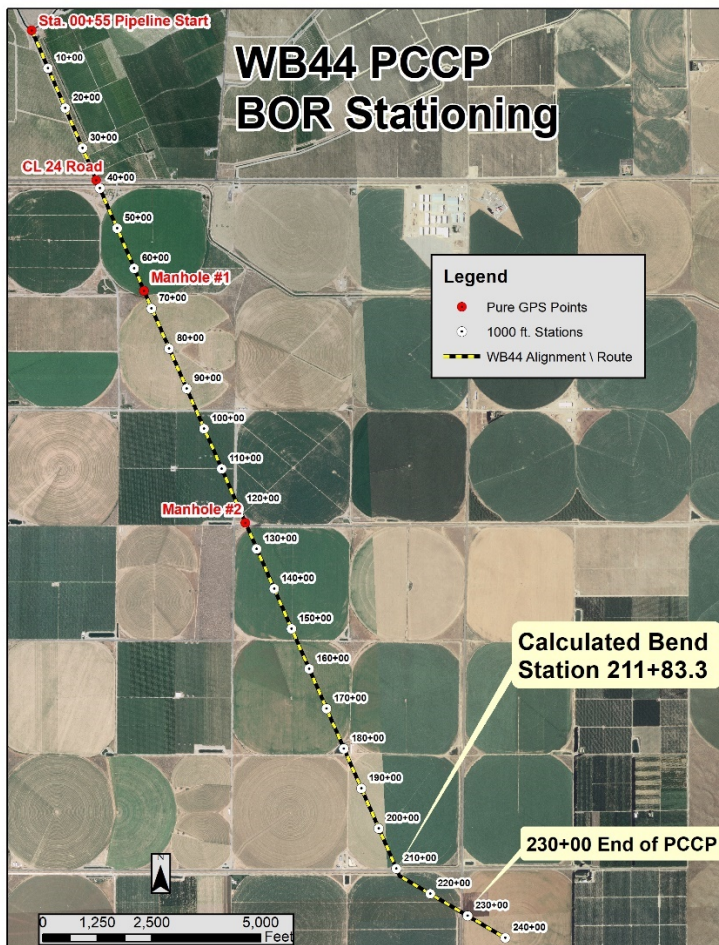


RECLAMATION

Managing Water in the West

Technical Service Center Manual and Standard

Geospatial Linear Referencing



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
•Geographic Applications and Analysis Group
Denver, Colorado

September 2019

Mission Statements

The Department of the Interior conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

REPORT DOCUMENTATION PAGE				Form Approved OMB No. 0704-0188	
<p>The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.</p> <p>PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.</p>					
1. REPORT DATE (DD-MM-YYYY) 29-09-2019		2. REPORT TYPE		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Geospatial Linear Referencing			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
			5d. PROJECT NUMBER		
6. AUTHOR(S) Patrick Wright Denver Federal Center Bldg 67, PO Box 25007 Denver CO 80225-0007 303-445-2288 pwright@usbr.gov			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Bureau of Reclamation, Technical Service Center				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT https://www.usbr.gov/tsc/techreferences/mands/manuals.html					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT This manual was created to provide technical advice and direction on the use of the Linear Referencing tools available in ArcMap. Engineers and scientist with a working knowledge of the ArcMap software who need to apply stationing to linear features will find this manual a helpful reference.					
15. SUBJECT TERMS GIS, GPS, ArcMap, stationing, routes, alignment					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT U	18. NUMBER OF PAGES 38	19a. NAME OF RESPONSIBLE PERSON Patrick Wright
a. REPORT U	b. ABSTRACT U	THIS PAGE U			19b. TELEPHONE NUMBER (Include area code) 720-544-5719

BUREAU OF RECLAMATION
Technical Service Center, Denver, Colorado
Geographic Applications & Analysis Group, 86-68260

Technical Manual and Standard

Geospatial Linear Referencing



Prepared: Patrick Wright, Physical Scientist,
Geographic Applications & Analysis Group, 86-68260



Prepared: Alan Bell, Physical Scientist,
Geographic Applications & Analysis Group, 86-68260



Prepared: Jack Truax, Physical Scientist,
Geographic Applications & Analysis Group, 86-68260

Acknowledgements

The authors are grateful for funding provided by the Bureau of Reclamation's Manuals and Standards and Science and Technology Programs.

Disclaimer

This manual is made available with the understanding that Reclamation is not rendering professional advice or mandating actions. Reclamation strives to make the information in this manual as timely and accurate as possible, but neither Reclamation nor its employees make any claims, promises, or guarantees about the accuracy, completeness, or adequacy of its contents, and expressly disclaims legal liability for errors or omissions in its contents. Reclamation provides no warranty of any kind, implied, expressed, or statutory, relating to the use of this manual, including merchantability or fitness for a particular purpose.

Acronyms and Abbreviations

COGO	coordinate geometry
GIS	geographic information system
GPS	global positioning system
NAIP	National Agriculture Imagery Program
NW	northwest
RTK	real-time kinematic system
SE	southeast

Contents

	Page
1. Introduction and Background.....	1
1.1. About this Manual.....	1
1.2. Linear Referencing Tools	1
1.3. Stationing.....	1
1.4. Software Notes	1
2. Create an Alignment	2
2.1. Gather Alignment Data	2
2.2. Draft the Alignment.....	3
2.3. Add a Route Field.....	5
2.4. Check for Data Set Accuracy	5
3. Create a Route.....	5
3.1. Create an Initial Route	5
3.2. Verify the Route Locations	7
3.3. Calibrate the Route.....	8
4. Generate Station Index Points.....	13
4.1. Create the Hatches.....	13
4.2. Convert Hatches to Graphics	16
4.3. Convert to Point Features.....	17
5. Using Calibrated Routes to Generate a Designated Sub-Reach Event Layer	21
6. For More Information	25

Figures

Figure 1. Menu showing flip function.	3
Figure 2. The direction of an existing line with start and end boxes.....	4
Figure 3. Linear Referencing Toolbar.	5
Figure 4. Create Route function form.....	6
Figure 5. Identify Route Locations in the Linear Referencing commands tab.....	7
Figure 6. Identify route locations.	8
Figure 7. Calibrate Route function form.	10
Figure 8. Newly calibrated route.	11
Figure 9. Example of generated and calibrated alignment.....	12
Figure 10. Hatch features tab.	13
Figure 11. Hatch Definition form.	14
Figure 12. Example of hatches with text.	15
Figure 13. Convert Hatches to Graphics form.....	16
Figure 14. Feature conversions form.	16
Figure 15. Example of the route with station index points.....	17
Figure 16. Delete text centroids within the feature table.	18
Figure 17. Delete text centroids within the graphic layout.....	18
Figure 18. TEXT string field containing values representing the station index.....	19
Figure 19. Convert the TEXT field into stationing nomenclature by dividing the field by 100 and then adding +00.	20
Figure 20. TEXT is now converted to stationing nomenclature.....	21
Figure 21. Table from the calibrated route (top) and table incorporating from – to stationing (bottom).	22
Figure 22. From the ArcToolbox\Linear Referencing Tools, select Make Route Event Layer.....	23
Figure 23. Make Route Event Layer form.	23
Figure 24. Example of sub-reach feature classified by the unique identifier Pure_ID.	24

1. Introduction and Background

1.1. About this Manual

This manual was created to provide technical advice and direction on the use of the Linear Referencing tools available in ArcMap. Engineers and scientist with a working knowledge of the ArcMap software who need to apply stationing to linear features will find this manual a helpful reference.

1.2. Linear Referencing Tools

Linear Referencing (formally Dynamic Segmentation) is an incredibly powerful set of geographic information system (GIS) based tools you can use to generate a number of useful and dynamic spatial products. These guidelines explain how to create linear routes, associated stationing, and sub-reach data that is commonly used when building water conveyance databases.

1.3. Stationing

Stationing is a way to identify a specific location along a pipeline alignment, route, road, pipeline or other linear feature, typically in feet (U.S.) or in meters (metric). Although stationing does measure length, the primary use of stationing is not necessarily for measurement.

Stations in the U.S. are generally of the XXX+YY.ZZ' format, where XXX is the number of full 100-foot increments (or chains), YY is the number of partial chains (or individual feet), and ZZ is the partial foot decimal measurement. Thus, a Station of 1234+56.78 corresponds to 1,234 full 100' chains, or 123,400 feet plus 56.78 feet for a total measurement of 123,456.78 feet from the starting point.

If necessary, changes in length due to various reasons can be accounted for by using Station Equations. These equations modify the stationing at a single point to restore the proper stationing and align features.

1.4. Software Notes

This manual was built around ArcMap Version 10.6.1 but many of the noted techniques and processes will be applicable in later versions of ArcMap as well as ArcPro. The intent is to update this manual to versions of the software when necessary.

2. Create an Alignment

The ArcMap suite of linear referencing provides a means to incorporate measures (in terms of stationing, length) internally within a line feature called a “route”. A route can be used to reflect the stationing standard most often used by civil engineers to depict spatial locations based on length within a linear feature such as a road, canal or pipe alignment. Generally, a linear feature is developed within the GIS either as a new line feature using topography and ground features for reference or drafted from existing drawings. At this point, either measures from existing stationing or newly defined stationing are calibrated into the line feature creating a route.

A route can be used to:

1. Interpolate and identify measures along the route.
2. Create a point or line features (known as an event theme) from tabular data depicting a feature by a station value (point) or a station from and to values (line).
3. Develop path of least resistance models.
4. Interpolate measures between known values. This has been used to interpolate between known elevations from river and canal cross sections.

2.1. Gather Alignment Data

You can create the required feature in GIS, within the horizontal accuracy constraints of your baseline GIS data source (orthoimagery, topographic map, etc.) with either one or a combination of these data sources:

- Use survey coordinates to link vertices
- Convert existing a CAD file into GIS format
- Use as-built drawings as a template via coordinate geometry (COGO)
- Use orthophotos as background for visual reference

The accuracy of your alignment depends on the methods used to gather the original information. Document the methods used and the level of accuracy for each method. For example:

- A global positioning system (GPS) survey conducted by a handheld unit will provide less accurate results than a real-time kinematic system (RTK).
- Orthophotography using 1-meter resolution National Agriculture Imagery Program (NAIP) data is less accurate than a 6-inch resolution orthoimagery generated through photogrammetry using higher accuracy surveyed ground control points.

If you use a combination of data sources gathered by different methods, the least horizontally accurate data would define the level of horizontal accuracy of the data set.

Note, it is important to use a local State Plane coordinate system with unit of measurement common to stationing standard required (feet or meters) as you generate data for the alignment. This will establish a unit of measurement that is that is a measurement of length and thus avoid the confusion introduced in using a unit of measurement such decimal degrees or even worse degrees, minutes and seconds.

2.2. Draft the Alignment

In this step, you draft alignment in direction of increasing stationing and add Route relate field. It is good practice to draft an alignment to be stationing in the direction of the increasing stationing.

1. Select a line.
2. Activate the Edit Vertices toolbar by right-clicking on your mouse after you have selected the line. This makes the Edit Vertices toolbar visible and active.
3. Determine the direction of an existing line feature by selecting the Edit Vertices option while in the Edit Mode. The direction is indicated by green (start of the line) or red boxes (end of the line) (Figure 2.).
4. Use the Flip function within the Edit Vertices tool bar to change the direction of the alignment if necessary. Note, the alignment needs to be a single line element to be used in Linear Referencing.

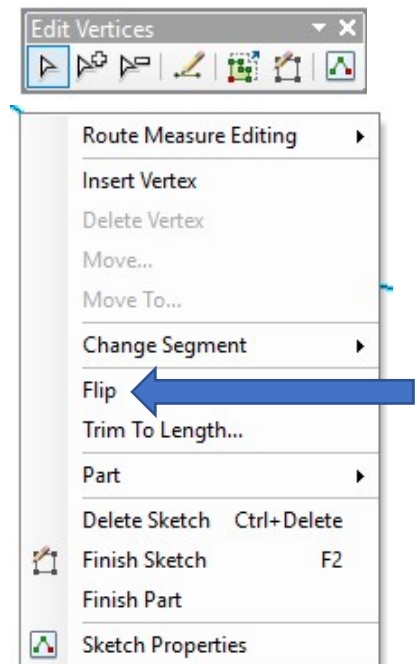


Figure 1. Menu showing flip function.

Using Linear Reference Tools in ArcGIS



Figure 2. The direction of an existing line with start and end boxes.

2.3. Add a Route Field

Add Route field to the new alignment and populate the route field with a unique route identifier (either text or numeric). This will be used as a relate to other features throughout the linear referencing processes.

2.4. Check for Data Set Accuracy

Check the spatial and measured accuracy of the drafted dataset.

1. Visually inspect the alignment using an orthophoto background to see if noted features or land disturbances correlate with the drafted alignment. Note, if the drafting method used is more accurate than orthophotography these representative data most likely will not line up with the orthophoto background.
2. Determine if the GIS calculated alignment length matches up to the stationing documented alignment length defined start and stop of stationing. For example, 12,500 feet to 15,500 feet is a difference of 3,000 feet, and this should be used as the distance measured with the GIS Measure tool between these two stations:
 - a. As Built stationing = 125+00 to 155+00 feet.
 - b. GIS measured length of alignment = 3,000 feet.

3. Create a Route

A route is a linear feature that contains some form of internalized measure, usually length or distance. Sometimes other measures are used. For example, surface topography could also be interpolated bridging gaps between two known points of elevation. This section explains how to create a route using length in feet as the internal measure.

3.1. Create an Initial Route

1. Open the Linear Referencing Tools under the Arc Toolbar and select the Create Routes function. (Figure 3)
2. Enter information to the required data fields to internalize measured length into a line feature (Figure 4).

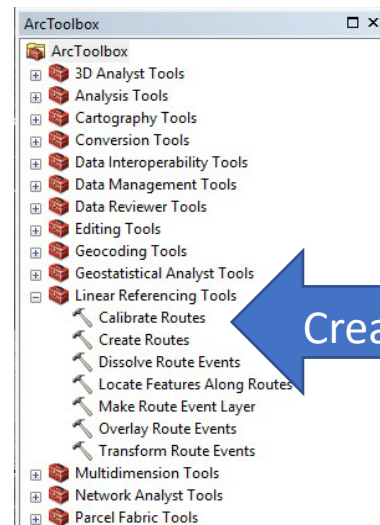


Figure 3. Linear Referencing Toolbar.

Using Linear Reference Tools in ArcGIS

Create Routes

Input Line Features

Route Identifier Field

Output Route Feature Class

Measure Source
LENGTH

From-Measure Field (optional)

To-Measure Field (optional)

Coordinate Priority (optional)
UPPER_LEFT

Measure Factor (optional)
1

Measure Offset (optional)
0

☒ Ignore spatial gaps (optional)

☒ Build index (optional)

OK Cancel Environments... << Hide Help

Figure 4. Create Route function form.

Form fields are:

- **Input Line Features** = Newly created alignment.
- **Route Identifier Field** = Select the route field recently added to the alignment feature from pulldown on right.
- **Output Route Feature Class** = Define a name and location for the new route feature.
- **Measure Source** = Selecting LENGTH will establish lengths along the line feature as the internal measure ranging from 0 at the start of the feature to the overall length of the line at the end of the feature.
- **Coordinate Priority** = Positional location of the start of the line. Although this is an optional entry, in this application it is important to create priorities.
- **Build Index** – Leave checked on as the default.

3. Clicking OK will create a route feature with internalized measures based on the actual route length throughout the route.

3.2. Verify the Route Locations

Check the new Route with the Identify Route Locations command to verify that route has internalized measures and that these measures increase in the proper direction (Figure 5).

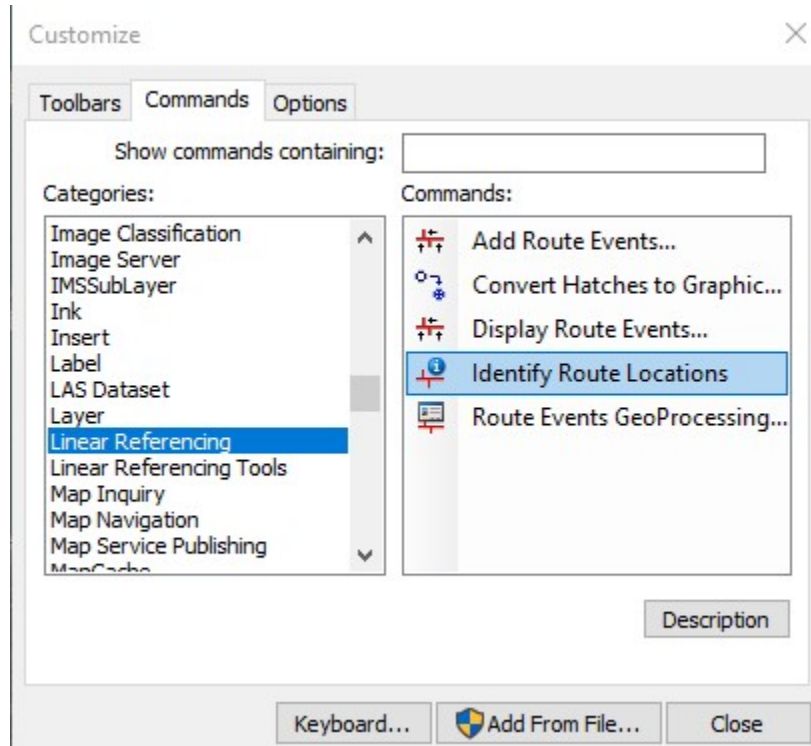


Figure 5. Identify Route Locations in the Linear Referencing commands tab.

1. Add the Identify Route Locations command button to the ArcGIS session
2. Drag and drop the button within an activated tool bar.
3. Add the Convert Hatches to Graphics command button to the Arc session by selecting this command from the Customize pull down menu within Commands tab, this will be used later in building stationing points.
4. Use the newly established Identify Route Locations command button to check measures along the route for logical consistency. Activate the button and click along the route. Measures should increase from the beginning through the end of the route. The minimum measure should be

Using Linear Reference Tools in ArcGIS

0 and the maximum measure should be the entire measured length of the route (Figure 6).

Note, the Identify Route Locations command button tends to be rather touchy, sometimes it will only work when the route being measured is the first feature in the Table of Contents.

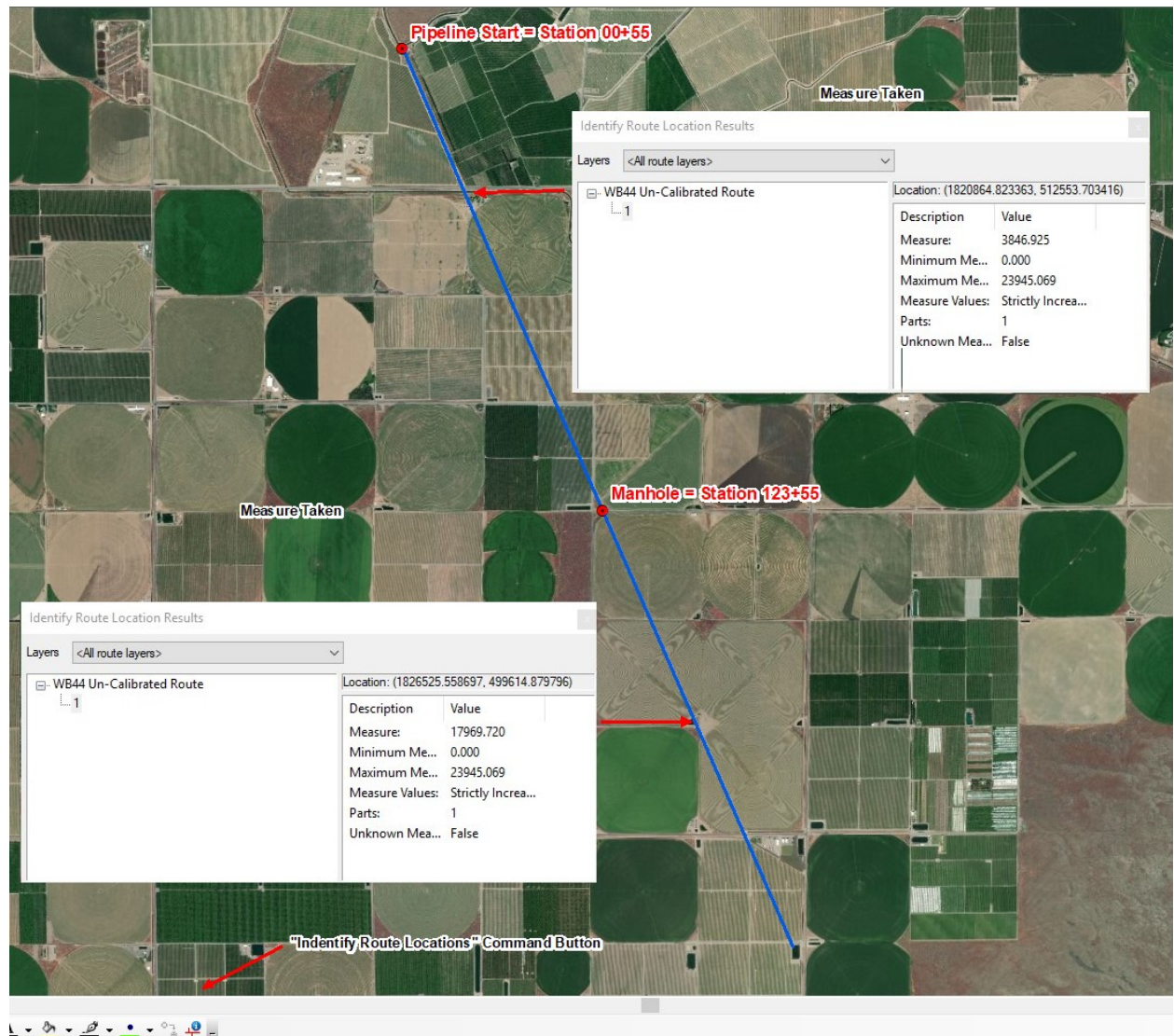


Figure 6. Identify route locations.

3.3. Calibrate the Route

Calibrate the route to recalculate measures along a route alignment to match actual stationing. Not all alignment stationing starts at 0 and or are evenly measured throughout a route. Uneven measurements or non-zero starting points can be caused by a Station Equation or inaccurate original stationing. Stationing errors in alignments are common and can be evenly distributed throughout the

alignment by using more than one identifiable calibration point features and associated numeric stationing along a route feature to calibrate the route. Station Equations can be built into the route using calibration points oriented extremely close to each other, for example 0.01 feet.

Calibration feature points can be one or a combination of:

- Start and/or stop of the alignment
- Physical features that are located by X and Y Coordinates
- Physical features that can be located on orthophotograph

Note, all of these calibration feature points have a level of error associated with them that will dictate the horizontal accuracy of the alignment.

1. Create a point data set representing the identified physical features with known stationing locations:
 - a. Add a Route field and unique route identifier identical to the Route identifier found in the original alignment route feature. This is used by the Calibrate Route function as a relate between the route and calibration point features.
 - b. Add a numeric field Station to populate with the station measure to calibrate newly created route feature. Again note, the numeric representation for station 250+00 would be 2500.
 - c. Add all relevant calibration points populating the Route and Station fields with each point's unique route identifier and associated station value. For example, a station value of 250+00 should be entered as 2500.
2. Complete the Calibrate Route function form to establish desired route stationing (Figure 7).
3. Input information for the Calibrate Route function form:

Using Linear Reference Tools in ArcGIS

Calibrate Routes

Input Route Features

Route Identifier Field

Input Point Features

Point Identifier Field

Measure Field

Output Route Feature Class

Measure Calculation Method (optional)
DISTANCE

Search Radius (optional)
0 Feet

☒ Interpolate between calibration points (optional)

☒ Extrapolate before calibration points (optional)

☒ Extrapolate after calibration points (optional)

☒ Ignore spatial gaps (optional)

☒ Include all features in the output feature class (optional)

OK Cancel Environments... << Hide Help

Figure 7. Calibrate Route function form.

- **Input Route Features** = Newly created route.
- **Route Identifier Field** = Select the Route field associated with the route alignment feature from the pulldown menu (click on the right downward arrow).
- **Input Point Features** = Select the newly created calibration point feature from the pulldown (click on the right downward arrow).
- **Point Identifier Field** = Select the Route field associated with the route alignment feature from pulldown on right. This field establishes the relate between the point data and the route data sets.
- **Measure Field** = Select the field (Station) containing the numeric station values from pulldown on right. This field is used to determine the measures to use in the calibration process.
- **Output Route Feature Class** = Define a name and location for the new calibrated route feature.

- **Measure Calculation Method** = Use the default of Distance.
 - **Search Radius** = Enter a minimum distance between the route and the calibration points to establish a spatial relate.
 - Select the optional check boxes as appropriate.
4. Click OK to create a route feature with internalized measures based on the calibration points and the station values associated with them.
 5. Check the newly calibrated route with Identify Route Locations command button to verify that route has internalized measures used in the previous Calibrate Routes function. You could also further verify the alignment by using a known station location left out of the calibration process to confirm a successful calibration and potential level accuracy. Note, the Minimum and Maximum measures have changed from the original route (Figure 8).

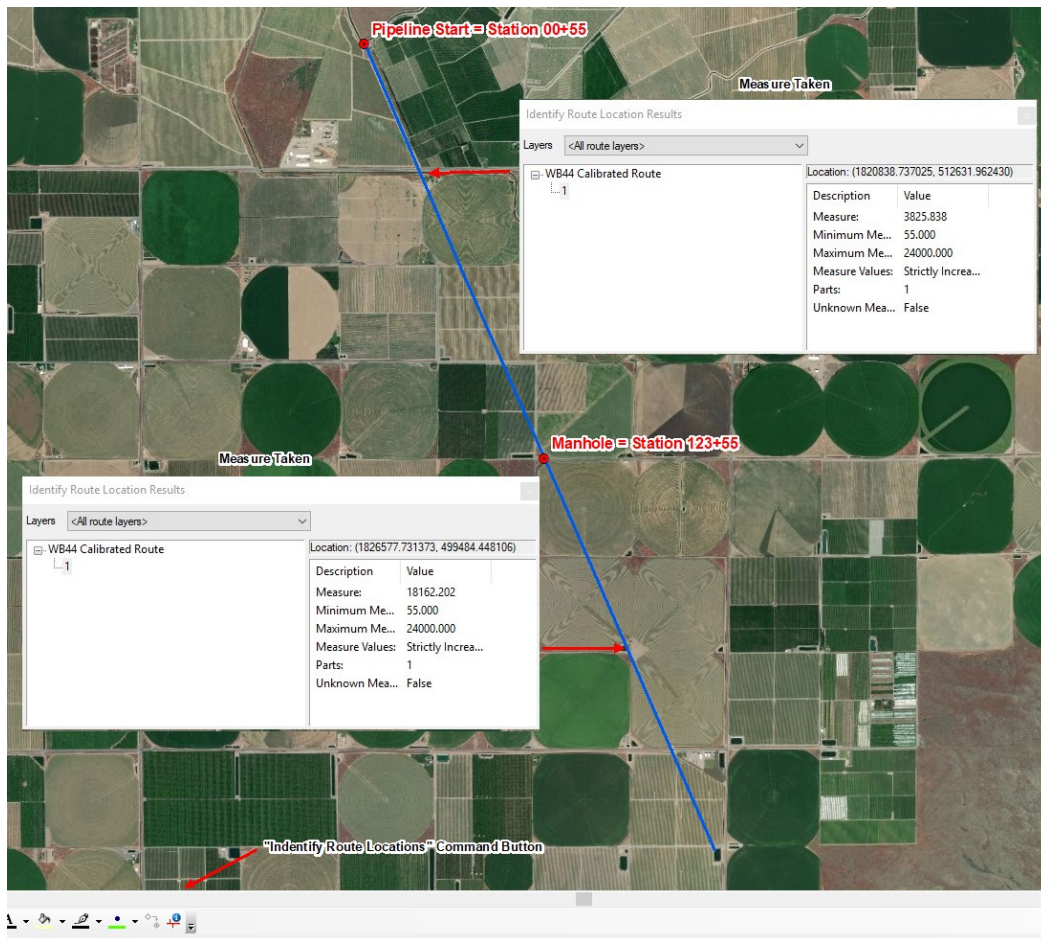


Figure 8. Newly calibrated route.

Using Linear Reference Tools in ArcGIS

Figure 9 shows a calibration example for a final alignment. Accurate GPS points and their associated stationing were provided by a contractor for two known features the beginning of the alignment at station 00+55 (55') and a manhole cover at station 123+50 (12,350') respectively. The northwest (NW) to southeast (SE) alignment was created by connecting the GPS points provided by the contractor and extending beyond the calculated points to the bend defined on the plan and profile. Once the Route was calibrated, the 35.63 degree bend was generated at Station 211+82.3 (identified on the plan and profile) and extended east to the completed alignment length of 23,945 feet (also identified in the plan and profile).



Figure 9. Example of generated and calibrated alignment.

4. Generate Station Index Points

Station index points represent stations along route. Generating station index points is a multistep conversion process to creates hatches within the route properties, convert to graphics, and then convert to point features representing station indices.

4.1. Create the Hatches

1. Open the layer properties of the calibrated route by 2X clicking on feature within the table of contents.
2. Open the Hatches tab and check the Hatch features in this layer box. Hatches are temporary graphic features that can be located along a route at use- specified intervals (Figure 10).

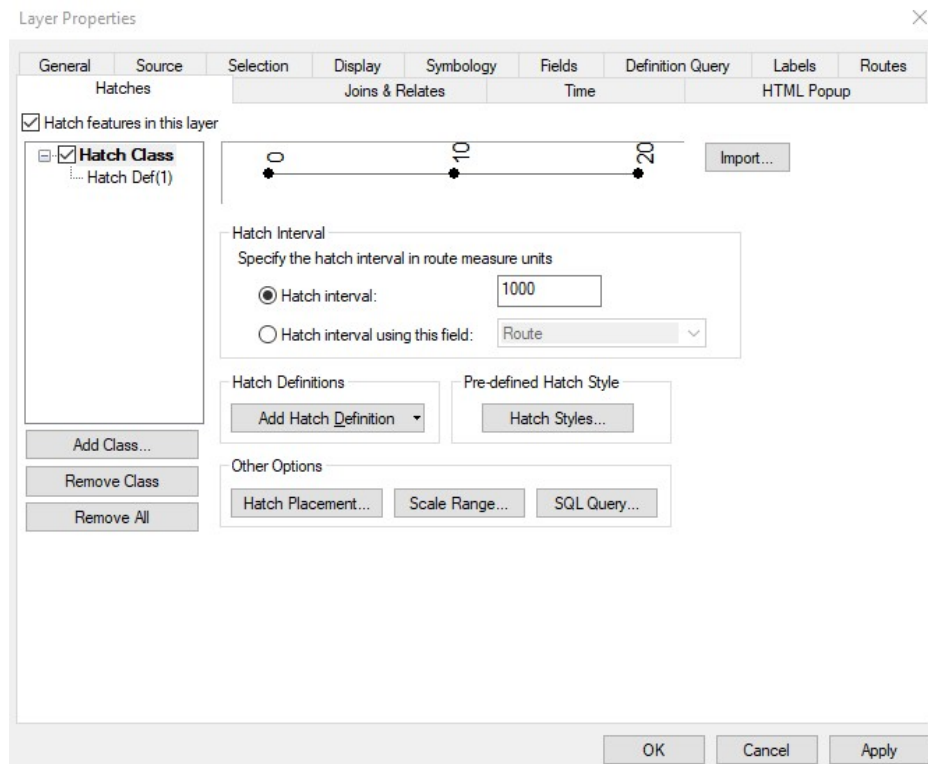


Figure 10. Hatch features tab.

3. Check the Hatch Interval button and add a numeric value to the box on the right. This value should be equal to the desired station index distance and use a consistent unit of measurement (most commonly feet).
4. Click on and highlight the Hatch Def in box below the Hatch Interval button in the same form to activate the hatch definition widow (Figure 11).

Using Linear Reference Tools in ArcGIS

The screenshot shows the 'Layer Properties' dialog box with the 'Hatches' tab selected. The 'Hatches' section is active, and the 'Hatch Class' is set to 'Hatch Def(1)'. A visual representation of the hatch intervals is shown with a line and three blue dots at 0, 10, and 20. The 'Place these hatches every' field is set to 1, and the unit is 'hatch intervals'. The 'Hatch' section has 'Line' and 'Marker' options, with 'Marker' selected. The 'Lateral offset' is set to 0 feet. The 'Labels' section has 'Label these hatches' checked, and the text 'AaBbCcZz' is displayed. Buttons for 'Add Class...', 'Remove Class', 'Remove All', 'Import...', 'Hatch Orientation...', 'Symbol...', and 'Label Settings...' are visible. The 'OK', 'Cancel', and 'Apply' buttons are at the bottom right.

Figure 11. Hatch Definition form.

5. Add numeric value in the Place these hatches every hatch intervals box to define number of hatch intervals to be displayed. If your hatch interval is 1,000, then a value of 1 would place a hatch every 1,000 units of measurement, a value of 2 would place a hatch every 2,000 units of measurement and so on.
6. The options available within the Hatch box facilitate the symbology and offset and orientation of hatches. As the ultimate goal of this process is to create point features, it would be best to use a small black point Marker symbol and to use 0 for the Lateral offset use the default for a Hatch Orientation.
7. Select the Label these hatches box within the Labels options box. The text generated by this option will become the numeric station value in the final point file being created.


8. Click ok to add the hatches to the calibrated route with text indicating stationing value (Figure 12).



Figure 12. Example of hatches with text.

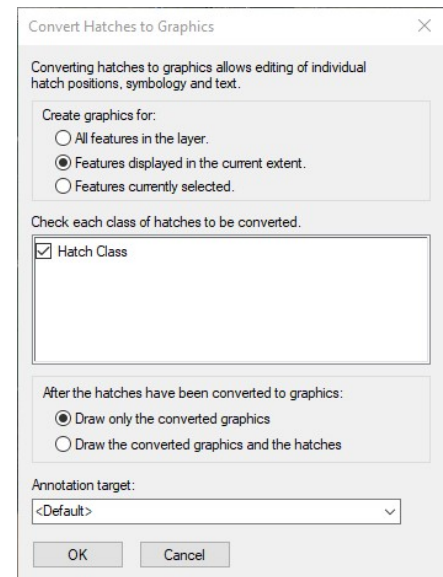
4.2. Convert Hatches to Graphics

1. Use the newly added Convert Hatches to Graphics

Button  to open a form to convert created hatches into graphics (Figure 13).

As long as all hatches are displayed in your layout window the defaults should work fine. By selecting OK the hatches should become graphics.

2. Use the X-Tools Graphics to Shapes in the Feature Conversions to convert newly generated graphics into a point feature. Define the locations for the feature and spatial reference. Click OK to create a point feature (Figure 14).



Convert Hatches to Graphics

Converting hatches to graphics allows editing of individual hatch positions, symbology and text.

Create graphics for:

- ☐ All features in the layer.
- ☒ Features displayed in the current extent.
- ☐ Features currently selected.

Check each class of hatches to be converted.

- ☒ Hatch Class

After the hatches have been converted to graphics:

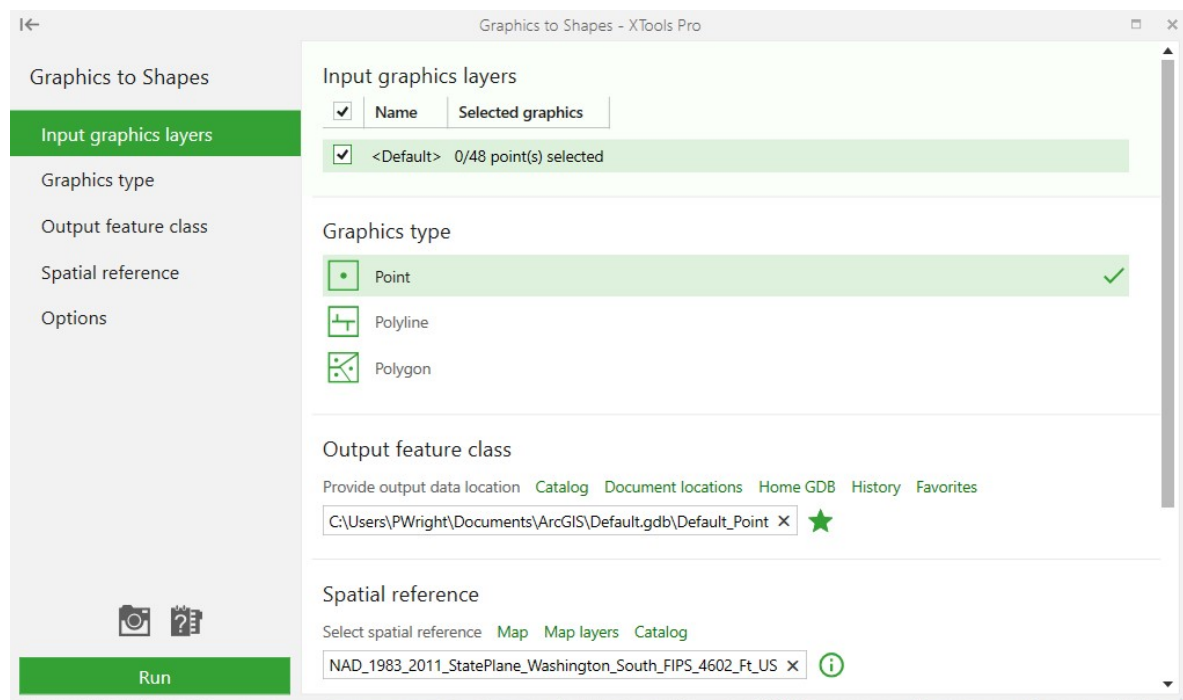
- ☒ Draw only the converted graphics
- ☐ Draw the converted graphics and the hatches

Annotation target:

<Default>

OK Cancel

Figure 13. Convert Hatches to Graphics form.



Graphics to Shapes - XTools Pro

Graphics to Shapes

- Input graphics layers
- Graphics type
- Output feature class
- Spatial reference
- Options

Run

Input graphics layers

Selected	Name	Selected graphics
<input checked="" type="checkbox"/>	<Default>	0/48 point(s) selected

Graphics type

- ☒ Point
- ☐ Polyline
- ☐ Polygon

Output feature class

Provide output data location Catalog Document locations Home GDB History Favorites

C:\Users\PWright\Documents\ArcGIS\Default.gdb\Default_Point

Spatial reference

Select spatial reference Map Map layers Catalog

NAD_1983_2011_StatePlane_Washington_South_FIPS_4602_Ft_US

Figure 14. Feature conversions form.


3. Clean up the layout display by using the Select Elements tool  and the delete key to select and delete all unneeded graphics. Figure 15 shows a finished example of the route with station index points.



Figure 15. Example of the route with station index points.

4.3. Convert to Point Features

Point features will be displayed as multiple side-by-side points, with one point intersecting the alignment (a good representation of the station index) and one point off the alignment (a text centroid that needs to be deleted).

1. Within Editor, select and delete all text centroids. You can do this either within the feature table or within the graphic layout (Figure 16 and Figure 17).

Using Linear Reference Tools in ArcGIS

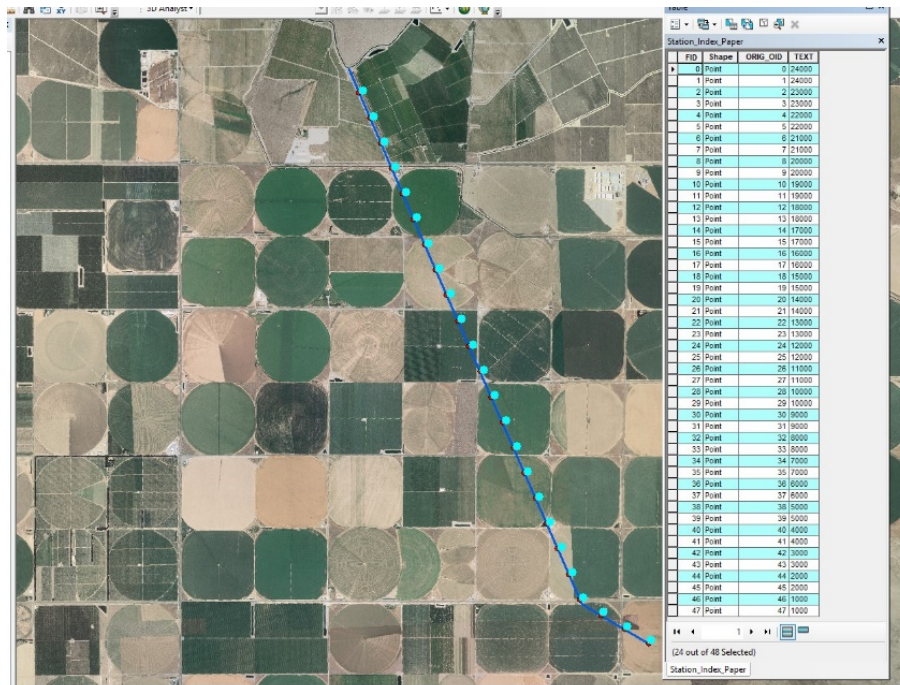


Figure 16. Delete text centroids within the feature table.

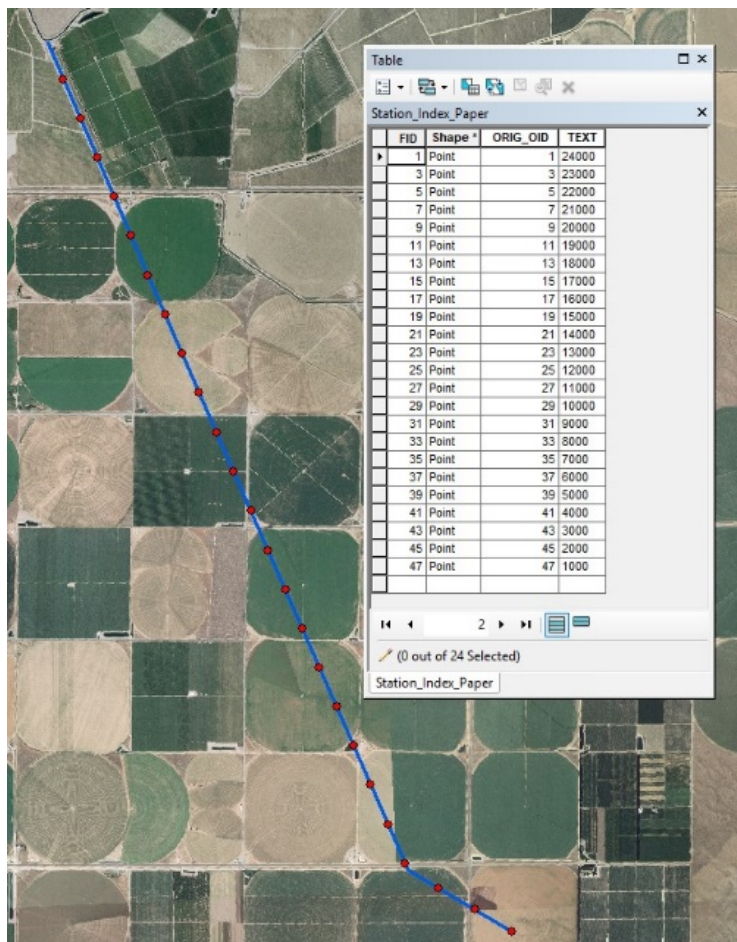


Figure 17. Delete text centroids within the graphic layout.

- After editing, the TEXT string field will contain values representing the station index. At this point, you can calculate the TEXT string over to a numeric field, saving the GIS equivalent of the station value. Now you can convert the TEXT field into stationing nomenclature by dividing the field by 100 and then adding +00 (Figure 18 through Figure 20).

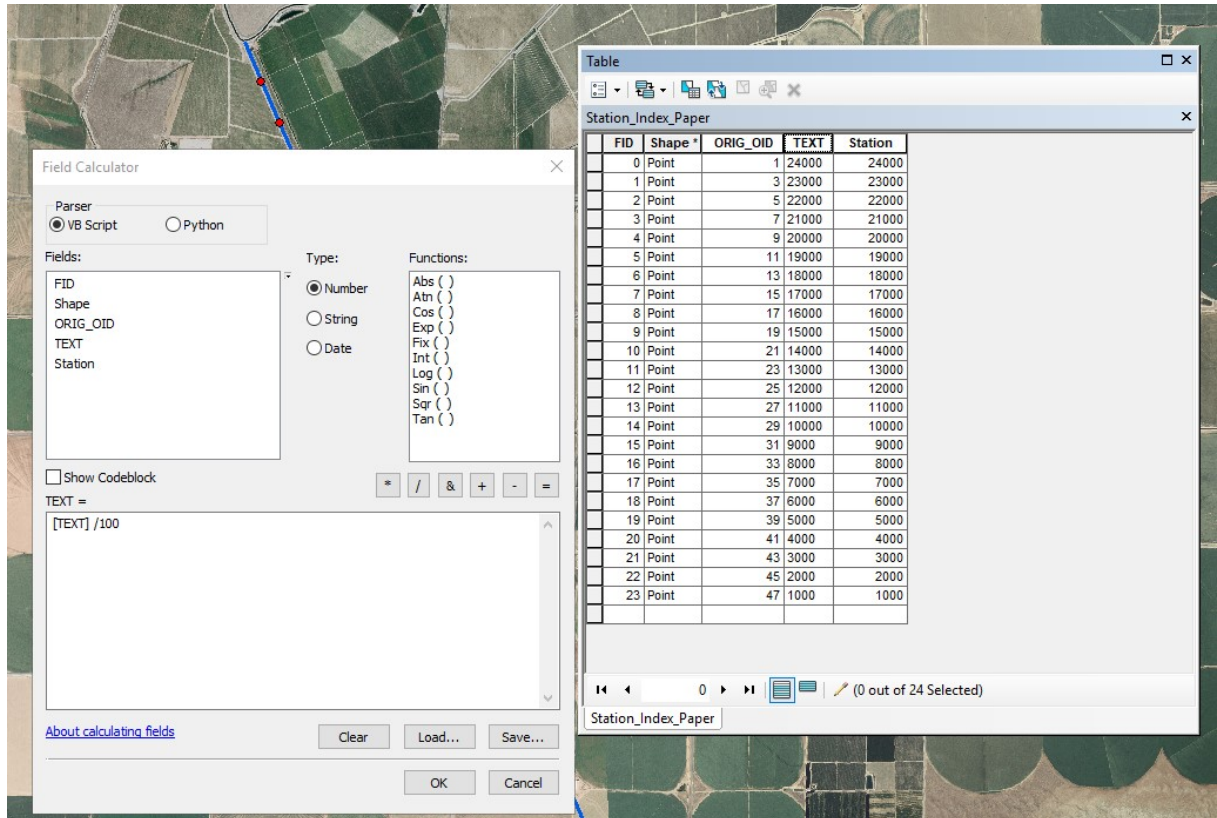


Figure 18. TEXT string field containing values representing the station index.

Using Linear Reference Tools in ArcGIS

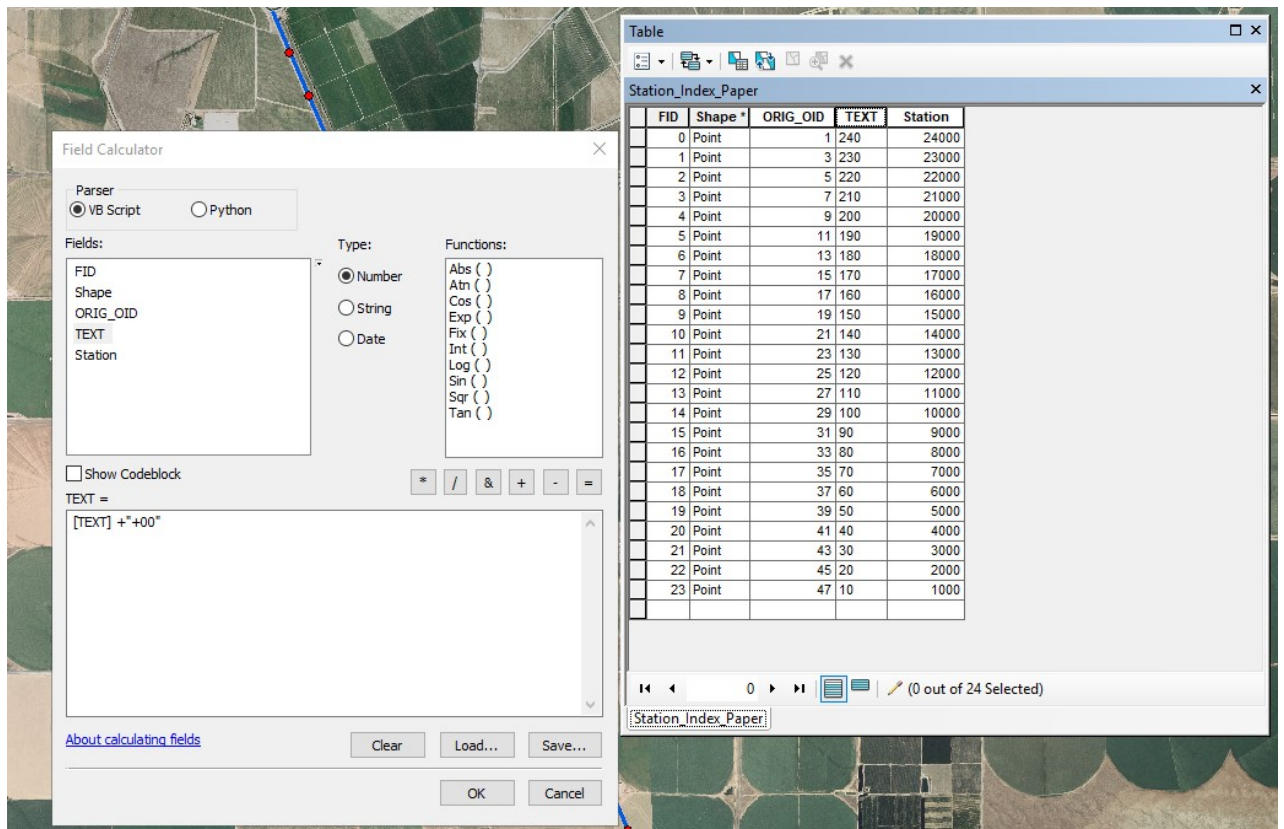
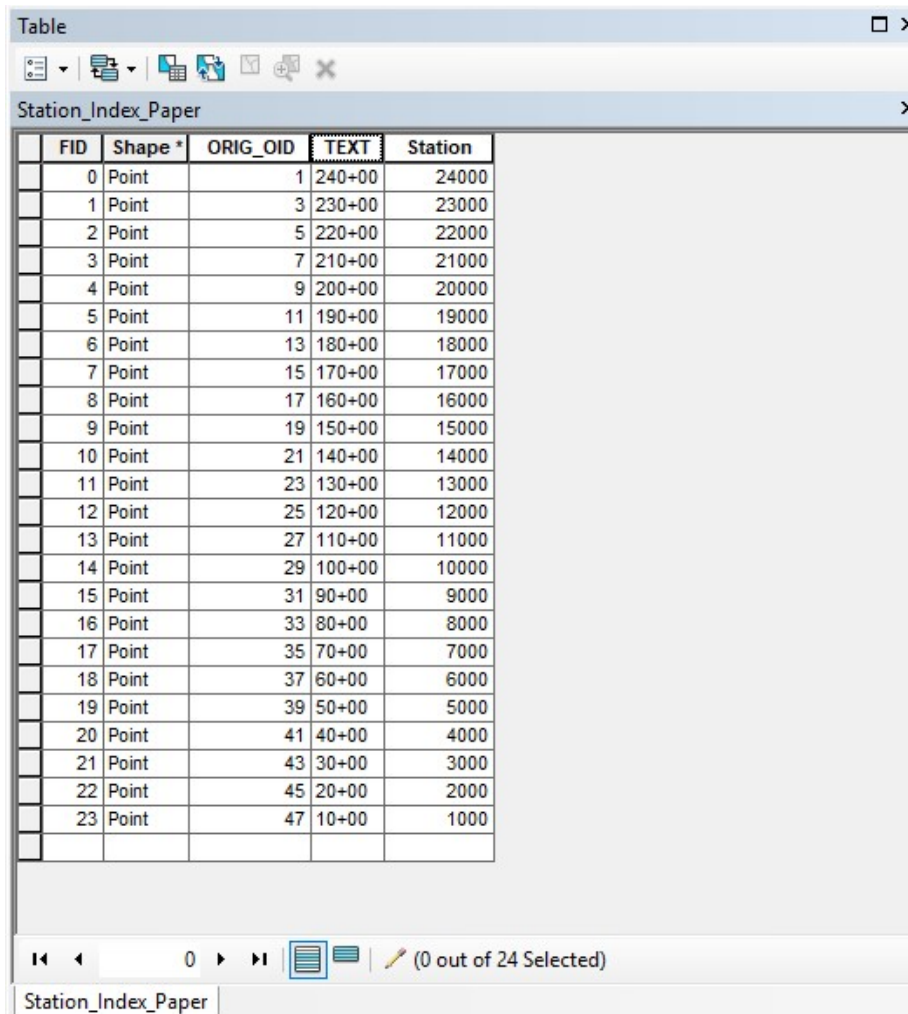


Figure 19. Convert the TEXT field into stationing nomenclature by dividing the field by 100 and then adding +00.



FID	Shape *	ORIG_OID	TEXT	Station
0	Point	1	240+00	24000
1	Point	3	230+00	23000
2	Point	5	220+00	22000
3	Point	7	210+00	21000
4	Point	9	200+00	20000
5	Point	11	190+00	19000
6	Point	13	180+00	18000
7	Point	15	170+00	17000
8	Point	17	160+00	16000
9	Point	19	150+00	15000
10	Point	21	140+00	14000
11	Point	23	130+00	13000
12	Point	25	120+00	12000
13	Point	27	110+00	11000
14	Point	29	100+00	10000
15	Point	31	90+00	9000
16	Point	33	80+00	8000
17	Point	35	70+00	7000
18	Point	37	60+00	6000
19	Point	39	50+00	5000
20	Point	41	40+00	4000
21	Point	43	30+00	3000
22	Point	45	20+00	2000
23	Point	47	10+00	1000

Figure 20. TEXT is now converted to stationing nomenclature.

5. Using Calibrated Routes to Generate a Designated Sub-Reach Event Layer

An Event Layer is created when a table representing from and to measurements (stationing) is used to generate individual sub-reaches from a calibrated route.

The top of Figure 21 represents a table from the calibrated route and the bottom of Figure 21 the table incorporating from – to stationing (event table). The Make Route Event Layer will read from and to station measurements from a table related to the route feature by the Route Identifier field and create a line feature segmented by the associated from and to measures.

This function can also be used to create a point feature by using a single measure or station as input.

Using Linear Reference Tools in ArcGIS

Note, the field Route is the relate between the two data sets attributed with 1 is common to both tables, this. The unique identifier field Pure_ID that will be carried over to the output feature.

Table - AWB44 Alignment \ Route

OBJECTID *	Shape *	Route *	Shape_Length
1	Polyline M	1	23945.067022

AWB44 Alignment \ Route

1 (0 out of 1 Selected)

Pure_SubR_Start_Stop_Good

OBJECTID *	Pure_ID	Pure_Start_Measured	Pure_End_Measured	Route
1	PS-1	3250	3260.98	1
2	PS-2	3260.98	3280.93	1
3	PS-3	3280.93	3300.89	1
4	PS-4	3300.89	3320.84	1
5	PS-5	3320.84	3340.8	1
6	PS-6	3340.8	3360.75	1
7	PS-7	3360.75	3380.71	1
8	PS-8	3380.71	3400.67	1
9	PS-9	3400.67	3420.62	1
10	PS-10	3420.62	3440.58	1
11	PS-11	3440.58	3460.53	1
12	PS-12	3460.53	3480.49	1
13	PS-13	3480.49	3500.44	1
14	PS-14	3500.44	3520.4	1
15	PS-15	3520.4	3540.35	1
16	PS-16	3540.35	3560.31	1
17	PS-17	3560.31	3580.27	1
18	PS-18	3580.27	3600.22	1

Pure_SubR_Start_Stop_Good

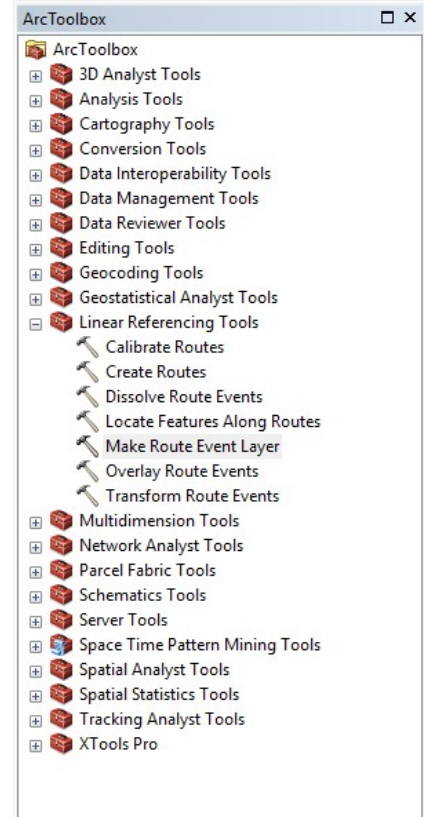
1 (0 out of 302 Selected)

Figure 21. Table from the calibrated route (top) and table incorporating from – to stationing (bottom).

Using Linear Reference Tools in ArcGIS

1. Open the Make Route Event Layer geoprocessing tool from ArcToolbox\Linear Referencing Tools (Figure 22 shows the menu bar and Figure 23 shows the form).

Figure 22. From the ArcToolbox\Linear Referencing Tools, select Make Route Event Layer.



2. Provide the information for the form:
 - **Input Route Features** = calibrated route
 - **Route Identifier Field** = route feature route field used in the relate
 - **Input Event Table** = event table representing from and to measures
 - **Route Identifier Field** = event table route field used in the relate
 - **Event Type** = line

The image shows the 'Make Route Event Layer' tool form. It has several input fields and checkboxes. The 'Input Route Features' field is empty. The 'Route Identifier Field' field is empty. The 'Input Event Table' field is empty. The 'Event Table Properties' section includes 'Route Identifier Field' (empty), 'Event Type' (set to 'POINT'), 'Measure Field' (empty), and 'To-Measure Field' (empty). The 'Layer Name or Table View' section includes 'Offset Field (optional)' (empty). There are two checkboxes: 'Generate a field for locating errors (optional)' and 'Generate an angle field (optional)', both of which are unchecked. The 'Calculated Angle Type (optional)' field is empty. At the bottom, there are buttons for 'OK', 'Cancel', 'Environments...', '<< Hide Help', and 'Tool Help'.

Figure 23. Make Route Event Layer form.

Using Linear Reference Tools in ArcGIS

- **Measure Field** = event table from measure field
 - **To-Measure Field** = event table to measure field
 - **Layer Name or Table View** = the name of the feature layer to be created – note, this is a temporary feature that will need to be converted into a permanent feature later in the process
 - **Offset Field and other optional selections** = Ignore these, as they are not necessary for a simple event layer
3. Click ok to add a temporary line feature layer to the project table of contents that has been subdivided by unique ID and sub-reaches. Figure 24 depicts the sub-reach feature classified by the unique identifier Pure_ID.

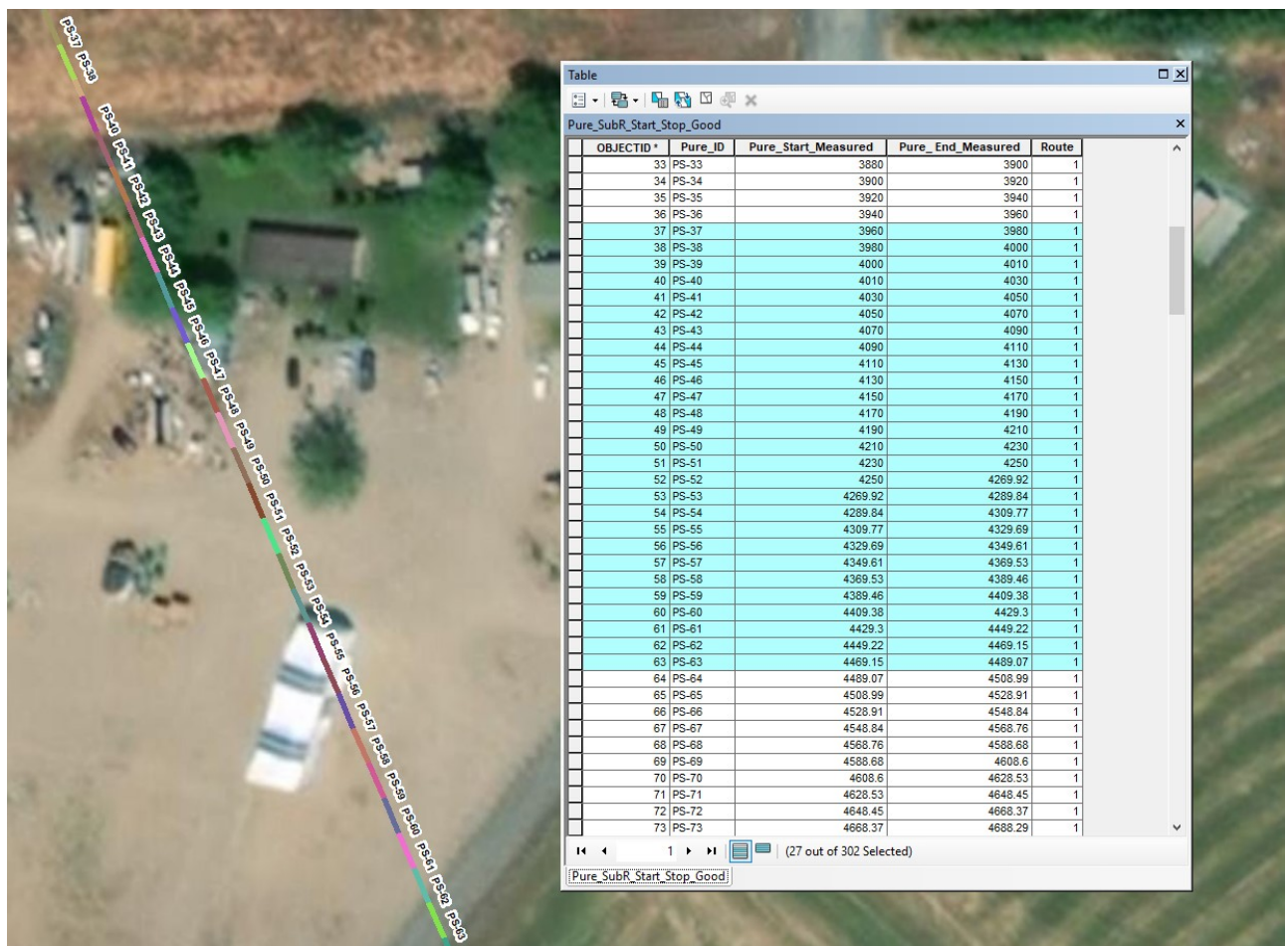


Figure 24. Example of sub-reach feature classified by the unique identifier Pure_ID.

3. Right click on the temporary feature and use the Export function to convert data set into a permanent feature.

6. For More Information

Contact Patrick Wright for more explanations and demonstrations.
Denver Federal Center Bldg 67,
PO Box 25007
Denver CO 80225-0007
303-445-2288
pwright@usbr.gov