different visualization methods. The **View Pane** is comprised of the following four sub-panes used to represent project data in various ways: **Plan Builder**, **3D View**, **Section View**, and **Report View**. More details on the **View Pane** sub-panes can be found in the **Help Menu**.*)

One can pan the view in the **Plan Builder** by clicking and dragging an area of the map that does not have any TNM objects. One can zoom the view in the **Plan Builder** using the mouse scroll wheel. Place your cursor on Edison, New Jersey (highlighted in FIGURE 7) and zoom in until Lincoln Hwy north of Plainfield Ave is centered, as shown in FIGURE 8.

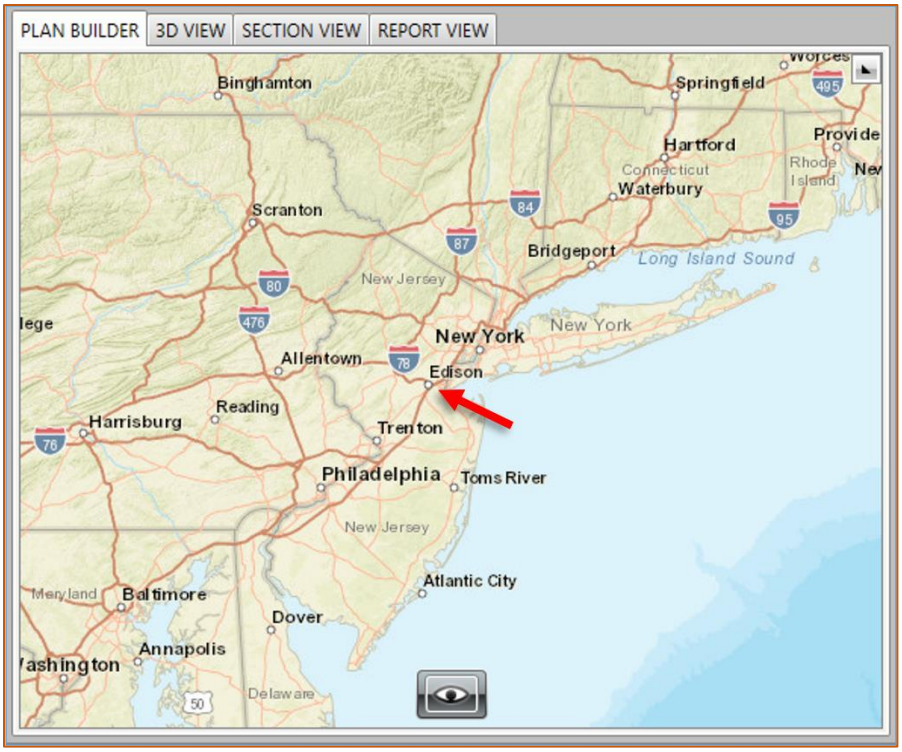


Figure 7 *Plan Builder in the View Pane, annotated to highlight Edison, New Jersey*

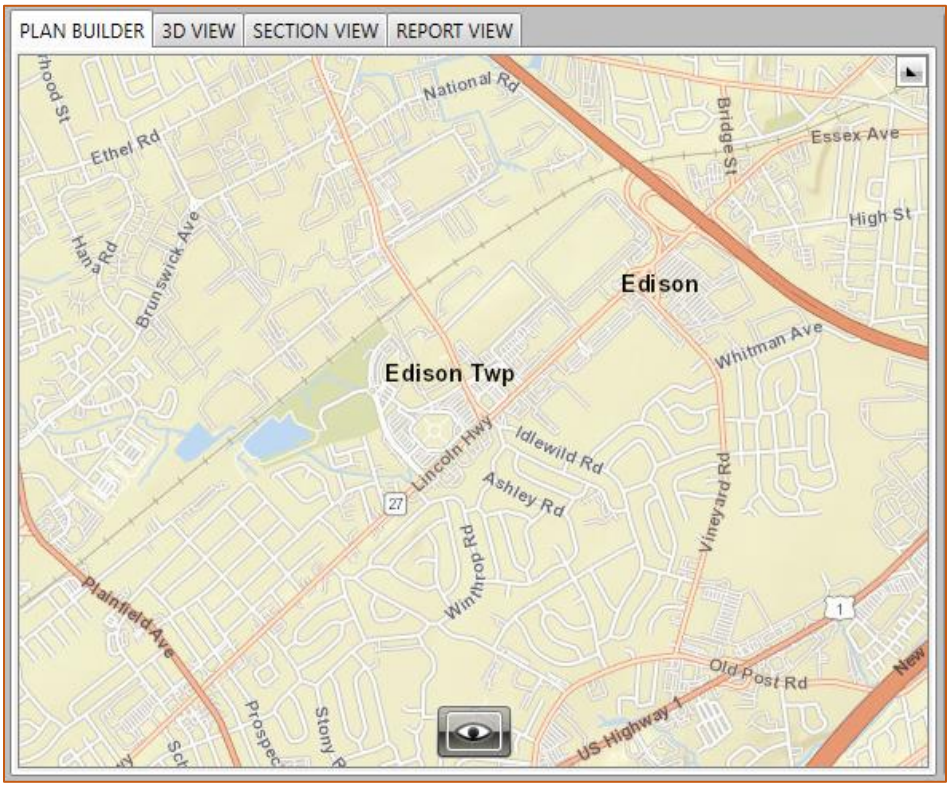


Figure 8 *Plan Builder in the View Pane, zoomed in to center Lincoln Highway in Edison, New Jersey*

With **Enable Object Add** toggled on in the **Edit/Modify** tab of the **Toolbar** and the **Roadway** icon selected in the **Edit Pane**, add a roadway to the project by clicking the left mouse button in the **Plan**

Builder sub-pane of the **View Pane** at several points along a displayed roadway. This is shown in **FIGURE 9** and **FIGURE 10**, moving southwest to northeast. Double click or right click to finish creating this roadway object.

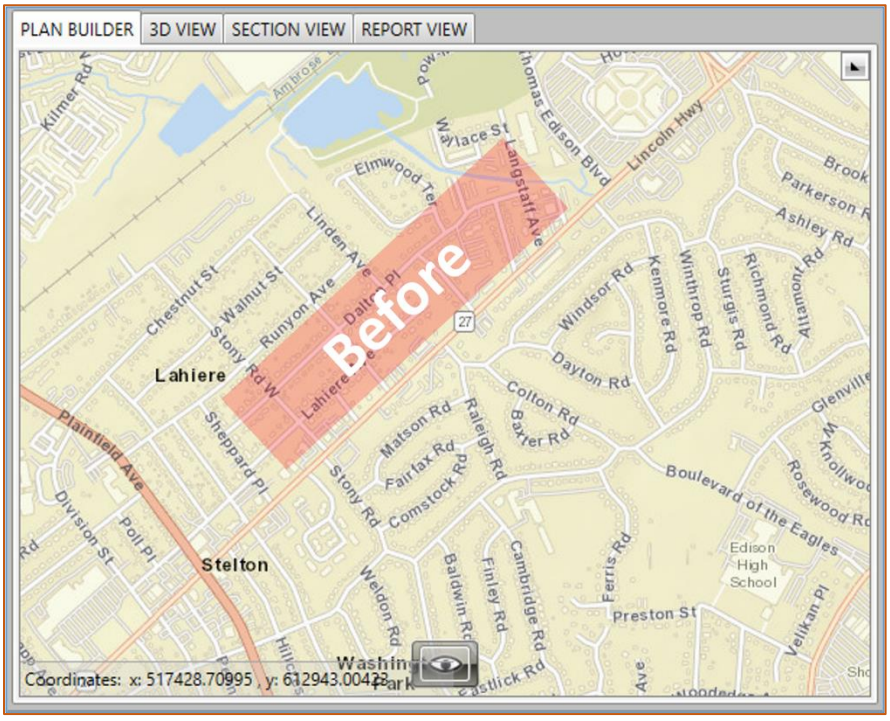


Figure 9 *Plan Builder in the View Pane, annotated prior to adding objects*

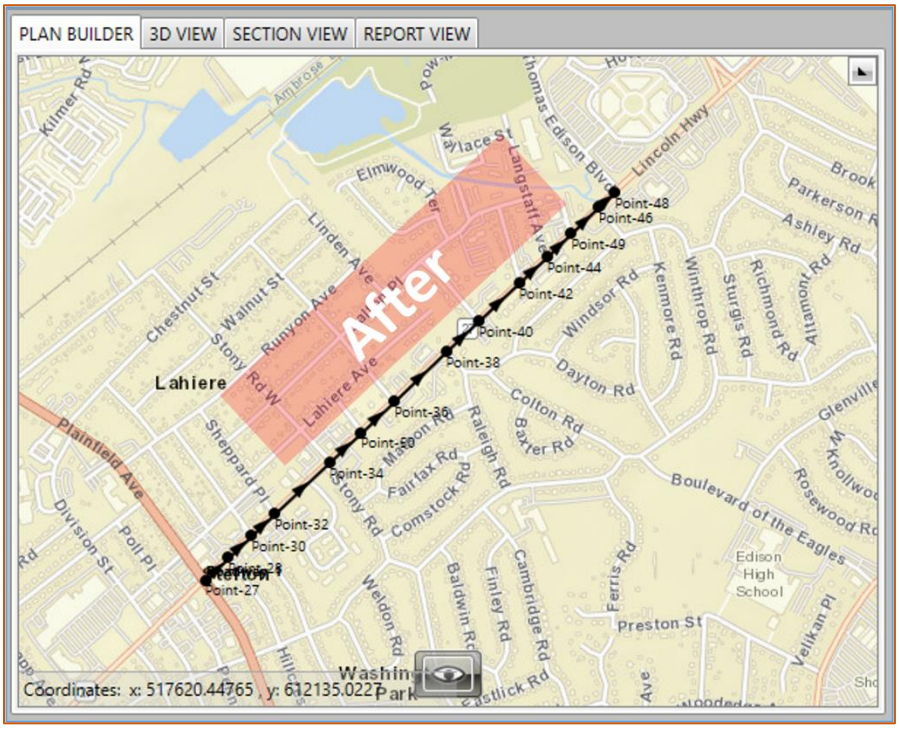


Figure 10 *Plan Builder in the View Pane, annotated after adding a roadway object*

One can change the type of map displayed below the TNM objects using the "eye" icon in the bottom of the **Plan Builder**. For example, **FIGURE 11** shows the northeast corner of the current project in the **Plan Builder** after selecting the Aerial View.

Figure 11 *Plan Builder using the Aerial View basemap*

This aerial view shows that the placement of the roadway object is not quite right as it does not align with the northeast-bound roadway centerline. While it is more accurate to obtain roadway coordinates from project plans or other reliable source and digitize individual lanes as separate objects, this simplified exercise will combine each direction of traffic flow into a single roadway object to demonstrate some of TNM's editing features. Note that when conducting precise noise analyses, several roadway lanes can be easily digitized at once using the Multi-Lane tool. Instructions on doing so can be found in Section 6.3.2 of the **Help Menu**.

To fix the roadway misalignment, go back to the **Edit/Modify** tab in the **Toolbar** and select the **Edit** icon, as shown in **FIGURE 12**. Once the **Edit** button is selected, TNM objects can be edited graphically by selecting points, segments, or entire objects. (Edits can also be made by adjusting coordinates in the **Object Details Pane** regardless of whether the **Edit** icon in the **Toolbar** is selected. We will discuss this later.)

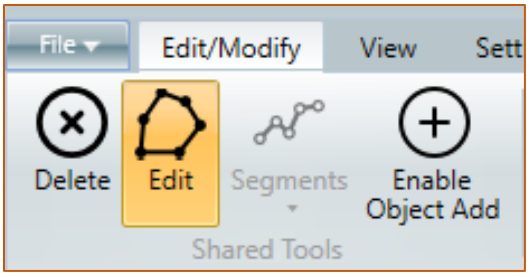


Figure 12 *Edit Icon in the Edit/Modify tab of the Toolbar*

We want this roadway object to align with the northeast-bound roadway centerline shown in the aerial view, therefore we need to move roadway points. Do this by clicking and dragging a roadway point to the desired location in the **Plan Builder.** (When hovering over the point, it will change color from black to light blue). It is easiest to edit object points by first zooming in close to the point using the mouse scroll wheel. **FIGURE 13** shows the roadway object, now shifted to align with the center of traffic traveling northeast. Note that the roadway centerline and endpoint are now grey to indicate that they are selected. To unselect an object, right click in the **Plan Builder** and choose Clear Selection from the menu options.

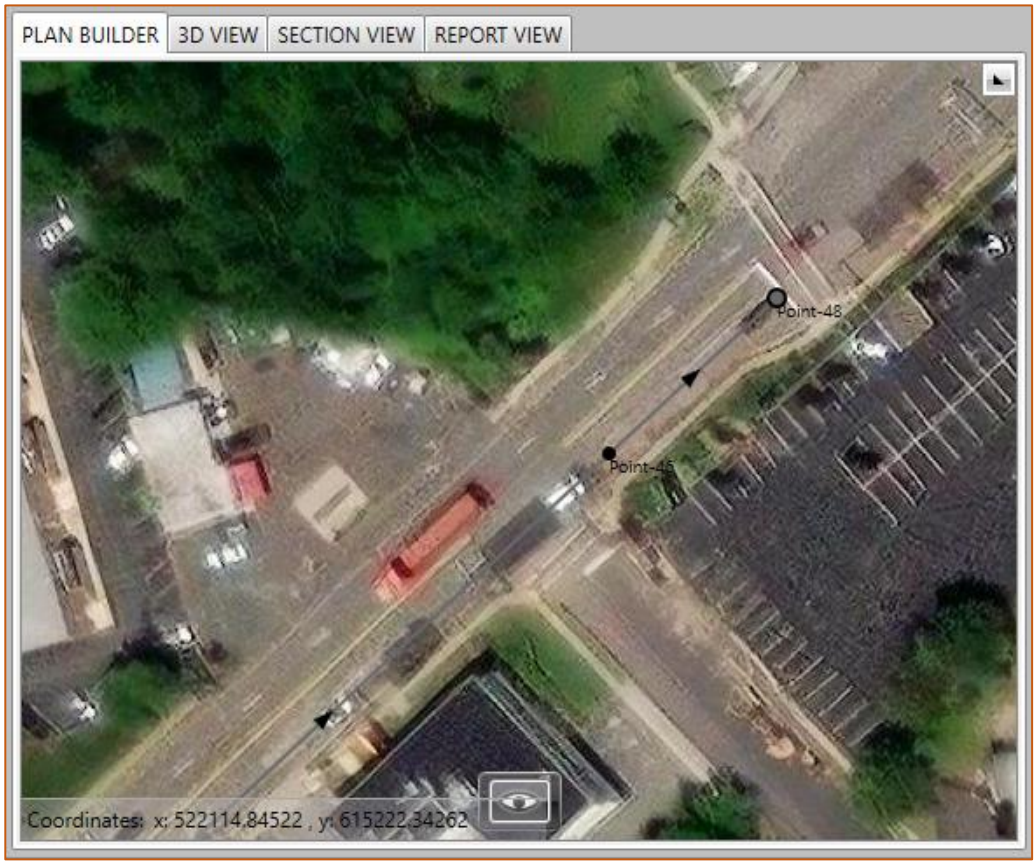


Figure 13 *Selected roadway object on the Aerial View basemap*

Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

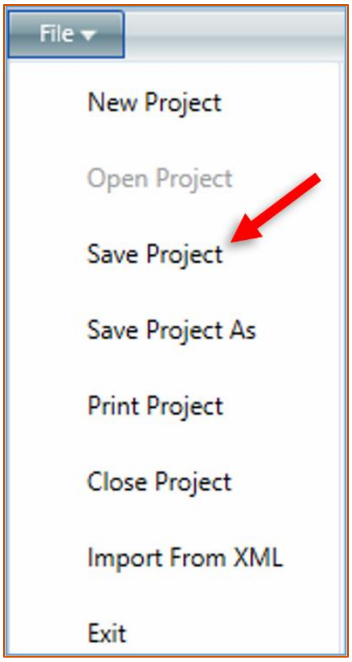


Figure 14 *File tab menu with Save Project annotated*

Now we want to add the following other objects in this project: a second roadway, two receivers, a building row, and one perturbable barrier. Follow the same procedure from adding the first roadway for the second, but this time start clicking on points in the northeast of the **Plan Builder** and continue down to the southwest to designate the proper roadway direction of travel. Once the roadway is roughed in, you can zoom and use the **Edit** button in the **Toolbar** in to make fine adjustments to the roadway location.

Next, in the **Edit Pane**, select the **Receiver** icon, and then the **Geocode tab**, highlighted in **FIGURE 15**. In the **Enter Address** field, type "1972 State Route 27, Edison, New Jersey, 08817", click the **Geocode Address** button, and then click the first option in the populated list below. A symbol will appear in the **Plan Builder** indicating this address, as shown in **FIGURE 16**. Repeat the same process for 1984 State Route 27, Edison, New Jersey, 08817. Return to the Receiver Defaults window using the **Edit** tab of the **Edit Pane**, shown in **FIGURE 15**. With **Enable Object Add** toggled on in the **Edit/Modify** tab of the **Toolbar**, click in the **Plan Builder** to add a receiver behind the geocoded address from **FIGURE 16** and in front of the second geocoded address. At this point, your **Plan Builder** should look something like **FIGURE 17**. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

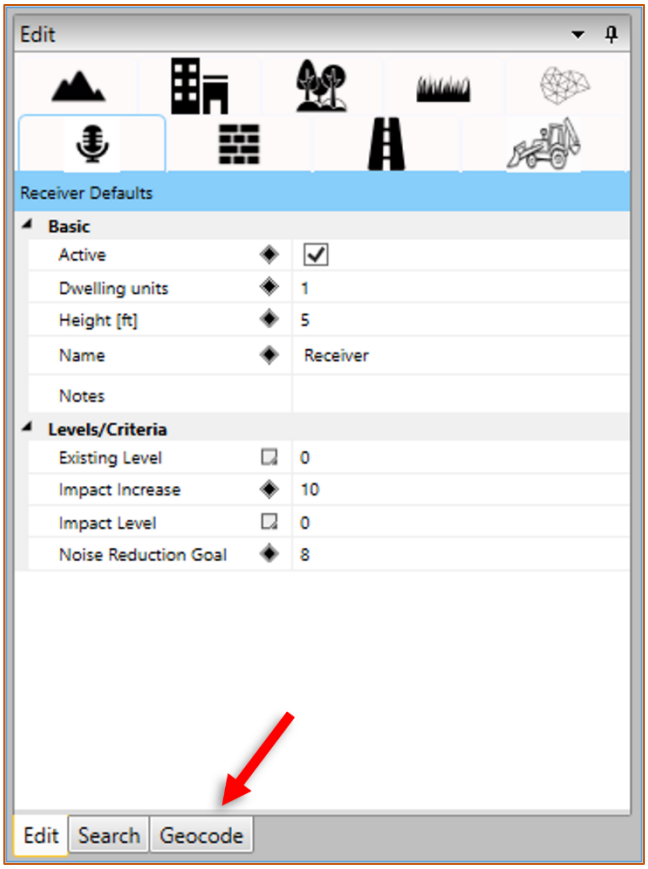


Figure 15 *Edit Pane and Receiver Defaults window with Geocode Tab highlighted*

Figure 16 *Geocode symbol in Plan Builder*

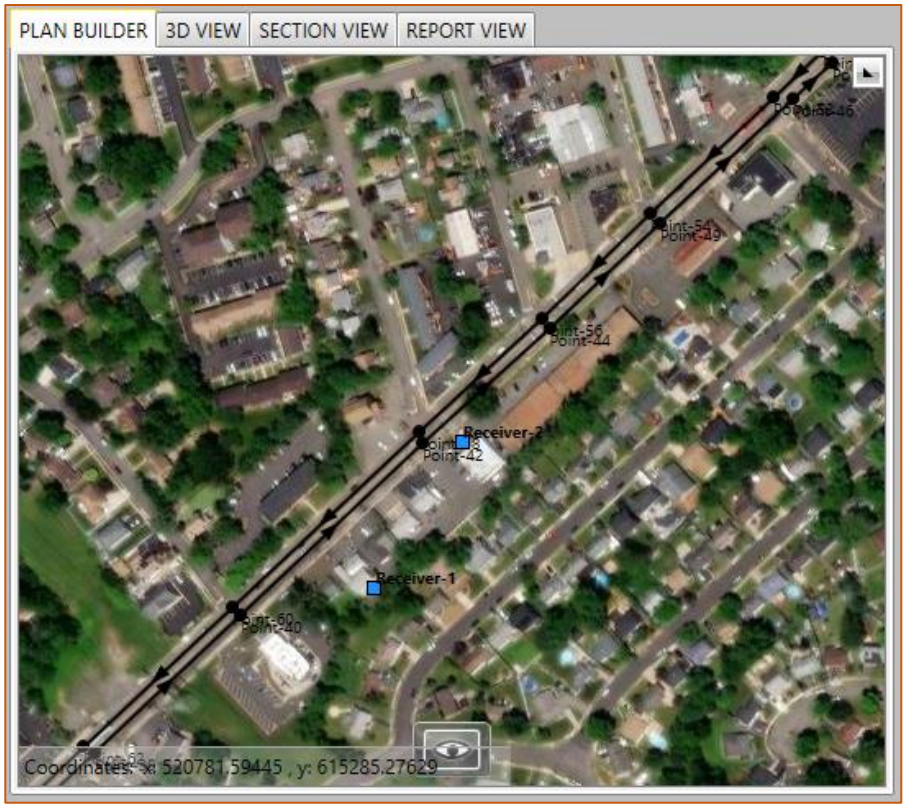


Figure 17 *Plan Builder with two roadways and two receivers on the Aerial View basemap*

Next, select the **Building Row** icon in the **Edit Pane**, as shown in **FIGURE 18**. With **Enable Object Add** toggled on in the **Edit/Modify** tab of the **Toolbar**, click in the **Plan Builder** to create a building row in front of the strip of separated buildings and Receiver-1. Once finished, your **Plan Builder** should look something like **FIGURE 19**. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

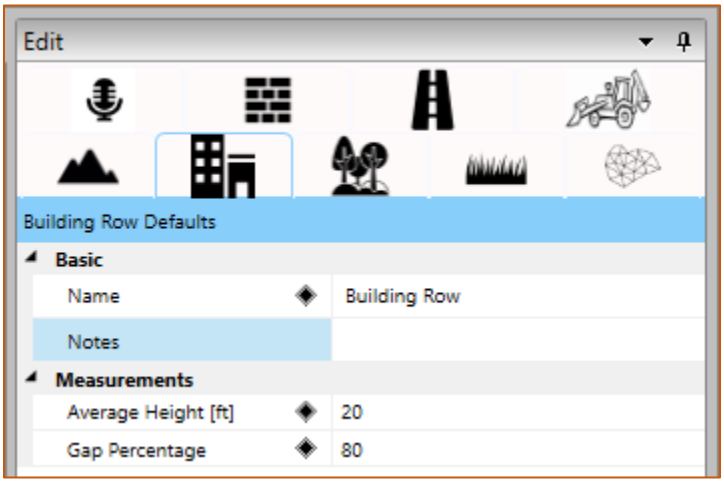


Figure 18 *Edit Pane and Building Row Defaults window*

Figure 19 *Plan Builder with two roadways, two receivers, and a building row on the Aerial View basemap*

Finally, select the **Barrier** icon in the **Edit Pane** to display the Barrier Defaults window, as shown in **FIGURE 20**. We will use the **Edit Pane** set the default cost parameters to apply to the barrier object we are about to create. In the **Wall Unit Cost** section of the Barrier Defaults window, type 100 in the **Area** field and 10 in the **Lineal** field. When complete, your Barrier Defaults window show look like **FIGURE 21**.

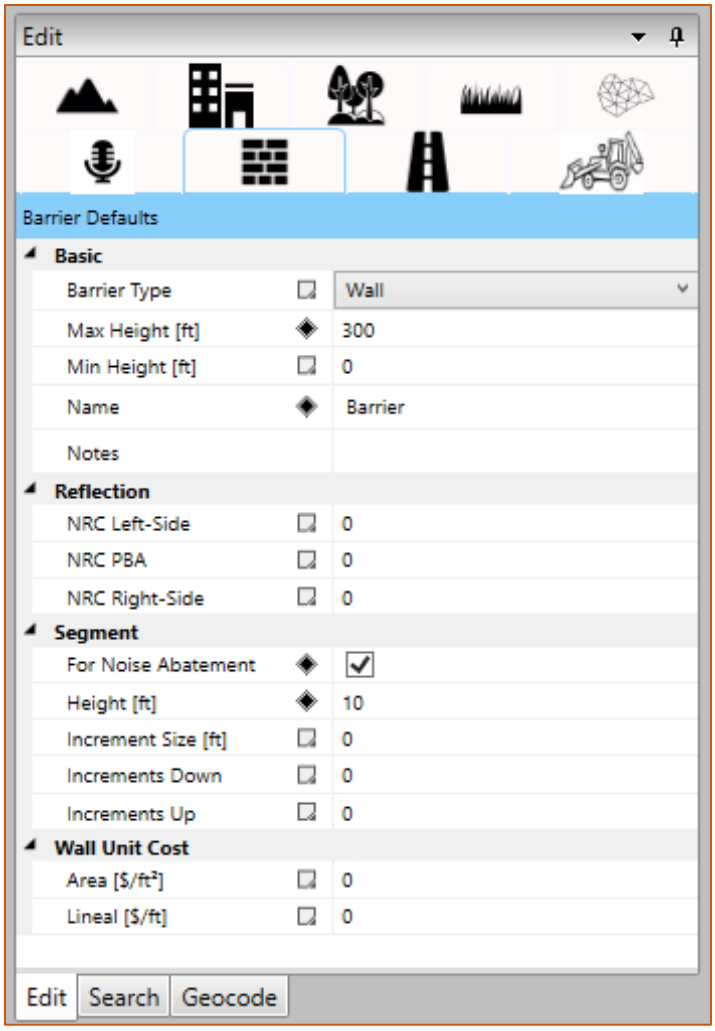


Figure 20 *Edit Pane and Barrier Defaults window*

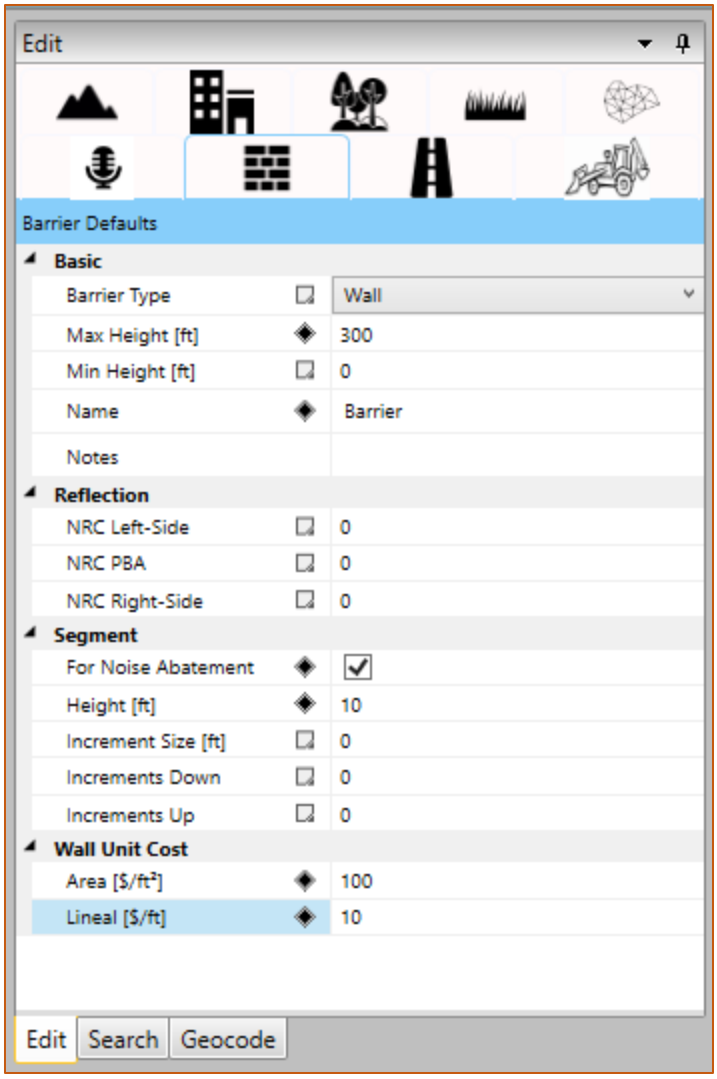


Figure 21 *Edit Pane and Barrier Defaults window with modified barrier cost default values*

With **Enable Object Add** toggled on in the **Edit/Modify** tab of the **Toolbar**, click in the **Plan Builder** to add the barrier between the building row/receivers and the roadway nearest to the receivers. (Note that the barrier may be blocking some driveways visible in the aerial view, which will be ignored for the sake of this demonstration of general TNM capabilities.) When finished, your **Plan Builder** should look something like **FIGURE 22**. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

The arrows along the barrier object will match whichever direction in which the object was digitized. These symbols indicate orientation relative to the barrier object in the event of differing absorptive material properties on either side of the barrier. **FIGURE 21** shows the final barrier default properties, including identical left and right-side NRC values in the **Reflection** section, so it does not matter whether the orientation of your barrier object matches that shown in **FIGURE 22**.

Figure 22 *Plan Builder showing all project objects on the Aerial View basemap*

LEGEND PANE

(*The **Legend Pane** displays the objects and features that have been added to a project. Once a feature is listed in the **Legend Pane**, you can choose whether that feature should be viewable in the **Plan Builder** and change its transparency. More **Legend Pane** details can be found in the **Help Menu**.*)

At this point, it may be easier to simplify the view so that we can see the objects more clearly. A clean look can be obtained by unchecking the **Basemap** checkbox in the **Legend Pane**. This will hide the map entirely so that the project now looks like **FIGURE 23**.

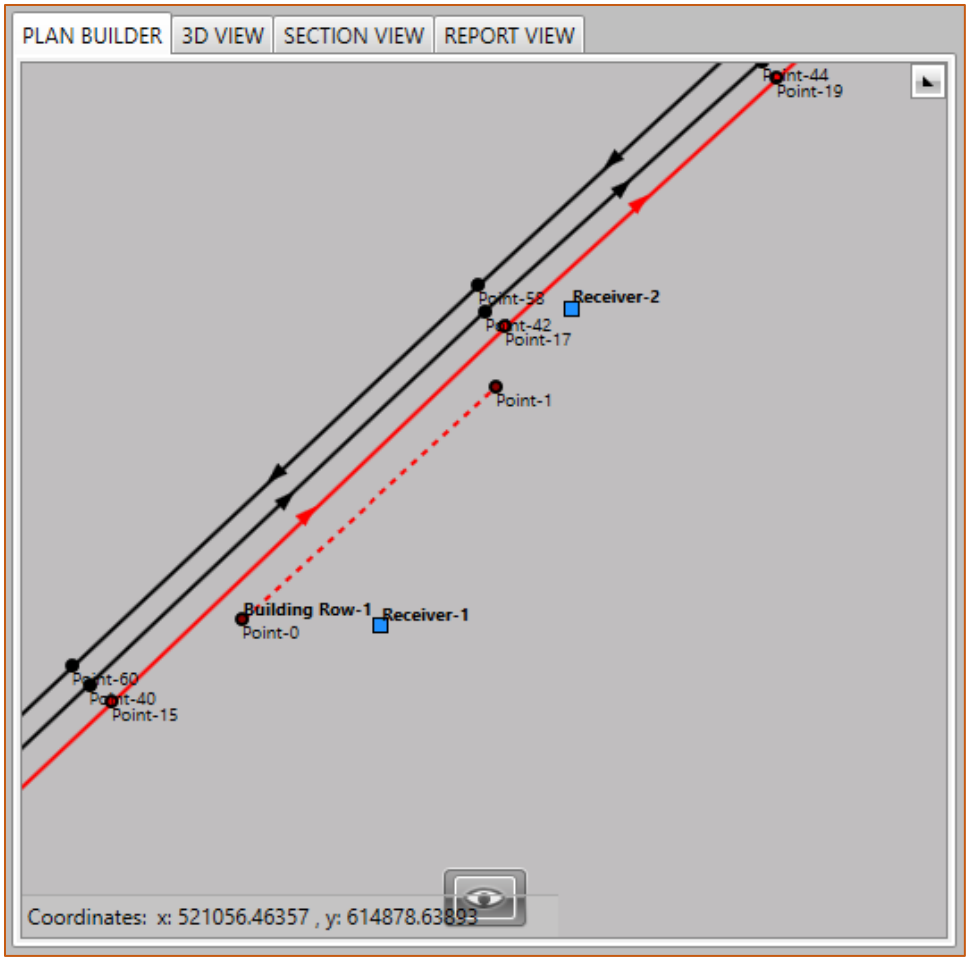


Figure 23 *Plan Builder showing all project objects with no basemap*

We have designated the X- and Y-coordinates for the objects that we want in our project, but we have not yet designated Z-coordinates or other parameters that are important for the calculations. We can add these by going to the **Object Details Pane**.

Object Details Pane

(*The **Object Details Pane** lists the data for each object that has been added to the project.*)

To adjust the Z-coordinates of objects, we go to the **Object Details Pane** and select the tab on the bottom to open the sub-pane for the object type we want to edit. For example, if we want to edit the Z-coordinates for one of the roadway objects, we would select the **Roadways Object Details Sub-pane**. For all objects except receivers, we would then select the **Points** tab on the left-hand side. (The other tabs present on the left side will depend on what Object Details sub-pane is open.) Select the **Roadways Object Details Sub-pane**, select the **Points** tab on the left, and then select the desired roadway object from the dropdown list, as shown in **Figure 24**.

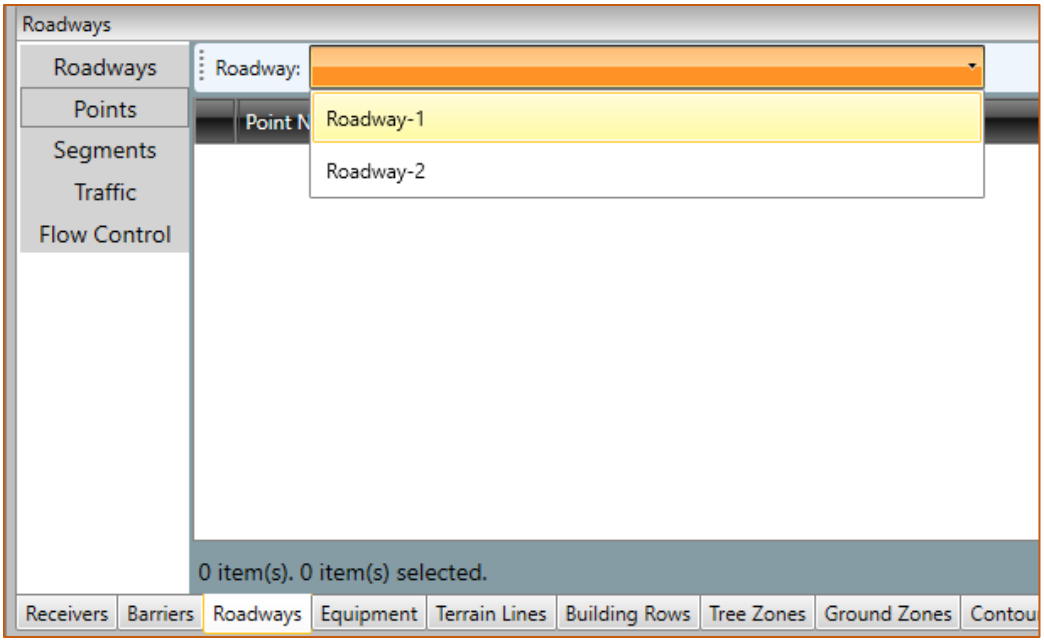


Figure 24 *Selecting a roadway object in the Points tab of the Roadways Object Details Sub-pane*

Once the individual object has been selected, the grid will be populated with data related to the object points. An example is shown for a roadway in **FIGURE 25**. For the time being, we will assume that the ground around the project all has the same elevation, so we can leave the Z-coordinates for all objects at the same relative value, i.e., 0 ft.

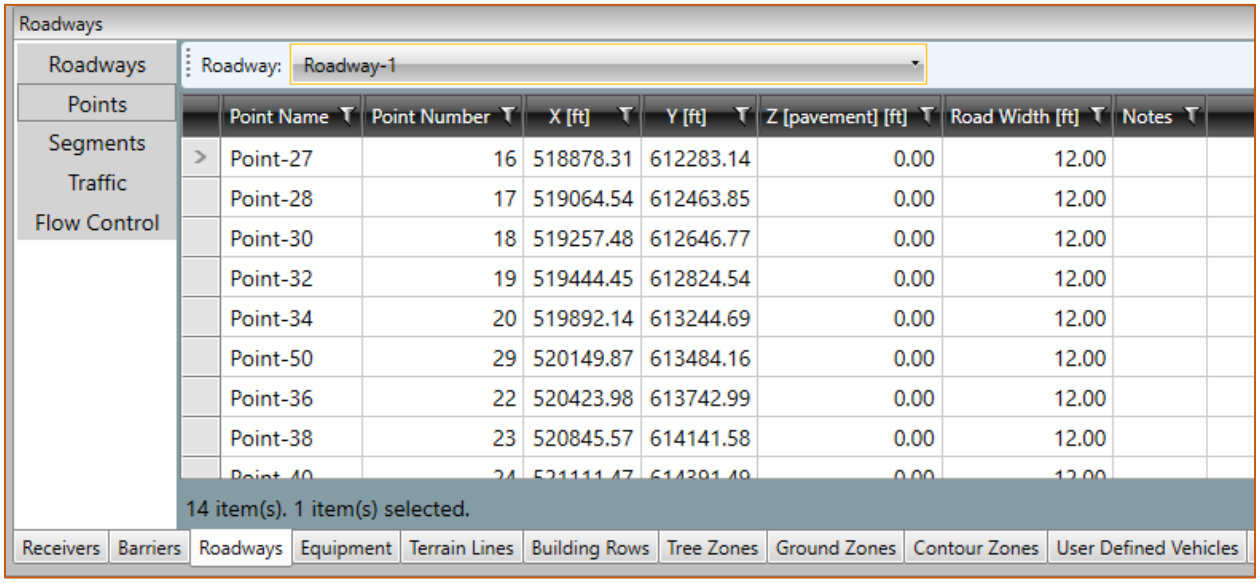


Figure 25 *Points tab for a roadway in the Object Details Pane*

Because we represented each direction of travel as a single roadway object, we should type in the **Roadway Width** field to set 24 ft at all roadway points to account for both lanes of pavement. When complete, the **Points** tab of your **Roadways Object Details Sub-pane** should look like **FIGURE 26**. Be sure to make this change for both roadway objects using the dropdown menu shown in **FIGURE 24** because this will impact the results. Roadway objects include built-in pavement ground zones extending

symmetrically from the object centerline. The acoustic impedance of the pavement ground zone (quantified via the Effective Flow Resistivity value) will impact the acoustic calculations when other ground types are included in the model via the default ground type in the **Project Settings** (as per this example – see **FIGURE 2**) or via Ground Zone objects.

As a reminder, it is more accurate to digitize individual lanes as separate roadway objects. This simplified exercise combines each direction of traffic flow into a single roadway object to demonstrate some of TNM's editing features. Note that when conducting precise noise analyses, several roadway lanes can be easily digitized at once using the Multi-Lane tool. Instructions on doing so can be found in Section 6.3.2 of the TNM 3.2 User's Guide in the **Help Menu**.

Note that the roadway width value could have been set in the **Basic** section of the roadway defaults window shown in **FIGURE 6** to automatically apply to all roadway points.

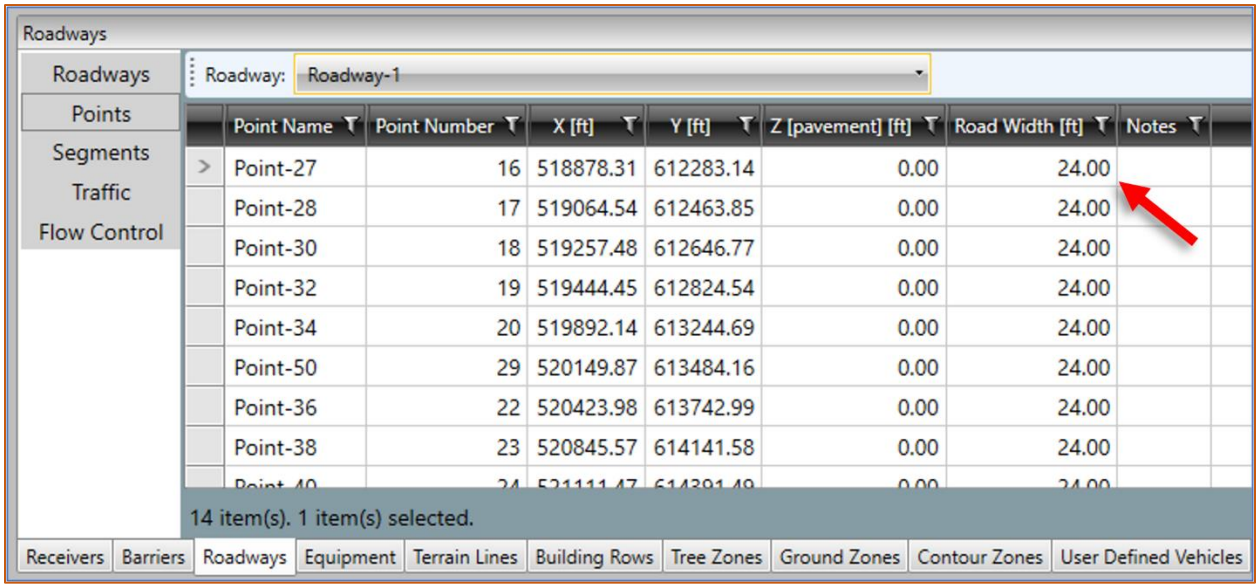


Figure 26 *Points tab for a roadway in the Object Details Pane with modified roadway width*

The roadway pavement ground zone width can be visualized in the **Section View** tab of the **View Pane.** Go to the **View** tab in the **Toolbar** and click the **Start Section** button within the **Basic Tools** function, highlighted in **FIGURE 27**. In the **Plan Builder**, click slightly southeast of Receiver-1 and move the mouse to draw a line approximately perpendicular to the polyline objects. The line should intersect Receiver-1, Building Row-1, Barrier-1, and both roadways. Double click to finish drawing the section line, symbolized via the dotted blue line in the **Plan Builder** shown in **FIGURE 28**. The **Section View** tab of the **View Pane** will open, as shown in **FIGURE 29**. The horizontal blue line on the bottom of the section view diagram represents the ground terrain profile with the acoustic properties of the default ground type. Note that the roadway pavement ground zones bordered by the black vertical lines in the bottom right corner slightly overlap with no blue default ground showing between them, which is the desired result of modifying the roadway width. You can also see that the barrier is not tall enough to block the line of sight between the upper roadway source (top circle above the roadways) and the receiver through the building row. We'll address that later.

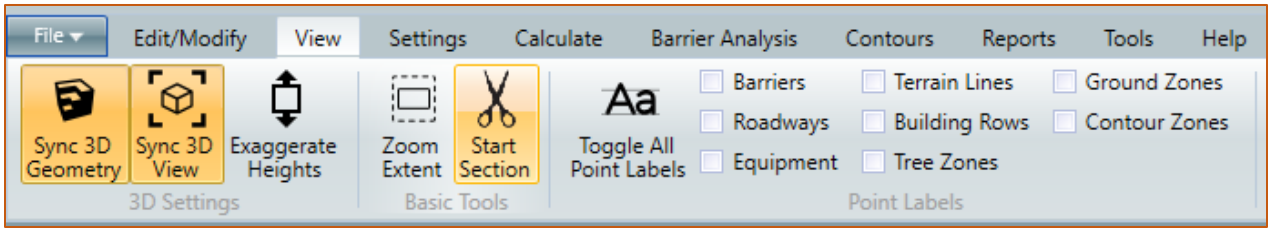


Figure 27 *View tab of the Toolbar showing the Toggle All Point Labels off and the Start Section button highlighted*

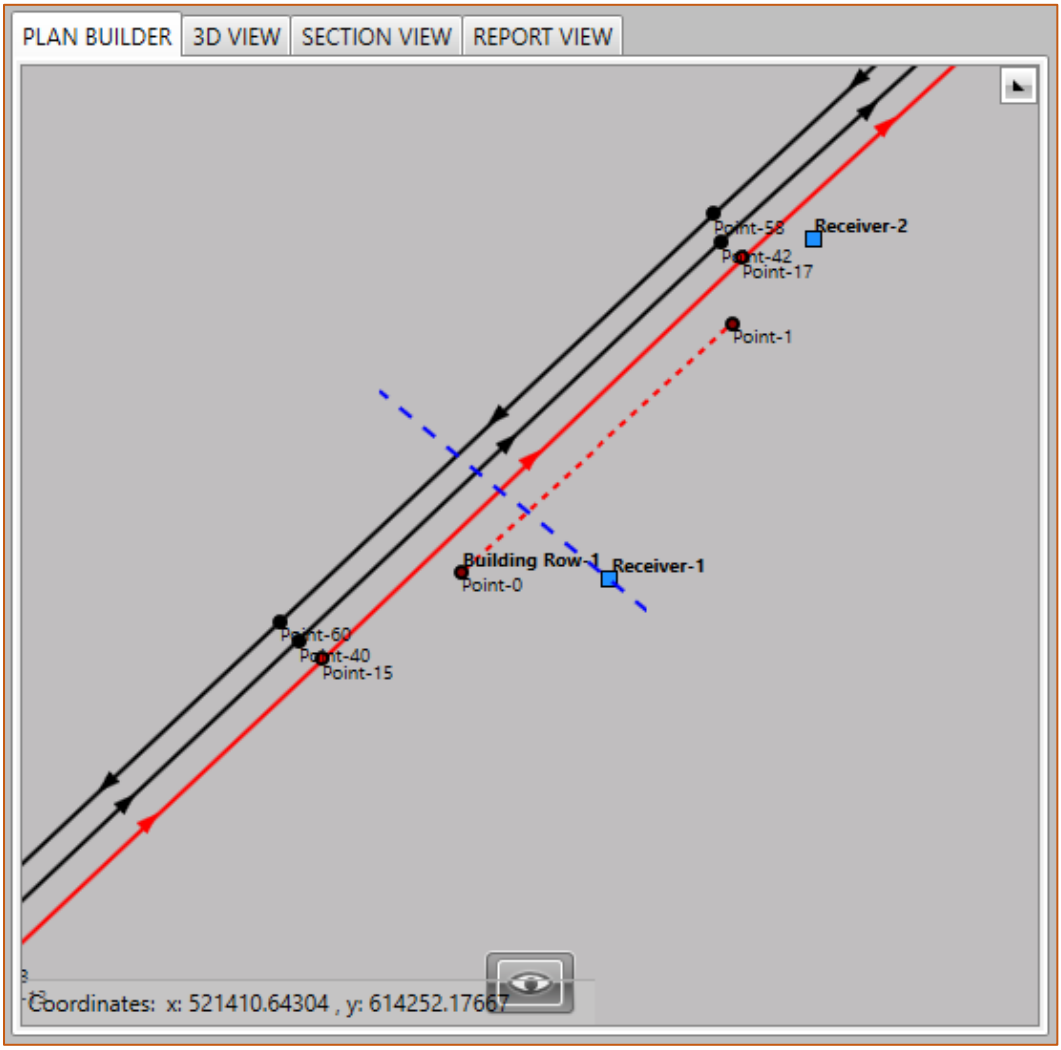


Figure 28 *Plan Builder showing section line drawn*

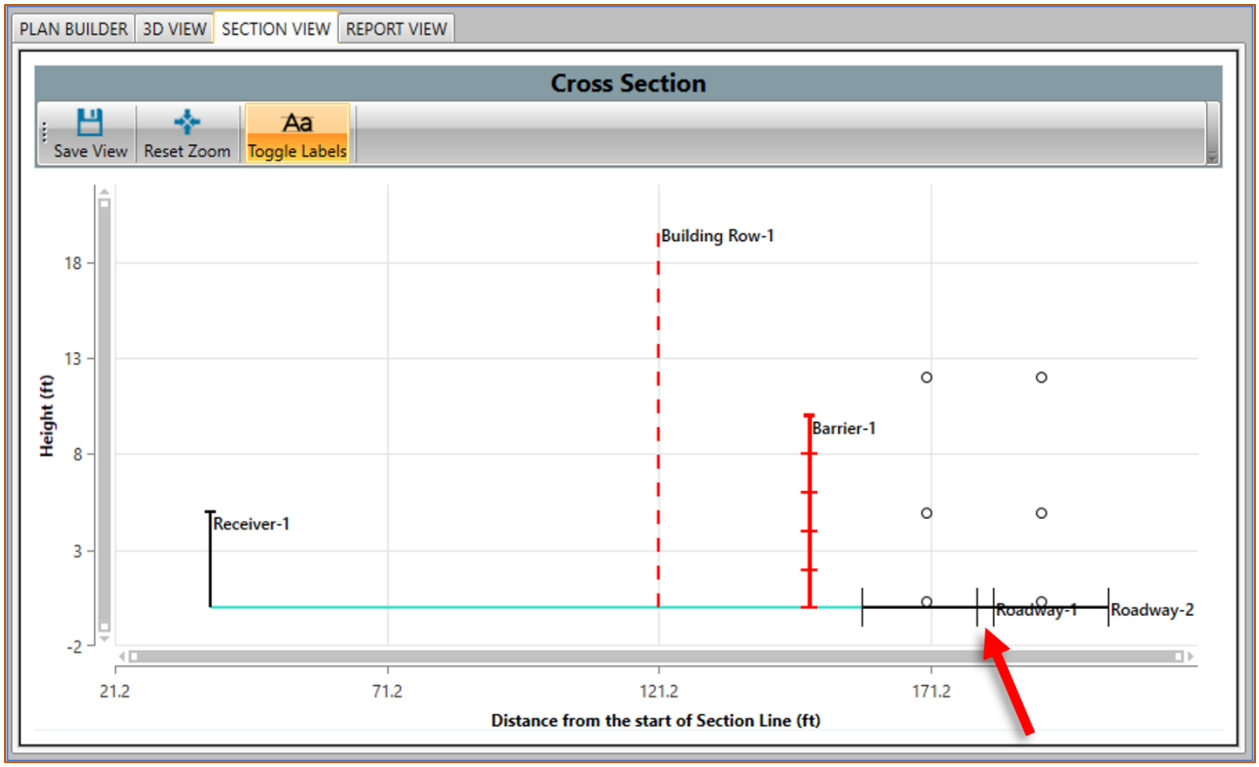


Figure 29 *Section View tab of the View Pane annotated to illustrate overlapping pavement width between Roadway-1 and Roadway-2*

To add traffic on each roadway, select the **Traffic** tab on the left. You will then see a table that displays 0 for all traffic volumes and speeds. It is often easiest to enter the traffic volumes and speeds for the first row of the table (pertaining to the first roadway segment) and then use the **Copy Down** function at the top of the **Object Details Pane** to apply these data to the subsequent segments of the roadway object. **FIGURE 30** shows sample traffic data added to a roadway. Be sure to add traffic data for both roadways using the dropdown menu shown in **FIGURE 24**. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

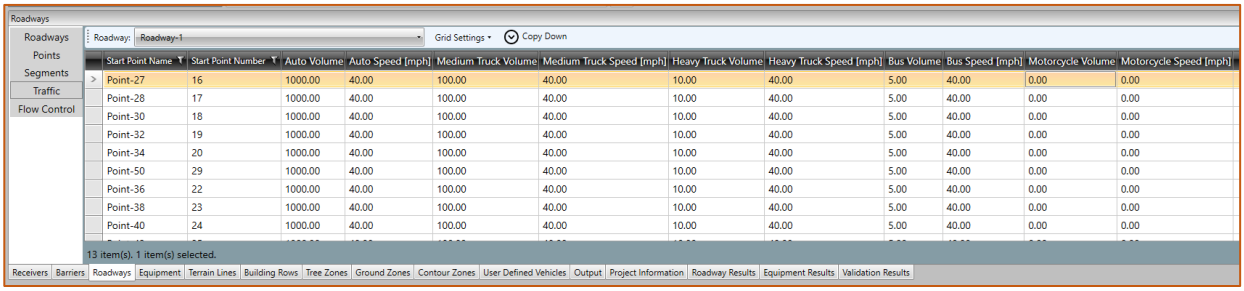


Figure 30 *Traffic tab for a roadway in the Object Details Pane with sample input data*

Next, examine the receivers using the **Receivers Object Details Sub-pane**. Let's assume that the first receiver represents the second floor of a building. We will want to increase the height of the receiver. This can be done in the **Receivers** tab on the left-hand side. Note that there are two ways the receiver elevation can be changed. The Z-coordinate can be changed (**Z [ground]**) and the height of the receiver above the ground (**Height**) can be changed. If you change **Z [ground]**, the geometry of the model will change, effectively adding a slope in the terrain between the receiver and the next object in the

propagation path. This is not what we want to do here. Rather, we want to tell TNM that we are interested in the noise level a certain distance above the ground, thus we need to edit the **Height**. FIGURE 31 shows the two receivers, each having a different height above the ground. Note that the checkbox containing the **Active** indicator is checked for both receivers. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in FIGURE 14.

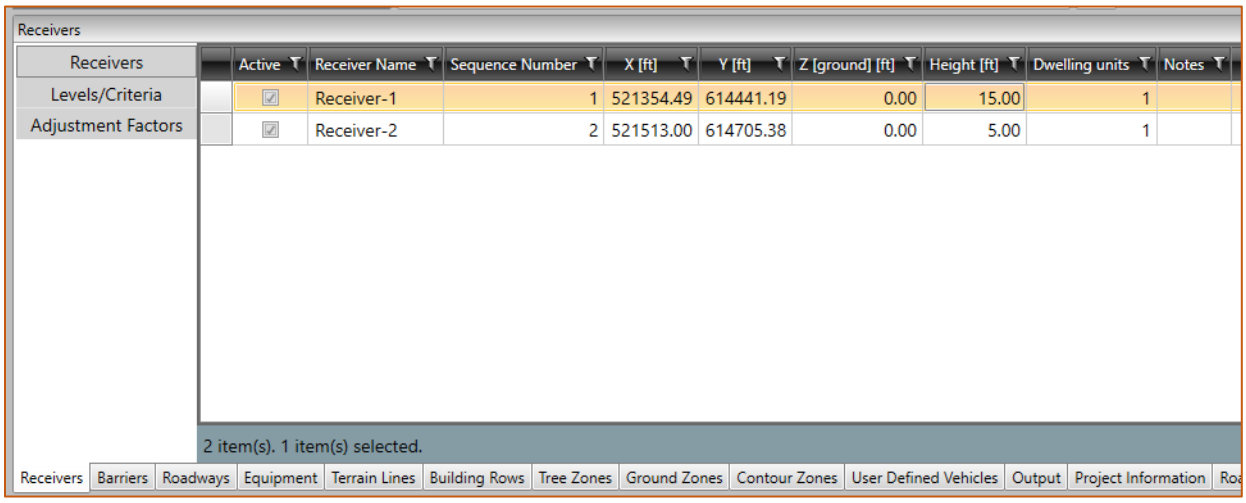


Figure 31 *Receivers tab in the Object Details Pane with edited receiver Height*

Next, we want to set the height of the **Building Row**. Select the **Building Rows Object Details Sub-pane**. The Z-coordinates (found in the **Points** tab) affect the terrain between the building row and the nearest objects along the propagation path. We want to change the height of the buildings above the ground, so we will need to adjust the **Average Height** in the **Building Rows** tab on the left. Let's set the **Average Height** to 30 feet. We can also change the spacing between buildings by adjusting the **Gap Percentage.** Set the **Gap Percentage** to 20% to indicate that the buildings provide 80% line of sight blockage between the roadways and receiver. When finished, the settings for the building row should look as shown in FIGURE 32. Note that the **Average Height** and **Gap Percentage** values could have been set in the **Measurements** section of the building row defaults window shown in FIGURE 18 to automatically apply to all building row objects. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in FIGURE 14.

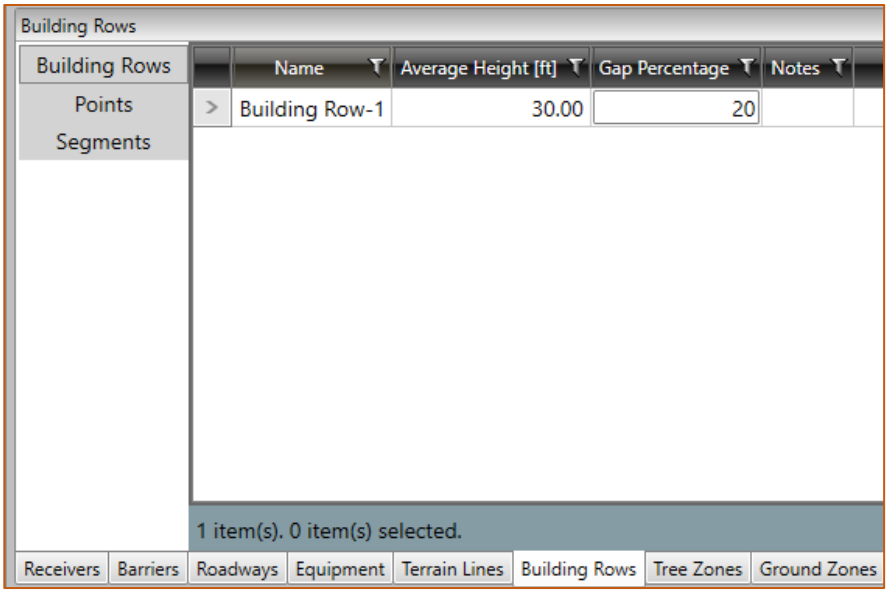


Figure 32 *Building Rows tab in the Object Details Pane with edited Average Height and Gap Percentage*

Now let's finalize the barrier. Select the **Barriers Object Details Sub-pane**. The **Barriers** tab in **FIGURE 33** shows that the default values for **Wall Area Unit Cost** and **Wall (Additional) Lineal Unit Cost** have been applied according to the input settings shown in **FIGURE 21**.

Figure 33 *Barriers tab in the Object Details Pane with appropriate barrier costs*

Next, we want to tell TNM to compute the effect of the barrier with multiple segment heights. We do this in the **Segments** tab on the left. Select the barrier object from the dropdown list and set the input heights using the **Segment Height** value. Let's start the computations with a large value for the **Segment Height**, e.g., 30 ft for all barrier segments. We will then tell TNM to compute the effect of the barrier with different combinations of heights for each segment. To do this, set the **Increment** to 2 ft, leave the number of **Up Increments** at 0, and set the number of **Down Increments** to 10 for all barrier segments, as shown in **FIGURE 34**. Note that these values could have been set in the **Segment** section of the barrier defaults window shown in **FIGURE 20** to automatically apply to all barrier segments. Also note that the checkbox containing the **For Noise Abatement** indicator is checked for all barrier segments, as shown in

FIGURE 34. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

For this example, when TNM computes levels at the receivers, it will start with all segments of the barrier at 30 feet and store these values. It will then reduce one segment by 2 feet, re-compute the levels, and store these values. It will continue perturbing the segments until all combinations have been evaluated, e.g. 30, 30, 30 ft; 28, 30, 30 ft; 26, 30, 30 ft; … 10, 30, 30 ft; 30, 28, 30 ft; … 30, 10, 30 ft; 28, 28, 30 ft, … 10, 10, 10 ft. As such, including many perturbations across many barrier segments greatly increases the number of computations. To keep runtimes reasonable, choose perturbations carefully.

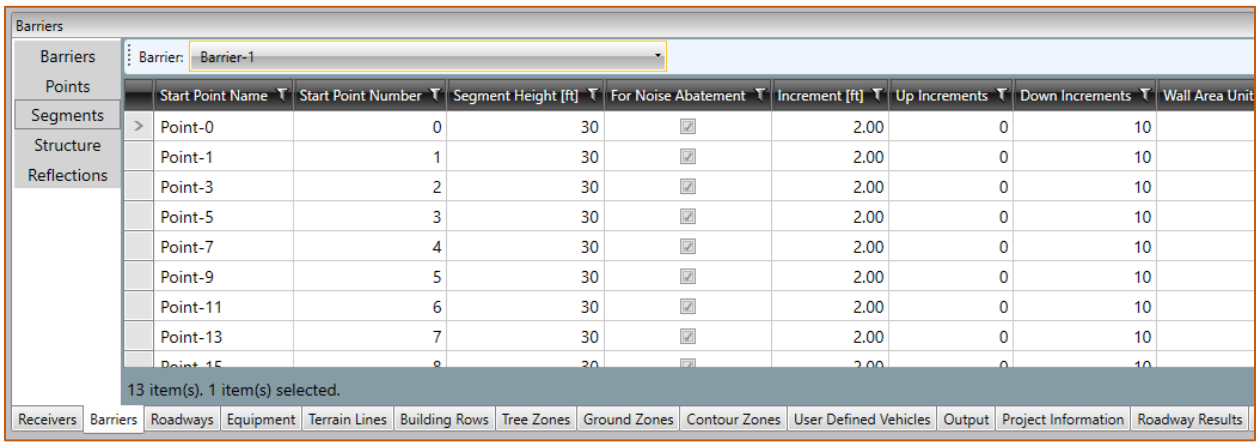


Figure 34 *The Segments tab for a barrier in the Object Details Pane with edited Segment Height and perturbation settings*

CALCULATING AND REVIEWING RESULTS – ROADWAY NOISE ANALYSIS

TOOLBAR - CALCULATE TAB

At this point, our project is ready to be run. Go to the **Calculate** tab in the **Toolbar** and select **All Receivers** within the **For Roadways** function, highlighted in FIGURE 35. A calculation window appears displaying the computation progress, as shown in FIGURE 36. You will be prompted to click Ok when the calculation is complete.

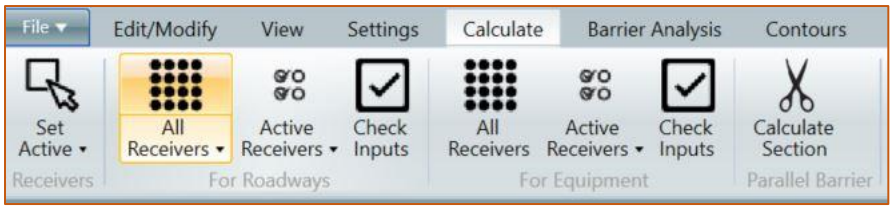


Figure 35 *Calculate tab of the Toolbar with All Receivers For Roadways selected*

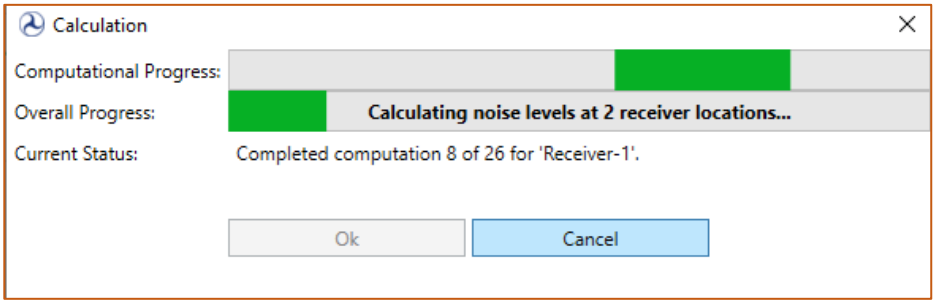


Figure 36 *Calculation window, calculations in progress*

The **Roadway Results** tab of the **Object Details Pane** will open to display the computed noise levels with and without the barrier object at its input height, as shown in FIGURE 37. (Results including barrier segment perturbations are not shown here. We'll get to that later.) Note, it will take a few seconds for the **Roadway Results** tab to update after the calculations are complete.

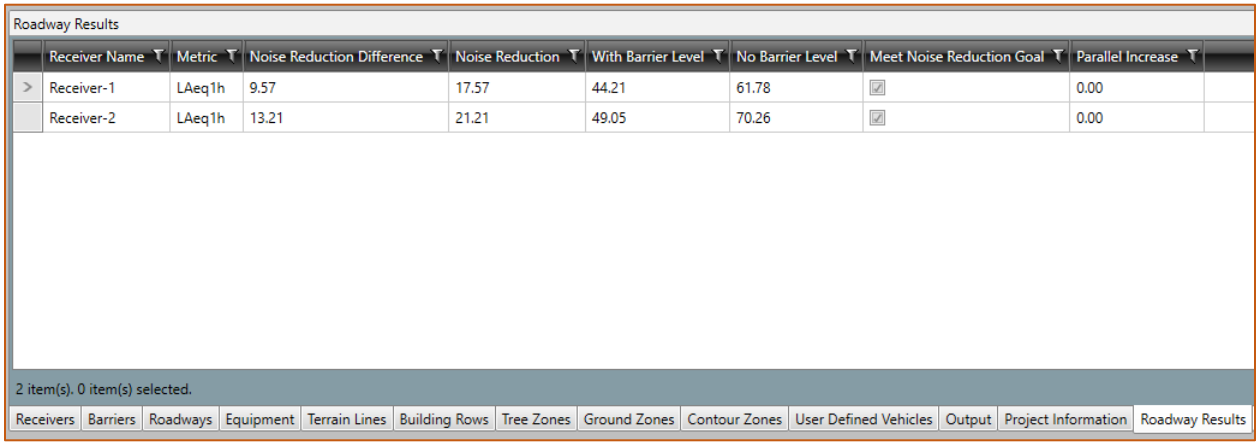


Figure 37 *Roadway Results tab of the Object Details Pane displaying computed noise levels*

TOOLBAR - REPORTS TAB AND THE VIEW PANE - REPORTS VIEW

There are several reports that the user can view once TNM has finished its calculations. They can be opened by selecting the desired report from the **Result Reports** section of the **Results** tab in the **Toolbar**, shown in **FIGURE 38**.

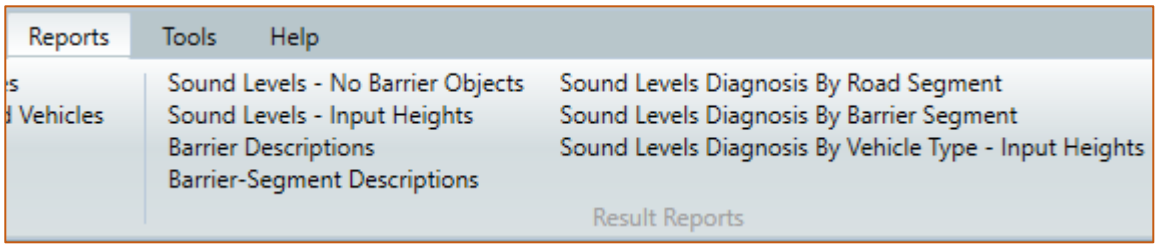
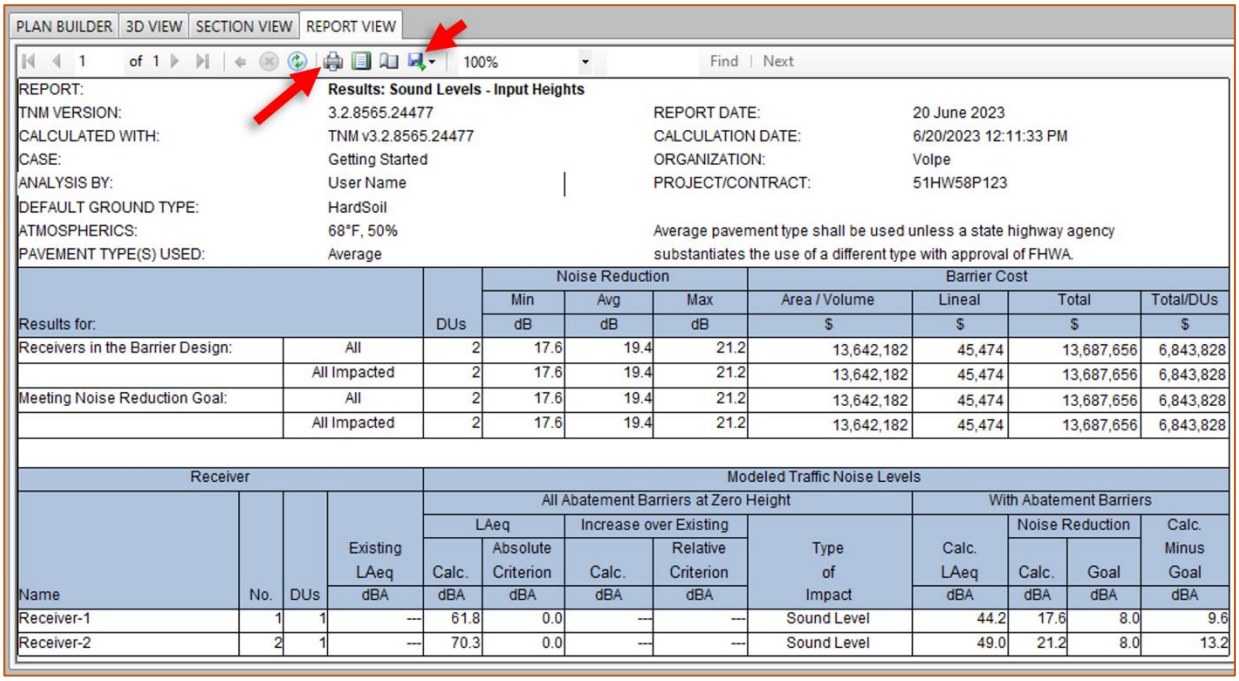


Figure 38 *Result Reports section of the Reports tab in the Toolbar*

For example, selecting the **Sound Levels – Input Heights** report will generate a report in the **Report View** tab of the **View Pane**, as shown in **FIGURE 39**. Note that all reports can be printed directly from the **Report View** or they can be exported to many common formats. To print or export the report, use the options in the ribbon annotated on the screenshot in **FIGURE 39**.



Results for:		DUs	Noise Reduction Min dB	Noise Reduction Avg dB	Noise Reduction Max dB	Barrier Cost Area / Volume $	Barrier Cost Lineal $	Barrier Cost Total $	Barrier Cost Total/DUs $
Receivers in the Barrier Design:	All	2	17.6	19.4	21.2	13,642,182	45,474	13,687,656	6,843,828
	All Impacted	2	17.6	19.4	21.2	13,642,182	45,474	13,687,656	6,843,828
Meeting Noise Reduction Goal:	All	2	17.6	19.4	21.2	13,642,182	45,474	13,687,656	6,843,828
	All Impacted	2	17.6	19.4	21.2	13,642,182	45,474	13,687,656	6,843,828

Receiver				Modeled Traffic Noise Levels								
				All Abatement Barriers at Zero Height					With Abatement Barriers			
				LAeq		Increase over Existing				Noise Reduction		Calc.
Name	No.	DUs	Existing LAeq dBA	Calc. dBA	Absolute Criterion dBA	Calc. dBA	Relative Criterion dBA	Type of Impact	Calc. LAeq dBA	Calc. dBA	Goal dBA	Minus Goal dBA
Receiver-1	1	1	---	61.8	0.0	---	---	Sound Level	44.2	17.6	8.0	9.6
Receiver-2	2	1	---	70.3	0.0	---	---	Sound Level	49.0	21.2	8.0	13.2

Figure 39 *Results: Sound Levels – Input Heights Report annotated in the Report View tab of the View Pane*

TOOLBAR - BARRIER ANALYSIS TAB

The Barrier Analysis module allows the user to view precomputed receiver levels for all combinations of barrier height perturbations for each segment, as defined in the **Segments** tab of the **Barriers Object Details sub-pane** (see **FIGURE 34**). Once TNM has evaluated all the possible combinations, the user can begin a barrier design. To do so, select the **Start Analysis** icon in the **Barrier Analysis** tab of the **Toolbar**, as shown in **FIGURE 40**.

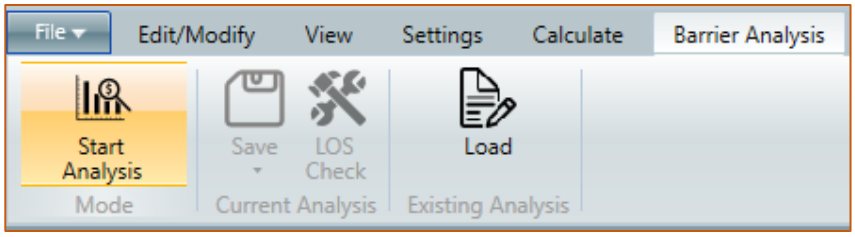


Figure 40 *Start Analysis button in the Barrier Analysis tab of the Toolbar*

Pressing the **Start Analysis** icon will change the layout of TNM to that shown in **FIGURE 41**. This layout is designed for the user to perturb selected barrier segments while seeing how these changes affect the receiver levels, barrier costs, and project geometry. The **Barrier Analysis Plan Builder** shows only roadways, **For Noise Abatement** barriers, and **Active** receivers (see the **Object Details Pane** section of this document for where these settings are designated). Note that these objects can be selected in the **Barrier Analysis Plan Builder** and the **Barrier Analysis Plan Builder** view can be panned and zoomed (see the **View Pane** section of this document), but new objects cannot be added to the **Barrier Analysis Plan Builder** and existing objects cannot be modified. The **Barrier Analysis 3D View** can be used to visualize the segment heights for the current barrier design as they change with perturbations. You can change the perspective of the **Barrier Analysis 3D View** to focus on a barrier of interest by holding down the scroll wheel on the mouse while dragging. The **Barrier Analysis Tool** panel in the upper right is where most of the user interaction will take place. The lower panels show tables with content that updates to reflect the noise levels and costs for the current barrier design as they change with perturbation.

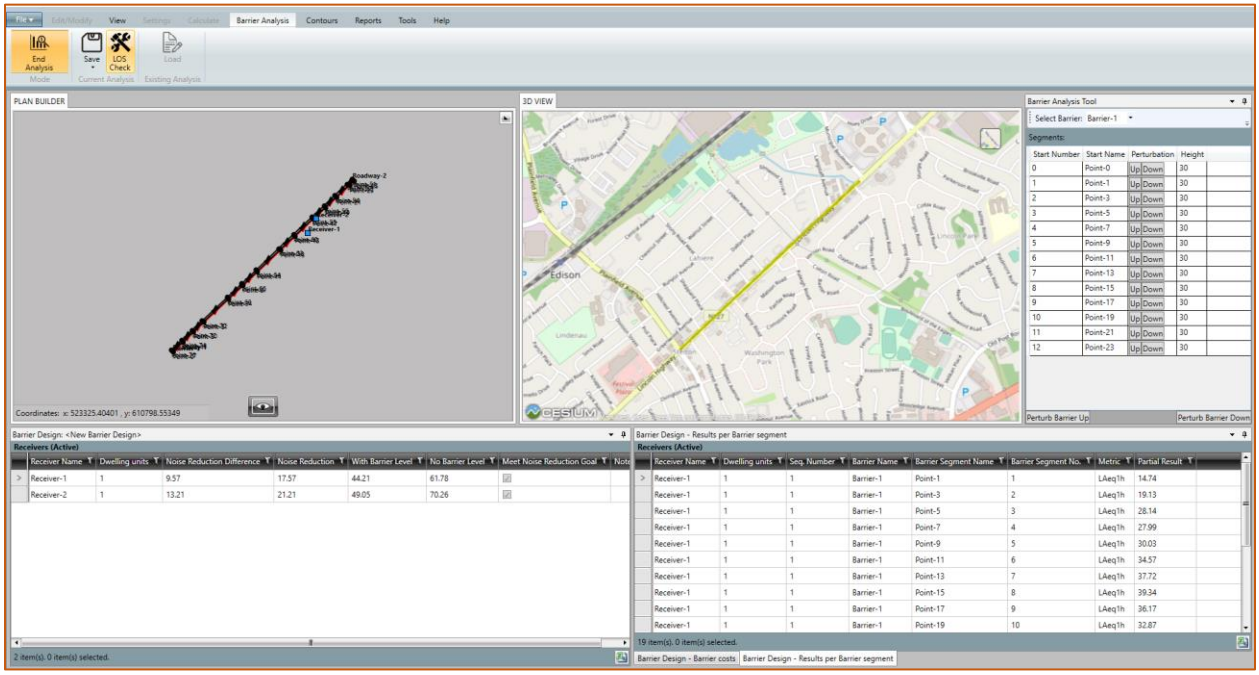


Figure 41 *Barrier Analysis module upon starting analysis*

The user can select a barrier to perturb in the **Barrier Analysis Tool** as shown in **FIGURE 42**. This will display the segments for the selected barrier. The **Barrier Analysis Tool** includes buttons for perturbing each segment up or down and a column that indicates the segment height for the current design. Note that the entire barrier can be perturbed up or down by utilizing the buttons in the lower corners of the

Barrier Analysis Tool, shown in **FIGURE 42**. When a barrier segment has reached its minimum or maximum perturbation height, it will remain at this height when attempting further perturbations in that direction.

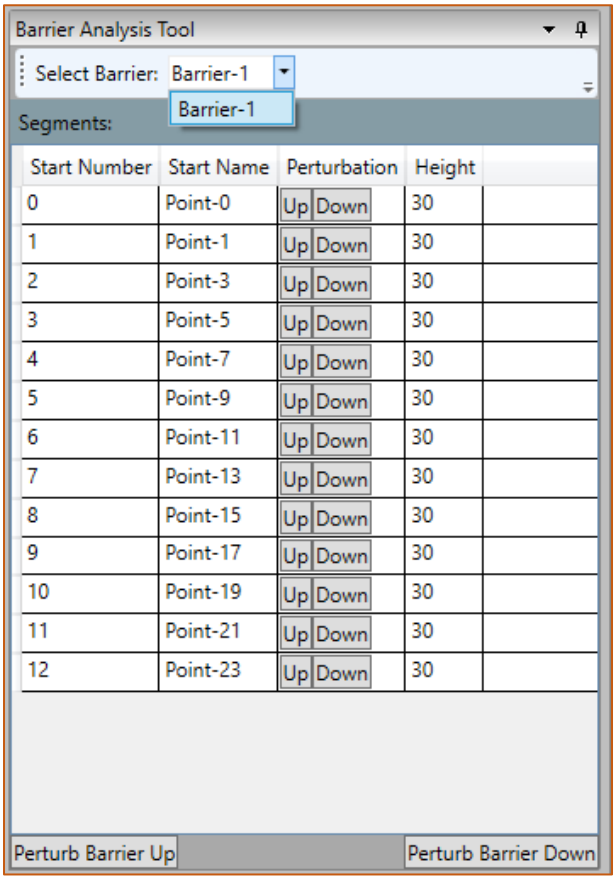


Figure 42 *Barrier Selection within the Barrier Analysis Tool*

FIGURE 43 shows the Barrier Analysis Module with a manipulated **Barrier Analysis 3D View** displaying all barrier segments at their input heights. Notice the receiver levels and barrier costs in the tables as well as the geometry of the barrier design in the **Barrier Analysis 3D View**.

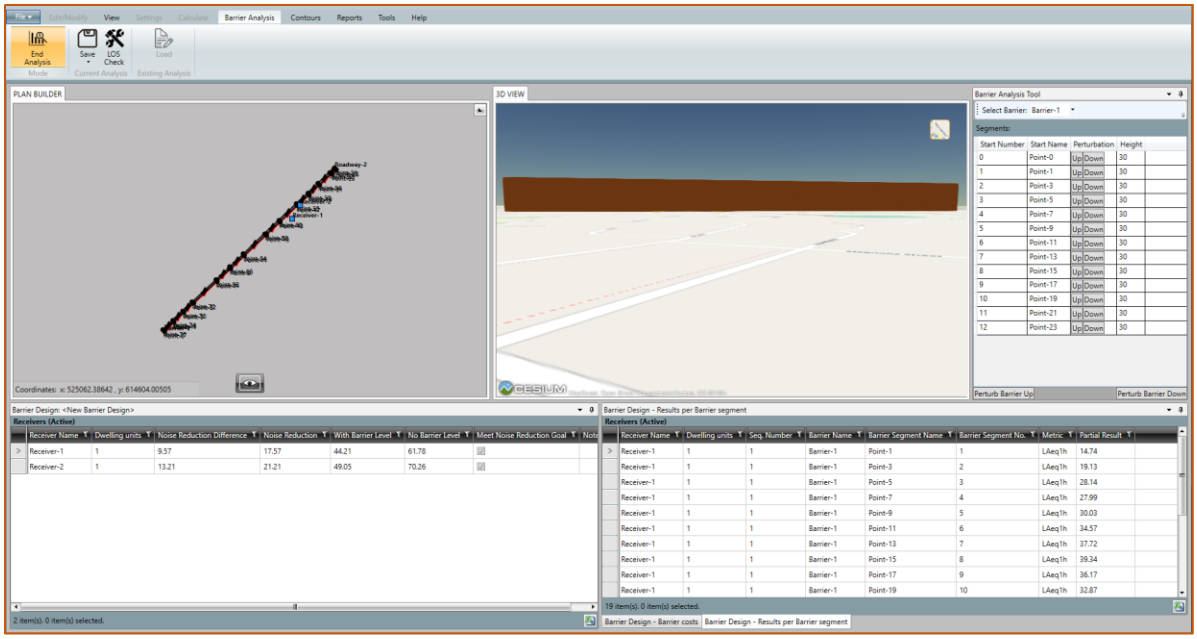


Figure 43 *Barrier Analysis module with modified view*

FIGURE 44 shows a design for this barrier where segments 3 through 7 have been perturbed down from their input height of 30 ft to the design height of 16 ft. Notice the updated receiver levels and barrier costs in the tables as well as the geometry of the barrier design in the **Barrier Analysis 3D View**.

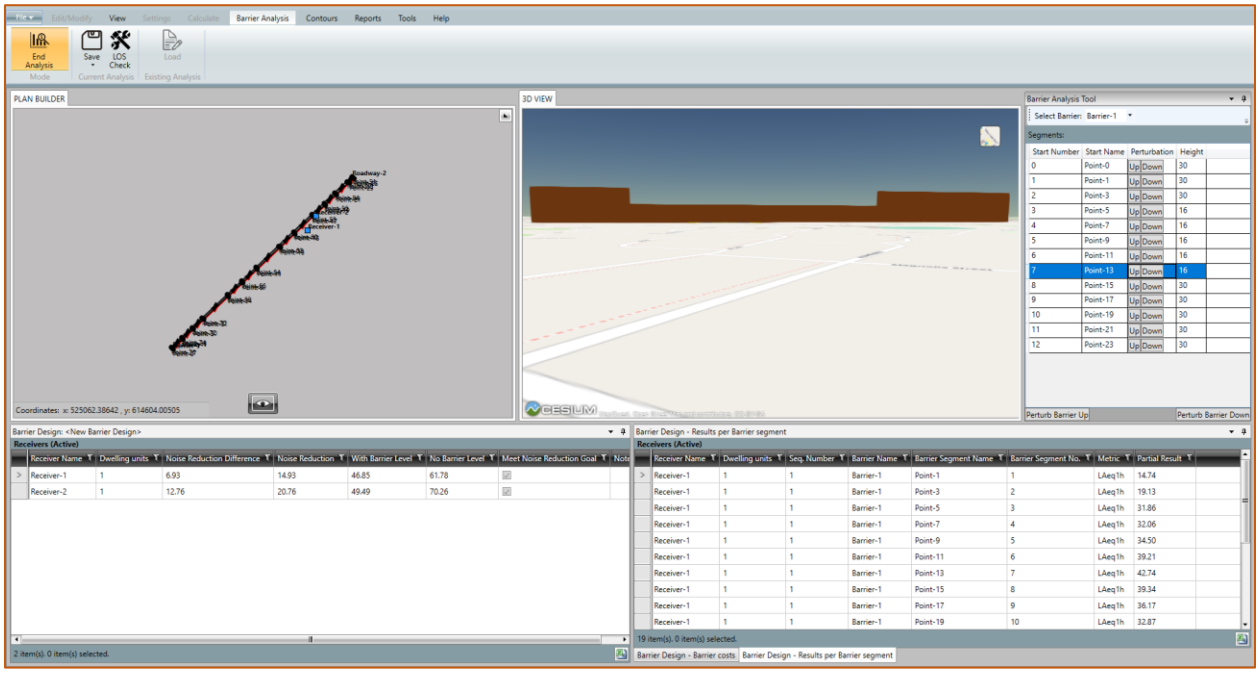


Figure 44 *Barrier Analysis tab with perturbed barrier segments*

The data in the tables can be exported by clicking the Excel icon in the bottom right of the respective table, annotated on the screenshot in **FIGURE 45**.

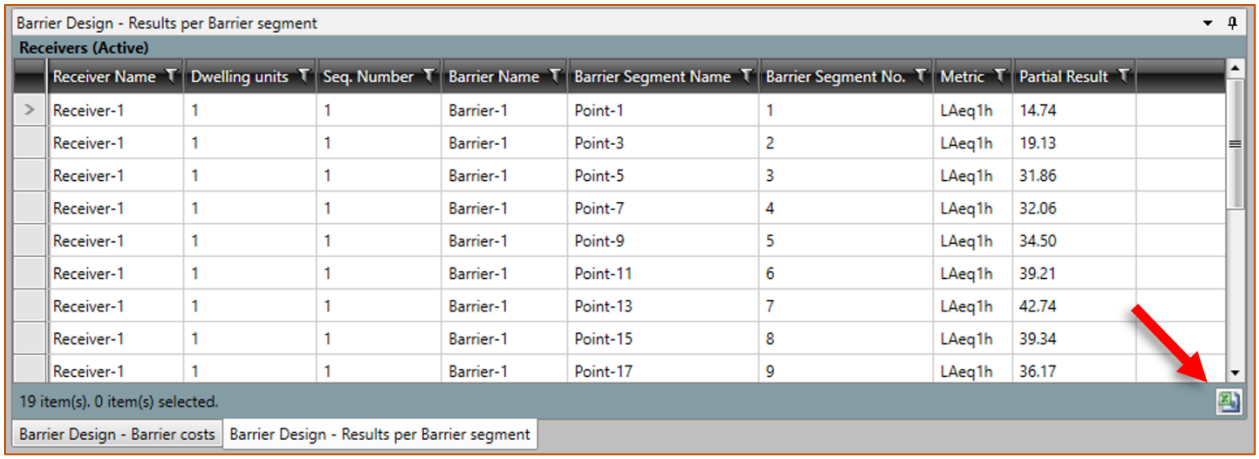


Figure 45 *Barrier Analysis table, annotated for export*

Once satisfied with the barrier design, it should be saved. This is done by clicking on the **Save** icon in the **Barrier Analysis** tab of the **Toolbar**, shown in **FIGURE 46**.

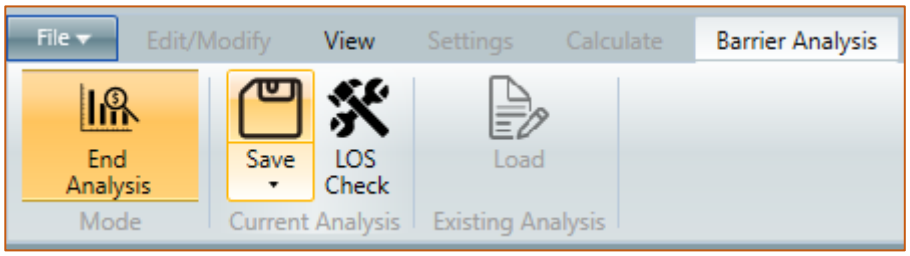


Figure 46 *Save button in the Barrier Analysis tab of the Toolbar*

This will open a dialog box where a name can be entered for the new barrier design, as shown in **FIGURE 47**. The three design names shown in the **Other Saved Analyses** list are automatically generated. Press Save after entering the desired name.

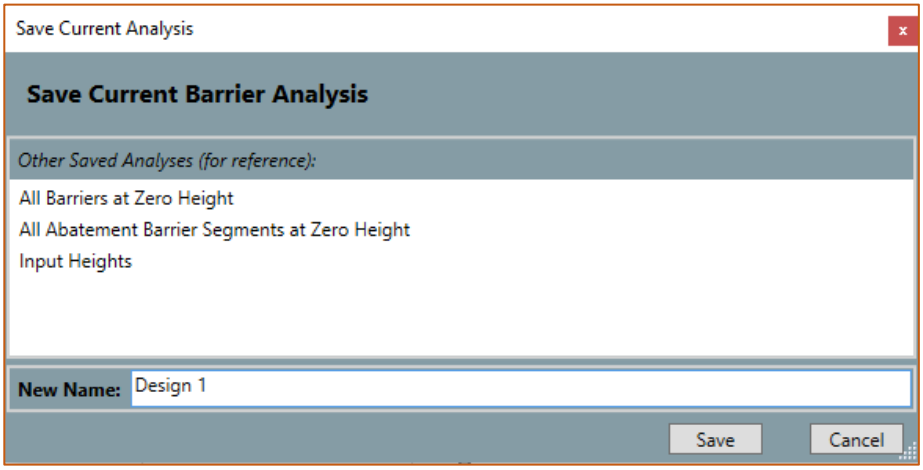


Figure 47 *Save Current Analysis dialog box*

Pressing **End Analysis** in the **Barrier Analysis** tab of the **Toolbar** (shown in **FIGURE 48**) closes the Barrier Analysis module and returns the TNM application to the previous layout.

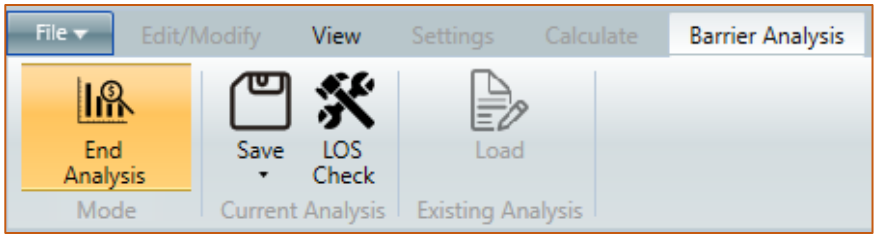


Figure 48 *End Analysis button in the Barrier Analysis tab of the Toolbar*

Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

INPUTTING AND REVIEWING OBJECTS – CONSTRUCTION NOISE ANALYSIS

In TNM 3.2 and beyond, separate roadway and construction noise analyses can be integrated into a single project file. When roadway and equipment objects coexist within a project file, TNM will compute the noise levels at the same receiver locations, while only accounting for either the roadway or equipment sources, as indicated by the user. That is, when the user initiates computation of equipment noise results, the acoustic calculations will incorporate the attenuation from all existing input objects between the equipment objects and receivers, but ignore the noise emitted from any roadway objects in the model. Vice versa, noise emissions from any equipment objects will be ignored when the user executes roadway noise computations and all other input objects will be included in the acoustic calculations.

We will now demonstrate how to add equipment objects to an existing project file containing a roadway noise analysis. Doing so will take advantage of the existing barrier, building row, and receiver objects from the previously created project file. Note that the order of which noise sources are added to the project file or which calculations are executed first does not matter. Analysts may conduct equipment noise analyses first and subsequently add roadway objects and calculate roadway noise results, if desired.

TOOLBAR – EDIT MODIFY TAB

(*The **Toolbar** is found at the top of the application and is used to perform various functions in TNM. You can minimize or maximize the toolbar by right clicking and selecting **Minimize the Ribbon**. **Toolbar** details can be found in the **Help Menu**.*)

To start adding TNM objects to the project, press "D" on the keyboard or go to the **Edit/Modify** tab in the **Toolbar** and click on the **Enable Object Add button**. Using either method will highlight the Enable Object Add button, as shown in FIGURE 49.

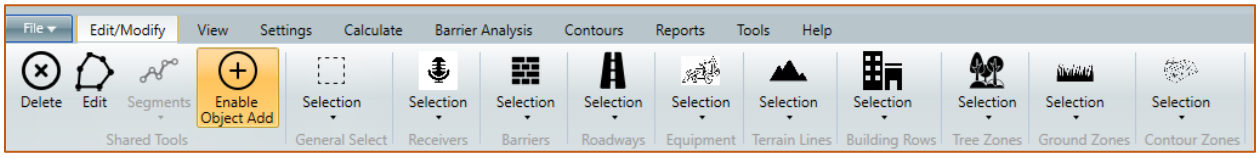


***Figure 49** Toolbar – Edit/Modify tab with Enable Object Add toggled on*

EDIT PANE

(*The **Edit Pane** is found on the right side of the application below the **Toolbar.** This pane contains settings for object defaults that are applied when creating new objects. The **Edit Pane** also allows you to select an object type to add to the project. More details on the **Edit Pane** can be found in the **Help Menu**.*)

Select the **Equipment** icon at the top of the **Edit Pane** to designate the object type to be added to the project. When selected, it will be outlined in blue, as shown in FIGURE 50. Use the **Equipment Type** dropdown list in the Equipment Defaults **Edit Pane** to choose the Asphalt Distributor Truck, as shown in FIGURE 51. Note that in the Equipment Defaults **Edit Pane**, the **Draw Type** display changes from "Point" to "PolyLine" and the **is Stationary** display changes from "True" to "False" when the Asphalt Distributor Truck **Equipment Type** is selected. This equipment object is deemed a non-stationary object that will be

symbolized in the **Plan Builder** using a series of line segments because the Asphalt Sprayer generates noise while moving throughout the construction site.

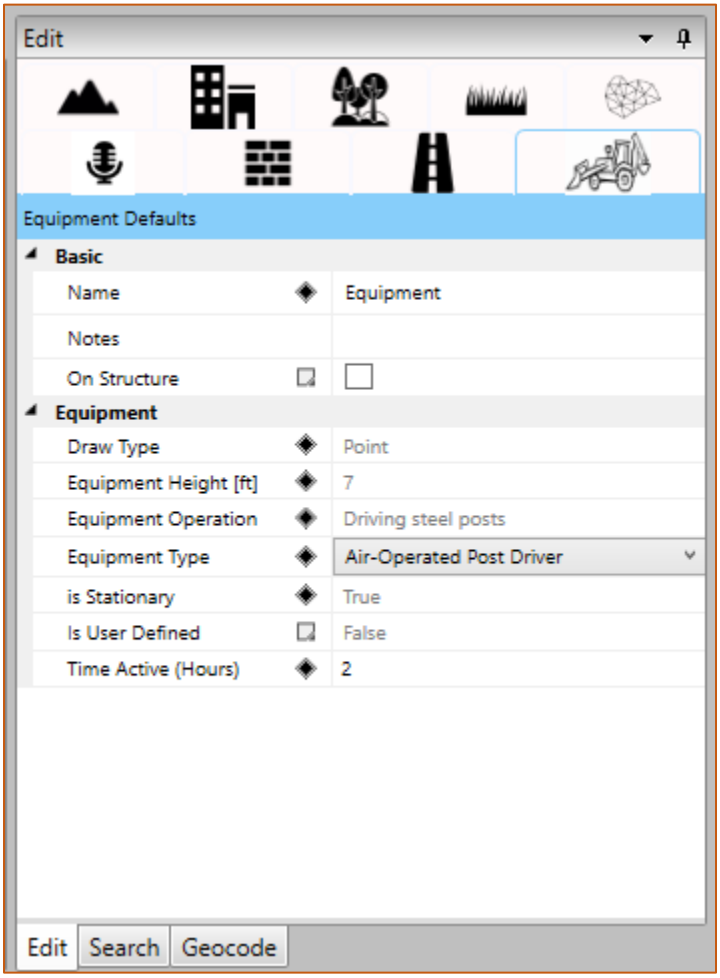


Figure 50 *Edit Pane Equipment Defaults window*

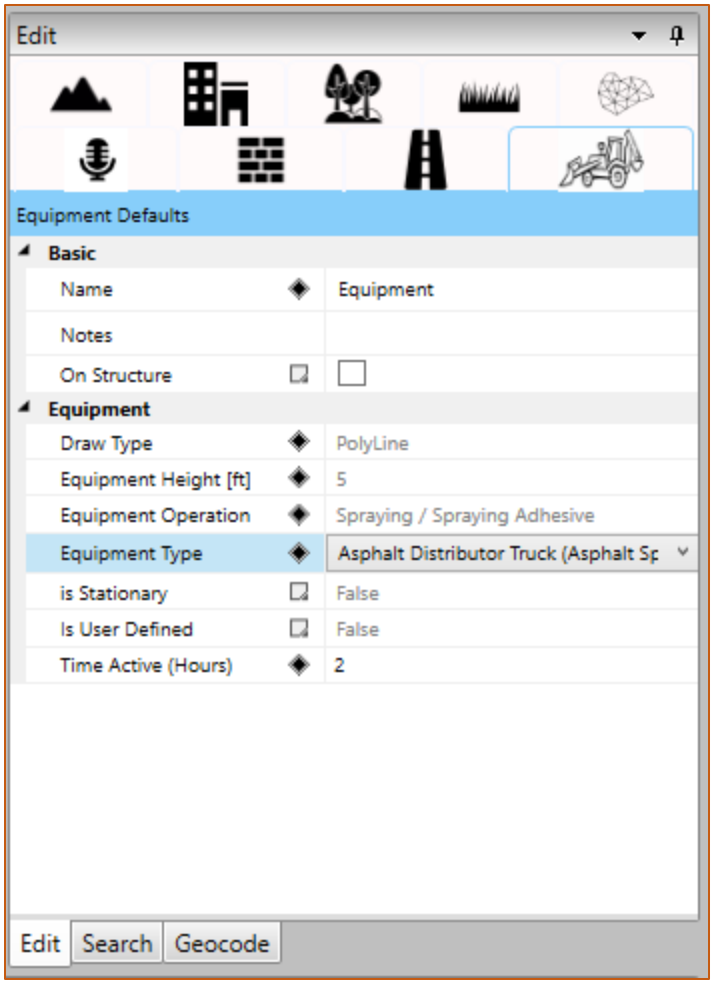


Figure 51 *Edit Pane Equipment Defaults window – Asphalt Distributor Truck*

VIEW PANE

(*The **View Pane** displays the map and associated map data using different visualization methods. The **View Pane** is comprised of the following four sub-panes used to represent project data in various visualization forms: **Plan Builder**, **3D View**, **Section View**, and **Report View**. More details on the **View Pane** sub-panes can be found in the **Help Menu**.*)

With **Enable Object Add** toggled on and the **Equipment** icon selected, add an Asphalt Distributor Truck to the project by clicking the left mouse button several times in the **Plan Builder** sub-pane of the **View Pane** at several points between the existing roadway objects. This is shown in **FIGURE 52** and **FIGURE 53**, moving southwest to northeast. Double click or right click to finish creating the equipment object. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

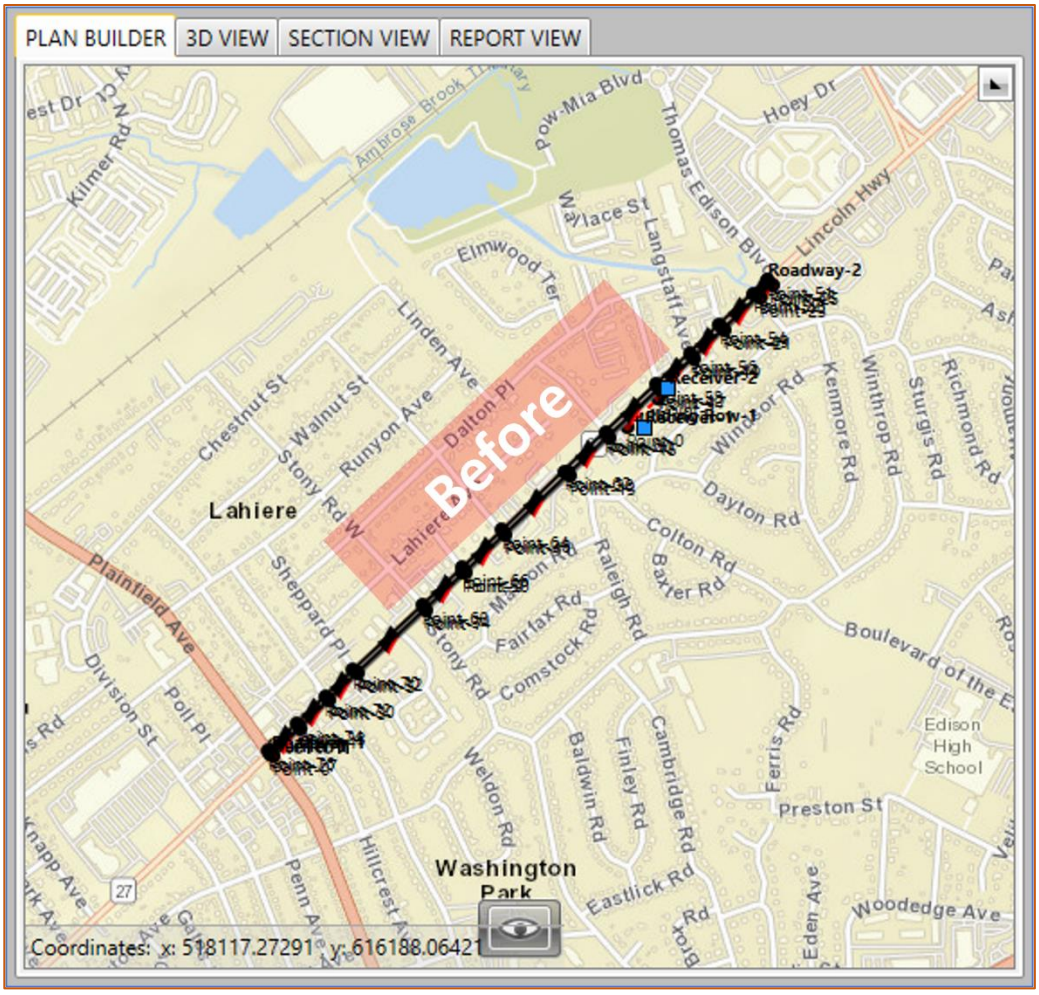


Figure 52 *Plan Builder in the View Pane, annotated prior to adding Asphalt Distributor Truck*

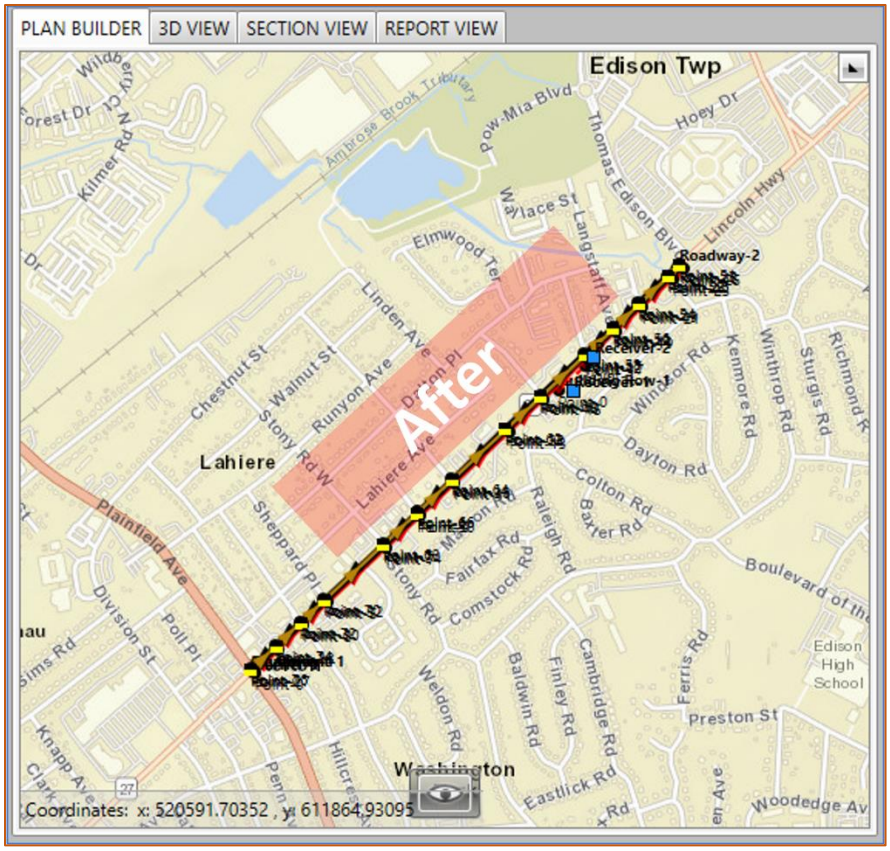


Figure 53 *Plan Builder in the View Pane, annotated after adding Asphalt Distributor Truck*

Return to the **Edit Pane**. In the Equipment Defaults window, use the **Equipment Type** dropdown list to choose the Warning Horn, as shown in **FIGURE 54**. Note that in the Equipment Defaults **Edit Pane**, the **Draw Type** display changes from "PolyLine" to "Point" and the **is Stationary** display changes from "False" to "True" when the Warning Horn **Equipment Type** is selected. This equipment object is deemed a stationary object that will be symbolized in the **Plan Builder** using a single point and a ray indicating its orientation because the air horn generates noise without moving throughout the construction site.

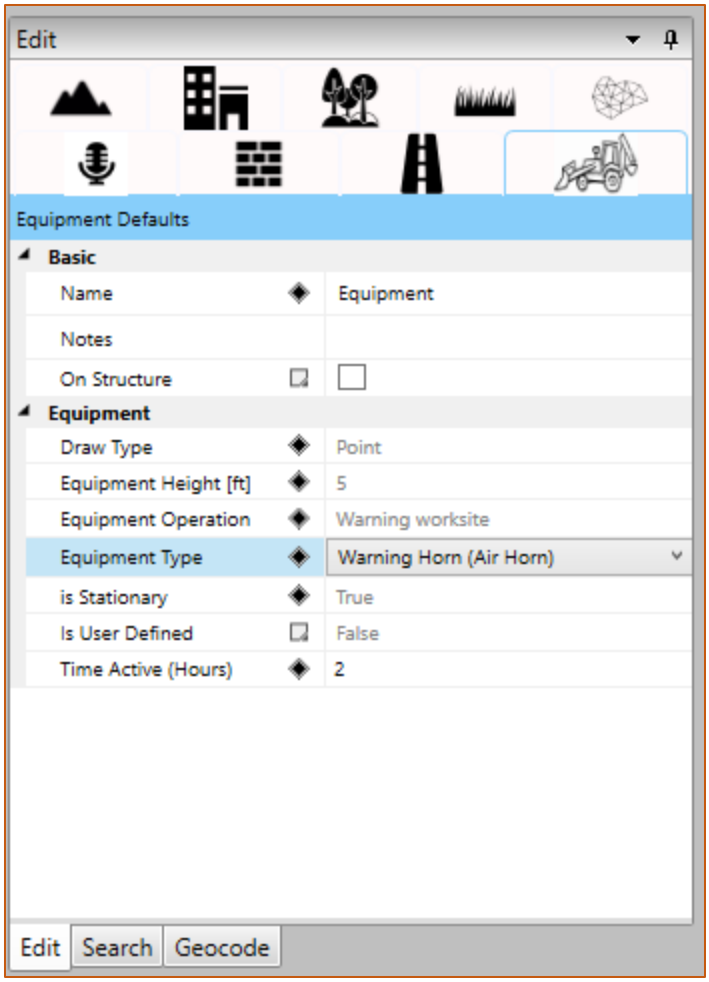


Figure 54 *Edit Pane Equipment Defaults window – Warning Horn*

With **Enable Object Add** toggled on and the **Equipment** icon selected, designate the location of the Warning Horn by clicking the left mouse button in the **Plan Builder** sub-pane of the **View Pane**. Double click or right click on another location in the **Plan Builder** to indicate the orientation of the Warning Horn.

Note, one can pan the view in the **Plan Builder** by clicking and dragging an area of the map that does not have any TNM objects. One can zoom the view in the **Plan Builder** using the mouse scroll wheel. One can also change the type of map displayed below the TNM objects using the "eye" icon in the bottom of the **Plan Builder**. For example, after panning, zooming, and selecting the Topographic View, the **Plan Builder** now looks as shown in FIGURE 55.

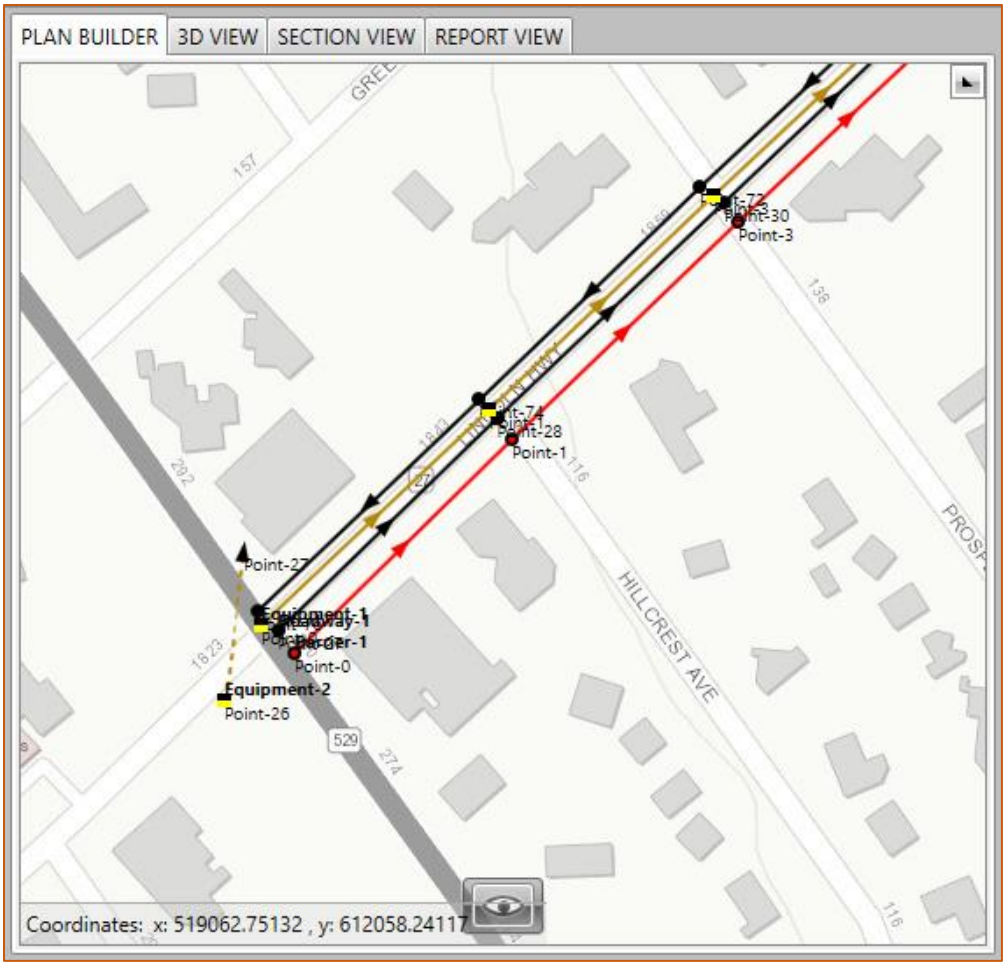


Figure 55 *Selected stationary equipment object on the Topographic View basemap*

The dotted line emanating from the Warning Horn point indicates its orientation, where the front of the object is represented by the arrow. **FIGURE 55** shows that the Warning Horn is facing away from the receivers. We can change this using TNM's editing features. Note that non-stationary equipment objects, like the Asphalt Distributor Truck, are edited the same way as was demonstrated for the roadway during the initial project creation.

Go back to the **Edit/Modify** tab in the **Toolbar** and select the **Edit** icon, as shown in **FIGURE 56**. Once the **Edit** button is selected, TNM objects can be edited graphically by selecting points, segments, or entire objects. (Edits can also be made by adjusting data in the **Object Details Pane** regardless of whether the **Edit** icon in the **Toolbar** is selected. We will discuss this later.)

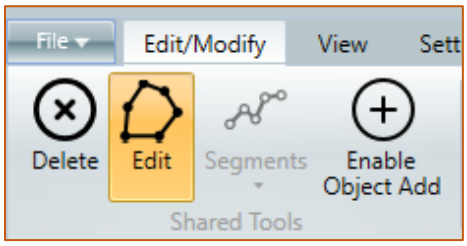


Figure 56 *Edit Icon in the Edit/Modify tab of the Toolbar*

We want the Warning Horn to be facing the receivers, therefore we need to adjust its orientation. Do so by clicking and dragging the arrow to the desired location in the **Plan Builder.** (When hovering over the arrow, it will increase in size). Note that the length of the dotted line segment does not matter because it has no impact on the noise level results. The location of the Warning Horn point and direction that the arrow is facing are the only stationary equipment object parameters visible in the **Plan Builder** that impact the acoustic calculations. **FIGURE 57** shows the Warning Horn, now oriented towards the receivers. Note that the dotted line is now grey to indicate that the object is selected. To unselect an object, right click in the **Plan Builder** and choose Clear Selection from the menu options. Save the project by clicking on the **File** tab in the **Toolbar**. Select **Save Project** in the File menu, shown in **FIGURE 14**. Once finished, your project should look something like **FIGURE 58**.

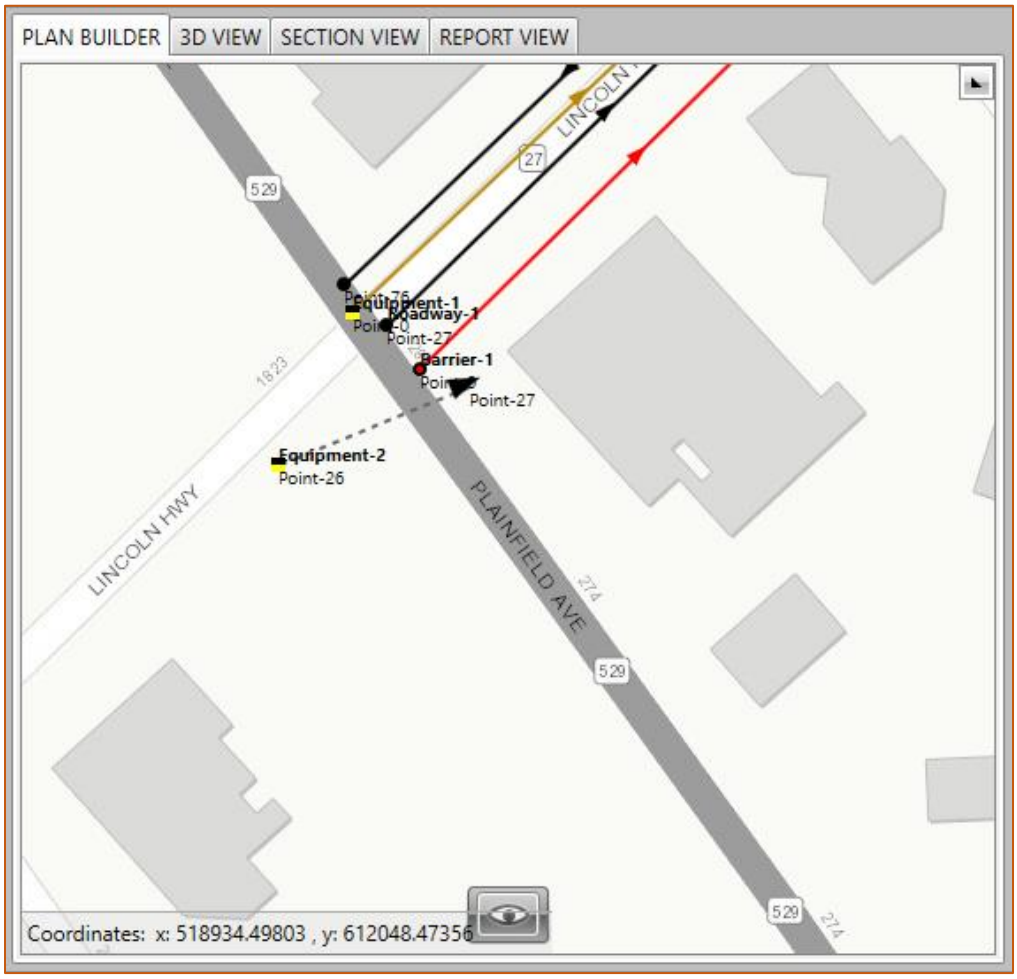


Figure 57 *Plan Builder manipulated to focus on the Warning Horn orientation*

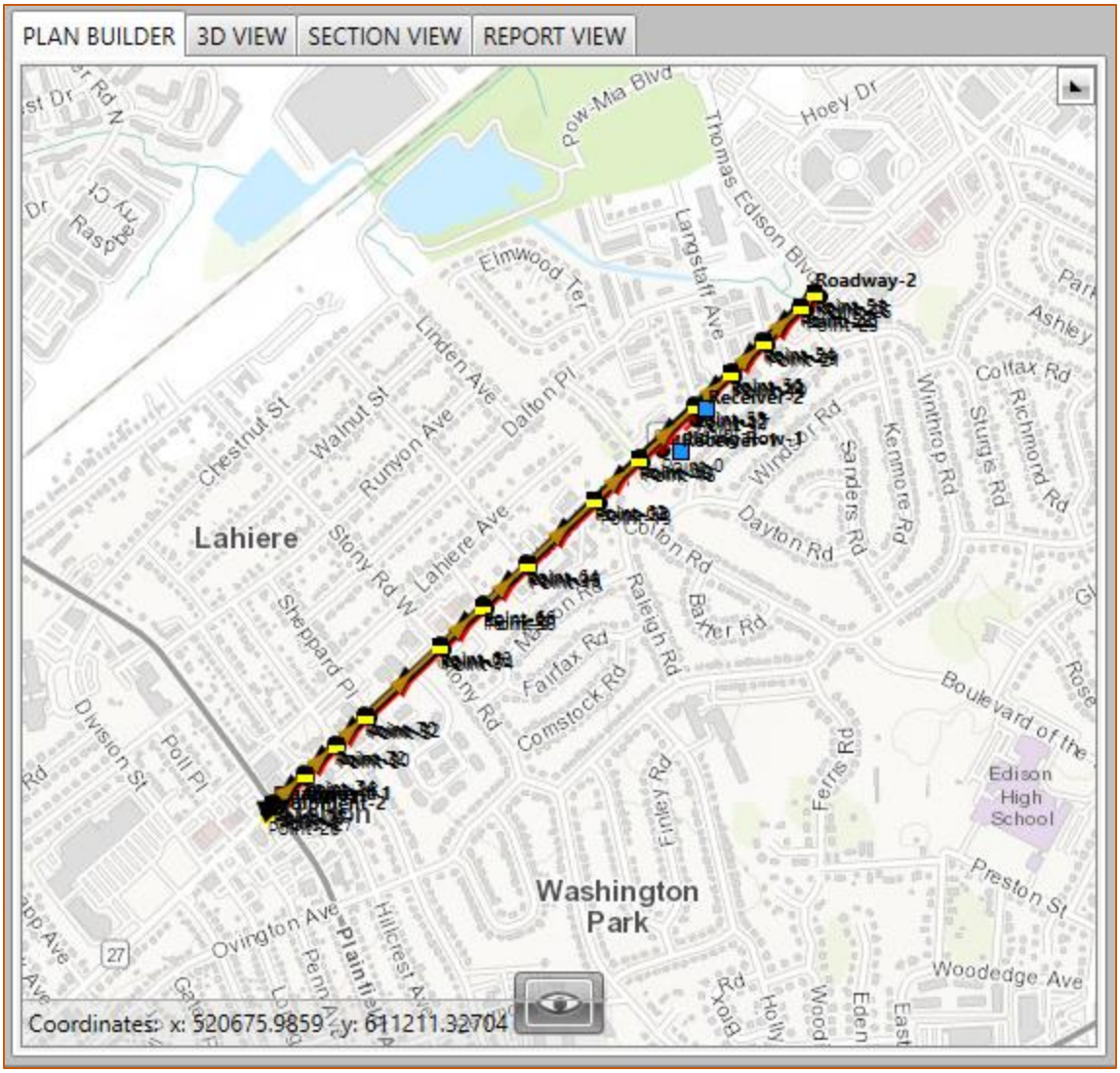


Figure 58 *Plan Builder showing all project objects on the Topographic View basemap*

LEGEND PANE

(*The **Legend Pane** displays the objects and features that have been added to a project. Once a feature is listed in the **Legend Pane**, you can choose whether that feature should be viewable in the **Plan Builder** and change its transparency. More **Legend Pane** details can be found in the **Help Menu**.*)

At this point, it may be easier to simplify the view so that we can see the relevant objects more clearly. A clean look can be obtained by unchecking the Basemap and Roadways checkboxes in the Legend Pane. This will hide these elements entirely so that the project now looks like **FIGURE 59**.

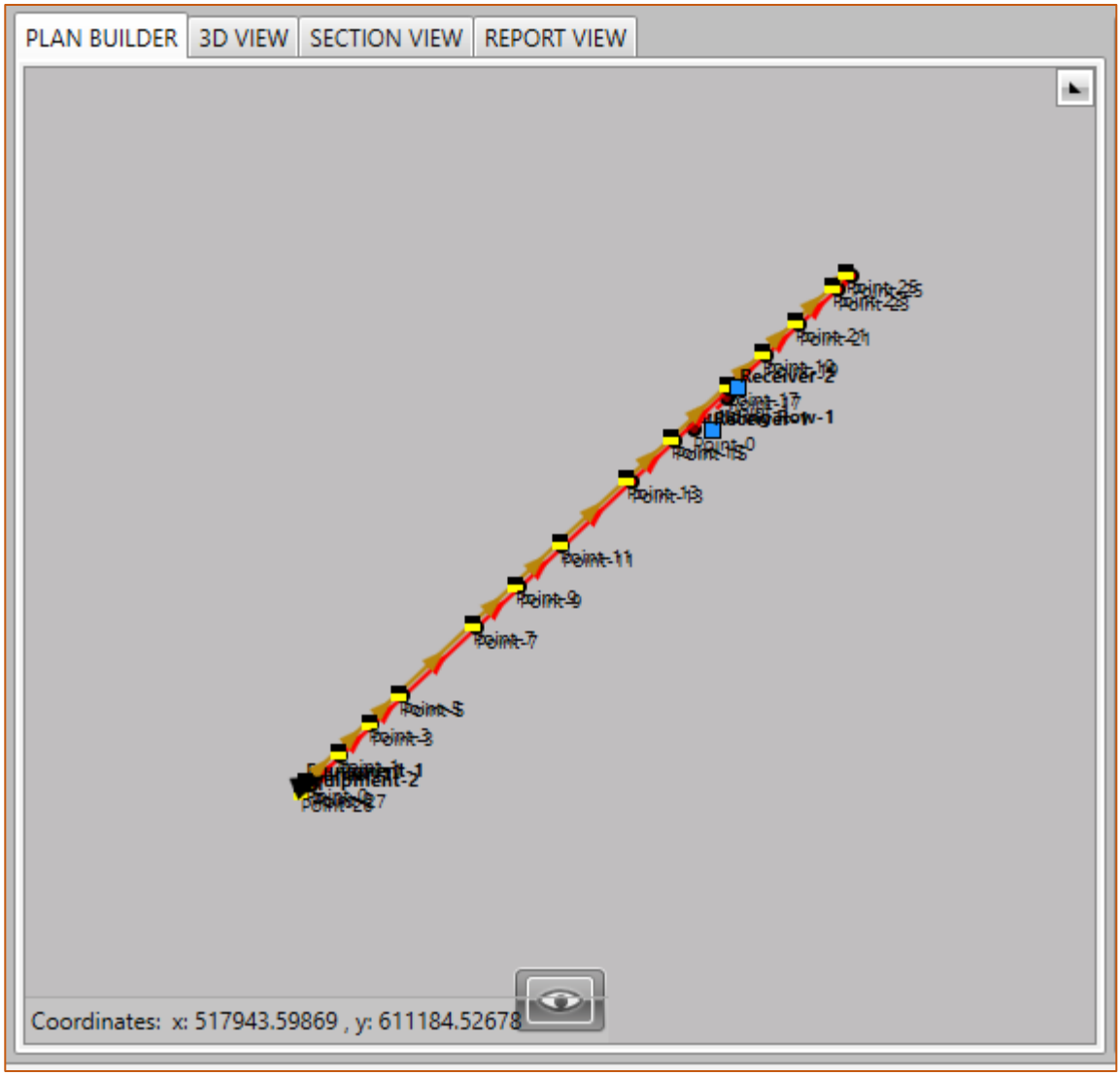


Figure 59 *Plan Builder without roadway objects or basemap*

We have designated the X- and Y-coordinates for the objects that we want in our project, but we do not have Z-coordinates or other parameters that are important for the calculations. We can add these by going to the **Object Details Pane**.

Object Details Pane

(*The **Object Details Pane** lists the data for each object that has been added to the project.*)

To adjust the Z-coordinates of objects, we go to the **Object Details Pane** and select the tab on the bottom to open the sub-pane for the object type we want to edit. For example, if we want to edit the Z-coordinates for one of the equipment objects, we would select the **Equipment Object Details Sub-pane**. For all objects except receivers, we would then select the **Points** tab on the left-hand side. (The other tabs present on the left side will depend on what Object Details sub-pane is open.) Select the **Equipment Object Details Sub-pane**, select the **Points** tab on the left, and then select Equipment-2 from the dropdown list, as shown in **Figure 60**.

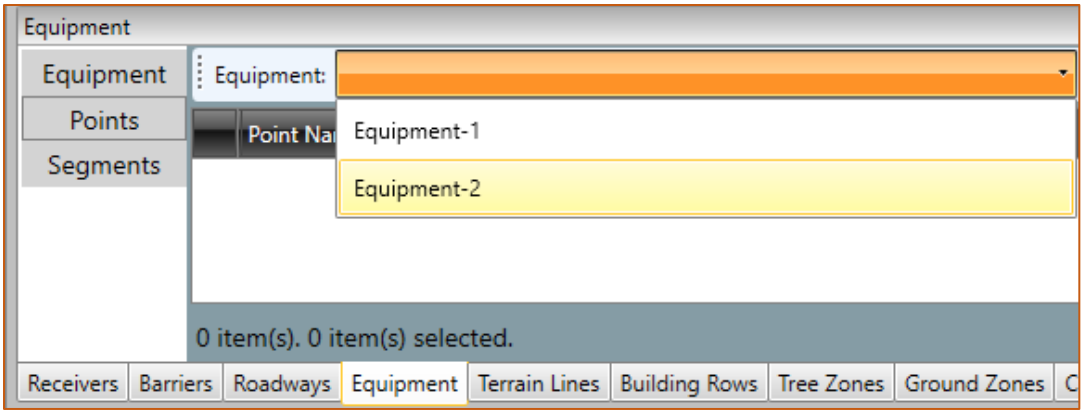


Figure 60 *Selecting an equipment object in the Points tab of the Equipment Object Details Sub-pane*

Once the individual object has been selected, the grid will be populated with data related to the object points. Change the **Z[ground]** coordinates in the grid from 0 to 10 feet for both points, as shown in **FIGURE 61**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

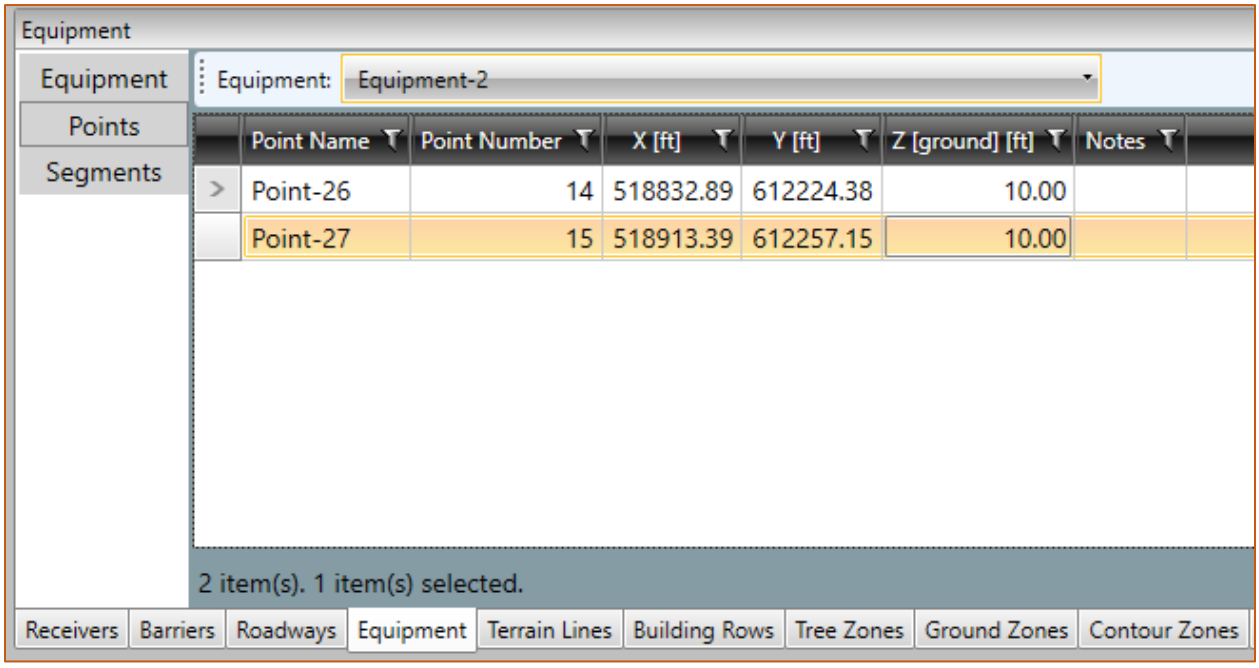


Figure 61 *Modified Points tab in the Object Details Pane for Equipment-2 showing elevated Z[ground] coordinates*

By changing the Z-coordinates for Equipment-2, we have now elevated the Warning Horn on an earthen tower. This elevation change can be visualized in the **Section View** tab of the **View Pane.** Go to the **View** tab in the **Toolbar** and click the **Start Section** button within the **Basic Tools** function, highlighted in **FIGURE 62**. In the **Plan Builder**, click slightly southwest of Equipment-2, move the mouse to draw a line through the point of Equipment-2 and the segment of Equipment-1, then double click to finish drawing the section line, symbolized via the dotted blue line in the **Plan Builder** shown in **FIGURE 63**. The **Section View** tab of the **View Pane** will open, illustrating the elevation change between the two equipment objects, as shown in **FIGURE 64**.

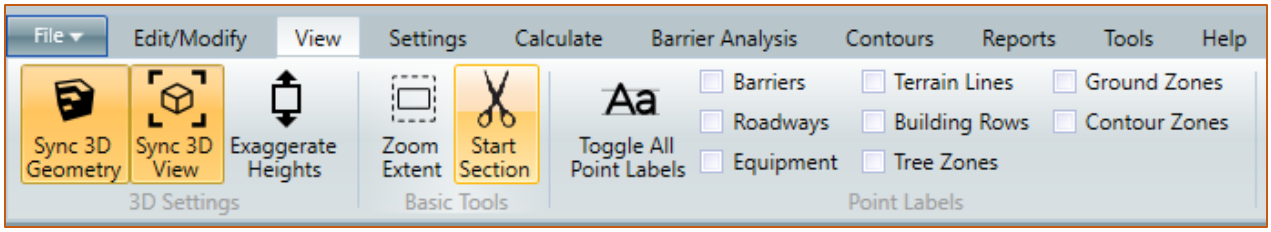


Figure 62 *View tab of the Toolbar showing the Toggle All Point Labels off and the Start Section button highlighted*

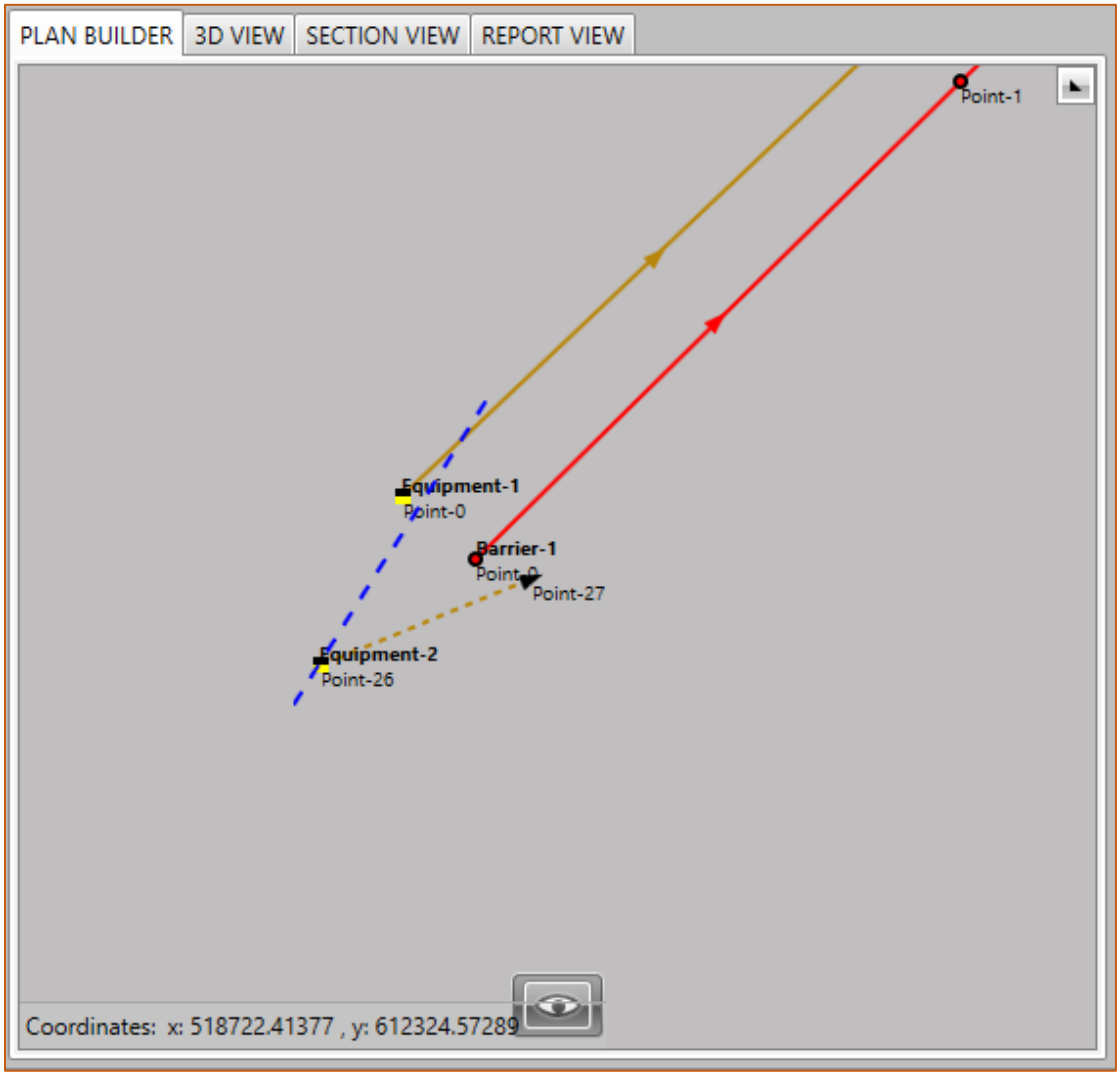


Figure 63 *Plan Builder showing section line drawn through both equipment objects*

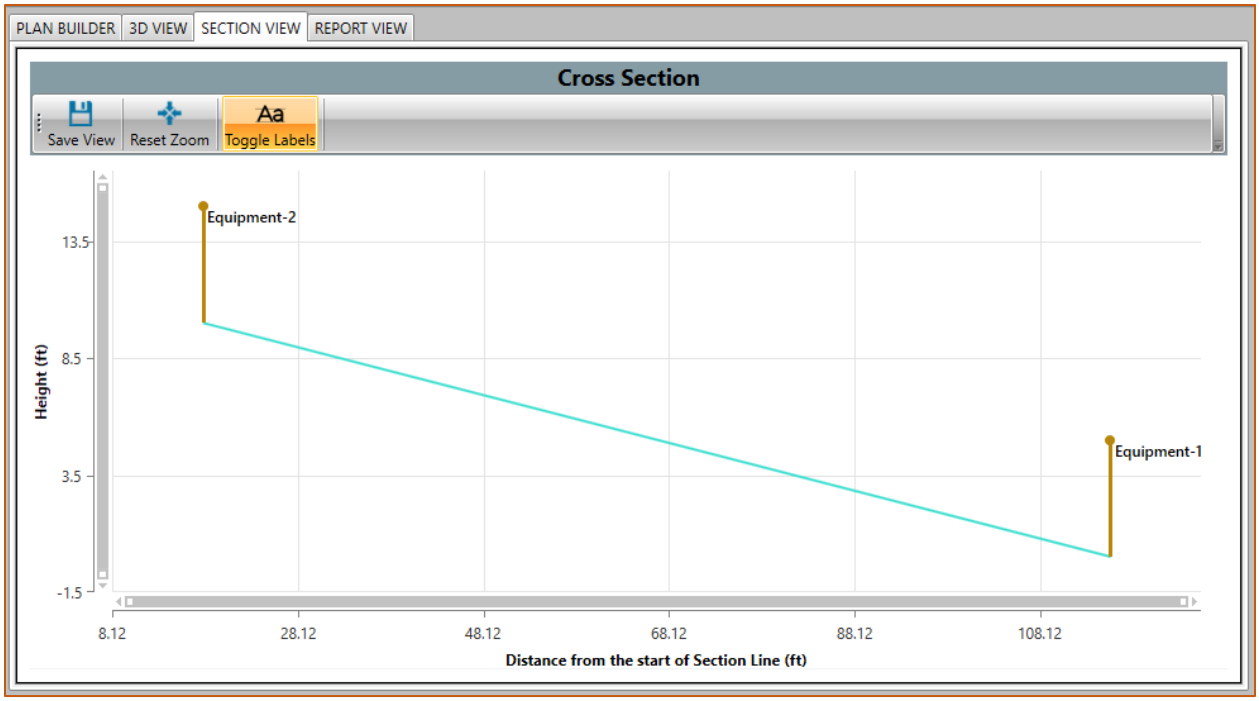


Figure 64 *Section View tab of the View Pane illustrating elevation change between Equipment-1 and Equipment-2*

Click the **Equipment** tab to the left of the **Equipment Object Details Sub-pane.** Note that both equipment objects in the model are listed, each with a **Time Active** attribute of 2 hours. Type in the **Time Active** field to enter a value of 8 hours for Equipment-1 to limit the Asphalt Distributor Truck to eight hours of noise generating activity within the 24-hour **Analysis Period** (see RCNM Analysis Period value in the New Project dialog box shown in **FIGURE 2**). Set the **Time Active** value for Equipment-2 to 0.5 hours to limit the Warning Horn to half an hour of noise generating activity within the 24-hour **Analysis Period**. The final grid should look as shown in **FIGURE 65**. Select **Save Project** in the File menu, shown in **FIGURE 14**.

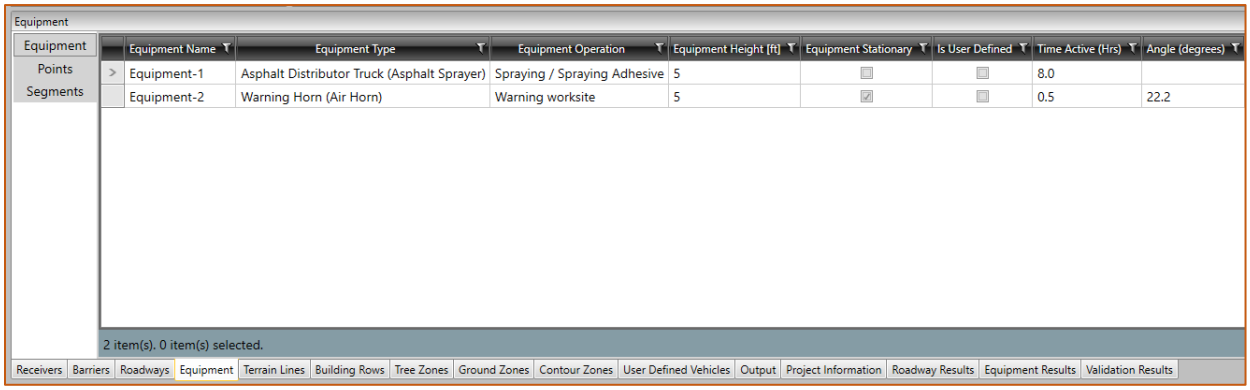


Figure 65 *Modified Equipment tab of the Equipment Object Details Sub-Pane showing new Time Active inputs*

CALCULATING AND REVIEWING RESULTS – CONSTRUCTION NOISE ANALYSIS

TOOLBAR - CALCULATE TAB

At this point, our project is ready to be run. Go to the **Calculate** tab in the **Toolbar** and select **All Receivers** within the **For Equipment** function, highlighted in FIGURE 66. A calculation window appears displaying the computation progress, as shown in FIGURE 67. You will be prompted to click Ok when the calculation is complete.

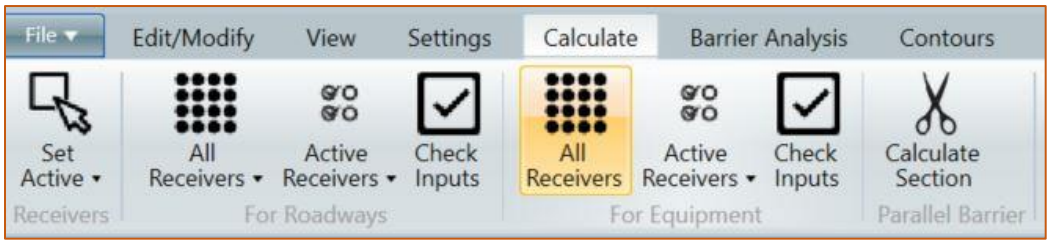


Figure 66 *Calculate tab of the Toolbar with All Receivers For Equipment selected*

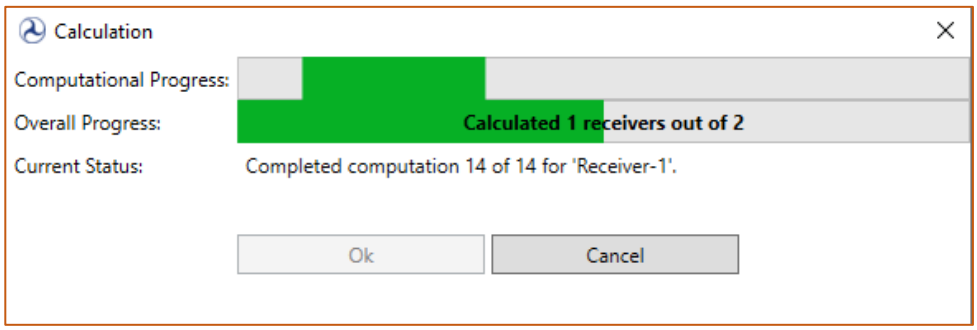


Figure 67 *Calculation window, calculations in progress*

The **Equipment Results** tab of the **Object Details Pane** will open to display the computed noise levels with and without the barrier object at its input height, as shown in FIGURE 68. It will take a few seconds for the **Equipment Results** tab to update after the calculations are complete. Note that the **Reports** tab of the **View Pane** and the **Barrier Analysis** tab of the **Toolbar** are not available for construction noise analyses.

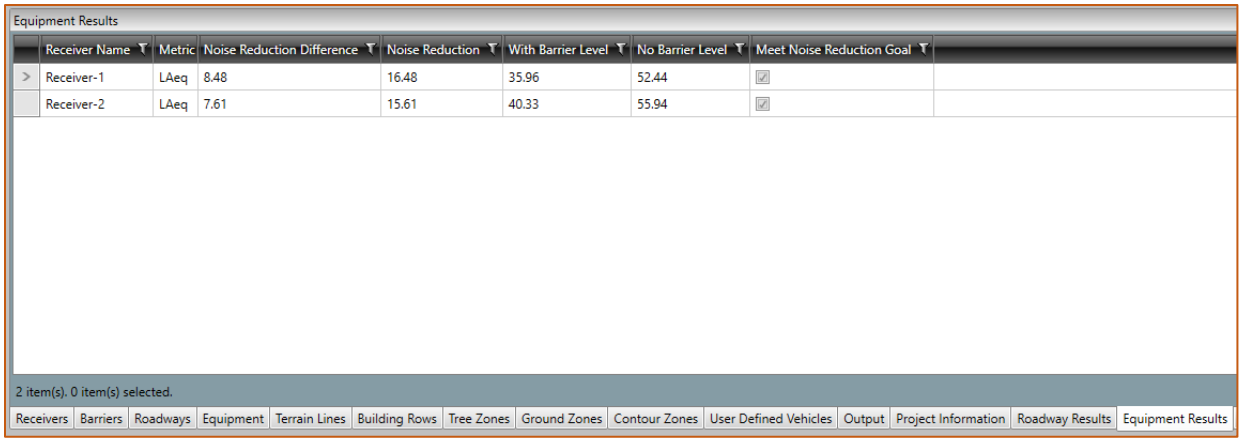


Figure 68 *Equipment Results tab of the Object Details Pane displaying computed noise levels*

SUMMARY

This concludes the walkthrough. You should now be able to:

- Set project defaults
- Create a new project
- Understand the main areas of the interface and how to interact with them
- Add TNM objects to the project
- Edit TNM objects added to the project
- Compute roadway and equipment noise levels
- View reports for completed roadway noise calculations
- Create a barrier design for roadway noise mitigation using the **Barrier Analysis** tool

Further details and functionality can be found in the **Help Menu**.