

Linear Referencing Guide for Petroleum Exploration



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Linear Referencing Guide for Petroleum Exploration

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- Displaying Seismic Navigation Routes
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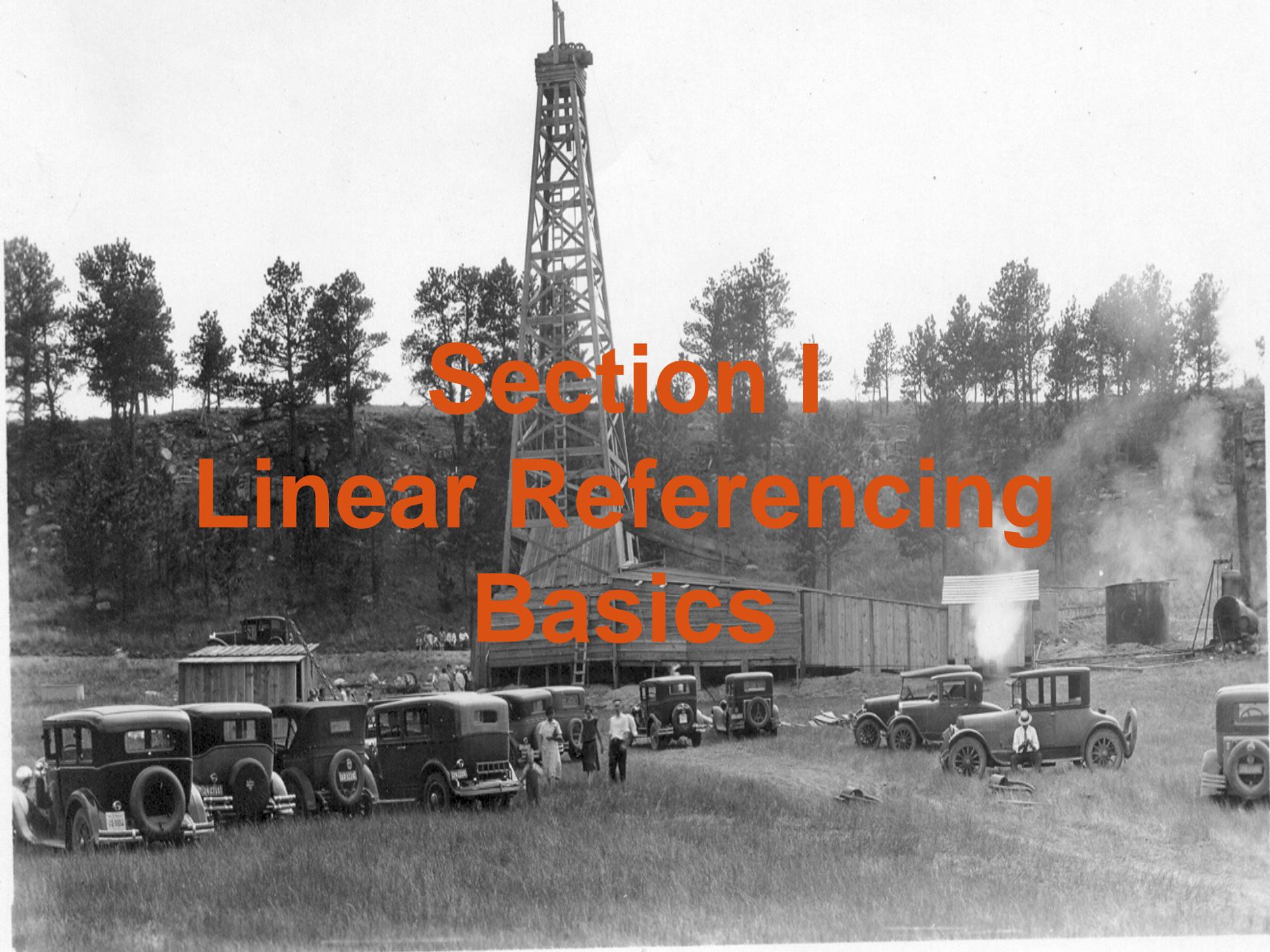
Linear Referencing Guide for Petroleum Exploration

Contents...

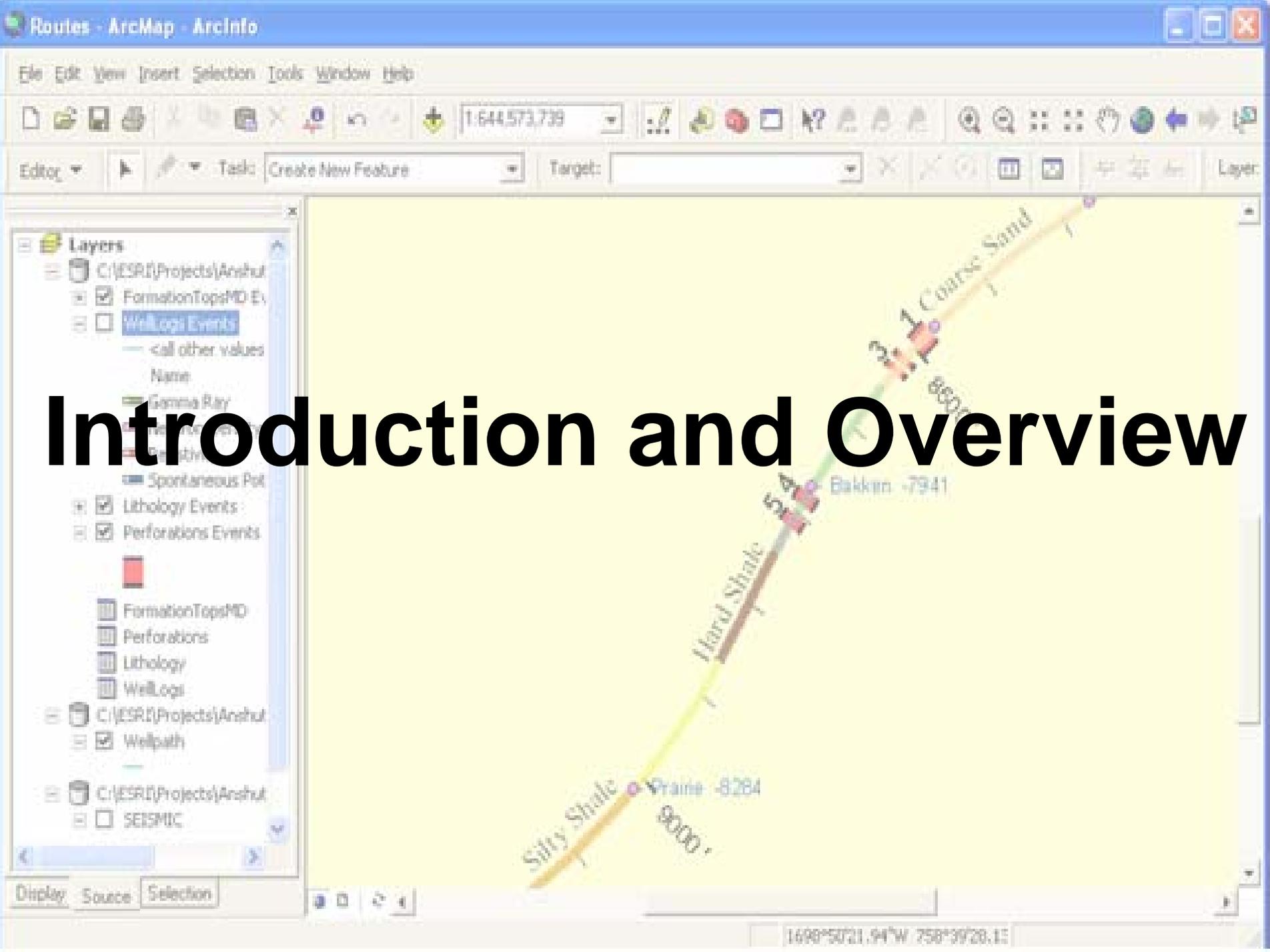
Section III: Route Events

- Point Route Events (Formation Tops)
- Line Route Events (Lithologic Units)
- Discontinuous Line Route Events (Perforation Intervals)
- Using a Hatch Interval Attribute (Drilling Rates)
- Using Route Event Offsets (Well Log Intervals)
- Using Route Event Offsets (Well Log Values)
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References

A black and white photograph of an oil well derrick in a field. The derrick is a tall, lattice-structured tower. In the foreground, several vintage cars from the 1920s or 30s are parked in a line. A wooden building is visible behind the cars, and a plume of white steam or smoke rises from a small structure to the right. The background consists of a line of trees on a hillside.

Section I Linear Referencing Basics



Introduction and Overview

Wellbore Data Overview

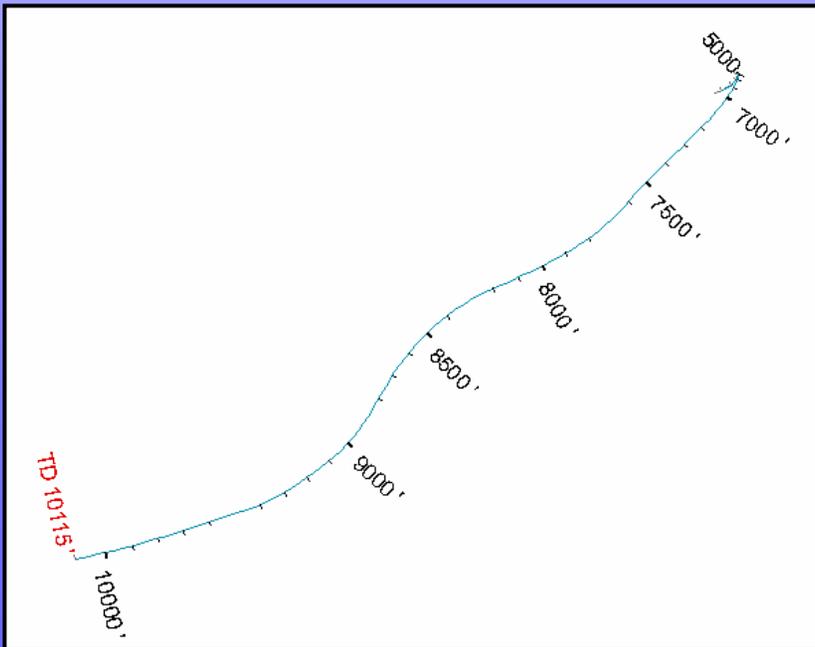
Map view shows the horizontal path of a directionally drilled well

MD – Measured depth

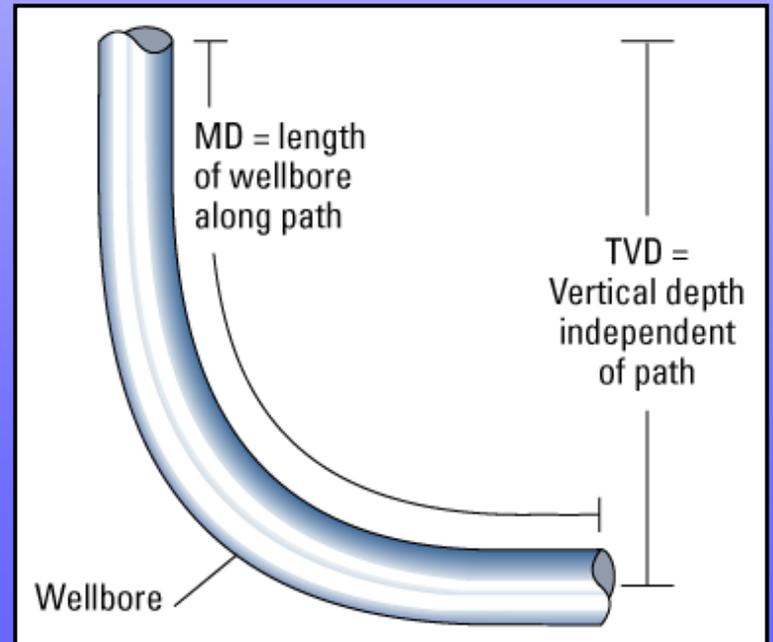
TVD – True vertical depth (MD corrected for horizontal displacement)

TVDSS – True vertical depth subsea (relative to a vertical datum)

Wellbore Path (MD)



Measured v.s. True Vertical Depth



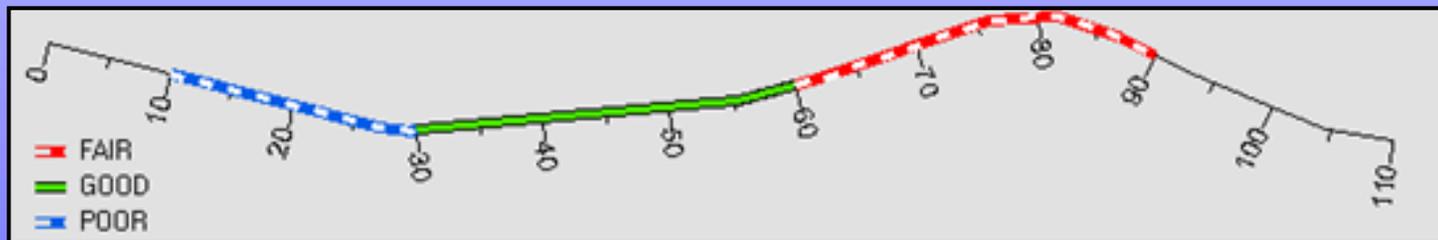
Linear Referencing Overview

Route – A linear feature containing a linear measurement system

Measures – Points which define the linear measurement system.
Location, Value, Sign, Units (distance, time, magnitude)

Route Event – An occurrence along a route feature

Dynamic Segmentation – The process of creating route event geometry

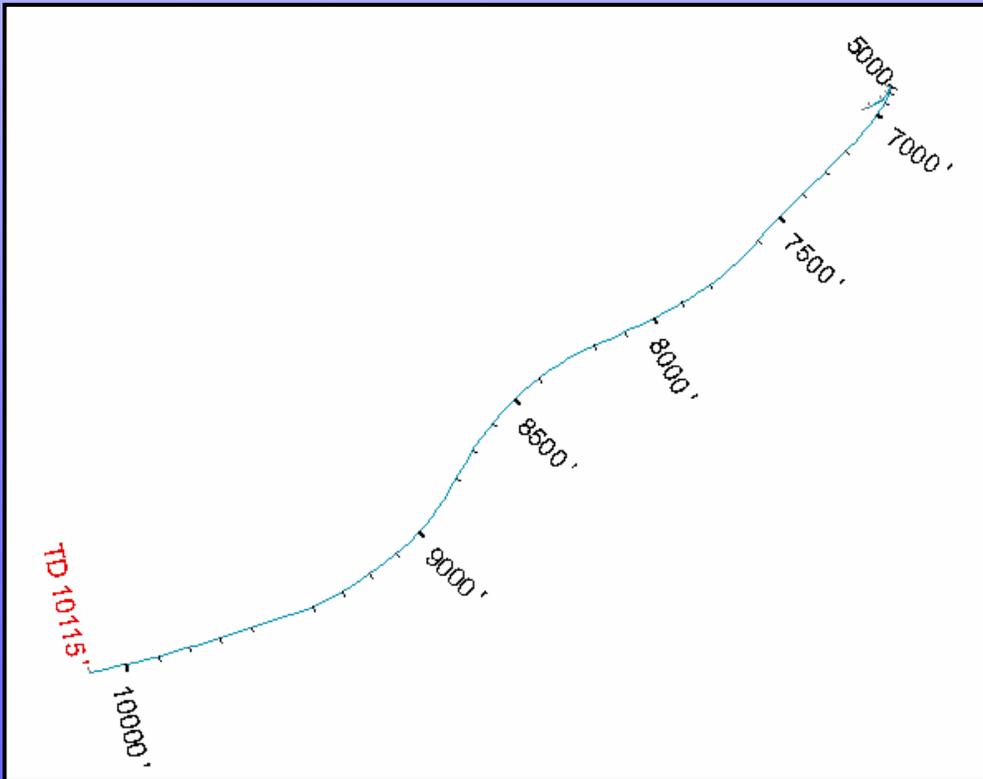


RKEY	FMP	TMP	COND
91	10	30	POOR
91	30	60	GOOD
91	60	90	FAIR

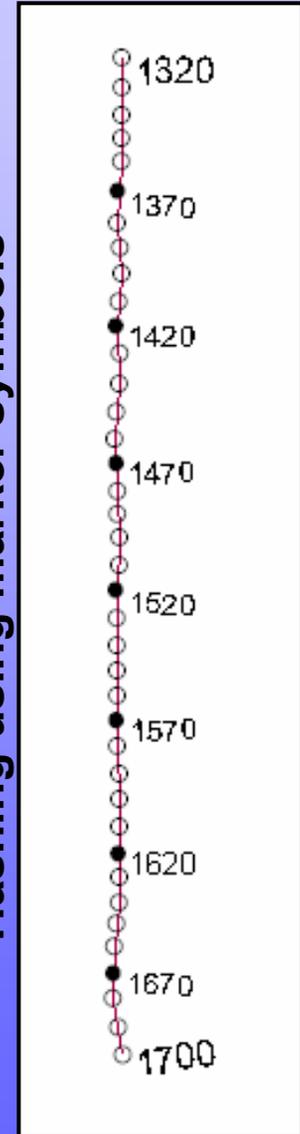
Hatching Overview

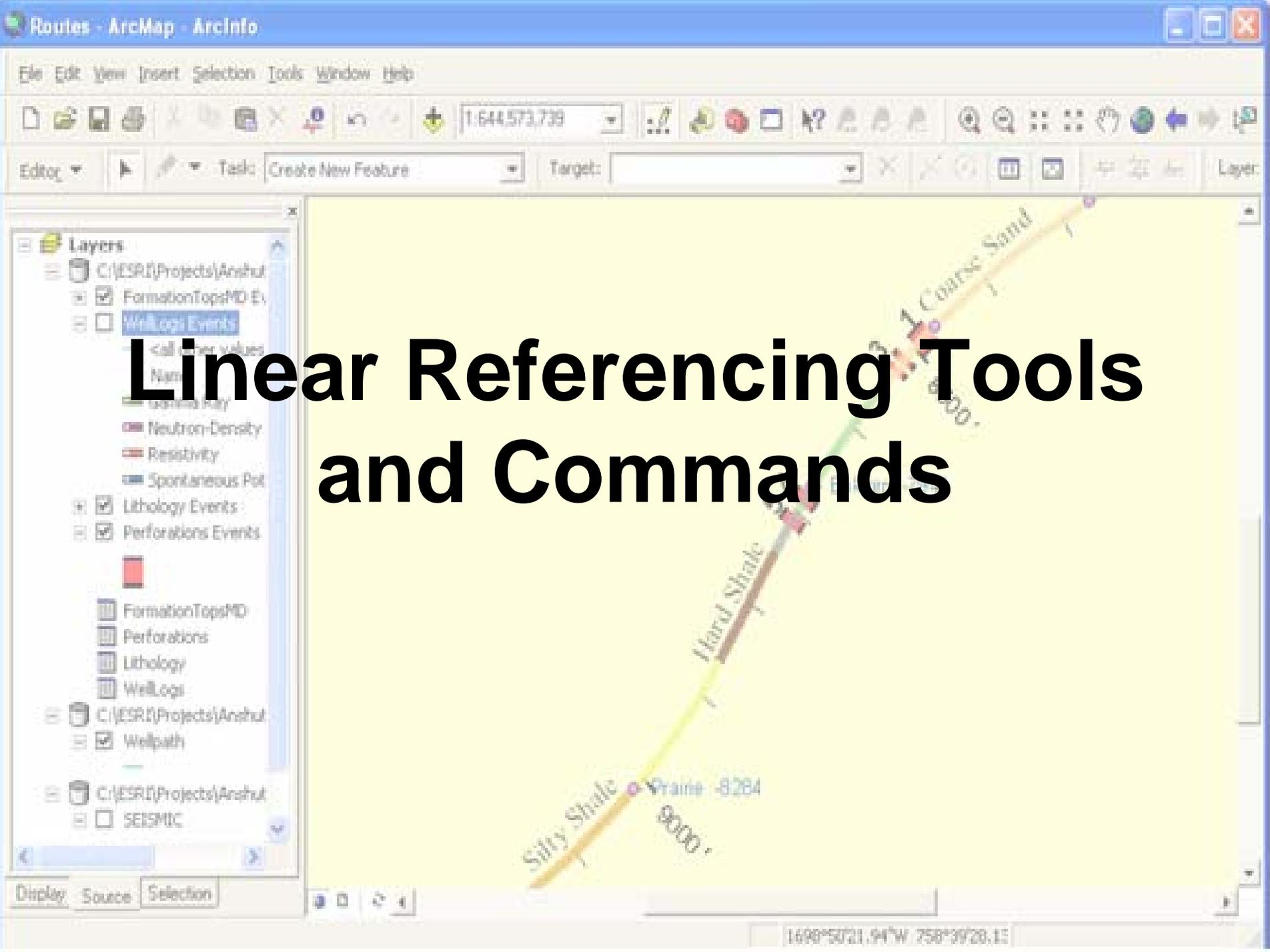
Hatching is a type of labeling that is designed to post and label hatch marks or symbols at a regular interval along measured linear features.

Hashing using line symbols



Hashing using marker symbols

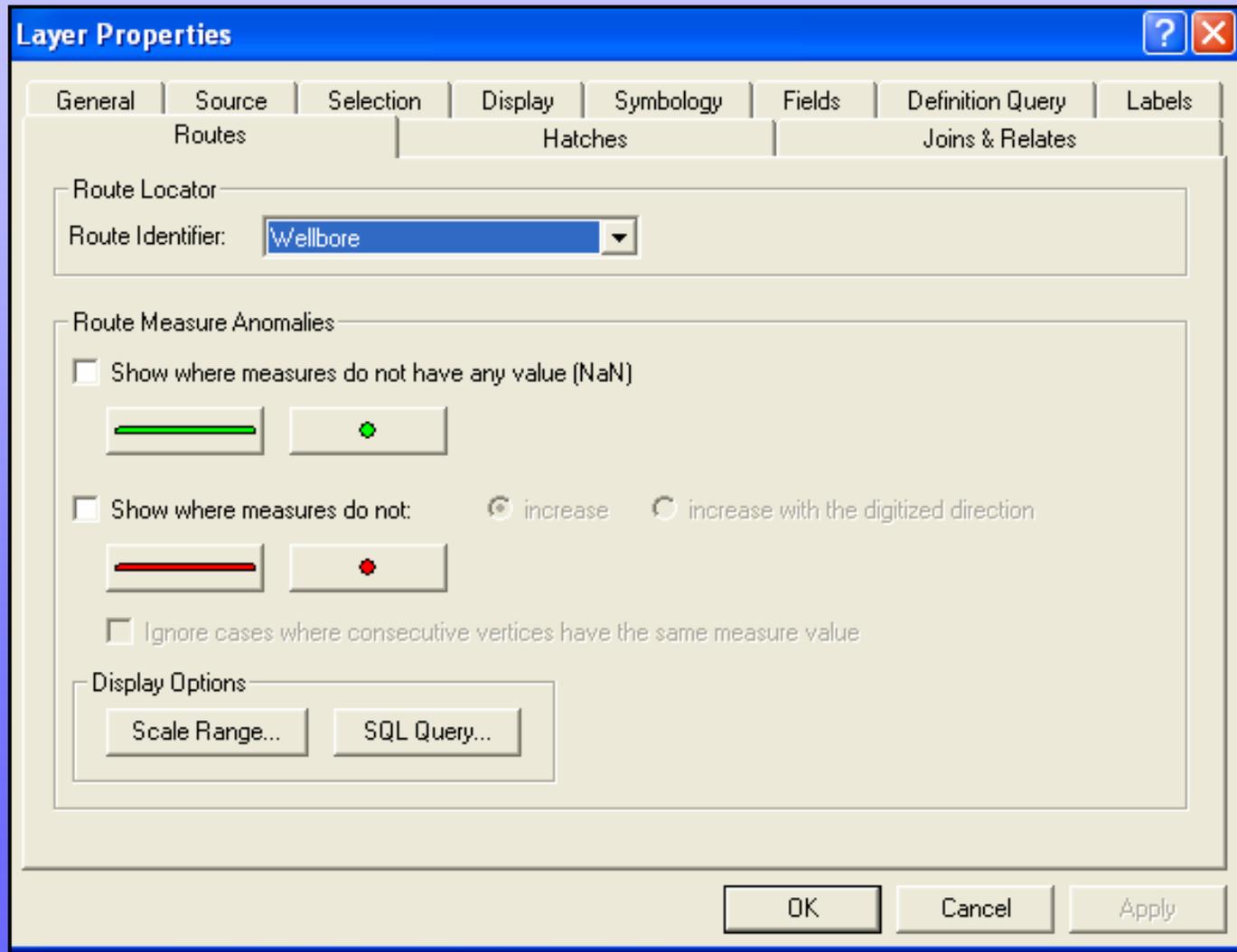




Linear Referencing Tools and Commands

Linear Referencing – Identifier Field

Identifier Field - optional setting which is used as a default in other route dialogs



Linear Referencing - ArcToolbox

Various tools can be used with route features

Recalculates route measures using points.

Create routes from existing lines segments.

Removes redundant information from event tables or separates event tables having more than one descriptive attribute into individual tables.

Computes the intersection of input features (point, line, or polygon) and route features and writes the route and measure information to a new event table.

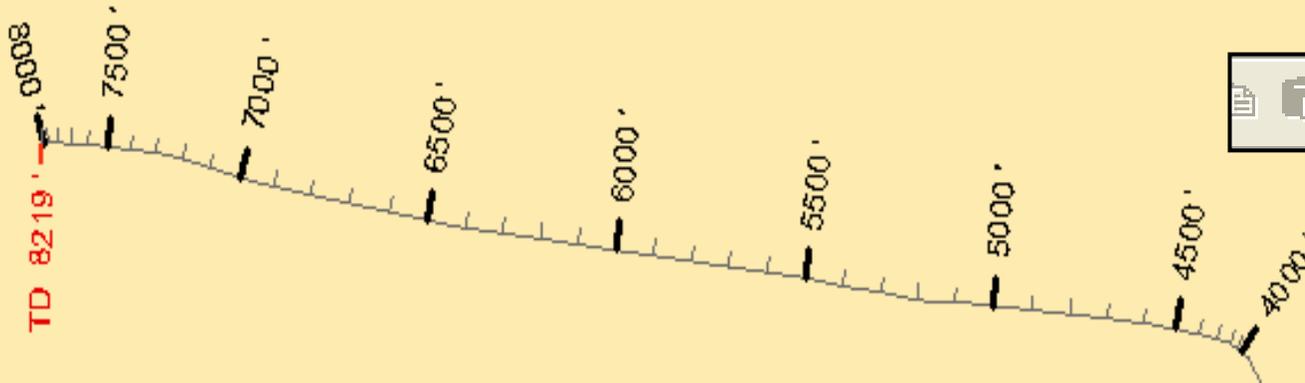
Creates a temporary feature layer using routes and route events.

Overlays two event tables to create an output event table that represents the union or intersection of the input.

Computes the intersection of input features (point, line, or polygon) and route features and writes the route and measure information to a new event table.



Identify Route Command tool



Shows measure values along a route

Identify Route Location Results

Layers: <All route layers>

WellpathC
Well C

Location: (2622093.914505, 1749780.702461)

Description	Value
Measure:	6141.713
Minimum Measure:	0.000
Maximum Measure:	8219.000
Measure Values:	Strictly Increasing
Parts:	1
Unknown Measures:	False

Customize

Toolbars | **Commands** | Options

Categories:

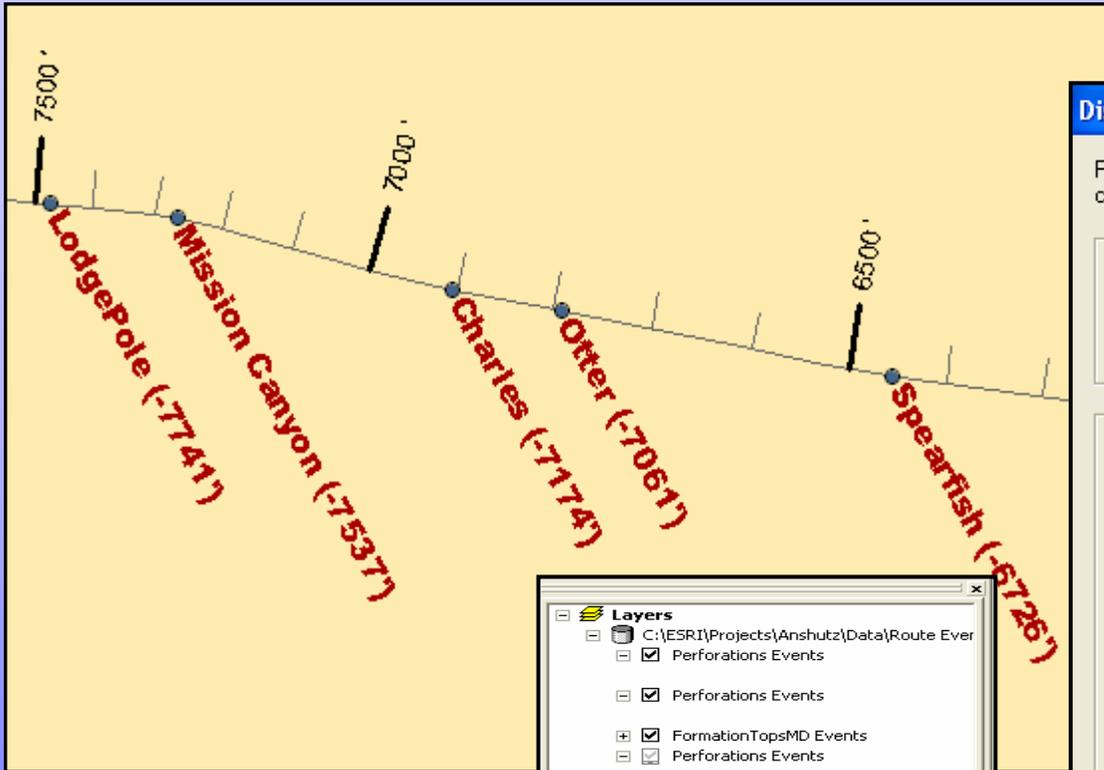
- Georeferencing
- Globe View
- GPS
- Help
- IMS
- IMSSubLayer
- Insert
- Label
- Layer
- Linear Referencing**
- Macros
- MapCache
- Maplex

Commands:

- Add Route Events...
- Convert Hatches to Graphics...
- Display Route Events...
- Identify Route Locations**
- Route Events GeoProcessing Wizard

Save in: Normal.mxt | Keyboard... | Add from file... | Close

Displaying Route Events



Display Route Events

Route events are objects with locations measured along routes. A table containing route events can be added to the map as a layer.

Specify the routes referenced by the events in the table

Route Reference: Wellpath

Route Identifier: Wellbore

Specify the table containing the route events

Choose a table from the map or browse for another table.

Event Table: FormationTopsMD

Route Identifier: WellBore

Choose the type of events the table contains:

- Point Events: Occur at a precise location along a route
- Line Events: Define a discontinuous portion of a route

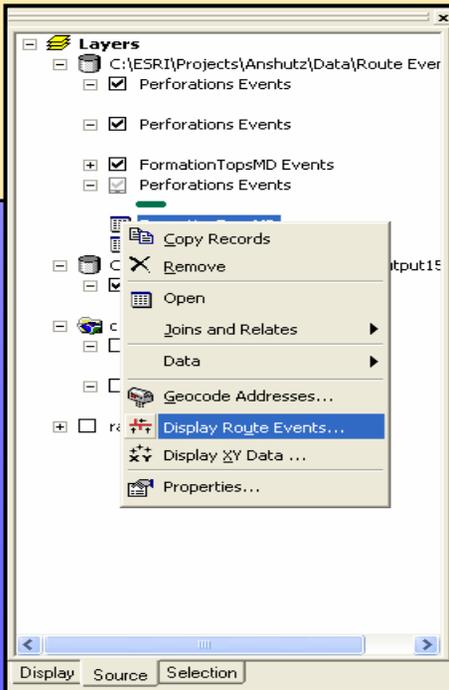
Choose the measure field for point events:

Measure: Event

Choose the offset field. Events can be offset from their routes.

Offset: <None>

Advanced Options... OK Cancel



Create a route event layer by using the "Display Route Events" dialog

Route Toolbar (ArcEditor)

ArcEditor tools which can be used to modify route data.



Define Line Portion

Defines a sketch that represents a portion of the currently selected line feature. The portion is defined between a start point and an end-point.



Make Route

Invokes the Make Route dialog, which creates a new route in the target line layer from the currently selected set of line features.



Calibrate Route

Opens the Calibrate Route dialog, which adjusts the current selected route's measures based on a series of digitized points.

Route Geoprocessing Wizard

Routes can be used in geoprocessing operations

Route Events GeoProcessing Wizard [?] [X]

Choose a route event processing operation, then click the Next button to choose options.

- Intersect two route event layers
- Union two route event layers
- Dissolve/Concatenate route events
- Transform events from one route reference to another
- Locate point features along routes
- Locate polygon features along routes

About locating points along routes

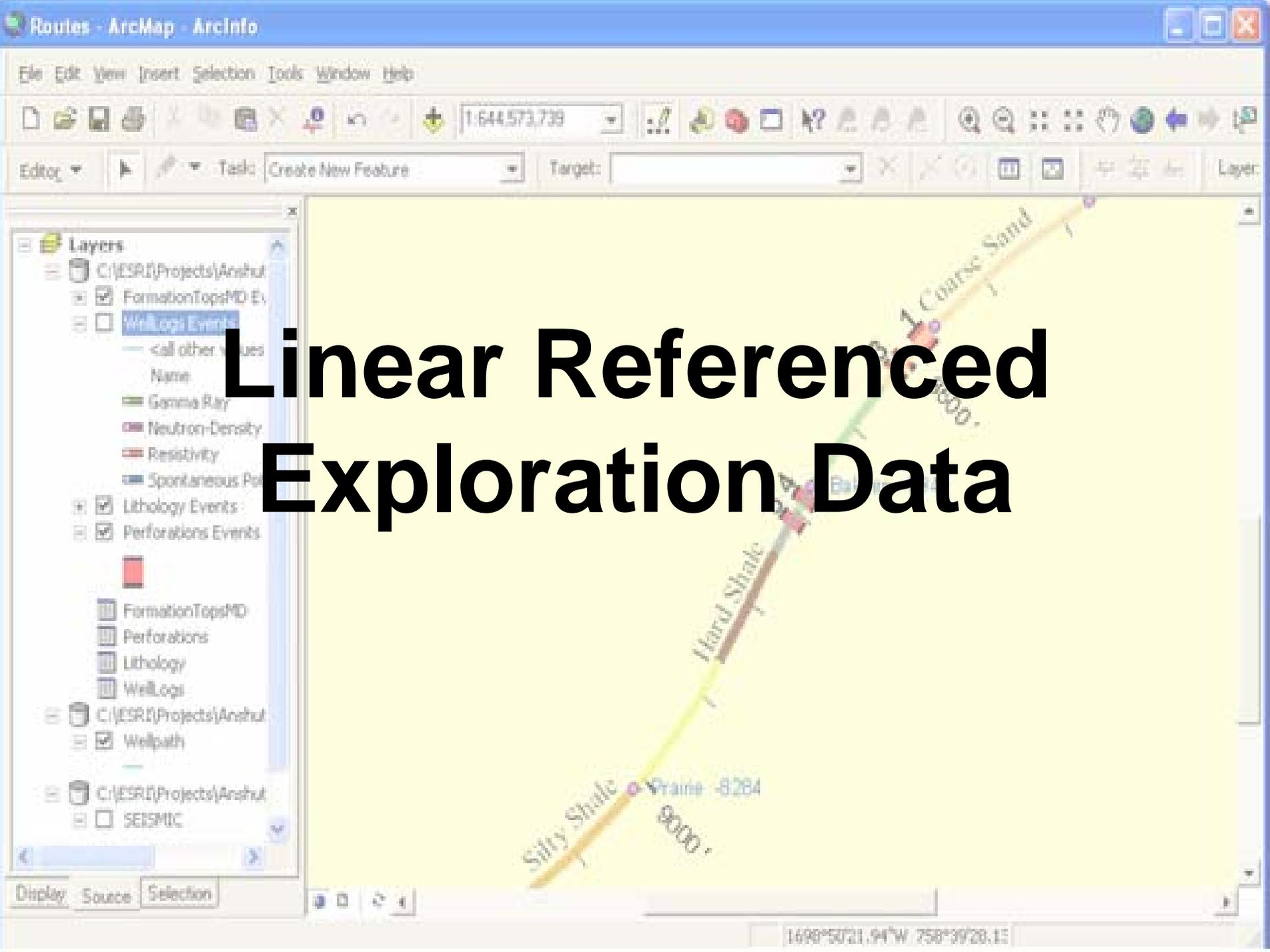
This operation derives point events from point features by locating the point features along a route reference.



Input Output

[More About Locating Points](#)

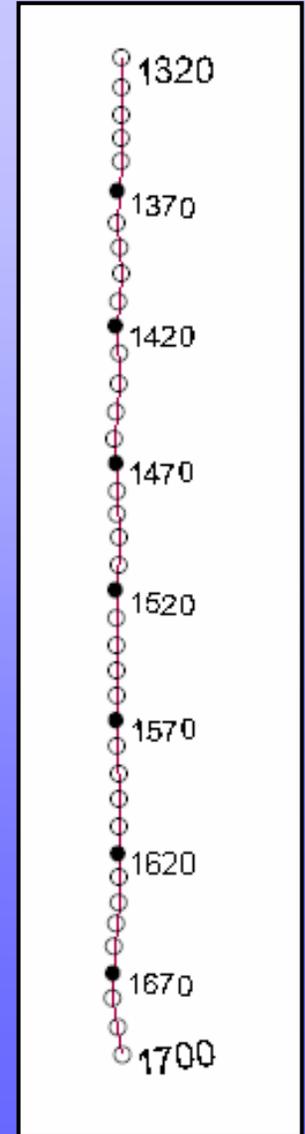
< Back Next > Cancel



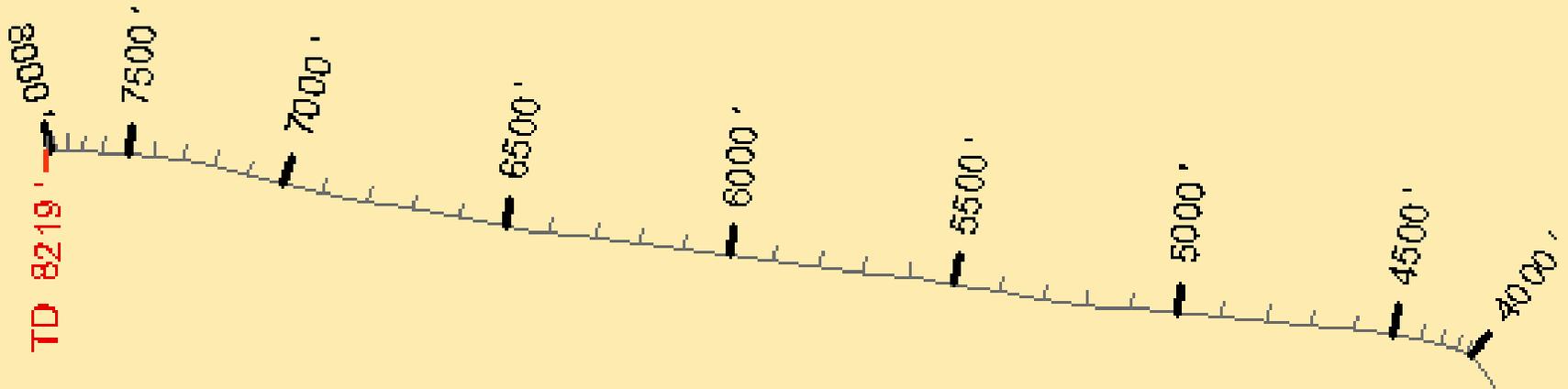
Linear Referenced Exploration Data

Linear Referencing of Seismic Navigation Data

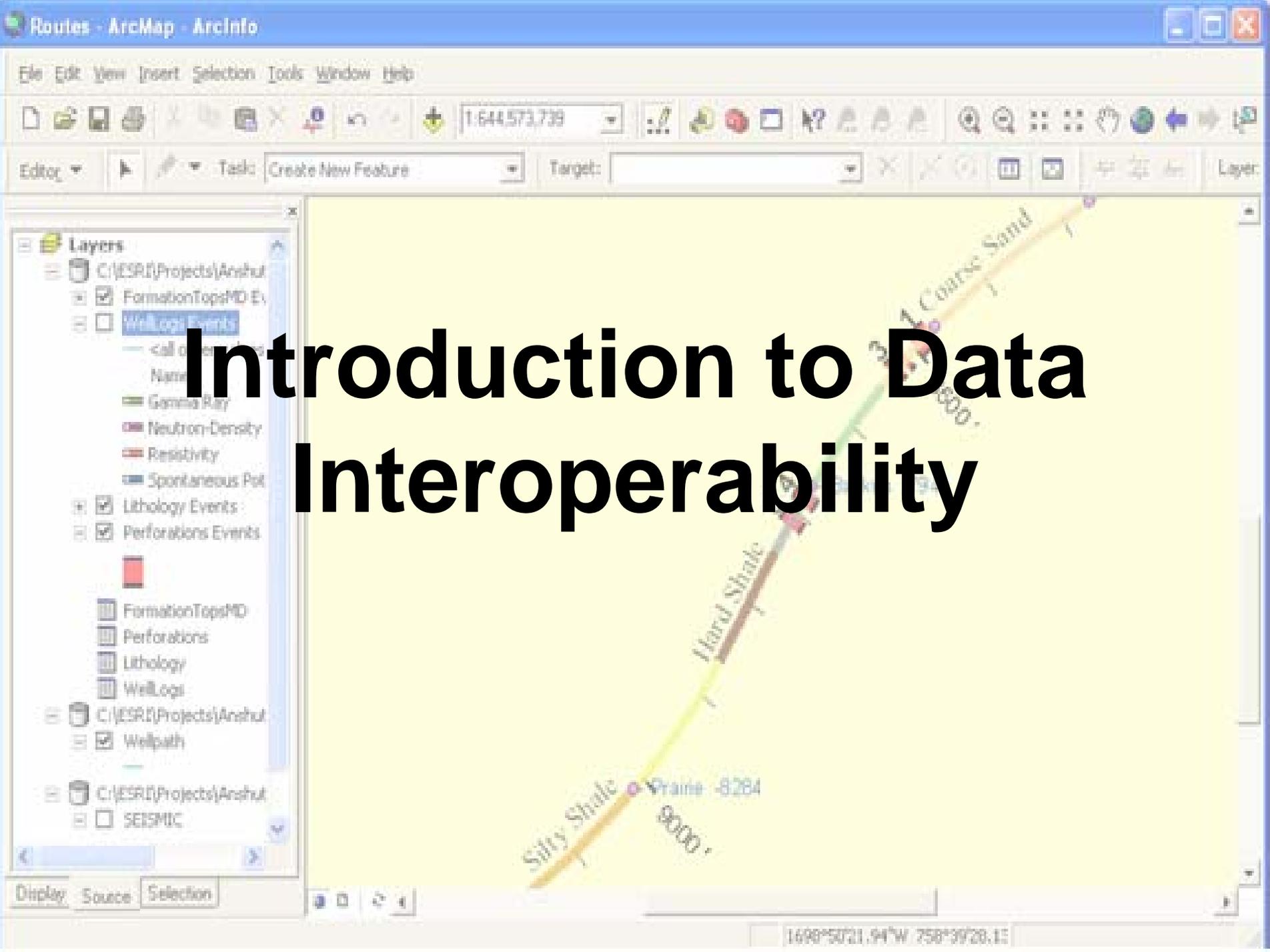
- Shotpoints are used to define routes
- Shotpoint measures can be used to interpolate the locations of missing shotpoints
- The display of shotpoint measures can be decimated so only some shotpoint locations are displayed
- Shotpoint measures can be labeled using an interval and orientation
- The end points can be displayed and labeled separately



Linear Referencing of Well Path Data



- Use MD to define measures
- Use TVDSS for Z values
- Point Route Events: Formation tops
- Line Route Events: Perforation, Core and DST intervals

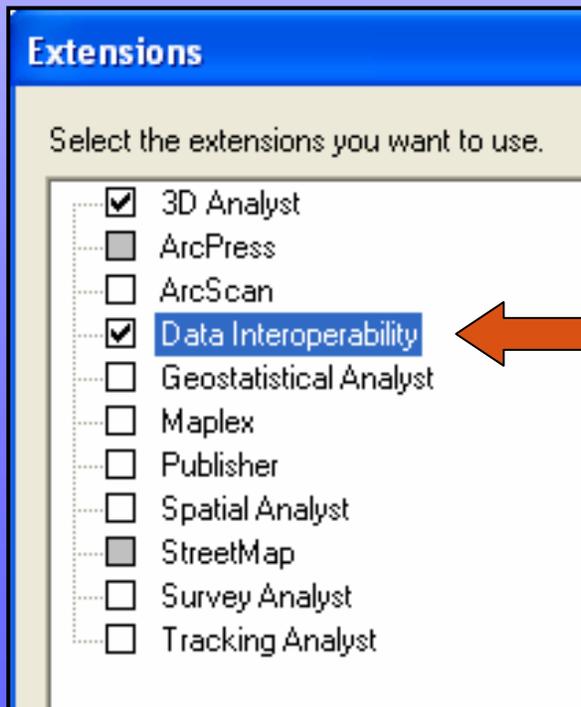
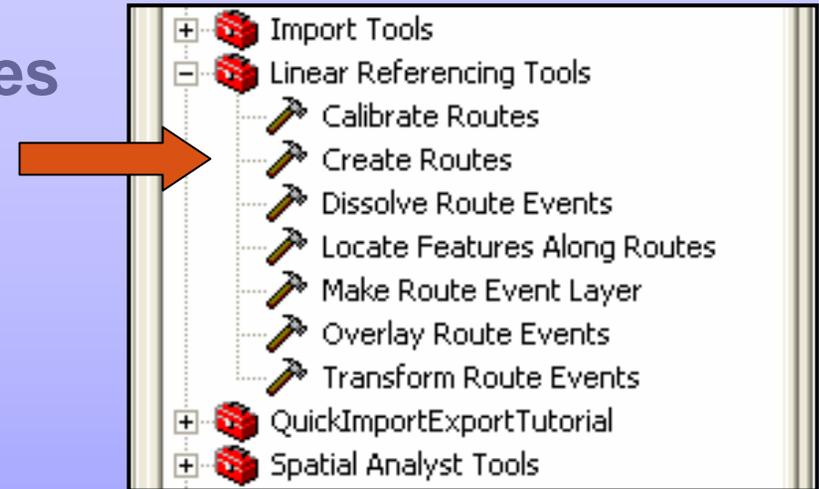


Introduction to Data Interoperability

Two Methods for Creating Routes

1. Add measures to existing lines

- Standard method for creating routes
- Use ArcGIS tools (Make Route)
- Lines must already exist
- Use distances to define measures



2. Create routes from points

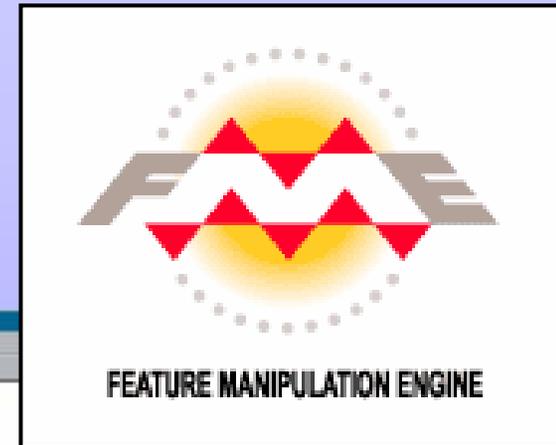
- Assemble a set of points into lines with routes
- Each point becomes a vertex with a measure
- Not supported using standard ArcGIS tools
- Requires Data Interoperability extension

FME and Data Interoperability

Based on Safe Software's Feature Manipulation Engine

Provides support for the conversion, translation and transformation of GIS and CAD data

Supports over 75 common data formats



The screenshot shows the FME Workbench interface with a workspace containing several transformers and data sources. The workspace is titled 'FME Workbench - F:\WorkbenchData\WKS.fmw MULTI -> FFS'. The main workspace area displays a workflow diagram with the following components:

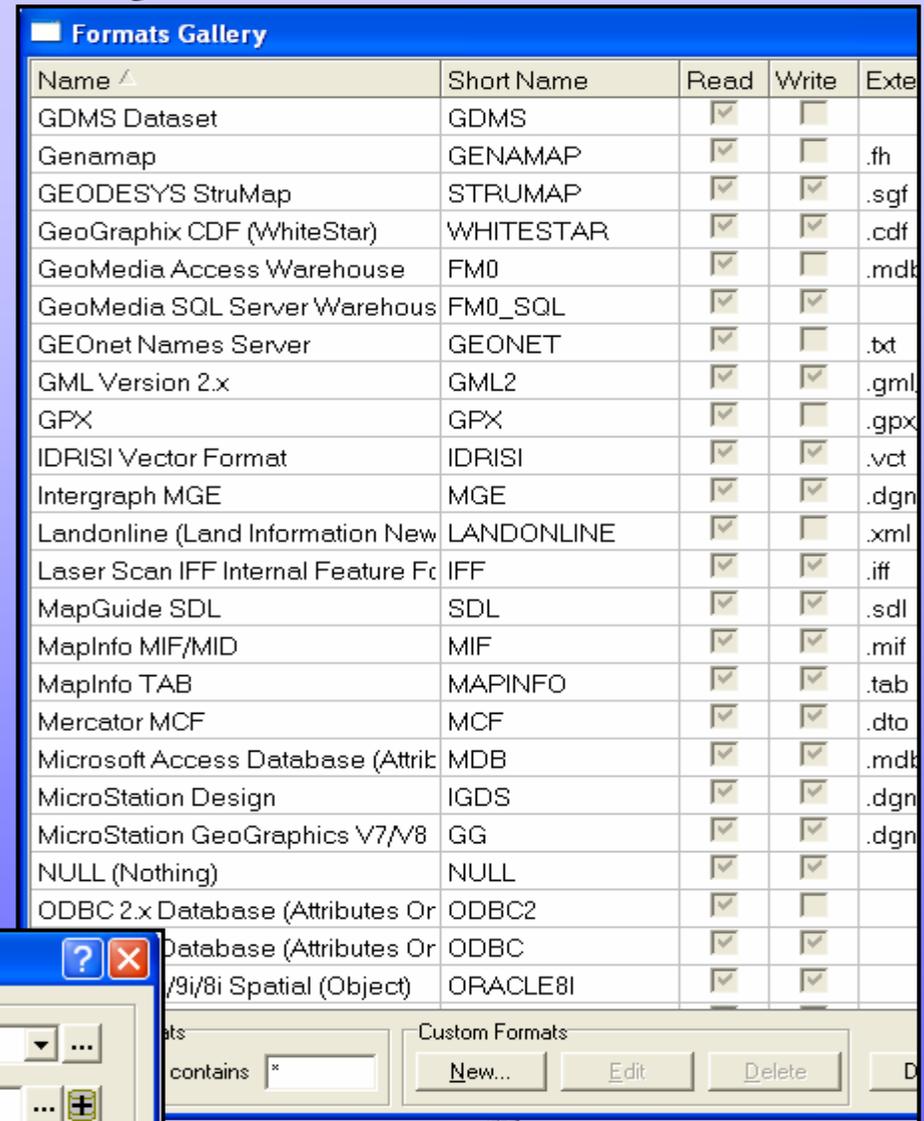
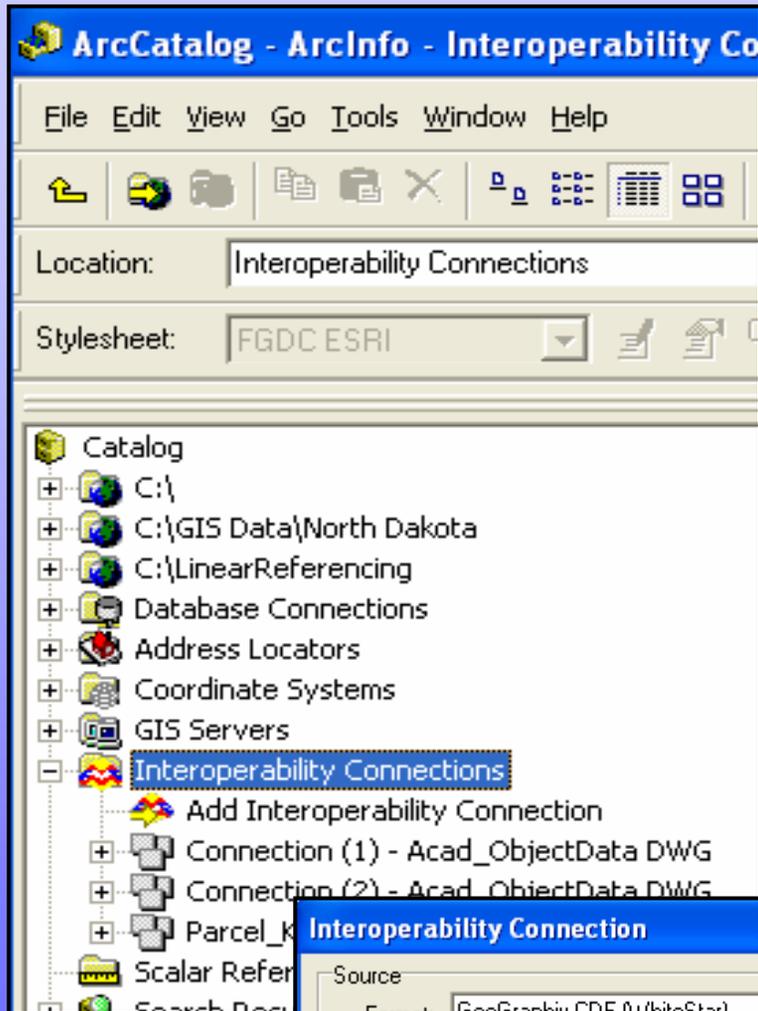
- LOT_POLYGON** (Reader): Attributes include POLY_ID, AREA, OVERLAPS, COUNTY, PURCHASE_D, and OWNER.
- TESTER [Tester]** (Tester): A yellow note above it says 'Find all lots that are owned by the city.' It has an INPUT and two outputs: PASSED and FAILED.
- ROADS** (Reader): Attributes include ROADS_ID, NUMOFLANES, TYPE, CONSTRUCTD, DIVIDED, and TRVLDIR.
- ATTRIBUTEFILTER [Attribute Filter]** (Attribute Filter): A yellow note above it says 'Filter based on whether or not the road has been constructed.' It has an INPUT and two outputs: true and false.
- CLIPPER [Clipper]** (Clipper): A yellow note above it says 'Clip the roads to the lot boundaries.' It has two inputs (from TESTER and ATTRIBUTEFILTER) and three outputs: CLIPPER, CLIPPED_INSL, and CLIPPED_OV.
- VISUALIZER [Visualizer]** (Visualizer): A yellow note above it says 'Display the "false" roads using the FME Universal Viewer.' It has an INPUT from the false output of the ATTRIBUTEFILTER.
- CITY_ROADS** (Writer): Attributes include ROADS_ID, NUMOFLANES, TYPE, CONSTRUCTD, DIVIDED, and TRVLDIR.

The workflow connects the ROAD and LOT_POLYGON readers to the TESTER transformer. The TESTER transformer connects to the CLIPPER transformer. The CLIPPER transformer connects to the CITY_ROADS writer. The ATTRIBUTEFILTER transformer also connects to the CLIPPER transformer and the VISUALIZER transformer.

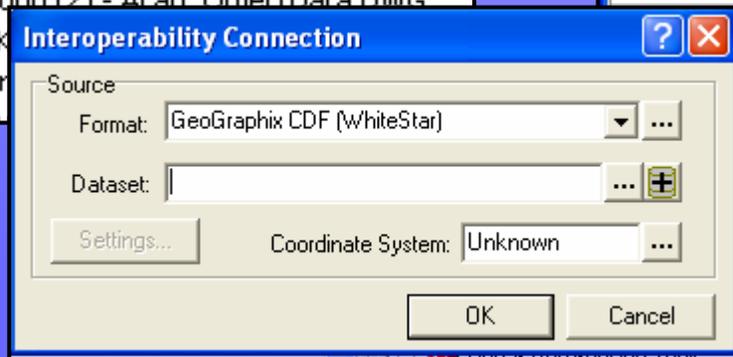
The bottom of the screenshot shows a command window with the following text:

```
MultiReader adding SHAPE Reader with keyword SHAPE 2
Using Multi Reader $Revision: 3.1 $ ( $Date: 2002/06/06 16:01:57 $ ) to read multiple datasets
Using Shape Reader $Revision: 3.1 $ ( $Date: 2002/06/06 16:02:01 $ ) to read shape files from directory 'F:\WorkbenchData'
Opened Shape File F:\WorkbenchData\ROADS.shp for input
Opened DBF File 'F:\WorkbenchData\ROADS.dbf' for input
DBF File F:\WorkbenchData\ROADS.dbf has fields : ROADS_ID char(6) NUMOFLANES number(2,0) TYPE char(5) CONSTRUCTD logical DIVIDED logical TRVLDIR char(6)
Shape Reader: Bounding box of shapefile 'F:\WorkbenchData\ROADS' is: (455682 5371954) (470509 5383453)
```

Data Interoperability Connections



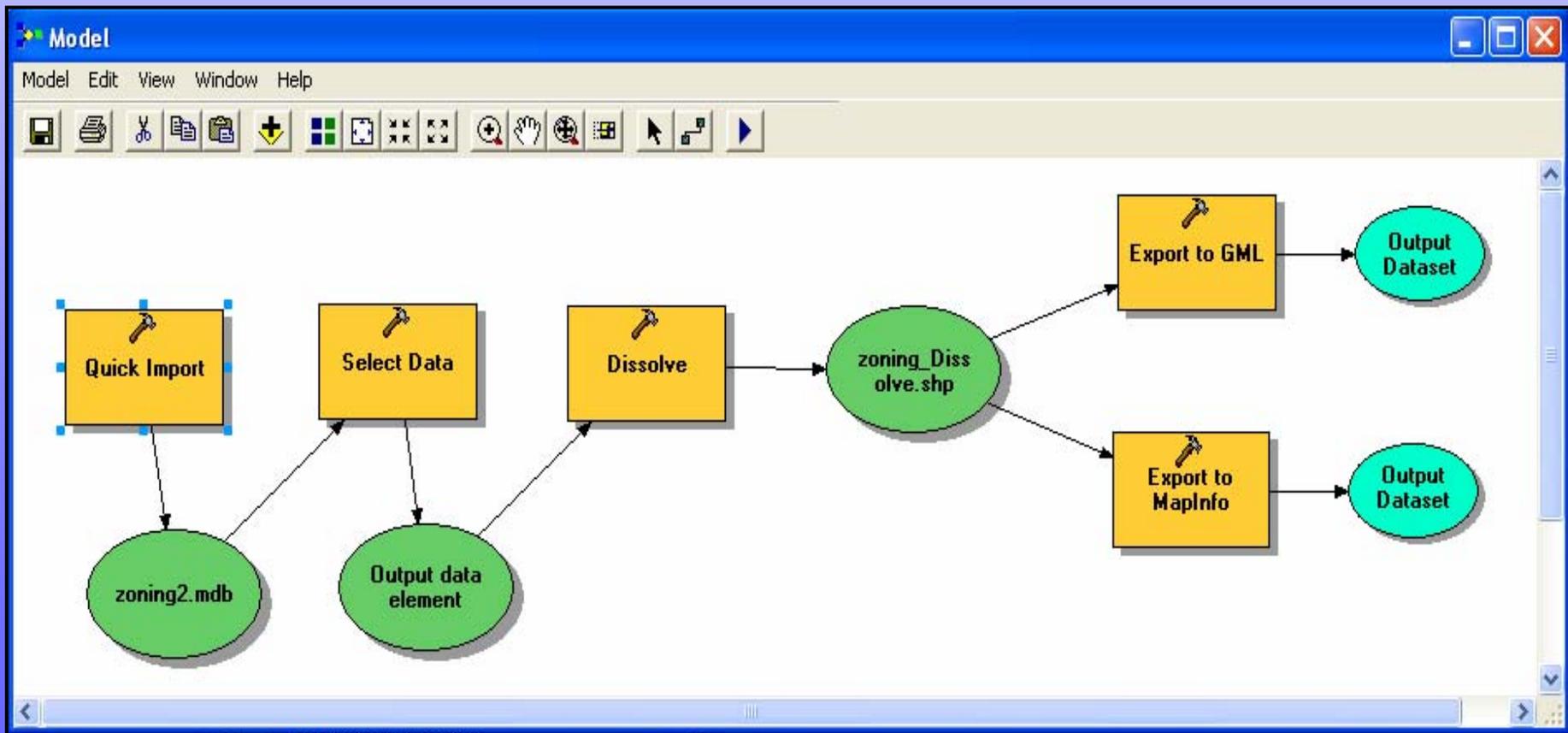
Create new nodes



Directly read supported formats as layers in your map

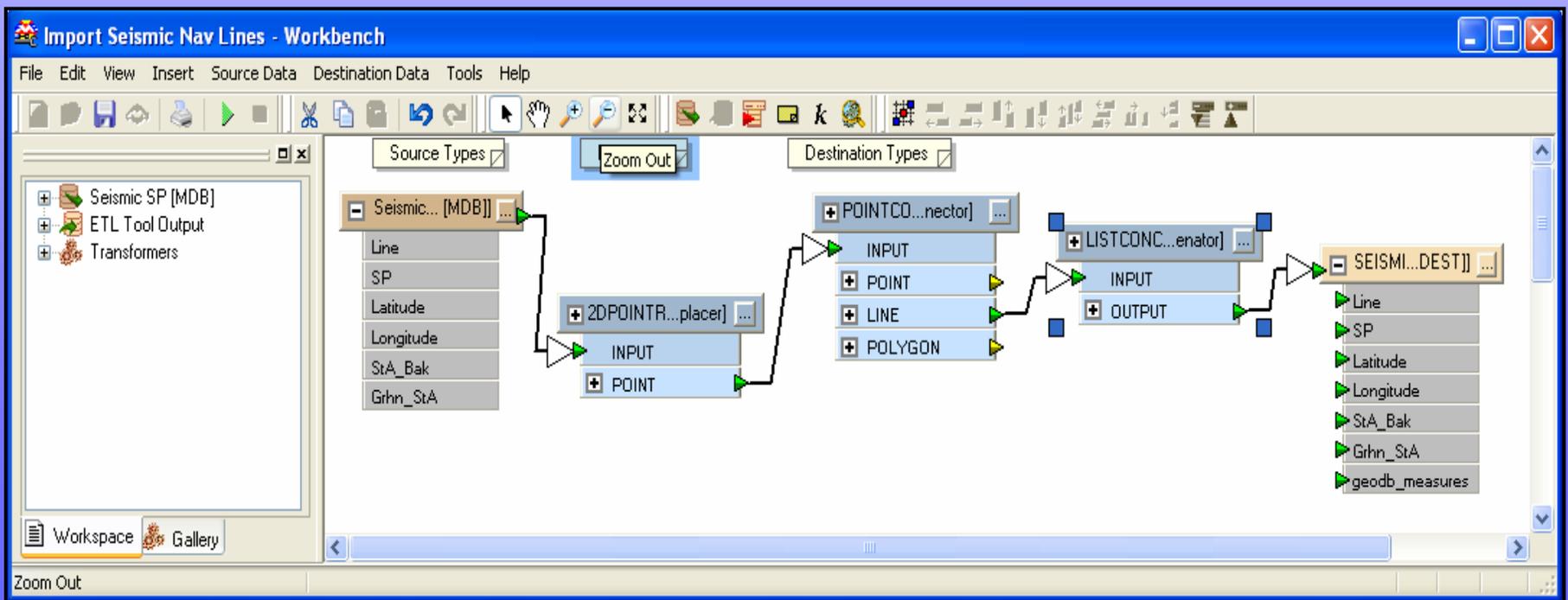
Quick Import and Export

- Import FME data into ESRI formats
- Export ESRI data into FME formats
- Use Quick Import and Export Tools in models



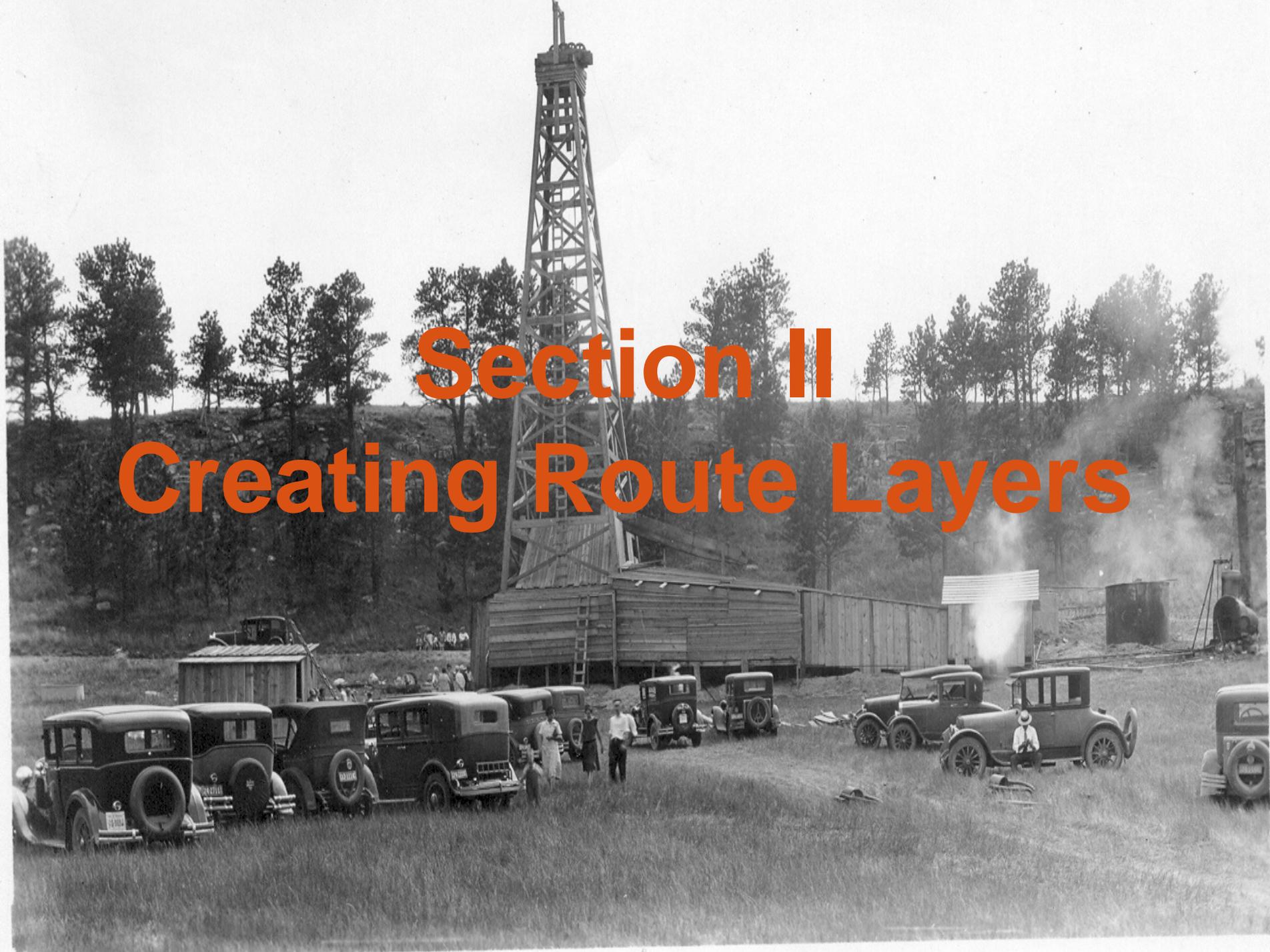
Custom Import and Export

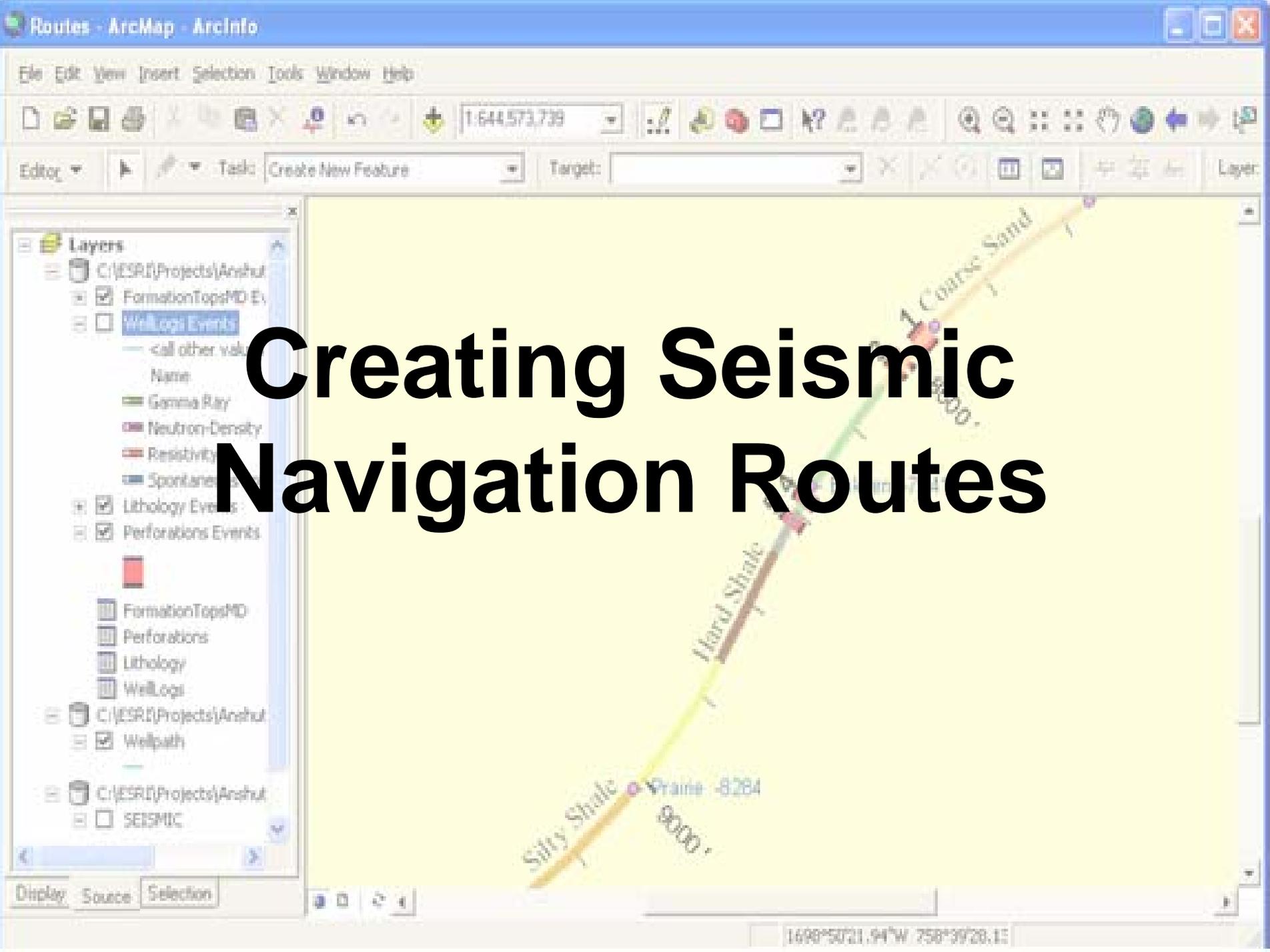
- Transform data being imported or exported
- Many types of transformation elements
- Connect transformations together
- Read/write using multiple data sets
- Uses a graphical interface to model transformations



Section II

Creating Route Layers





Creating Seismic Navigation Routes

Seismic Data

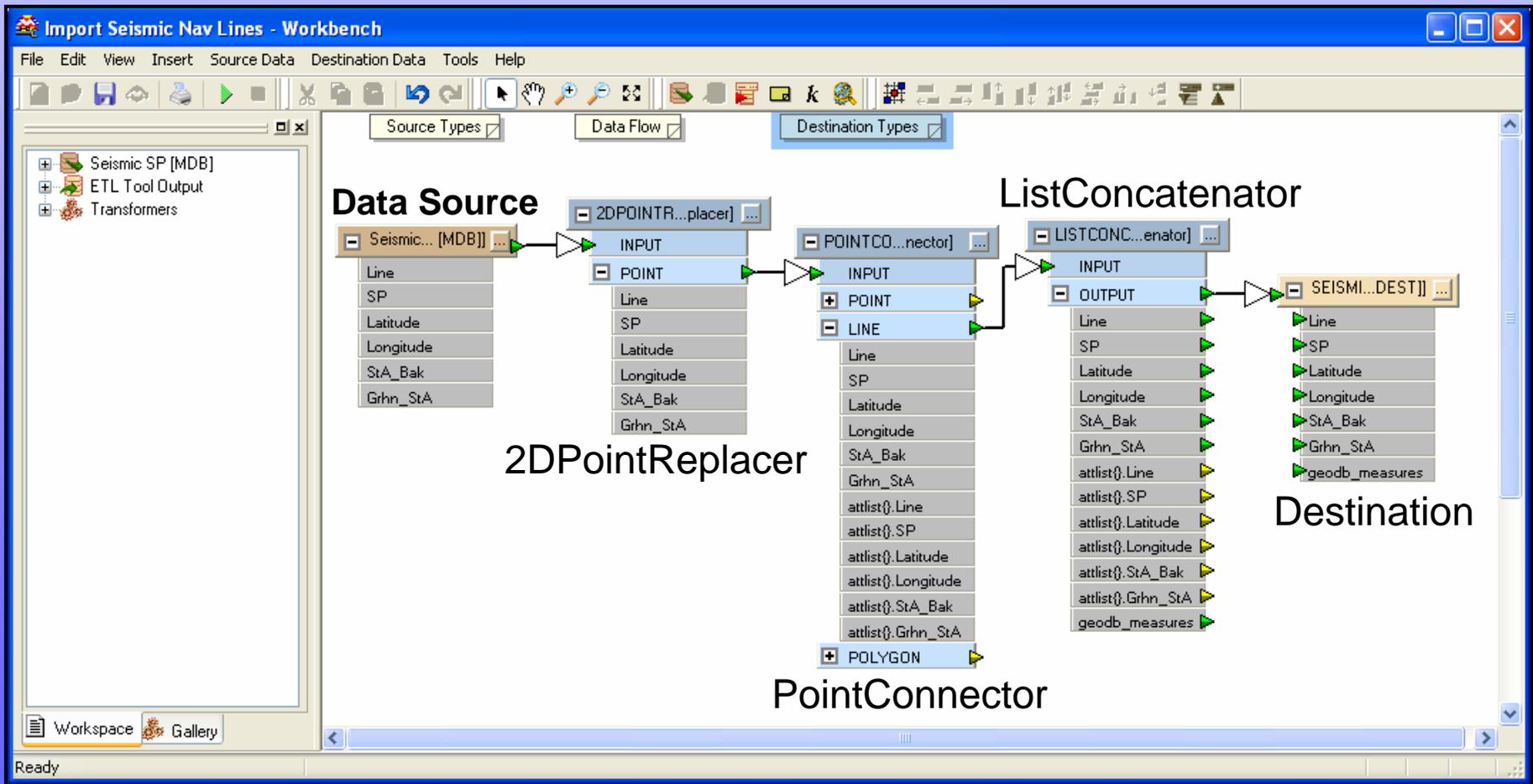
Line	SP	Latitude	Longitude
A1	120	47.9744377842	-102.049508113
A1	140	47.97124430073	-102.046402452
A1	160	47.96814330773	-102.043366193
A1	180	47.9648107266	-102.040330118
A1	200	47.96157062078	-102.037432368
A1	220	47.95837682375	-102.034259293
A1	240	47.95504397713	-102.031293301
A1	260	47.95166480135	-102.028120903
A1	280	47.94851699754	-102.02515578
A1	300	47.94541541674	-102.022191037
A1	320	47.94224427076	-102.019433347
A1	340	47.93881845813	-102.016262491
A1	360	47.93557775383	-102.013161000
A1	380	47.9323369699	-102.009991001
A1	400	47.92909609248	-102.00689029
B1	120	47.97519935251	-101.991196434
B1	140	47.97267528313	-101.995412347
B1	160	47.97035596746	-101.999719092
B1	180	47.96783603581	-102.004323894

Record: 23 of 99

Problem Statement
How do you create routes from a set of shotpoint locations stored in an Access database table?

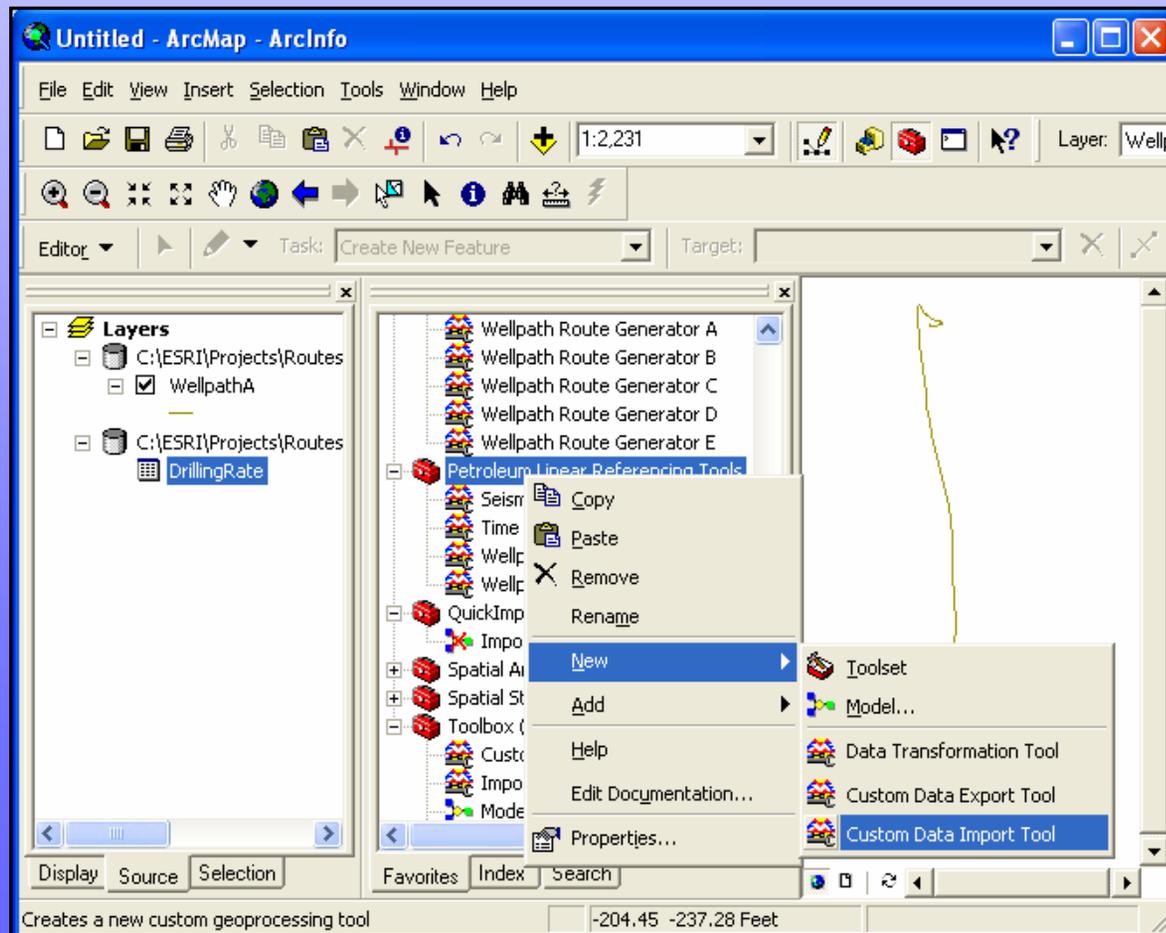
Seismic Route Builder Tool

- Create routes from data stored in a Microsoft Access table
- Uses latitude and longitude fields to create points (shotpoints)
- Uses shotpoint values for measures



Seismic Route Builder Tool

- Start with a new Data Interoperability custom import tool
- Drag transformers (2DPointReplacer, etc) from the list of transformers
- Configure the properties of each transformer (see following slides)



Seismic Route Builder Tool

- Start with a new Data Interoperability custom import tool
- Drag transformers (2DPointReplacer, etc) from the list of transformers
- Configure the properties of each transformer (see following slides)

The screenshot displays the 'Points to Polyline - Workbench' software interface. On the left, a tree view lists various transformers, with 'PointConnector' highlighted. The main workspace shows a workflow diagram with the following components:

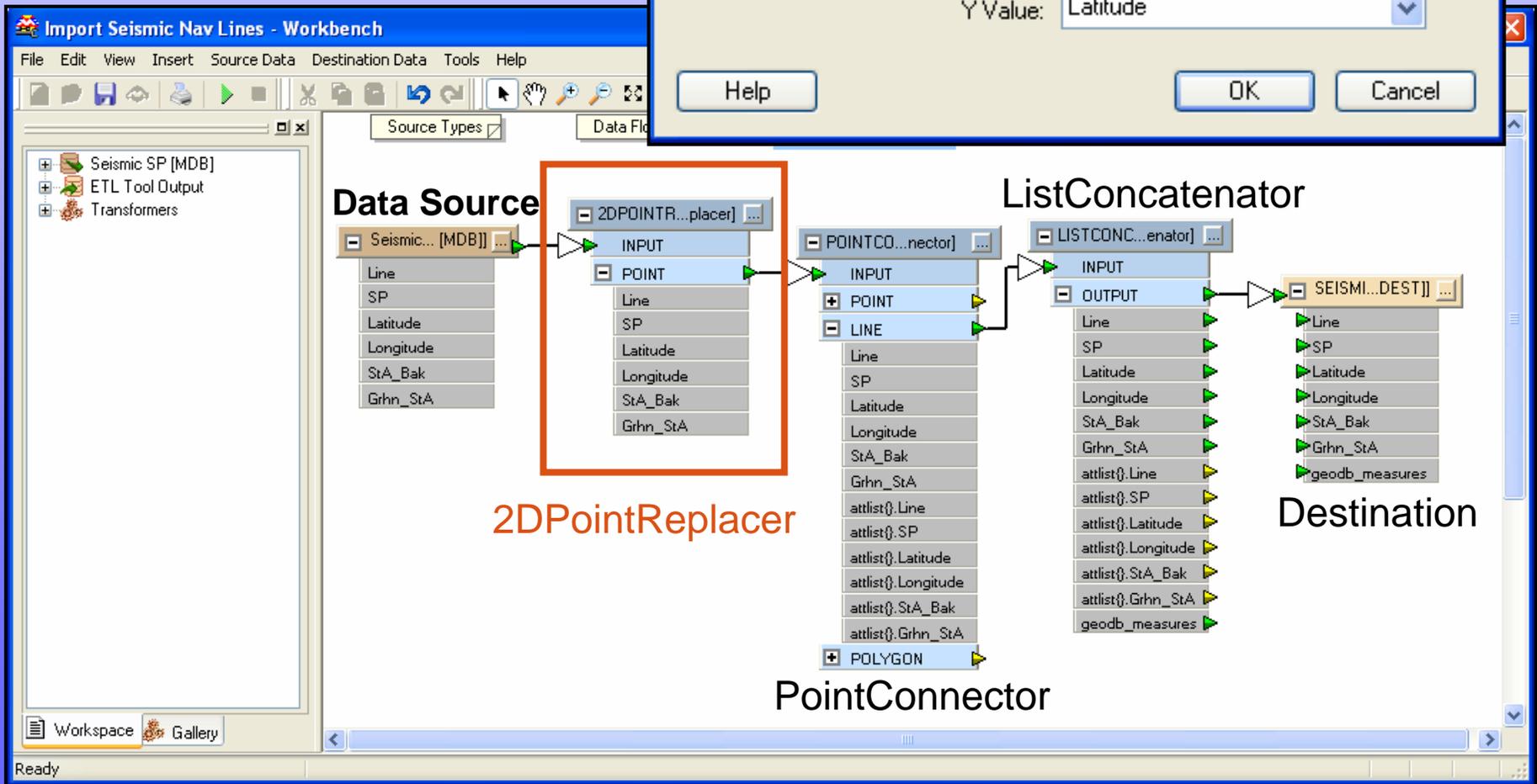
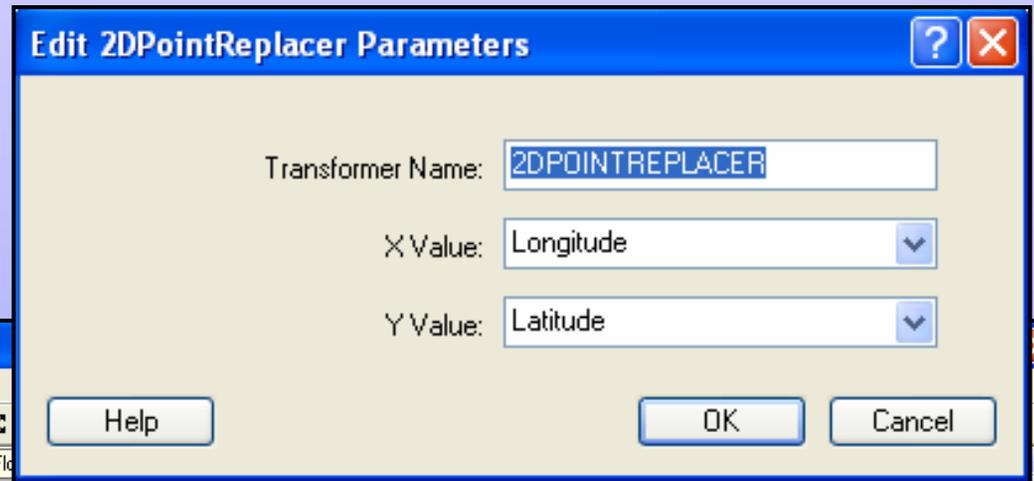
- Source Data:** A data source named 'Seismic... [MDB]' with properties: Line, SP, Latitude, Longitude, StA_Bak, Grhn_StA.
- 2DPointReplacer:** A transformer that takes the source data and outputs a 'POINT' with properties: Line, SP, Latitude, Longitude, StA_Bak, Grhn_StA.
- PointConnector:** A transformer that takes the output of the 2DPointReplacer and outputs a 'LINE' with properties: Line, SP, Latitude, Longitude, StA_Bak, Grhn_StA, attlist(). Line, attlist(). SP, attlist(). Latitude, attlist(). Longitude, attlist(). StA_Bak, attlist(). Grhn_StA.
- ListConcatenator:** A transformer that takes the output of the PointConnector and outputs a 'LISTCONC...enator' with properties: Line, SP, Latitude, Longitude, StA_Bak, Grhn_StA, attlist(). Line, attlist(). SP, attlist(). Latitude, attlist(). Longitude, attlist(). StA_Bak, attlist(). Grhn_StA, geodb_measures.
- Destination:** A final destination named 'SEISMI...DEST]' with properties: Line, SP, Latitude, Longitude, StA_Bak, Grhn_StA, geodb_measures.

The workflow is connected by arrows indicating the flow of data from left to right. The status bar at the bottom shows 'Ready'.

Seismic Route Builder – 2DPointReplacer

Creates points from x, y fields

Configure by setting the properties

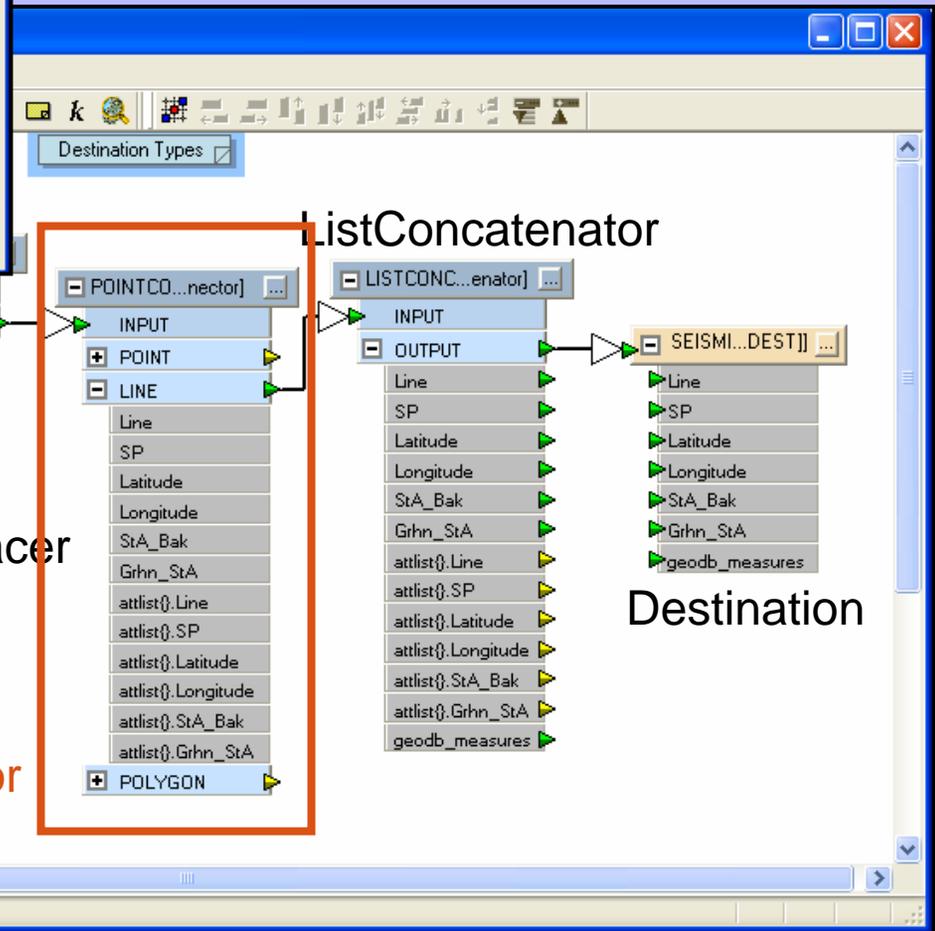
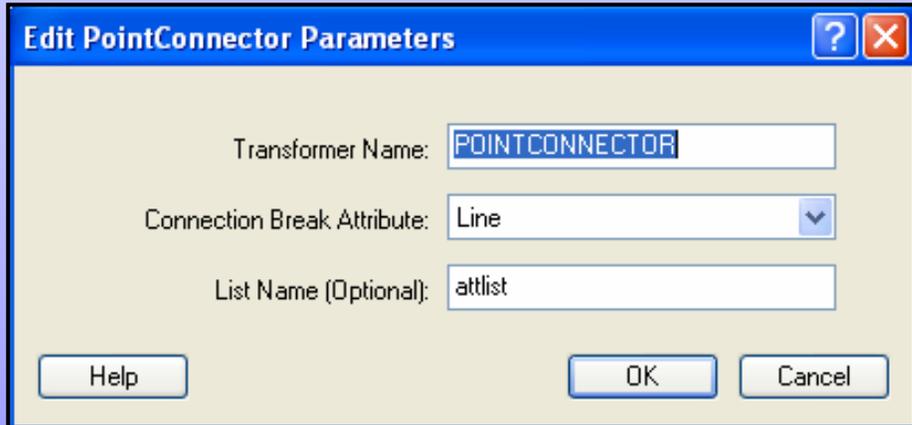


Seismic Route Builder - PointConnector

Constructs lines from input points

Uses an attribute for line breaks

Field attributes are saved in a list for each point



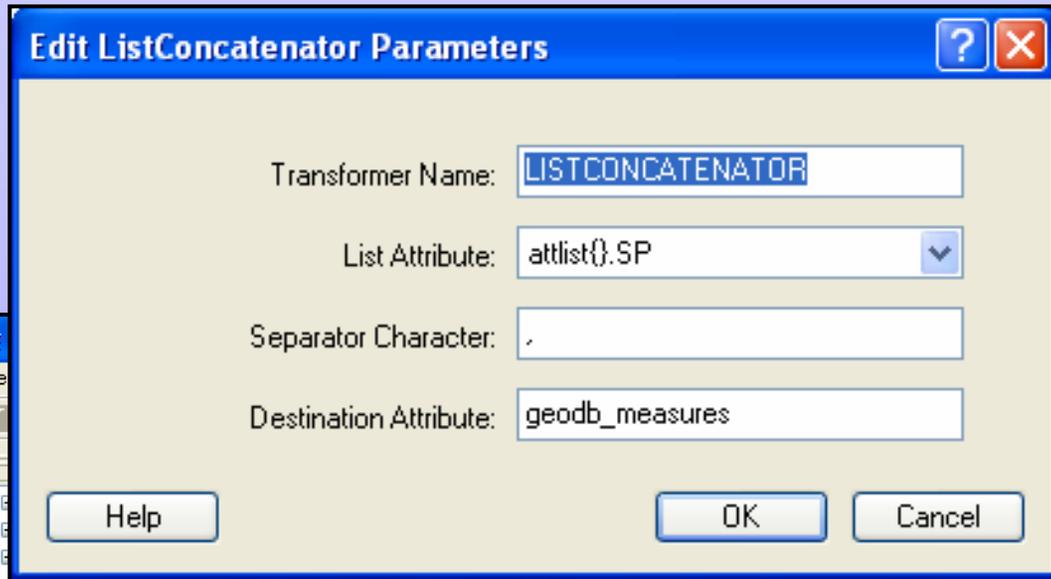
2DPointReplacer

PointConnector

ListConcatenator

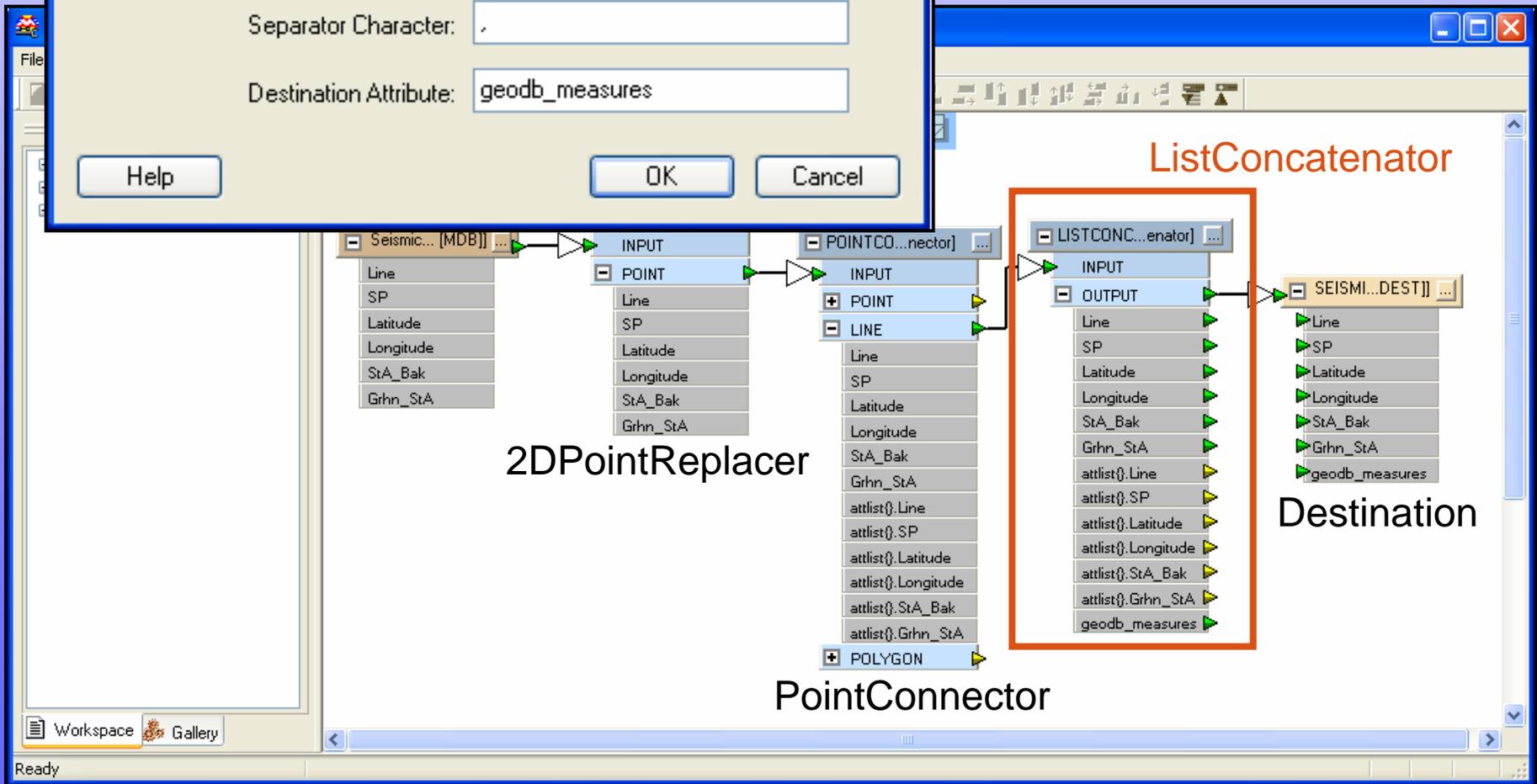
Destination

Seismic Route Builder - ListConcatenator



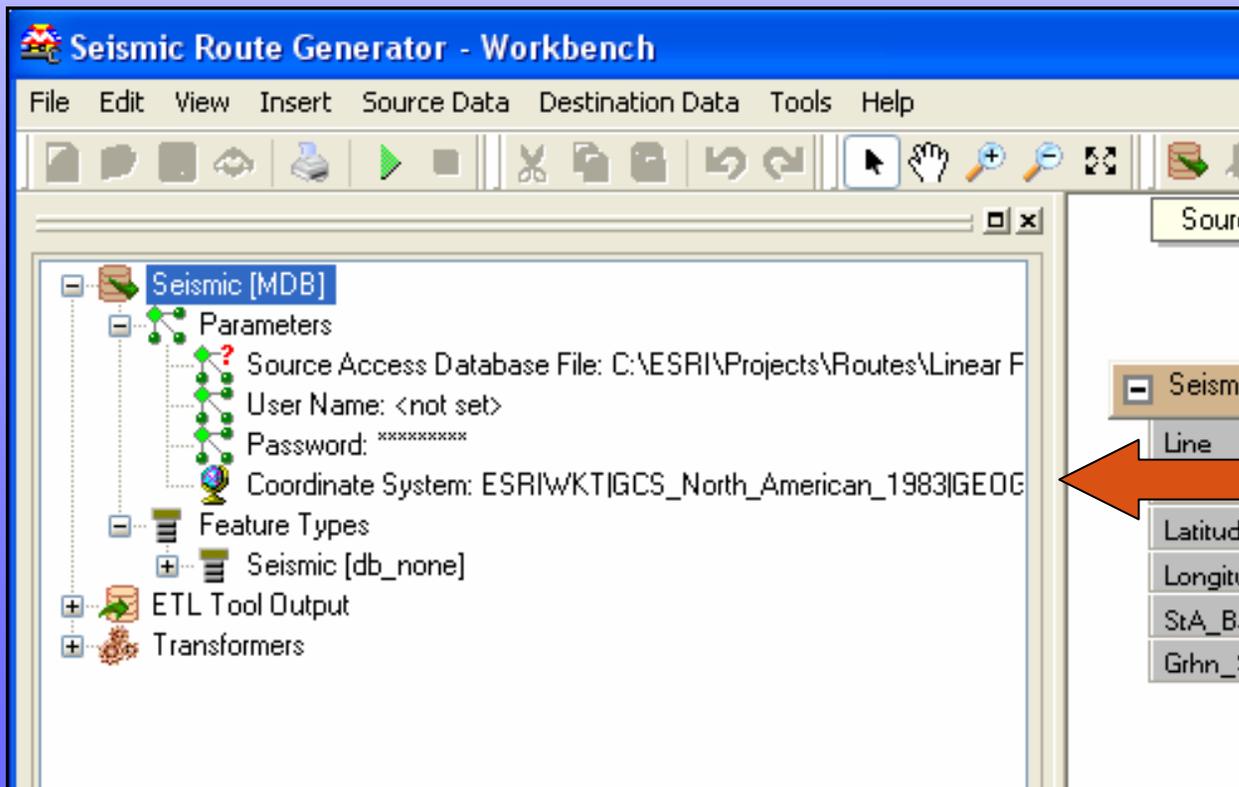
Adds a list to an output attribute

Puts shotpoint values into the geodb_measures attribute



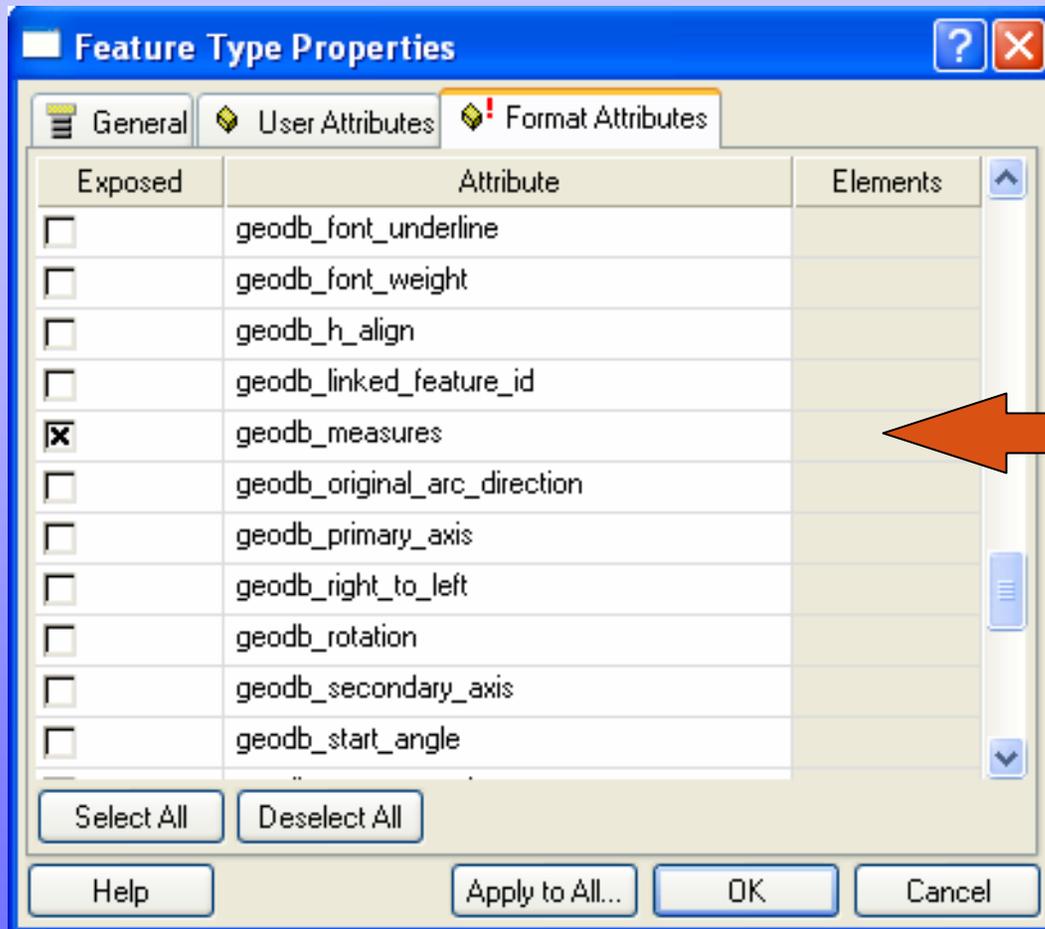
Seismic Route Builder - Parameters

Tool Parameters



Set the coordinate reference system to match the source data

Seismic Route Builder



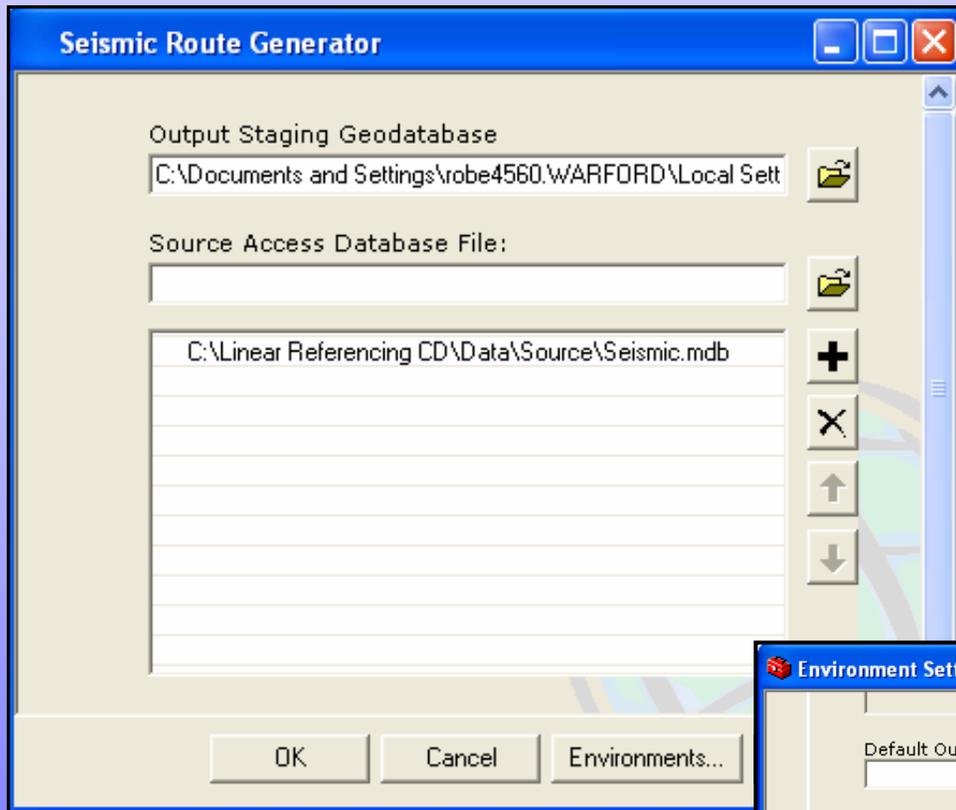
Destination Properties

Expose the geodb_measures attribute.



This is present for features that have measures when reading. To write measures, you simply build this list with one value for each vertex in the feature being written. This is a comma-separated list of floating values that correspond to the vertex measures. The first value is for the first vertex, second for the second, and so on.

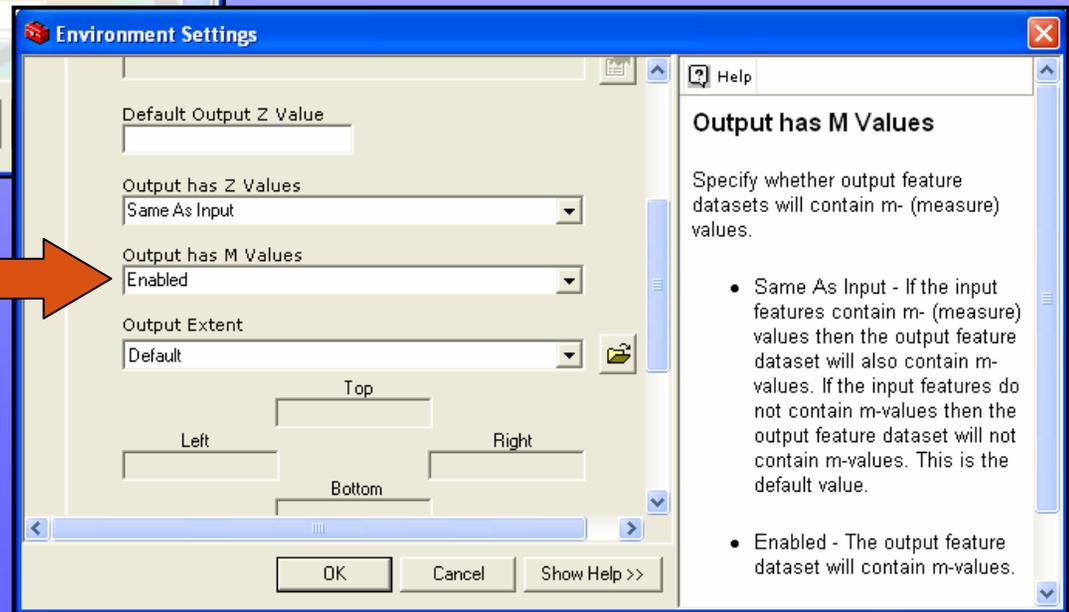
Seismic Route Builder



Run the tool to create seismic routes

1. Double click on the tool
2. Set the properties and environment
3. Click OK to start processing

Environment Settings



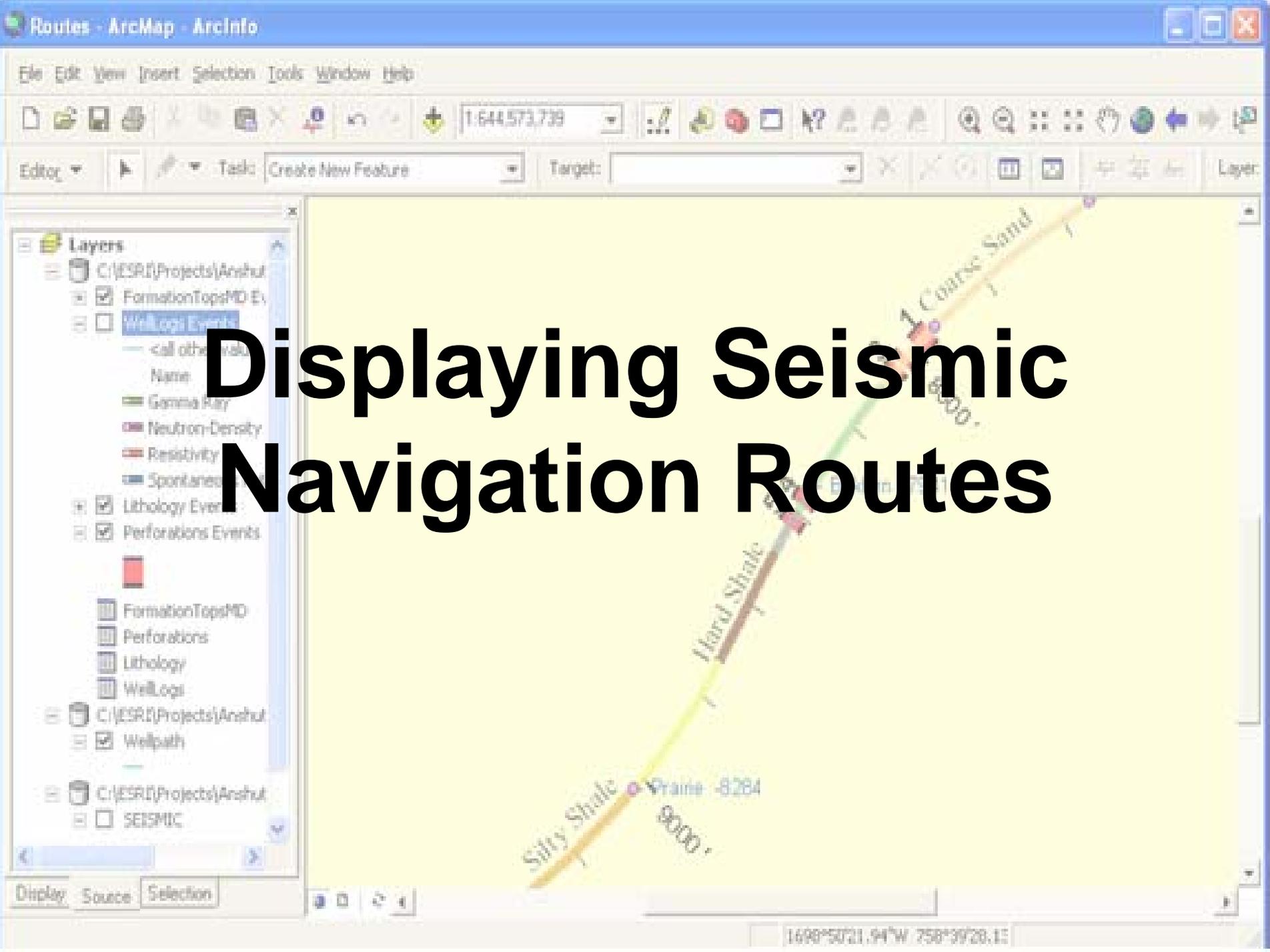
Set the “Output has M Values” property to “Enabled”



Output has M Values

Specify whether output feature datasets will contain m- (measure) values.

- Same As Input - If the input features contain m- (measure) values then the output feature dataset will also contain m-values. If the input features do not contain m-values then the output feature dataset will not contain m-values. This is the default value.
- Enabled - The output feature dataset will contain m-values.



Displaying Seismic Navigation Routes

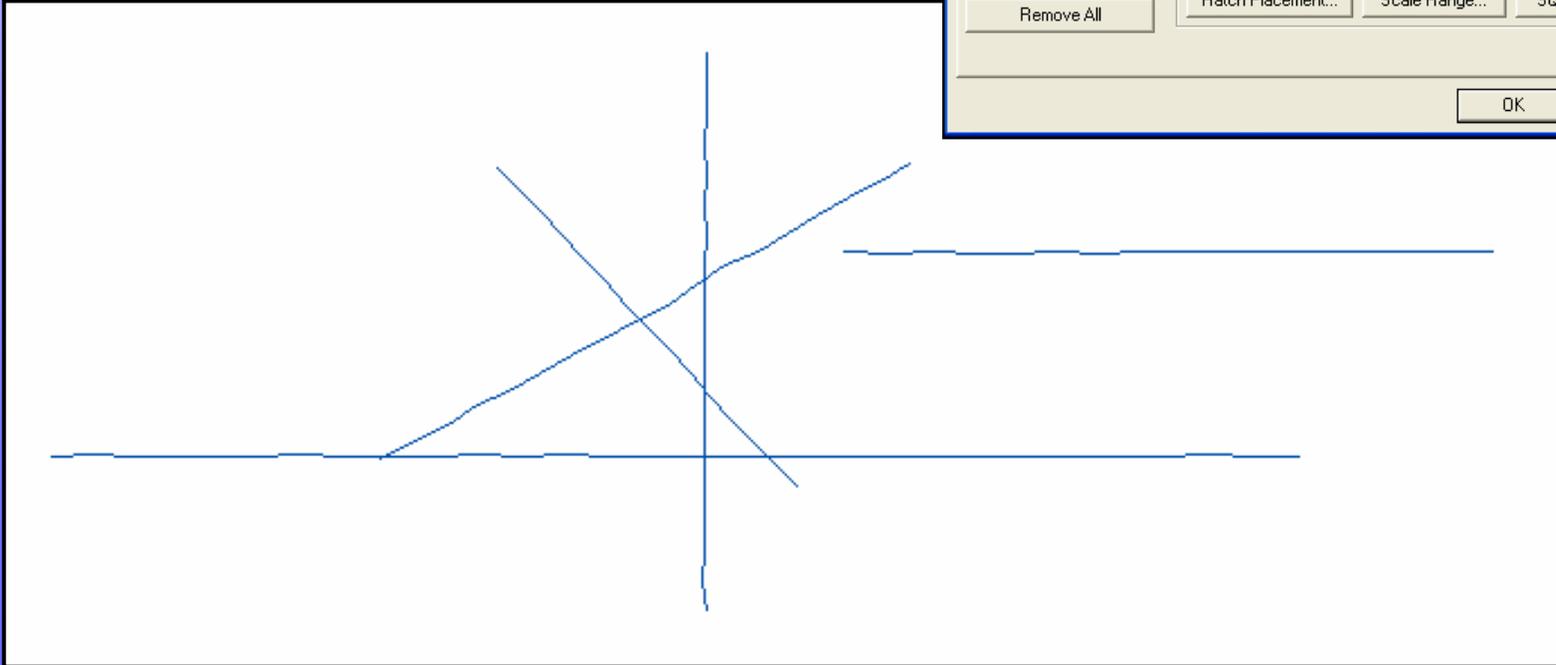
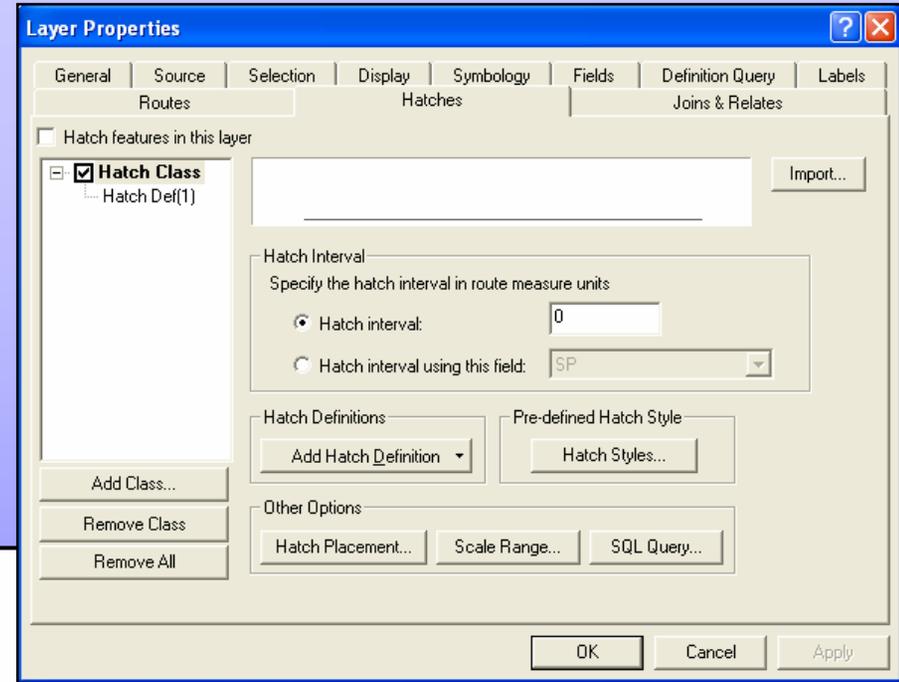
Layers

- C:\ESRI\Projects\Anshut
 - FormationTopsMD E
 - WellLogs Events
 - Call other valu
 - Name
 - Gamma Ray
 - Neutron Density
 - Resistivity
 - Spontaneous
 - Lithology Ever
 - Perforations Events
 - FormationTopsMD
 - Perforations
 - Lithology
 - WellLogs
- C:\ESRI\Projects\Anshut
 - Wellpath
- C:\ESRI\Projects\Anshut
 - SEISMIC

Display Source Selection

Displaying Seismic Routes

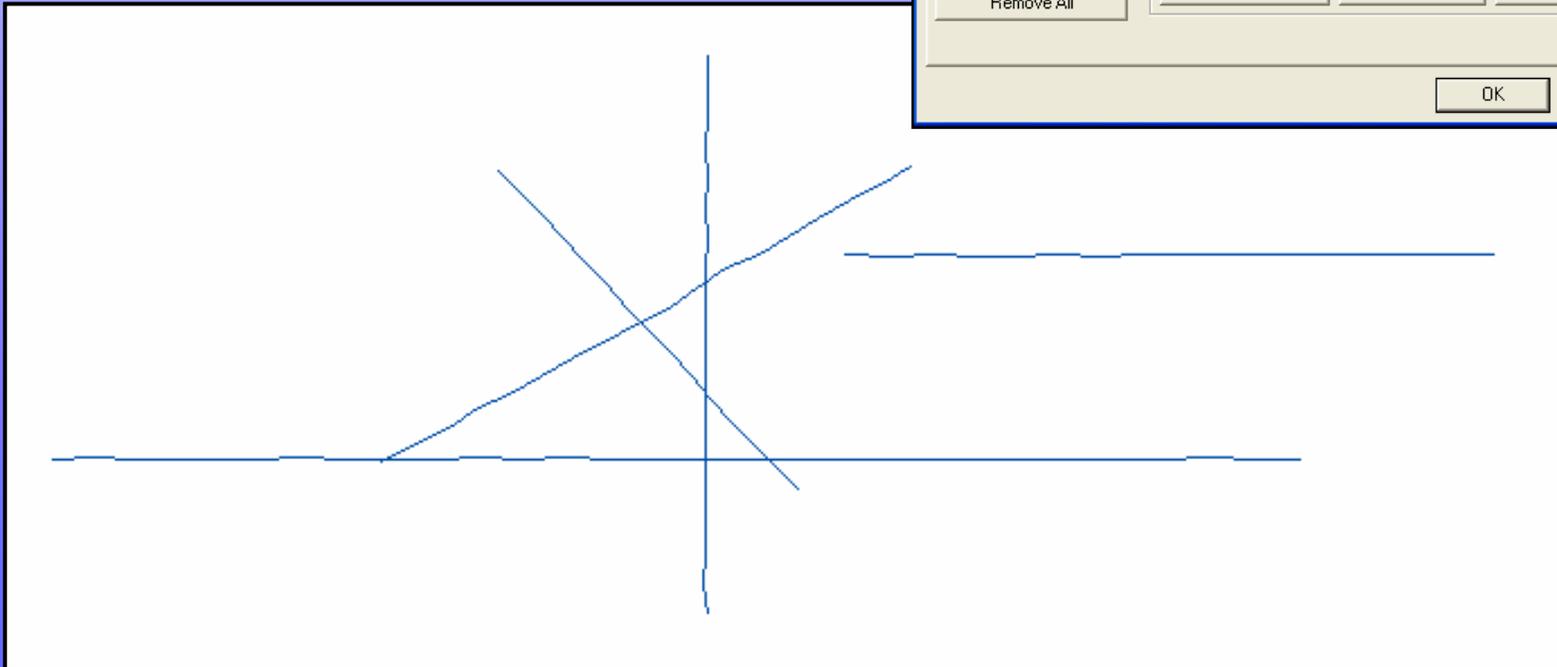
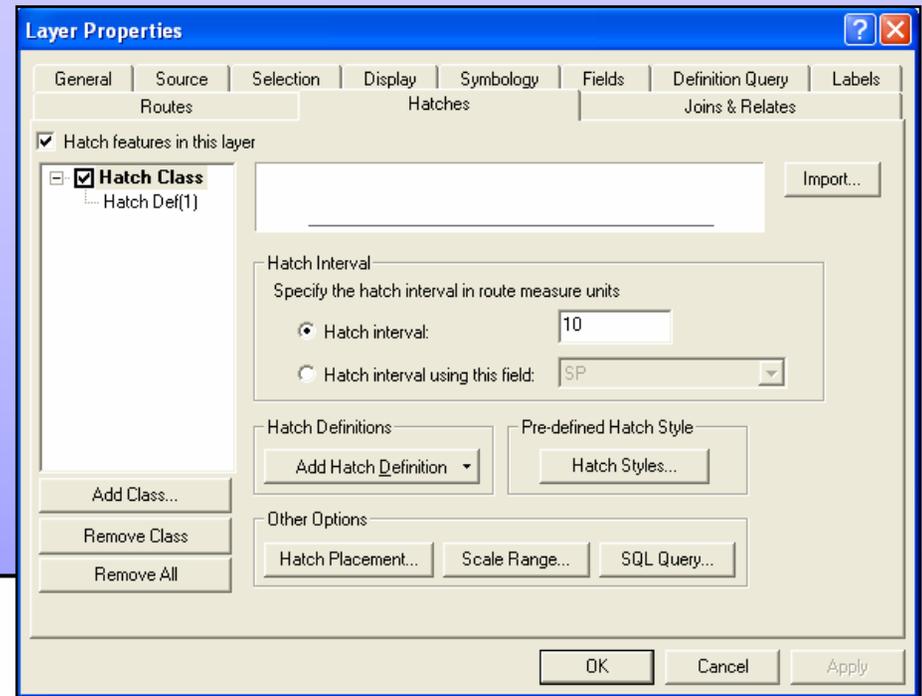
Route and hatch tabs are automatically available in the route layer properties dialog. But the “Hatch features” check box is not checked by default.



Displaying Seismic Routes – Hatch Class

Check the “Hatch features”
check box.

Set the hatch interval to 10



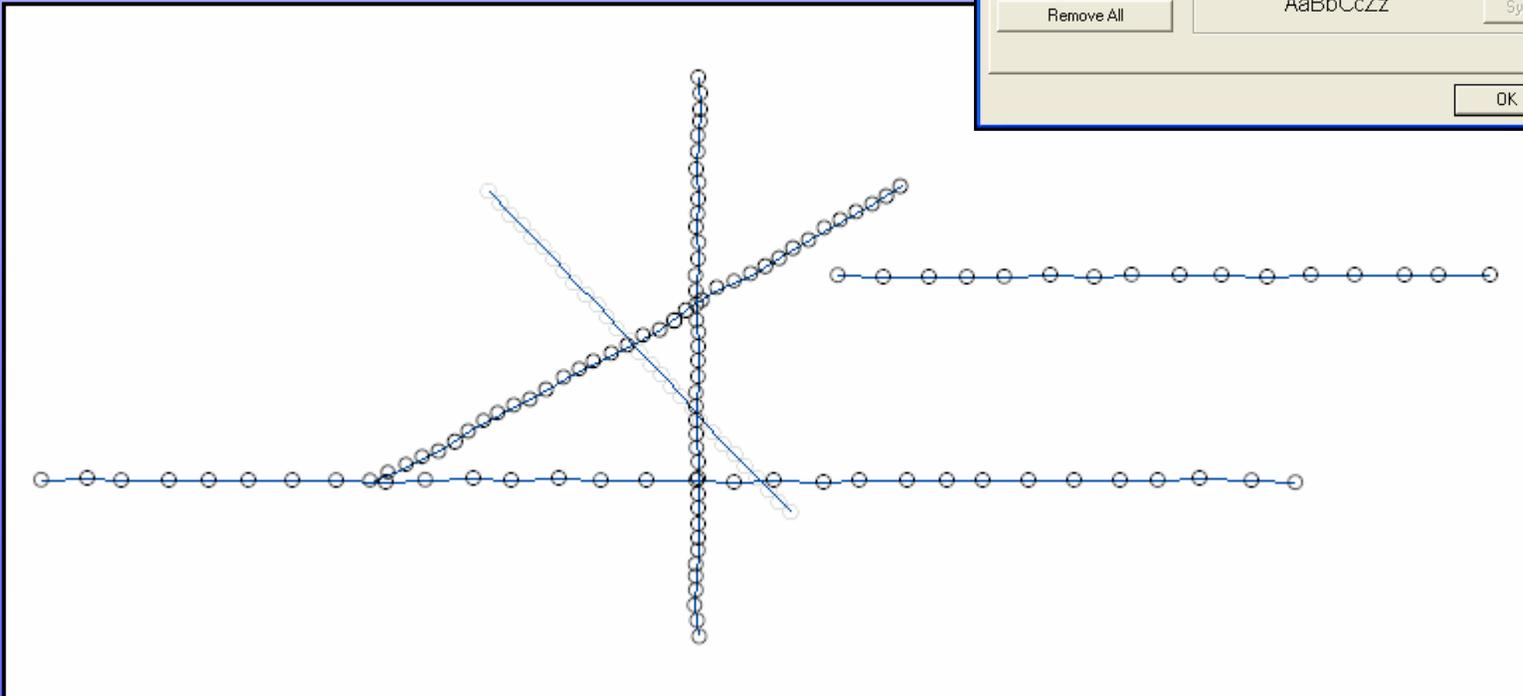
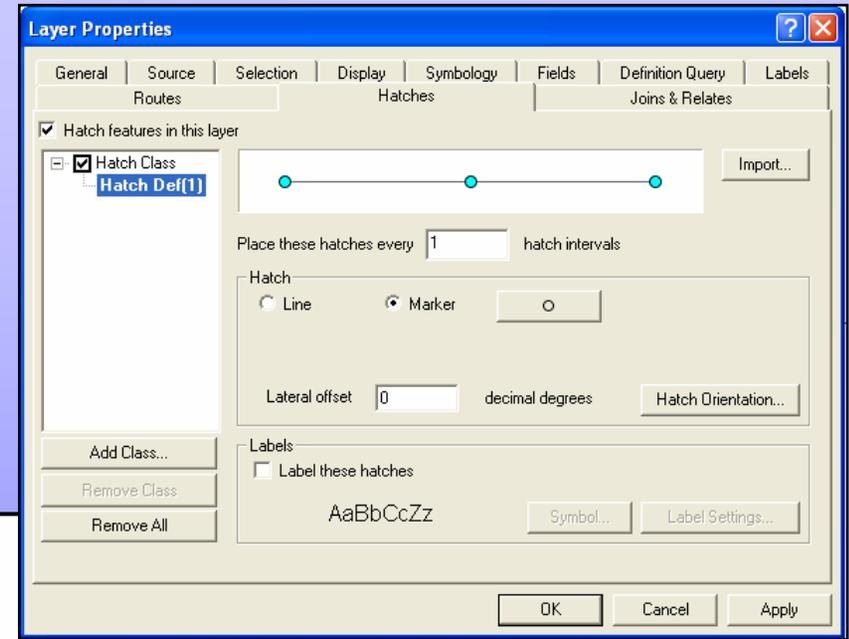
Displaying Seismic Routes – Hatch Definition 1

Click on Hatch Definition

Place hatches every 1 hatch interval

Use a marker symbol

Set the symbol properties to use a hollow circle, size 8



Displaying Seismic Routes – Hatch Definition 5

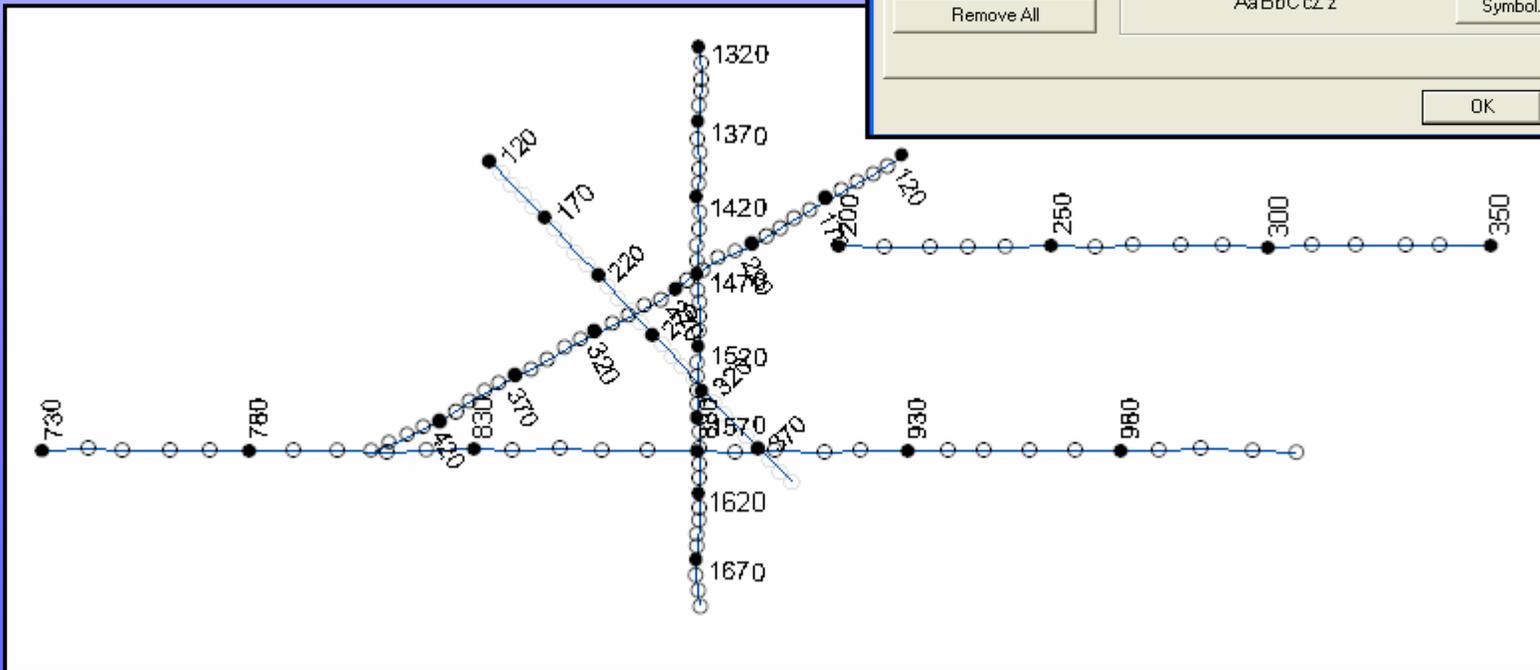
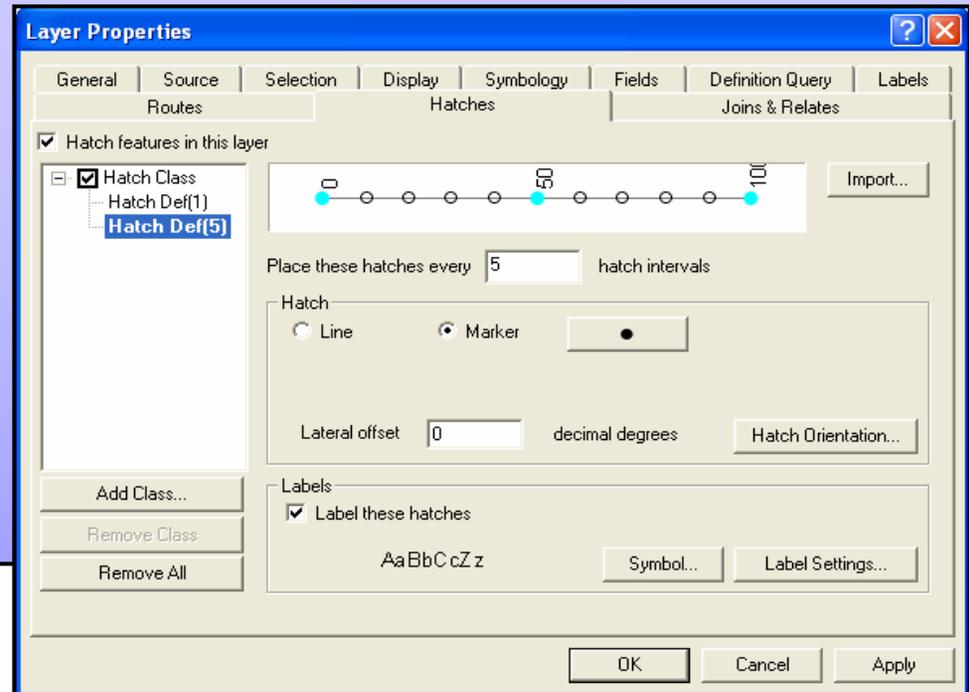
Create a new hatch definition

Place hatches every 5 hatch interval

Use a marker symbol

Set the symbol properties to use a black circle, size 8

Label the hatches with 10pt text



Displaying Seismic Routes – Hatch End Definition

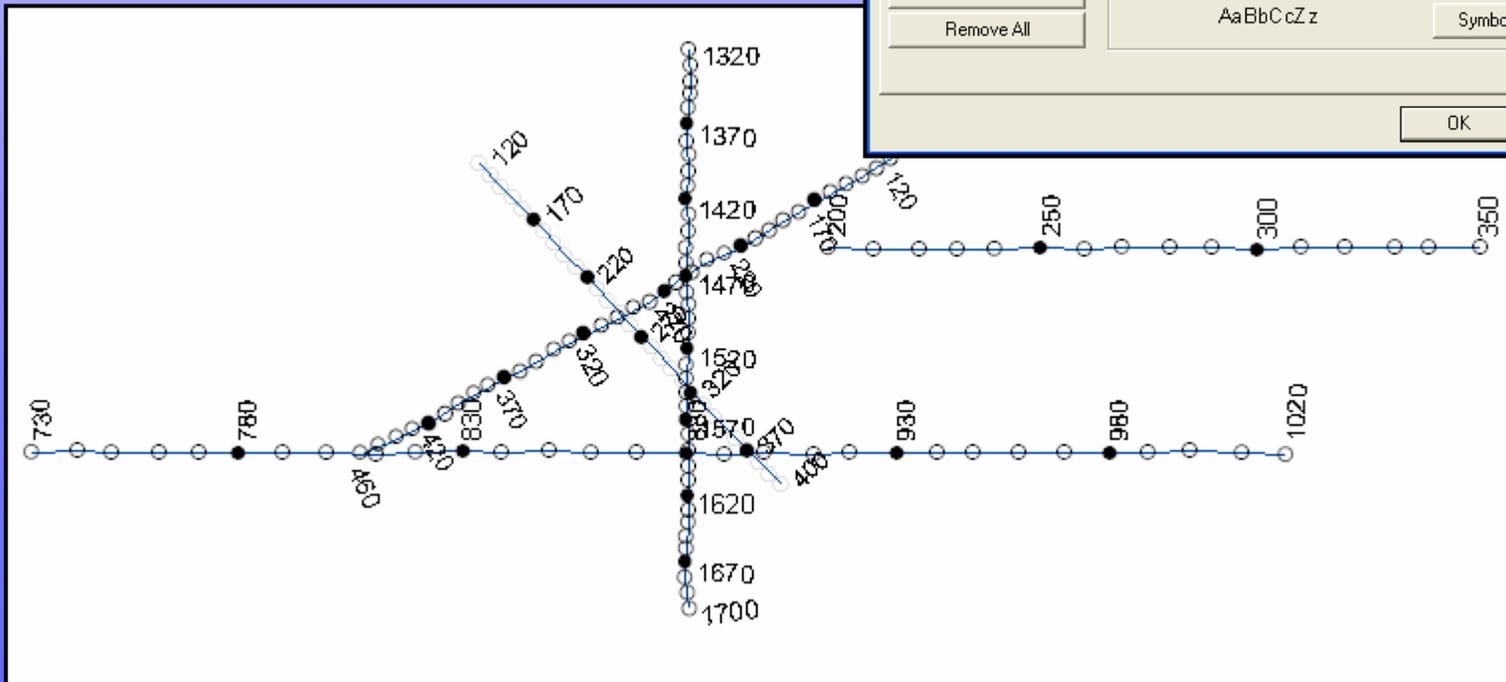
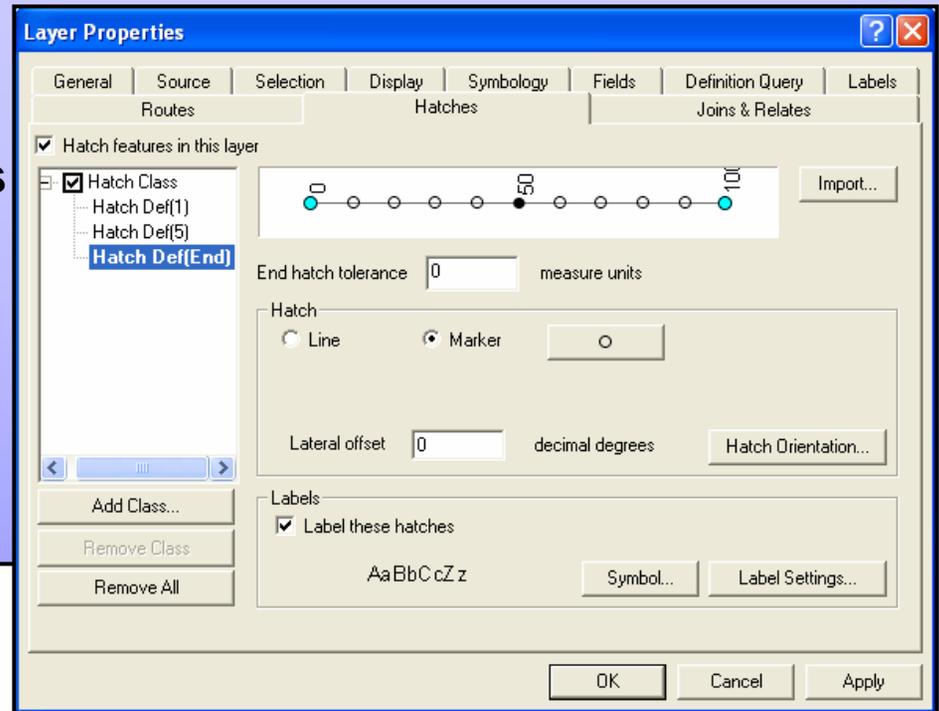
Create a new end hatch definition

Place hatches every 0 hatch intervals

Use a marker symbol

Set the symbol properties to use a hollow circle, size 8

Label the hatches with 10pt text



Displaying Seismic Routes – Line Labeling

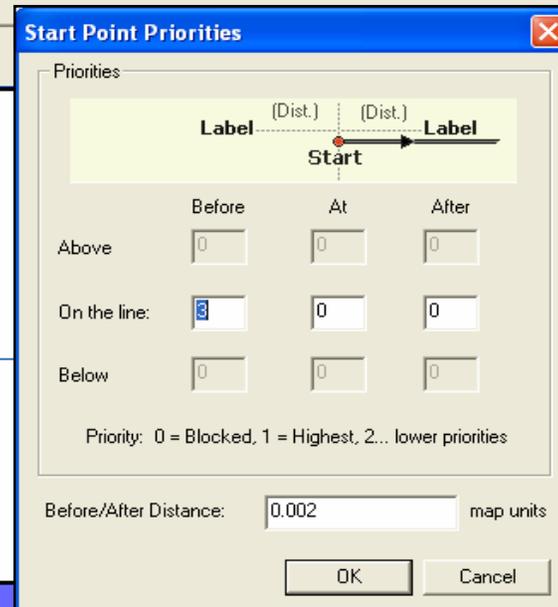
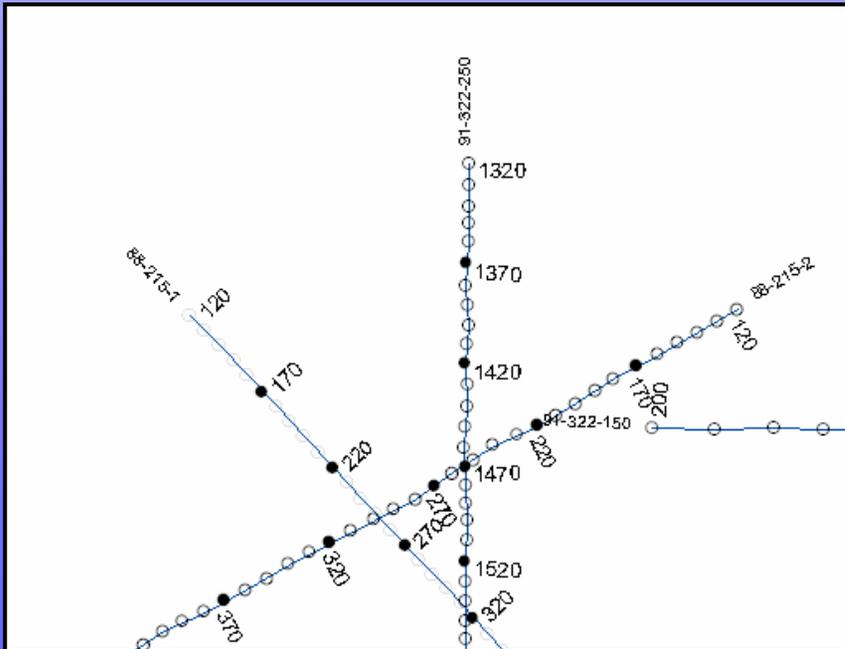
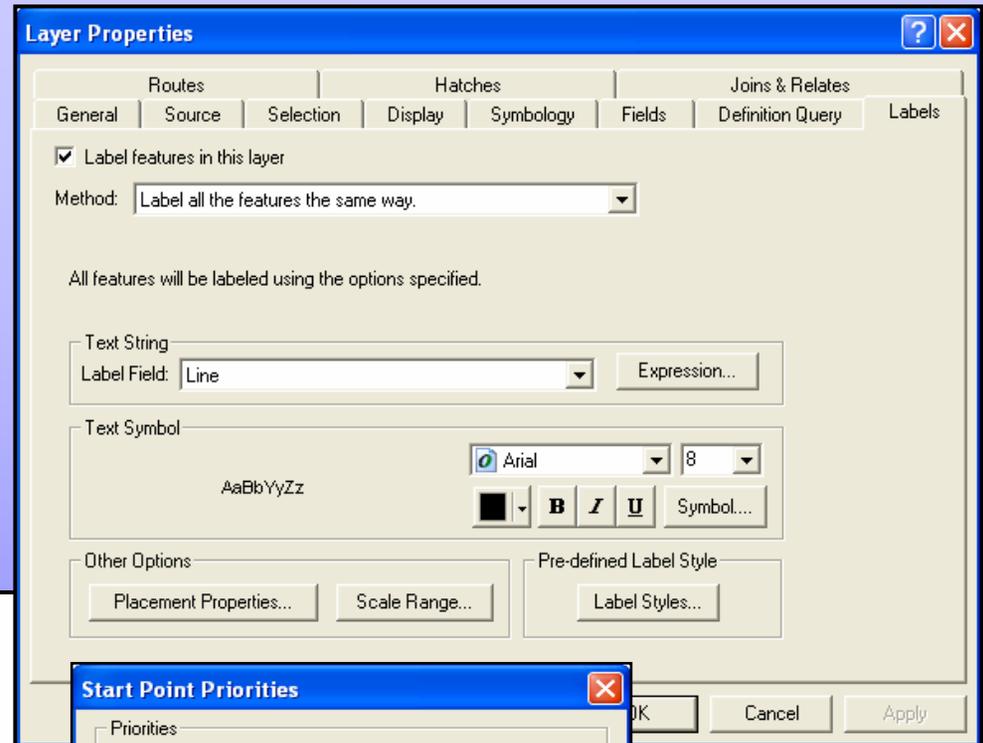
Click on the labels tab

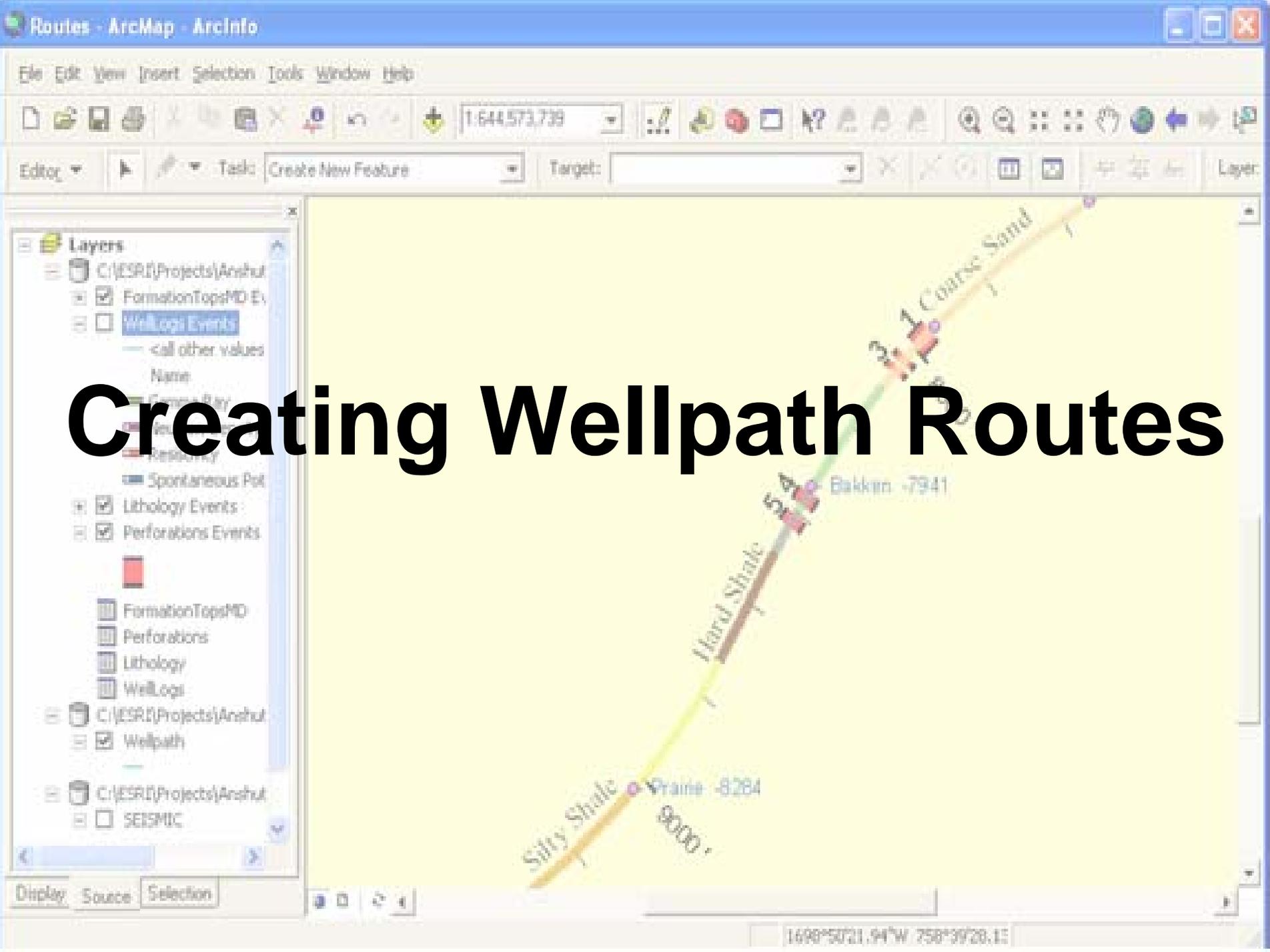
Check label features

Label field “Line”

Set the font size to 8pt

Set placement properties





Creating Wellpath Routes

Wellpath Data

Name	MD	Inclination	Azimuth	TVD	Northing	Easting	TVDSS
Well C	0	0	0	0	0	0	7178
Well C	2528	0	0	2528	0	0	4650
Well C	2730	1.63	332.76	2729.97275339	2.55	-1.32	4448.02724661
Well C	3012	1.35	324.6	3011.87744139	8.83	-5.08	4166.12255861
Well C	3296	1.1	333.23	3296.81255041	13.99	-8.24	3882.18744959
Well C	3577	1.05	324.33	3576.76328198	18.49	-10.96	3601.23671802
Well C	3844	0.9	304.68	3843.72529398	21.67	-14.11	3334.27470602
Well C	3876	1.1	306.49	3875.72040478	22	-14.56	3302.27959522
Well C	3907	0.9	309.26	3906.71566941	22.33	-14.99	3271.28433059
Well C	3939	1.08	300.32	3938.71089866	22.64	-15.44	3239.28910134
Well C	3970	1.03	298.49	3969.7056435	22.92	-15.94	3208.29435650
Well C	4001	1.45	310.73	4000.69836792	23.31	-16.48	3177.30163208
Well C	4033	1.85	298.58	4032.68513229	23.82	-17.24	3145.31486771
Well C	4065	2.76	304.06	4064.65894255	24.5	-18.34	3113.34105745
Well C	4094	3.03	300.38	4093.62193037	25.28	-19.58	3084.37806963
Well C	4125	3.8	297.85	4124.5666674	26.17	-21.19	3053.43333260
Well C	4155	4.32	296.78	4154.49128267	27.14	-23.08	3023.50871733
Well C	4186	4.75	291.69	4185.39428265	28.14	-25.31	2992.60571735
Well C	4216	5.2	288.24	4215.28125256	29.03	-27.76	2962.71874744
Well C	4248	5.85	286.48	4247.13244195	29.94	-30.7	2930.86755805
Well C	4279	6.65	283.53	4277.94801845	30.81	-33.96	2900.05198155
Well C	4310	7.53	282.31	4308.71069207	31.67	-37.69	2869.28930793
Well C	4342	8.48	282.35	4340.39851856	32.62	-42.04	2837.60148144
Well C	4372	9.27	281.98	4370.03910451	33.59	-46.57	2807.96089549

Record: 1 of 83

Problem Statement
 How do you create routes from a set of x, y, z locations stored in a Microsoft Access table?

Wellpath Route Builder Tool

- Creates 3D routes from data stored in a Microsoft Access table
- Uses x (easting) and y (northing), and TVDSS fields to create points
- Uses measured depths for measure values

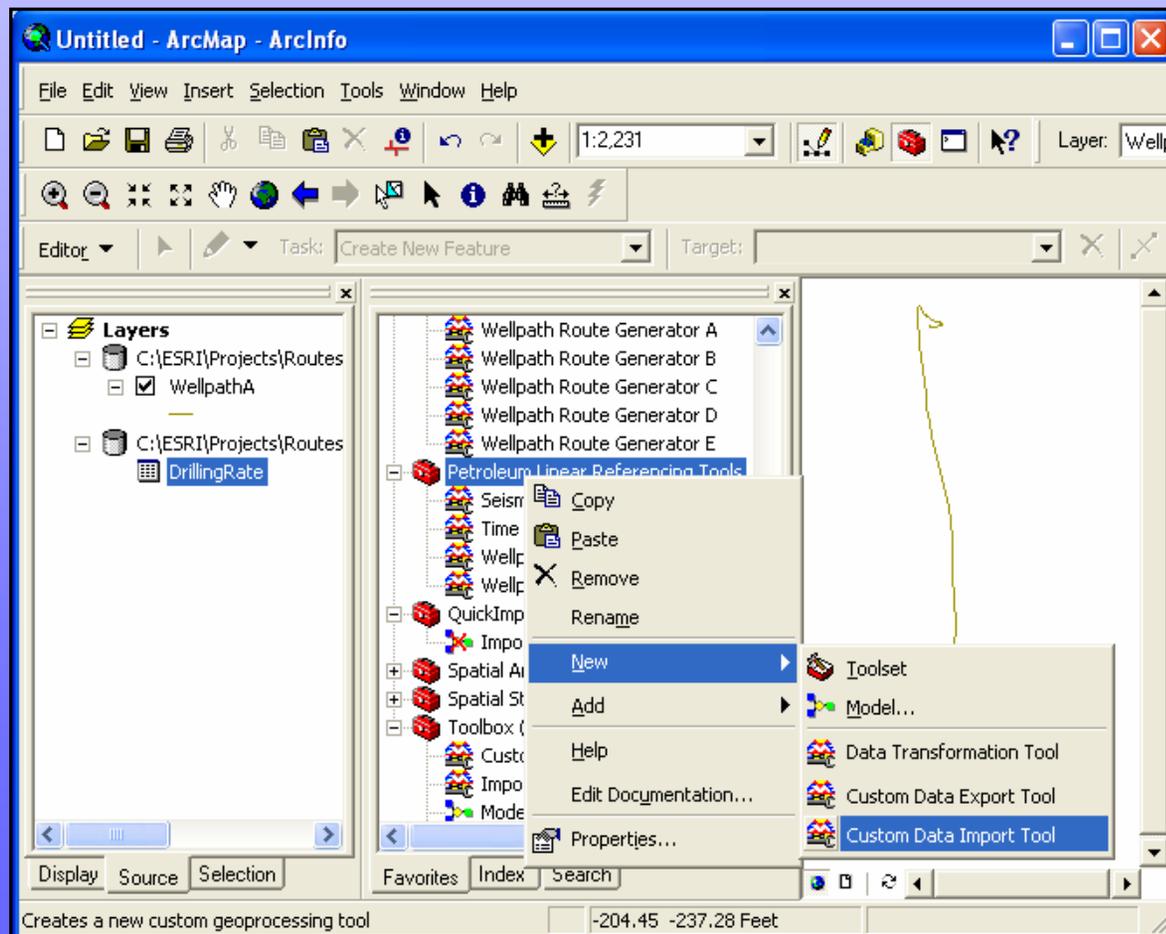
The screenshot displays the 'Wellpath Route Generator - Workbench' software interface. The main workspace shows a data flow diagram with the following components and connections:

- Data Source:** A table named 'Wellpat...MDB]' is selected in the 'Source Types' pane. Its fields are listed as: geodb_oid, Wellbore, MD, Incl, Azimuth, TVD, Northing, NS, Easting, EW, DLS, VS, TVDSS, and OBJECTID.
- 3DPointReplacer:** This tool receives input from the 'Wellpat...MDB]' table. It has an 'INPUT' and a 'POINT' output.
- PointConnector:** This tool receives input from the 'POINT' output of the '3DPointReplacer'. It has 'INPUT', 'POINT', 'LINE', and 'POLYGON' outputs.
- ListConcatenator:** This tool receives input from the 'POINT', 'LINE', and 'POLYGON' outputs of the 'PointConnector'. It has an 'INPUT' and an 'OUTPUT'.
- Destination:** The 'OUTPUT' of the 'ListConcatenator' is directed to a table named 'Wellpat...DEST]'. Its fields are listed as: Wellbore and geodb_measures.

The interface includes a menu bar (File, Edit, View, Insert, Source Data, Destination Data, Tools, Help), a toolbar with various icons, and a left-hand pane showing a project tree with folders for 'Seismic SP [MDB] (0)', 'Seismic SP [MDB] (1)', 'Seismic SP [GEODATAB]', 'ETL Tool Output', and 'Transformers'. The status bar at the bottom indicates 'Ready'.

Wellpath Route Builder Tool

- Start with a new Data Interoperability custom import tool
- Drag transformers (2DPointReplacer, etc) from the list of transformers
- Configure the properties of each transformer (see following slides)



Wellpath Route Builder Tool

- Start with a new Data Interoperability custom import tool
- Drag transformers (2DPointReplacer, etc) from the list of transformers
- Configure the properties of each transformer (see following slides)

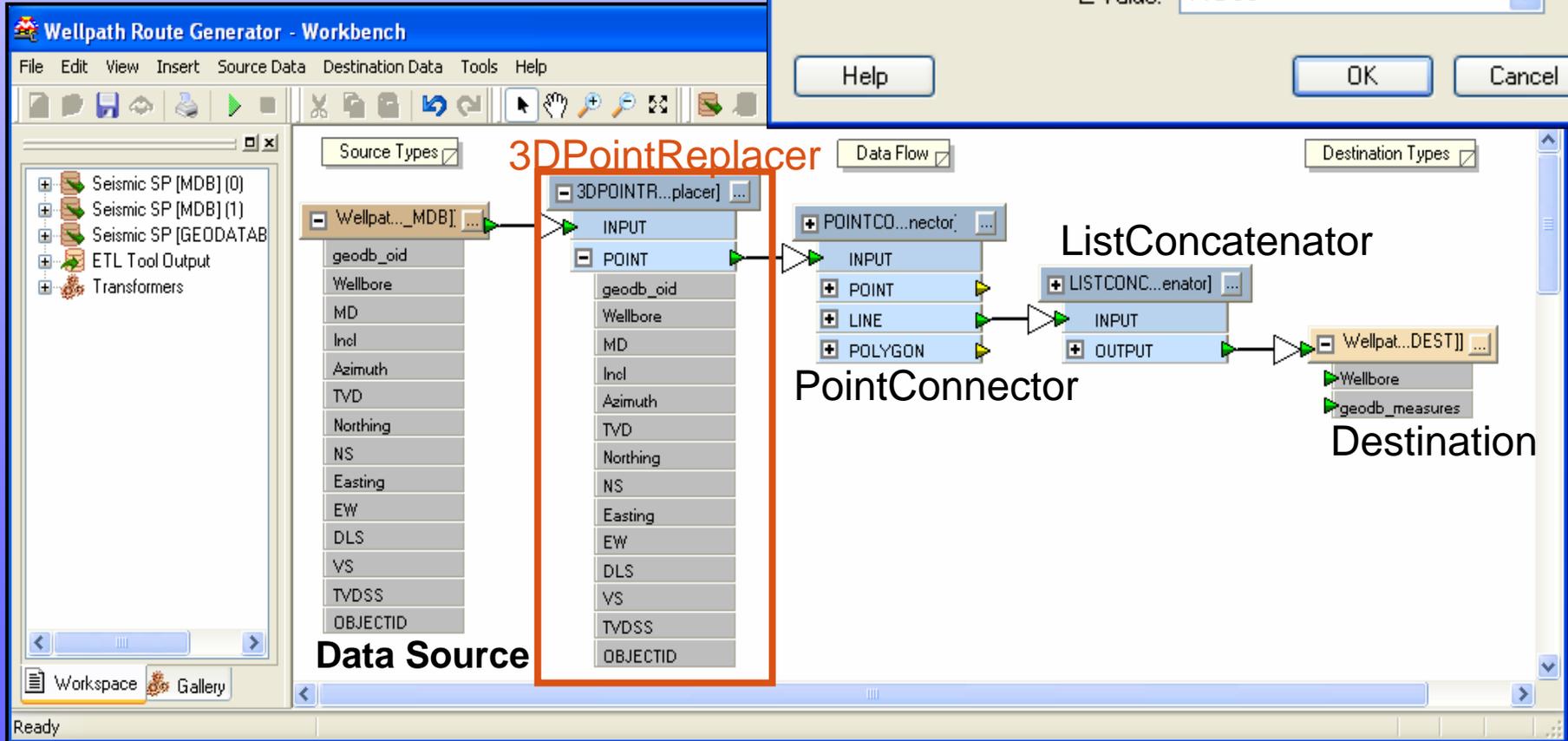
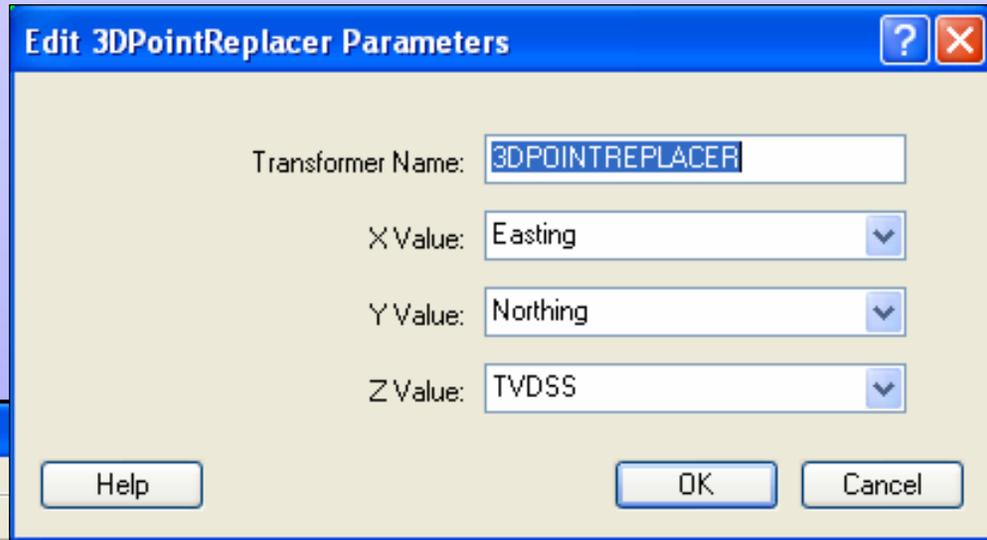
The screenshot displays the 'Points to Polyline - Workbench' application. On the left, a tree view shows various tool categories, with 'PointConnector' selected. The main workspace shows a data flow diagram with the following components and connections:

- 2DPointReplacer**: A transformer box with 'INPUT' and 'POINT' ports. The 'POINT' port is connected to the 'INPUT' port of the 'PointConnector'.
- PointConnector**: A transformer box with 'INPUT' and 'OUTPUT' ports. The 'INPUT' port is connected to the 'POINT' port of the '2DPointReplacer'. The 'OUTPUT' port is connected to the 'INPUT' port of the 'ListConcatenator'.
- ListConcatenator**: A transformer box with 'INPUT' and 'OUTPUT' ports. The 'INPUT' port is connected to the 'OUTPUT' port of the 'PointConnector'. The 'OUTPUT' port is connected to the 'Wellpat...DEST]]' destination.
- Destination**: A box labeled 'Wellpat...DEST]]' with two sub-items: 'Wellbore' and 'geodb_measures'.

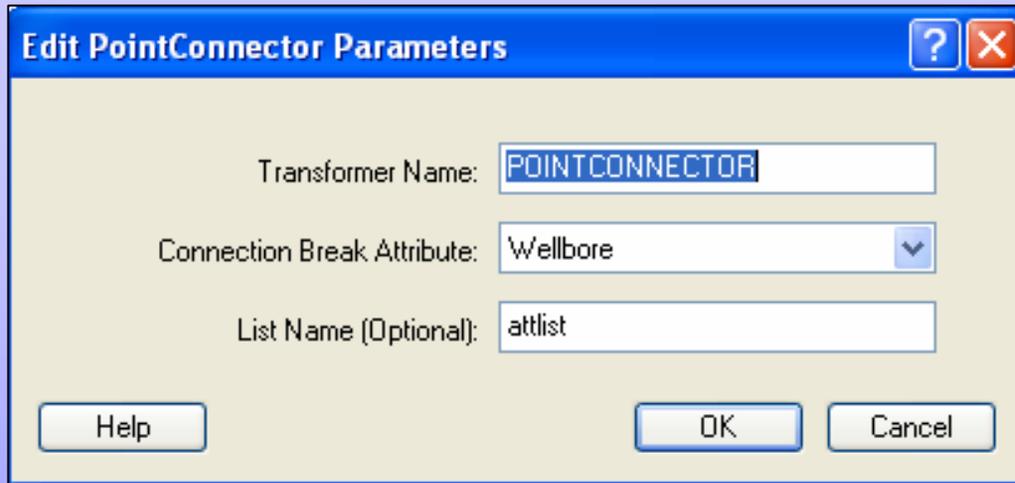
The 'Destination Types' dropdown is set to 'Wellbore'. The 'Data Flow' dropdown is set to 'Data Flow'. The 'Tools' menu is open, showing various tool icons.

Wellpath Route Builder – 3DPointReplacer

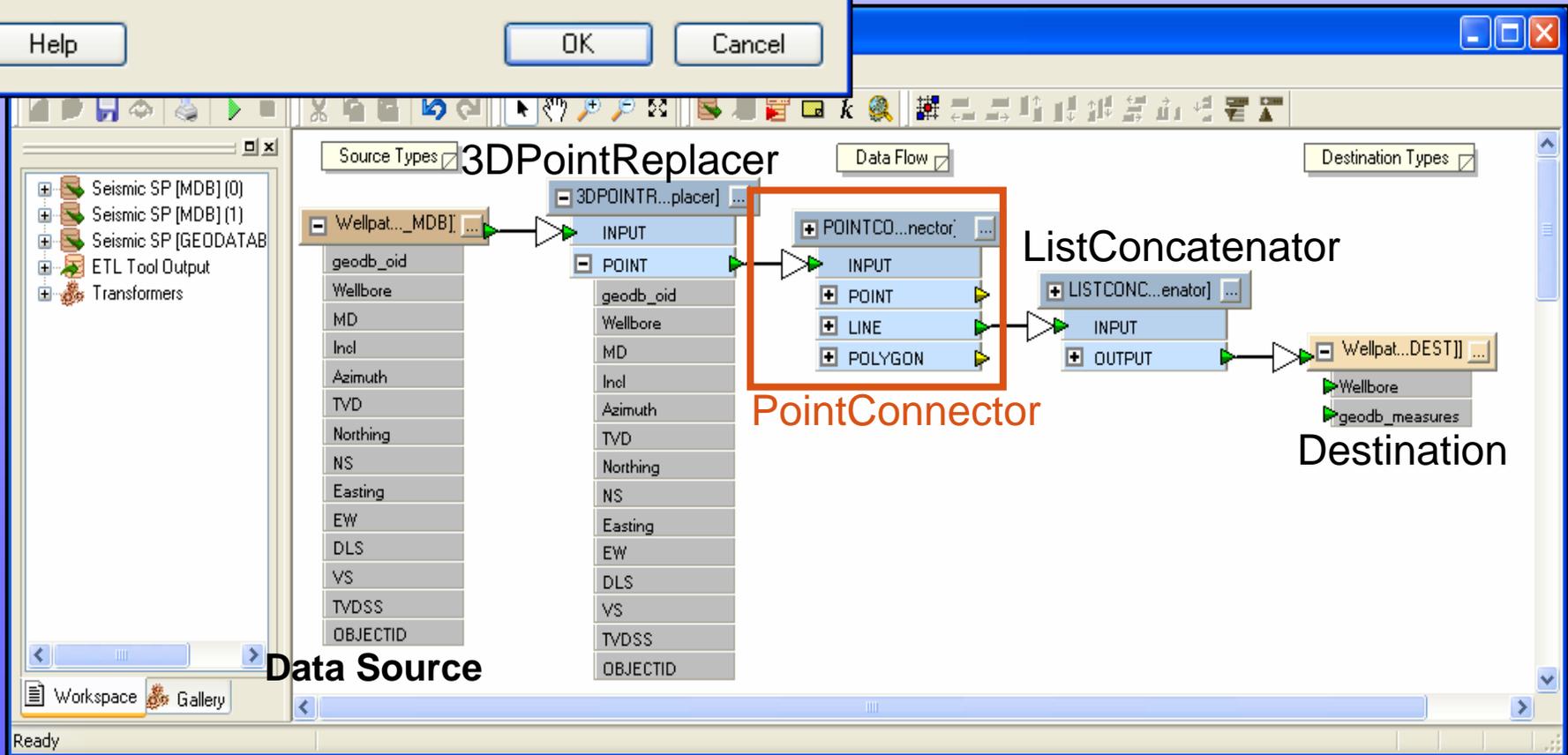
Creates points from x, y, z fields
Configure by setting properties



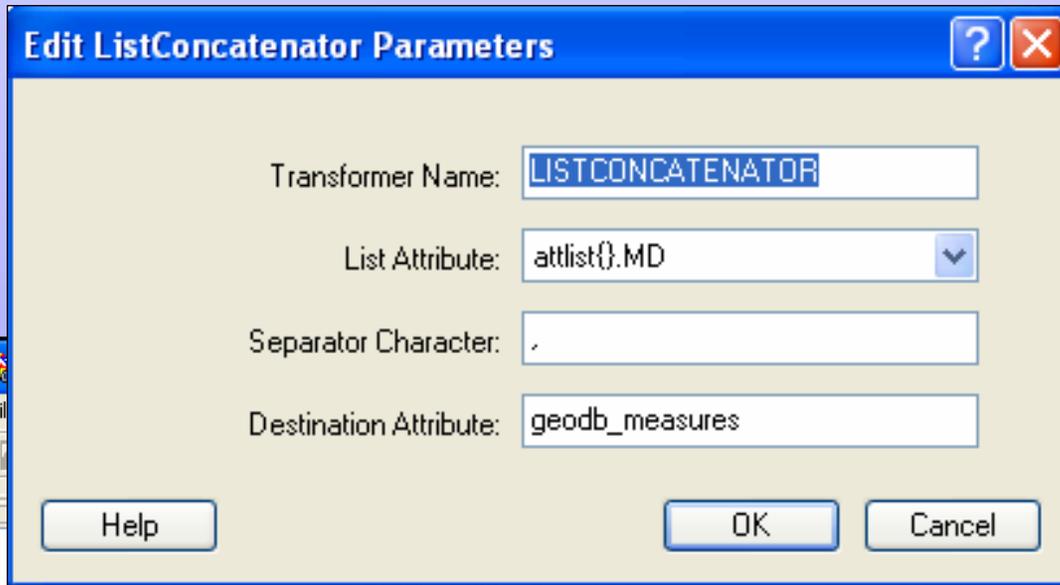
Wellpath Route Builder - PointConnector



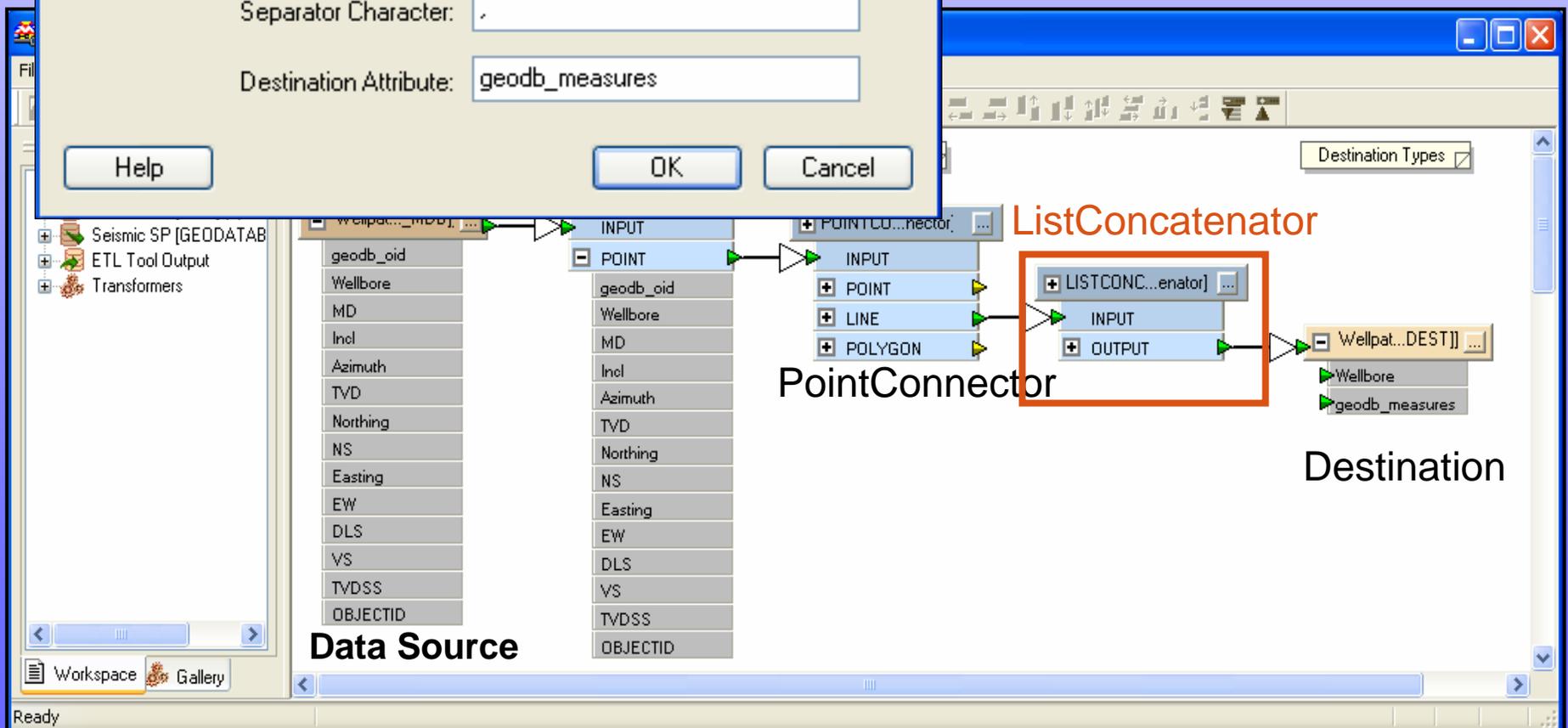
Constructs lines from input points
Uses an attribute for line breaks
Attributes are saved in a list for each point



Wellpath Route Builder - ListConcatenator



Adds a list to an attribute
Puts measured depth values
into the geodb_measures
attribute



Wellpath Route Builder - Parameters

New Projected Coordinate System [?] [X]

Name:

Projection

Name:

Parameter	Value
False_Easting	0.000000000000000000
False_Northing	0.000000000000000000
Central_Meridian	-106.8224380000000010000
Scale_Factor	1.000000000000000000
Latitude_Of_Origin	38.71809300000000003000

Linear Unit

Name:

Meters per unit:

Geographic Coordinate System

Name:

Alias:

Abbreviation:

Remarks:

Angular Unit:

Prime Meridian:

Set the coordinate reference system to match the source data.

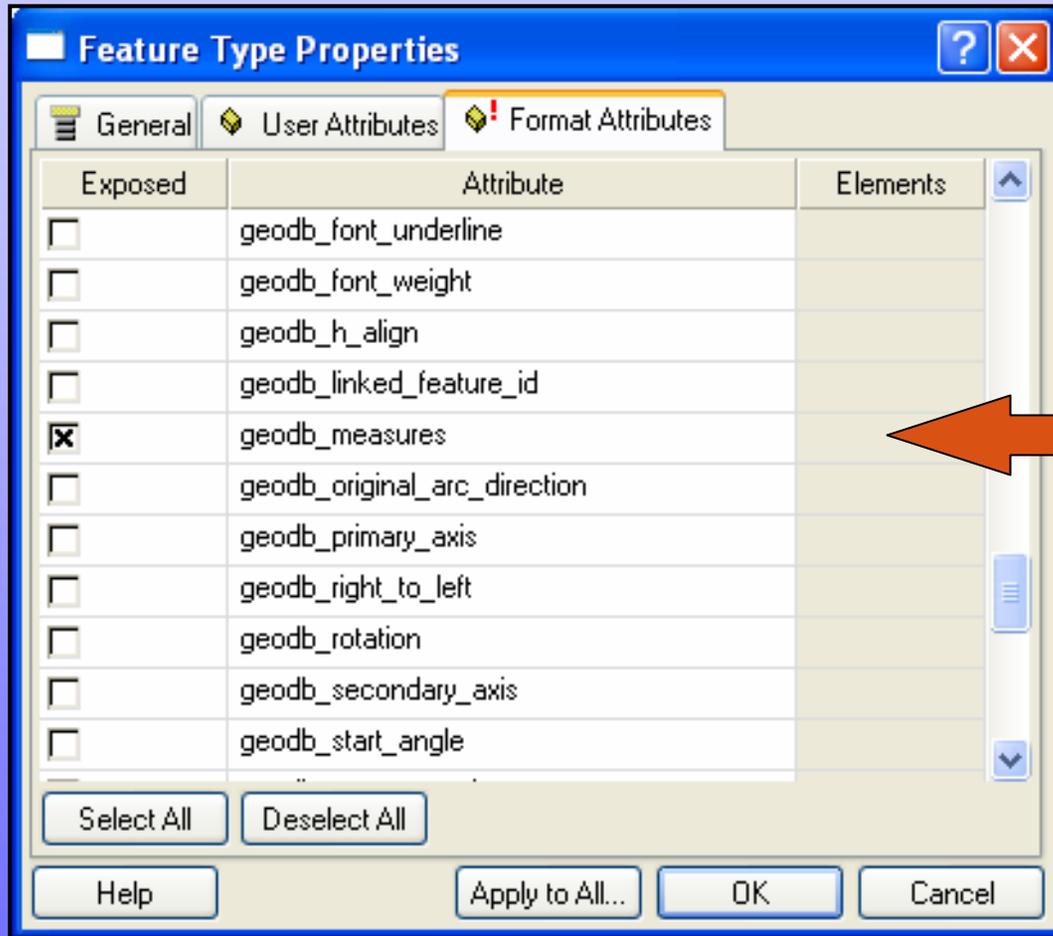
May require a custom coordinate system based on the latitude and longitude of the surface location of the well. Each wellpath requires a different custom coordinate reference system.



Source Type

- Wellpat...
- geodb_oid
- Wellbore
- MD
- Incl
- Azimuth
- TVD
- Northing
- EW
- DLS
- VS

Wellpath Route Builder



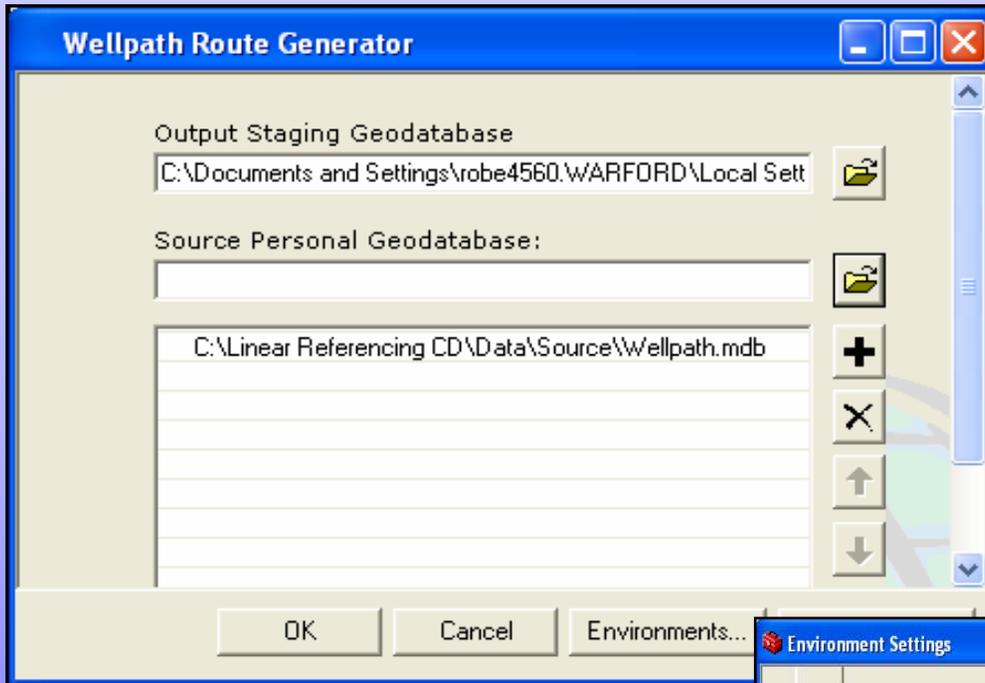
Destination Properties

Expose the geodb_measures attribute.



This is present for features that have measures when reading. To write measures, you simply build this list with one value for each vertex in the feature being written. This is a comma-separated list of floating values that correspond to the vertex measures. The first value is for the first vertex, second for the second, and so on.

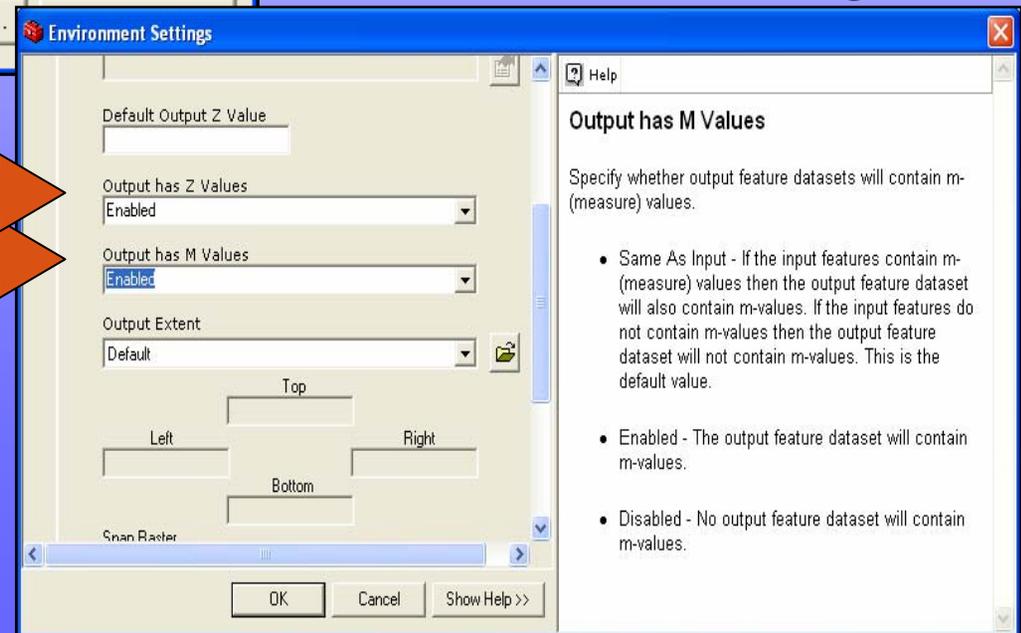
Wellpath Route Builder



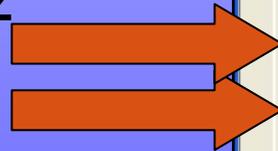
Run the tool to create wellpath routes

1. Double click on the tool
2. Set the properties and environment
3. Click OK to start processing

Environment Settings



Set the “Output has Z Values” property to “Enabled”

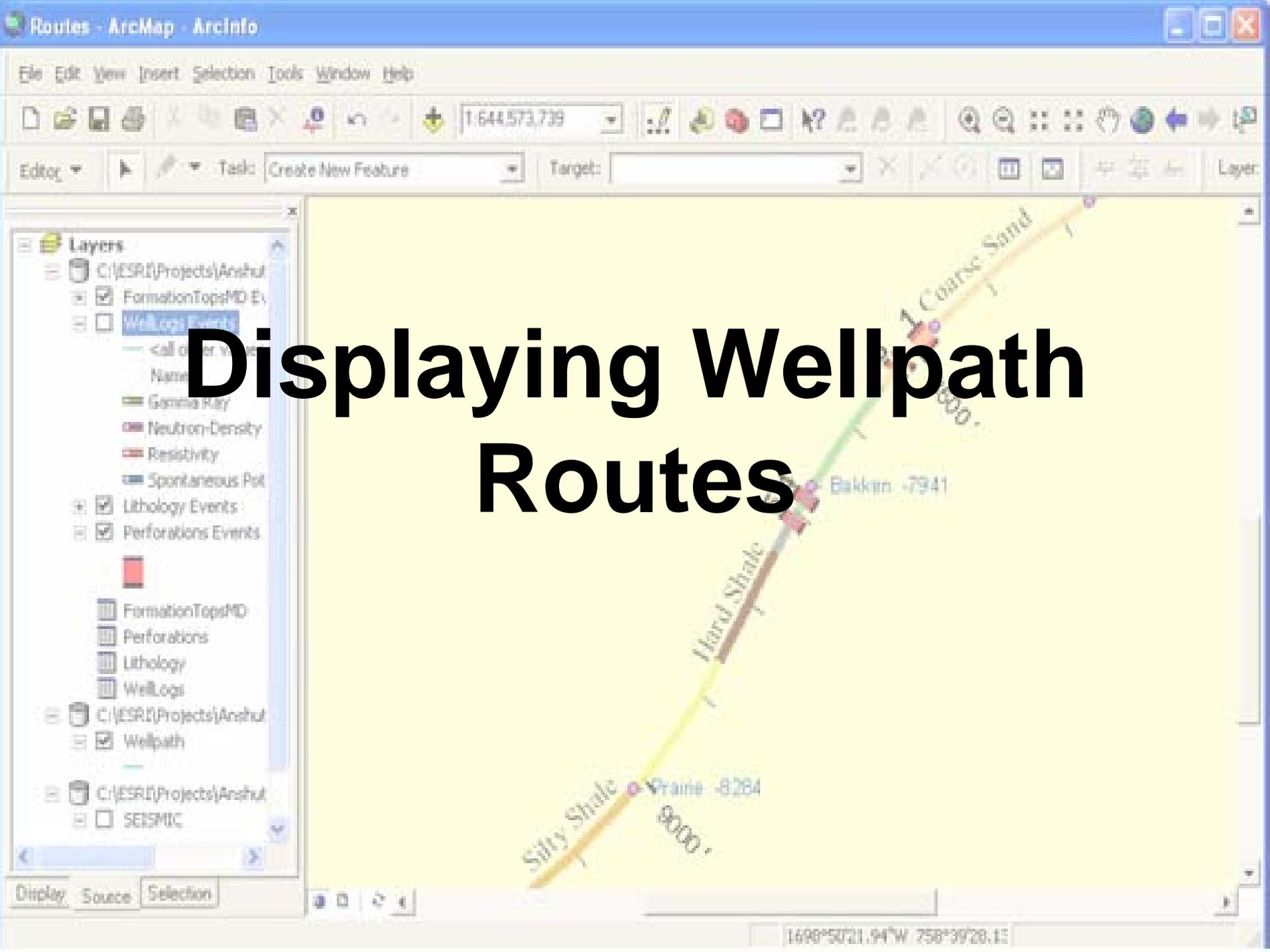


Set the “Output has M Values” property to “Enabled”

Output has M Values

Specify whether output feature datasets will contain m-(measure) values.

- Same As Input - If the input features contain m-(measure) values then the output feature dataset will also contain m-values. If the input features do not contain m-values then the output feature dataset will not contain m-values. This is the default value.
- Enabled - The output feature dataset will contain m-values.
- Disabled - No output feature dataset will contain m-values.



Displaying Wellpath Routes

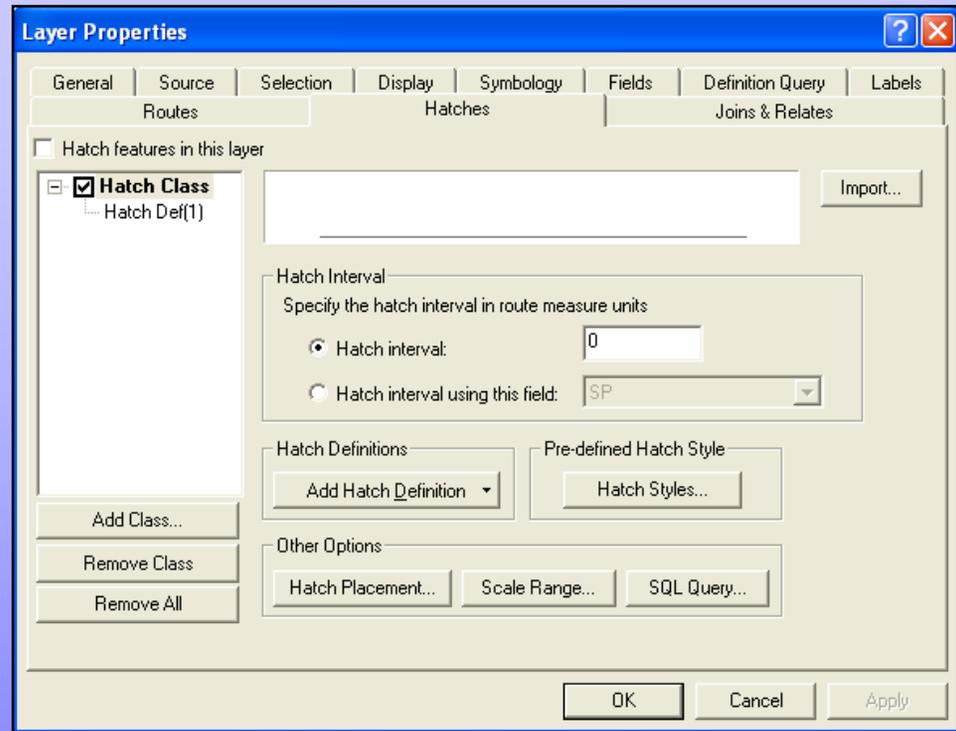
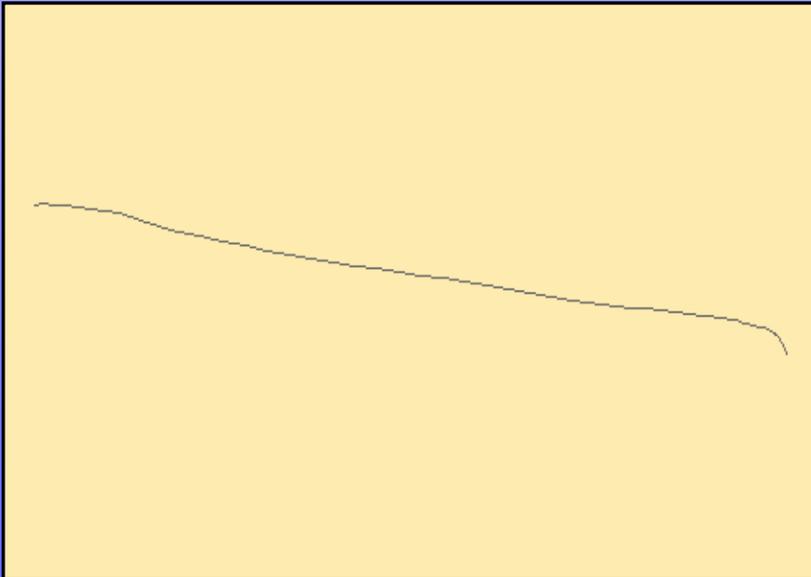
Layers

- C:\ESRI\Projects\Anshut
 - FormationTopsMD E
 - WellLogs Events
 - Call other v
 - Name
 - Gamma Ray
 - Neutron-Density
 - Resistivity
 - Spontaneous Pot
 - Lithology Events
 - Perforations Events
 - FormationTopsMD
 - Perforations
 - Lithology
 - WellLogs
- C:\ESRI\Projects\Anshut
 - Wellpath
- C:\ESRI\Projects\Anshut
 - SEISMIC

Displaying Wellpath Routes

Route and hatch tabs are automatically available in the route layer properties dialog.

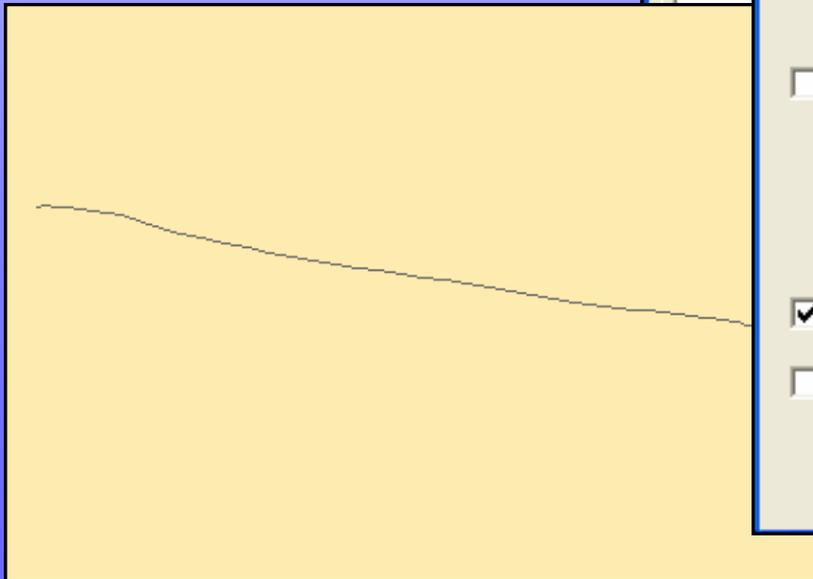
The “Hatch features” check box is not checked by default.



Displaying Wellpath Routes

Hatch Class: Lower Section

- Hatch Interval = 100'
- Start hatching at 4000'



Hatch Placement Options

Distance Units:

Offset hatch definitions (feet)

Offset hatches:

Offset hatches using this field:

Start hatching at a value other than the lowest measure

Start hatching at:

Start hatching using this field:

Finish hatching at a value other than the highest measure

Finish hatching at:

Finish hatching using this field:

Adjust hatch placement to hatch interval

Apply hatch settings to each part

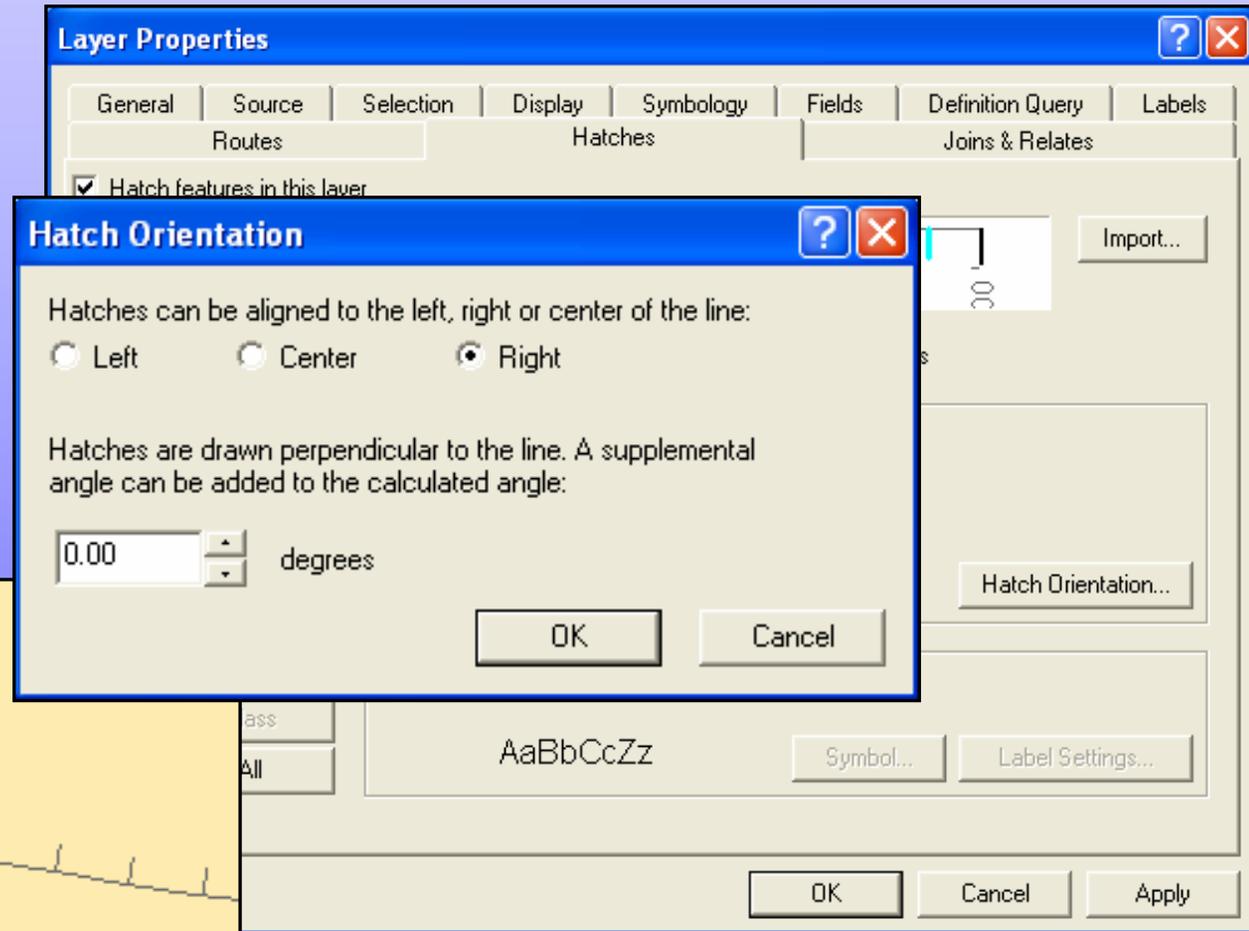
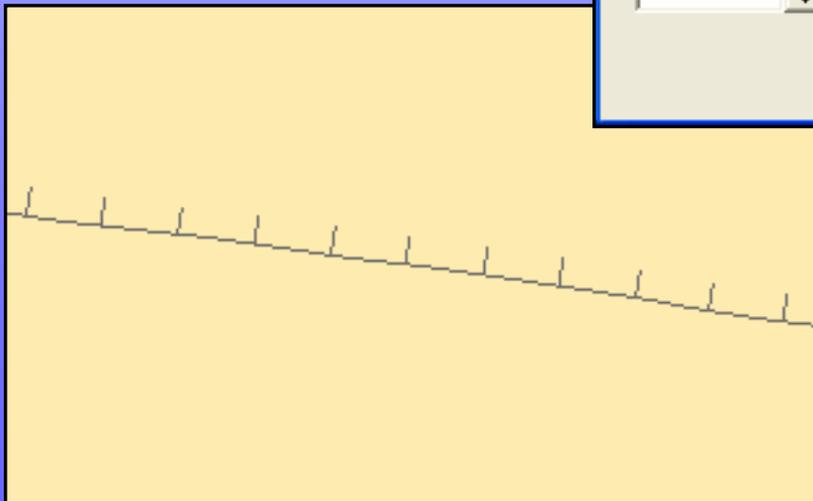
Displaying Wellpath Routes – Lower Section Def 1

The “Hatch features” check box must be checked.

Hatch Class: Lower Section

Def[1]

- Hatches every interval
- Normal line symbol
- Line symbol is 12’ long
- Hatches are not labeled
- Right hatch orientation

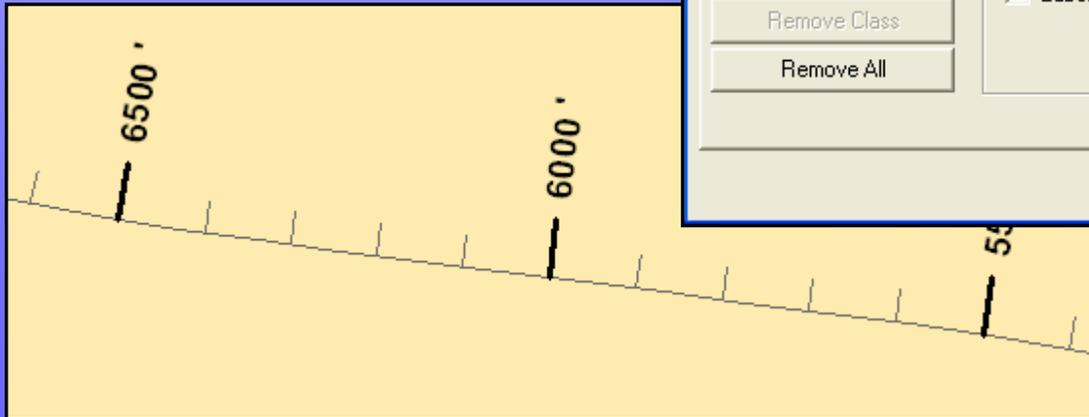
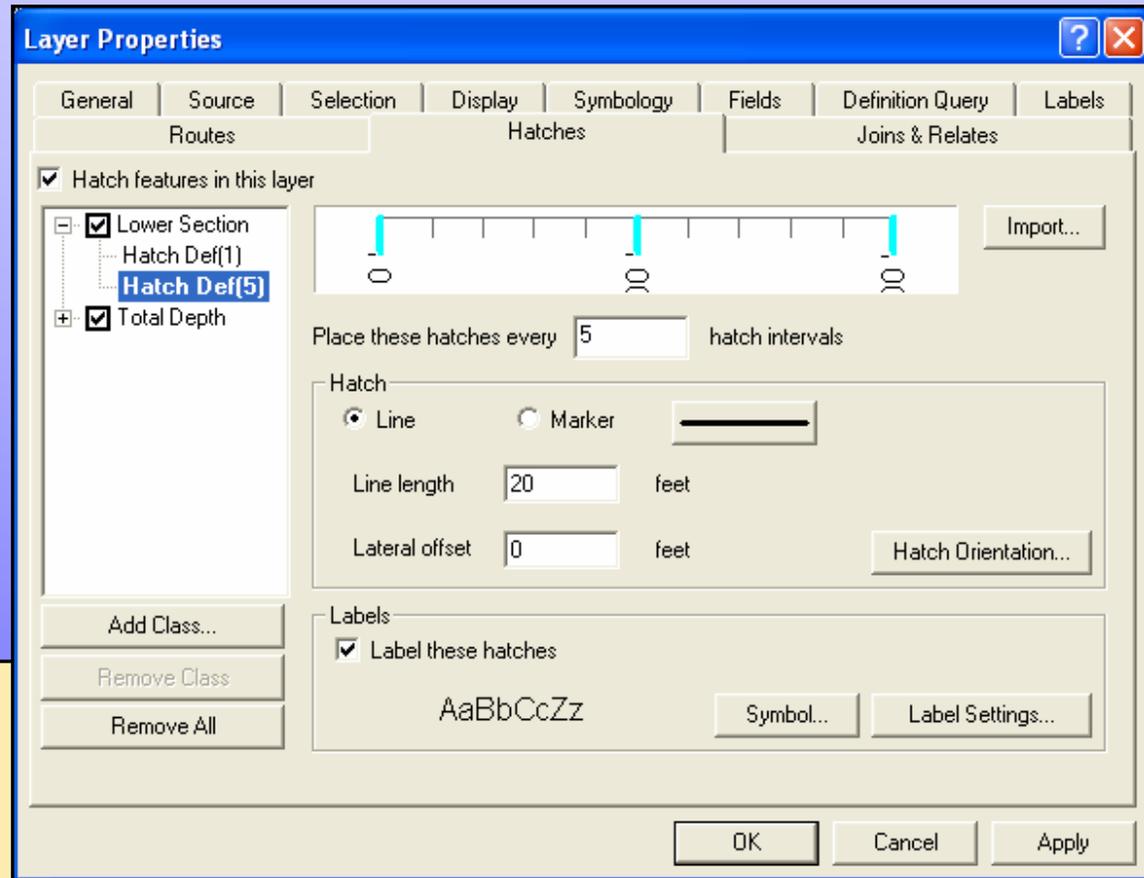


Displaying Wellpath Routes – Lower Section Def 5

The “Hatch features” check box must be

Hatch Class: Lower Section Def[5]

- Hatches every 5 intervals
- Bold line symbol
- Line symbol is 20’ long
- Hatches are labeled
- Right hatch orientation
- Text vertical alignment - Center

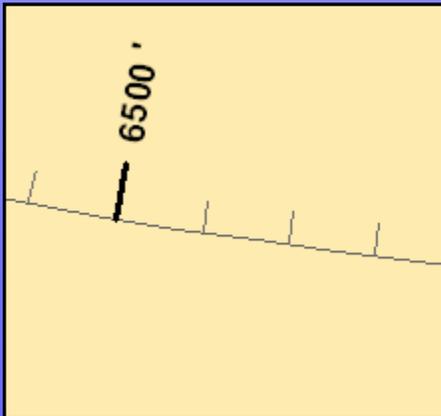
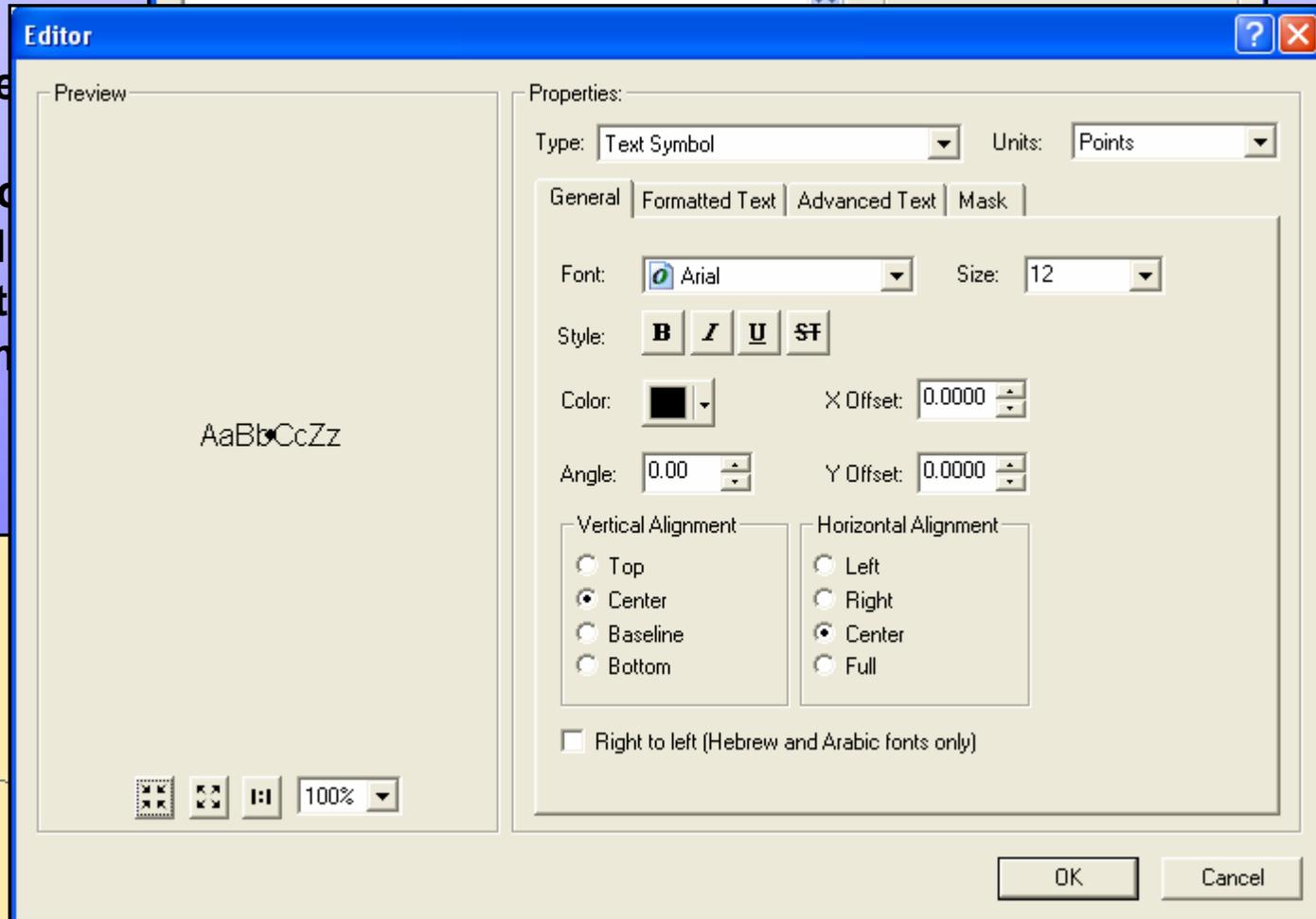


Displaying Wellpath Routes – Lower Section Def 5

Hatch Class: Lower Section

Def[5]

- Hatches every 5 into
 - Bold line symbol
 - Line symbol is 20' l
 - Hatches are labeled
 - Right hatch orientat
 - Text Vertical Alignm
- Center

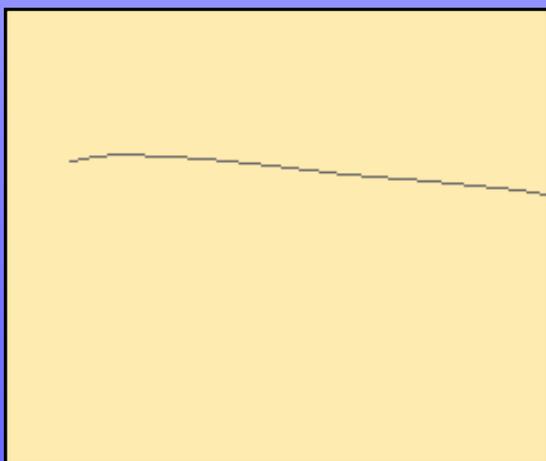


Displaying Wellpath Routes – Total Depth

The “Hatch features” check box must be checked.

Hatch Class: Total Depth

•Interval = 0



Layer Properties

General | Source | Selection | Display | Symbology | Fields | Definition Query | Labels

Routes | Hatches | Joins & Relates

Hatch features in this layer

- Lower Section
 - Hatch Def(1)
 - Hatch Def(5)
- Total Depth**
 - Hatch Def(End)

Import...

Hatch Interval
Specify the hatch interval in route measure units

Hatch interval: 0

Hatch interval using this field: MD

Hatch Definitions | Pre-defined Hatch Style

Add Hatch Definition | Hatch Styles...

Other Options

Hatch Placement... | Scale Range... | SQL Query...

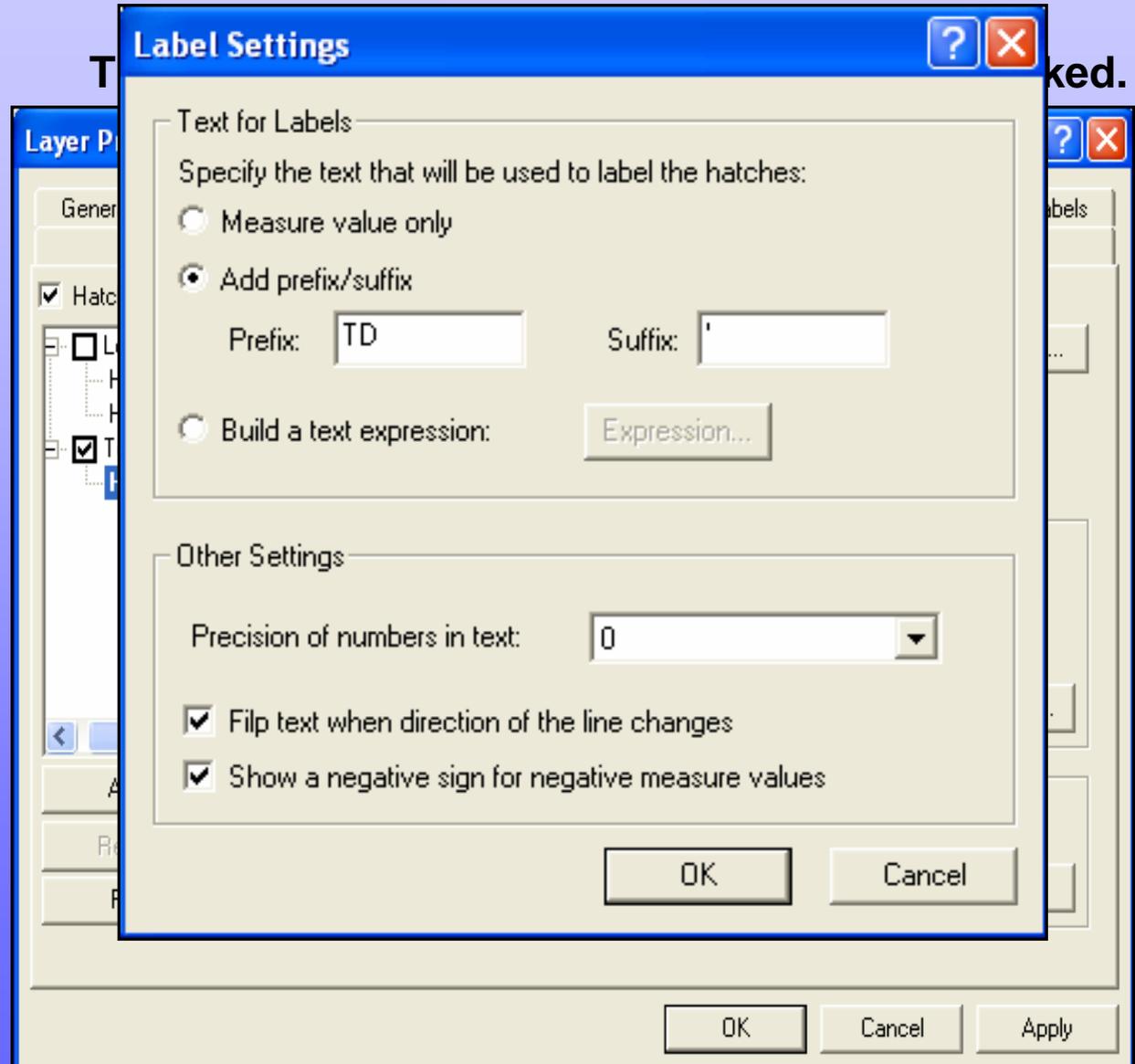
OK | Cancel | Apply

Displaying Wellpath Routes – Total Depth

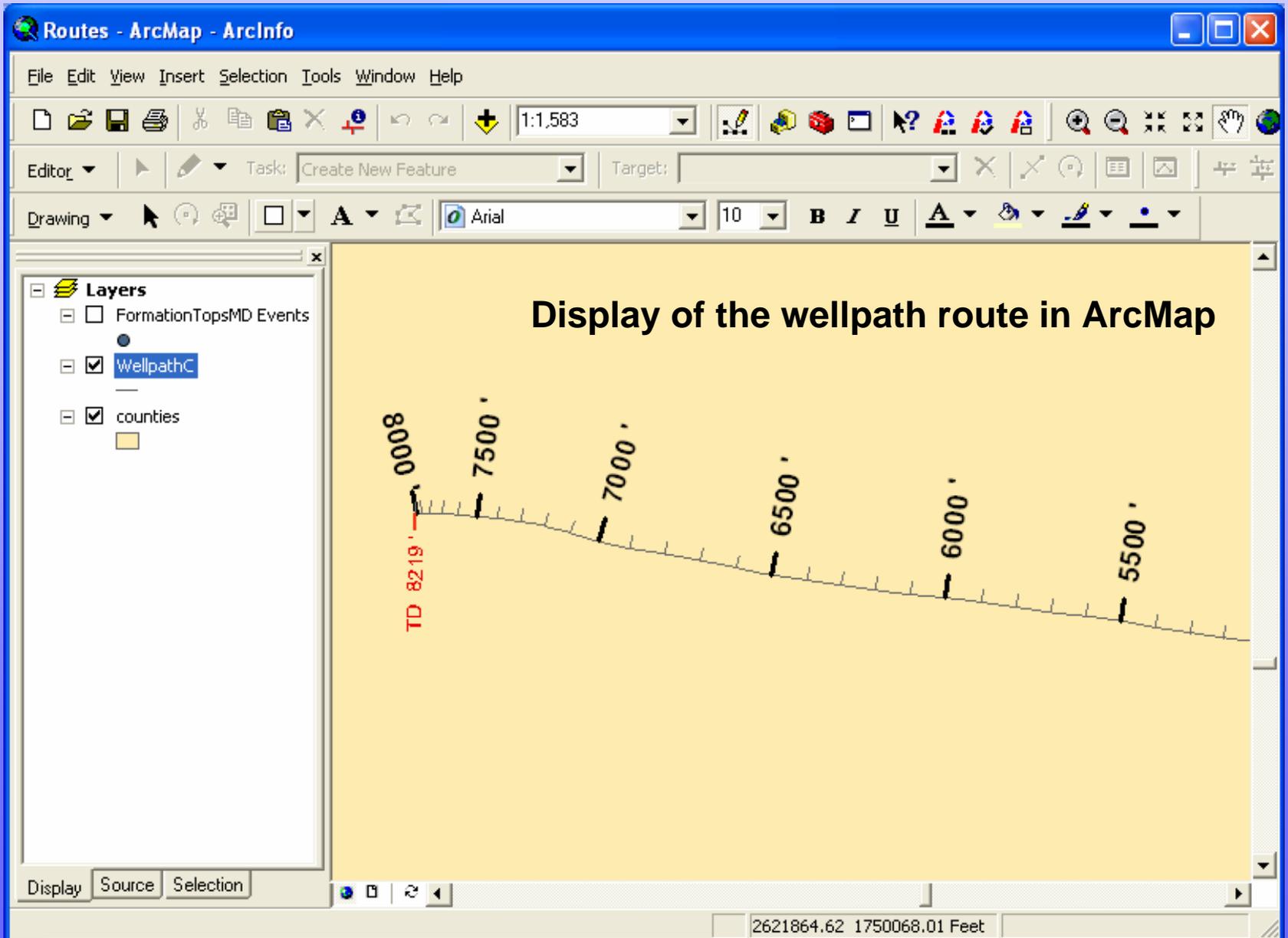
Hatch Class: Total Depth

Def[End]

- Line length 15 ‘
- Red line and text
- Use prefix/suffix



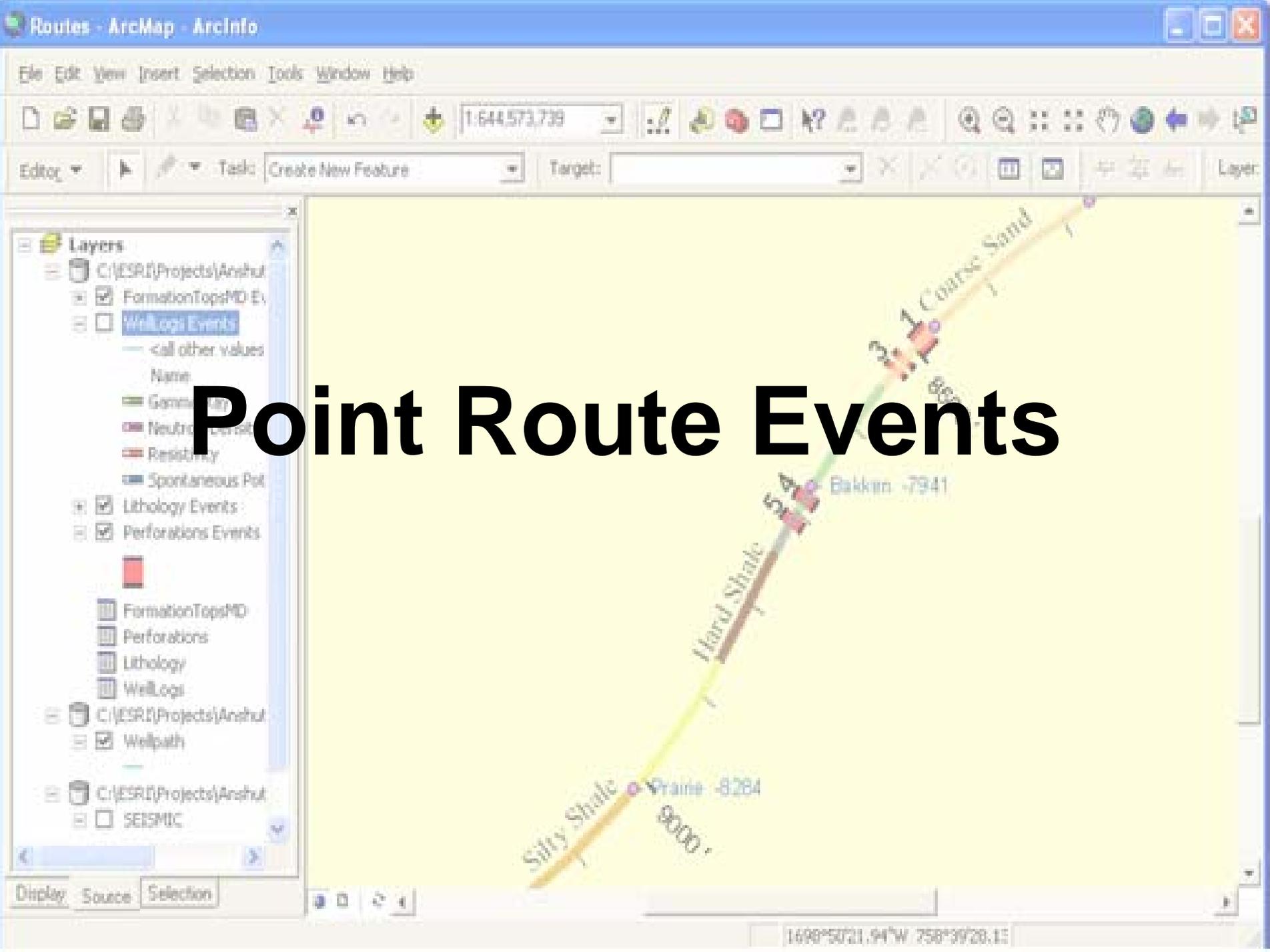
Displaying Wellpath Routes



Section III

Route Events





Point Route Events

Point Route Events Formation Tops

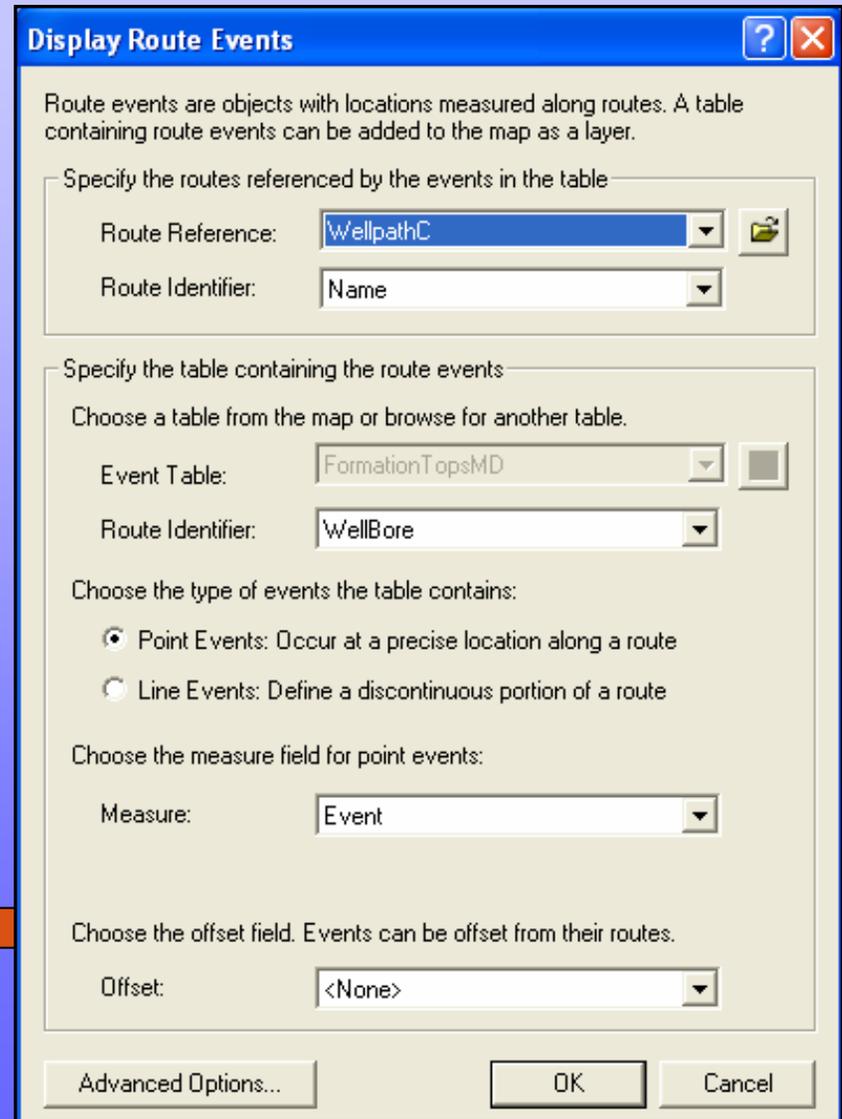
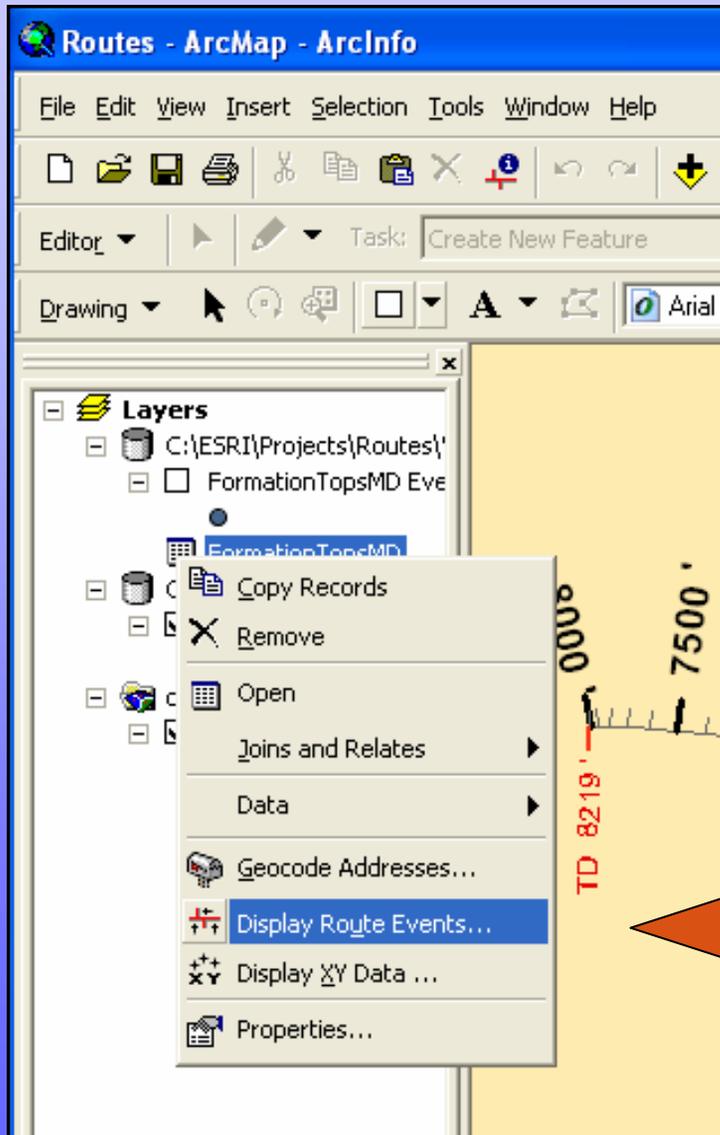
Example of a table containing formation tops

OBJECTID*	WellBore	Event	Formation	SubSea_Top
1	Well C	4823	Hell Creek	-4893
2	Well C	5186	Pierre	-5156
3	Well C	5291	Niobrara	-5561
4	Well C	5472	Carlile	-5742
5	Well C	5582	Greenhorn	-5852
6	Well C	5663	Belle Fourche	-5933
7	Well C	6134	Swift	-6404
8	Well C	6456	Spearfish	-6726
9	Well C	6791	Otter	-7061
10	Well C	6904	Charles	-7174
11	Well C	7267	Mission Canyon	-7537
12	Well C	7471	LodgePole	-7741
13	Well C	7671	Bakken	-7941
14	Well C	8014	Prairie	-8284

Record: 0 Show: All Selected Records (0 out of 0)

This table of formation top data was used in the following route event example.

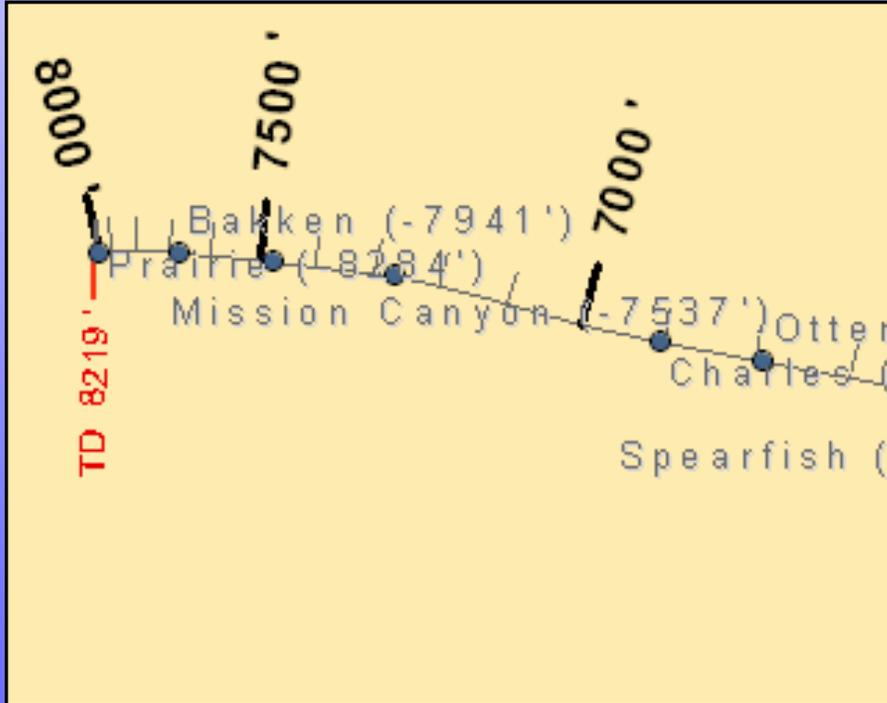
Point Route Events Formation Tops



Point Route Events

Formation Tops

Add a label expression to show the formation name and depth



Label Expression

Expression

Label Fields

To add a field into expression, double-click or drag & drop. Show Type ▾

OBJECTID	SubSea_Top
WellBore	
Event	
Formation	

Append Show Values... Display coded value description

Expression

Write the expression in the language of the selected parser. Advanced

[Formation] & " (" & [SubSea_Top] & ")"

Verify Reset Help Load... Save...

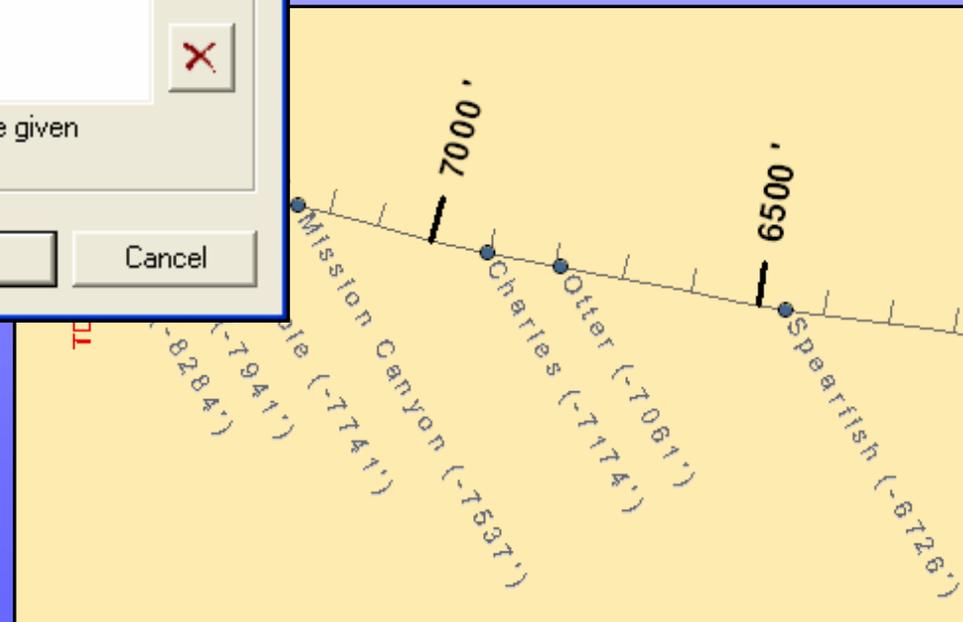
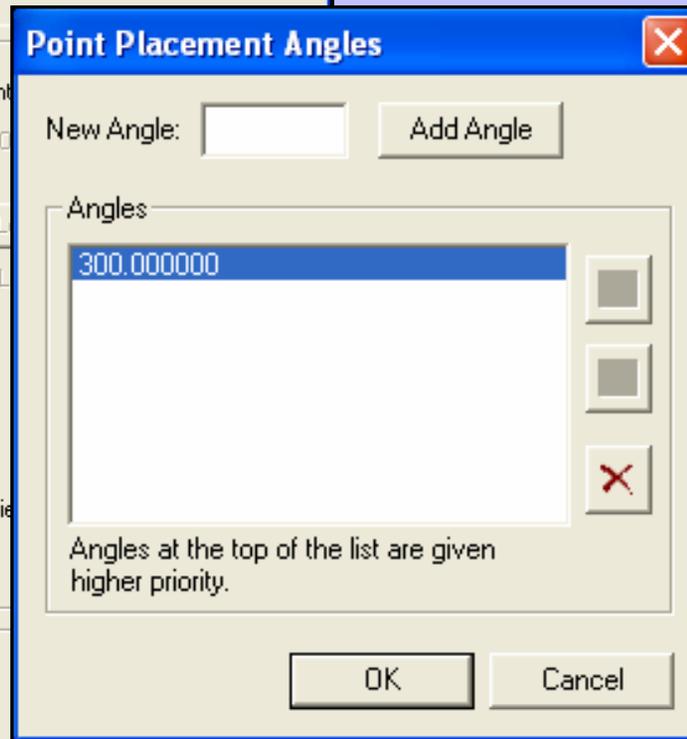
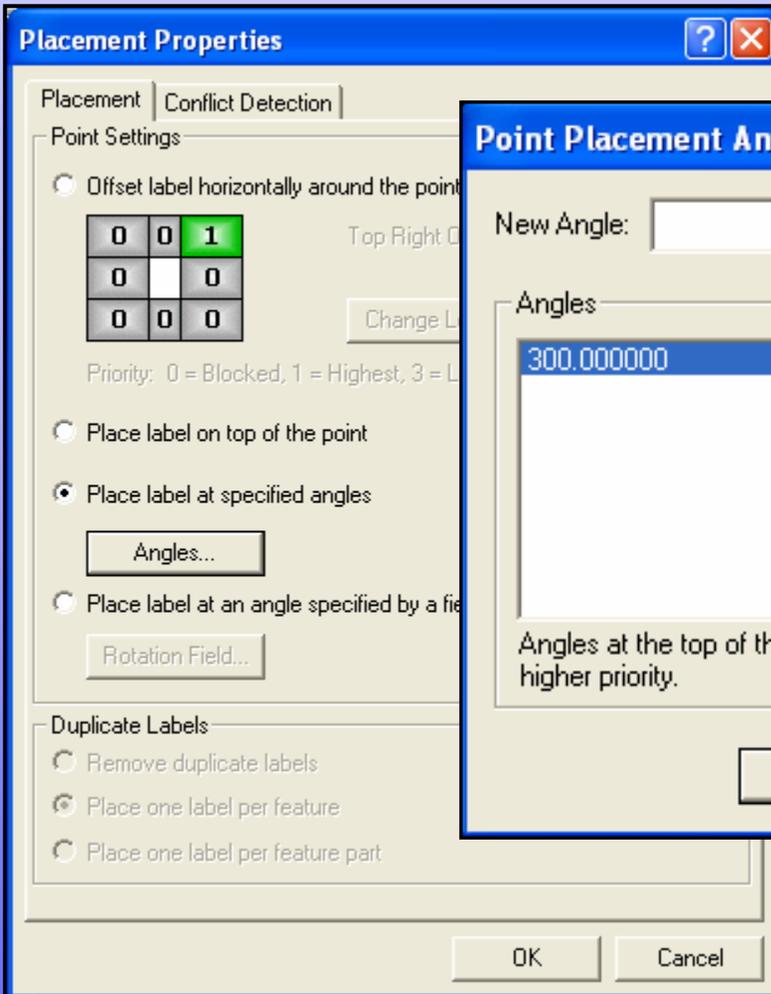
Parser: VBScript ▾

OK Cancel

Point Route Events

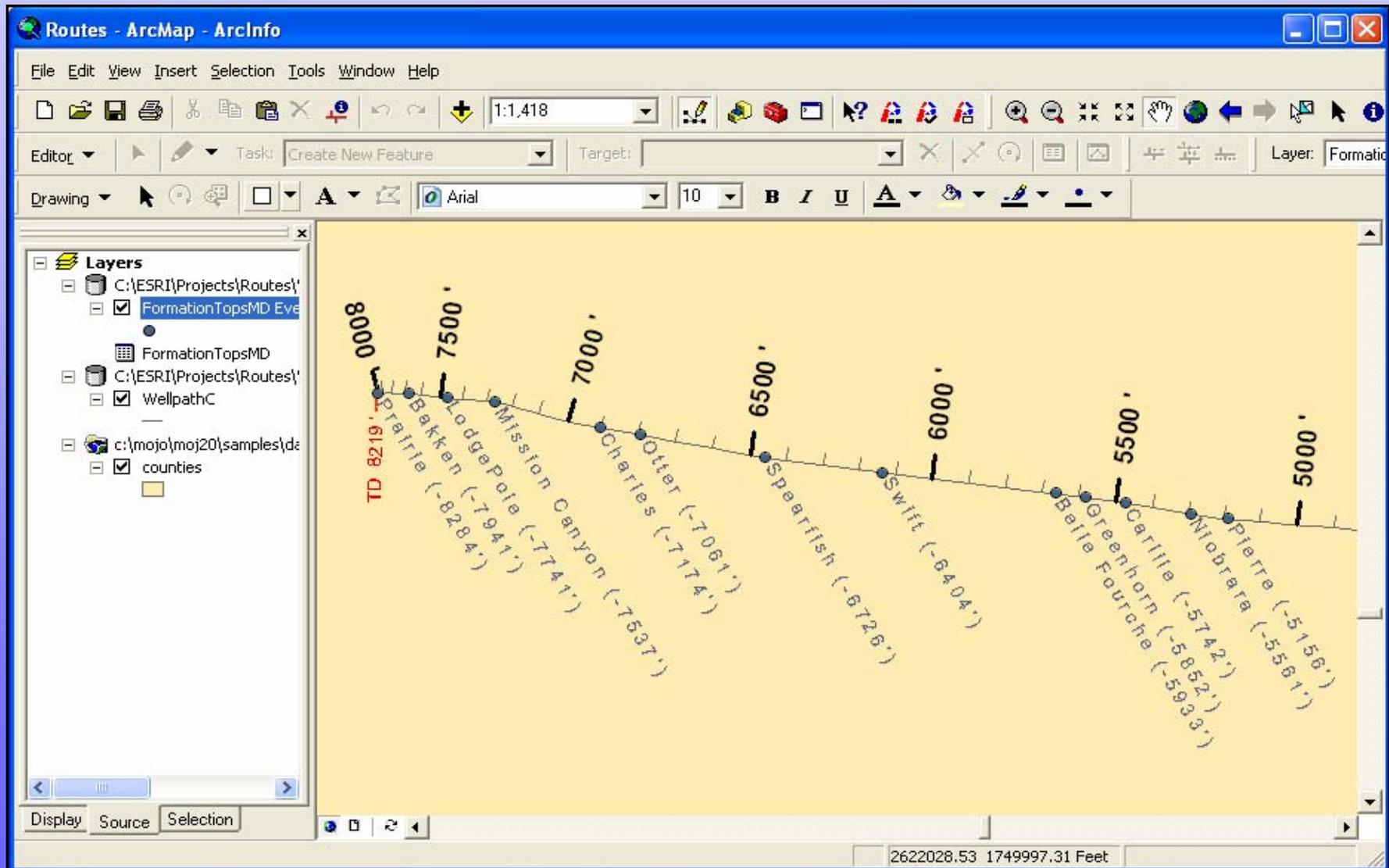
Formation Tops

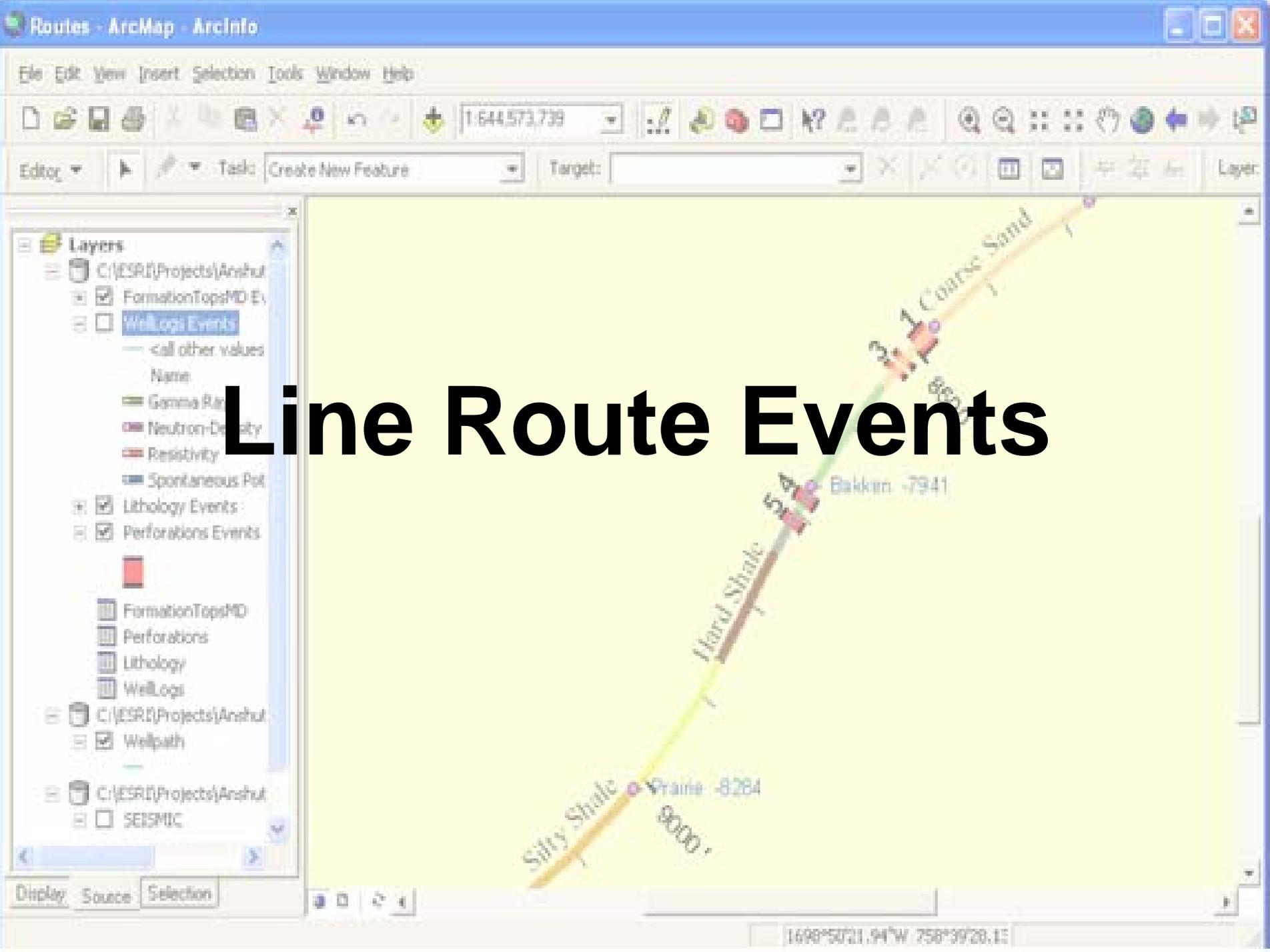
Set the label placement properties



Formation Tops in ArcMap

Formation top events displayed in ArcMap



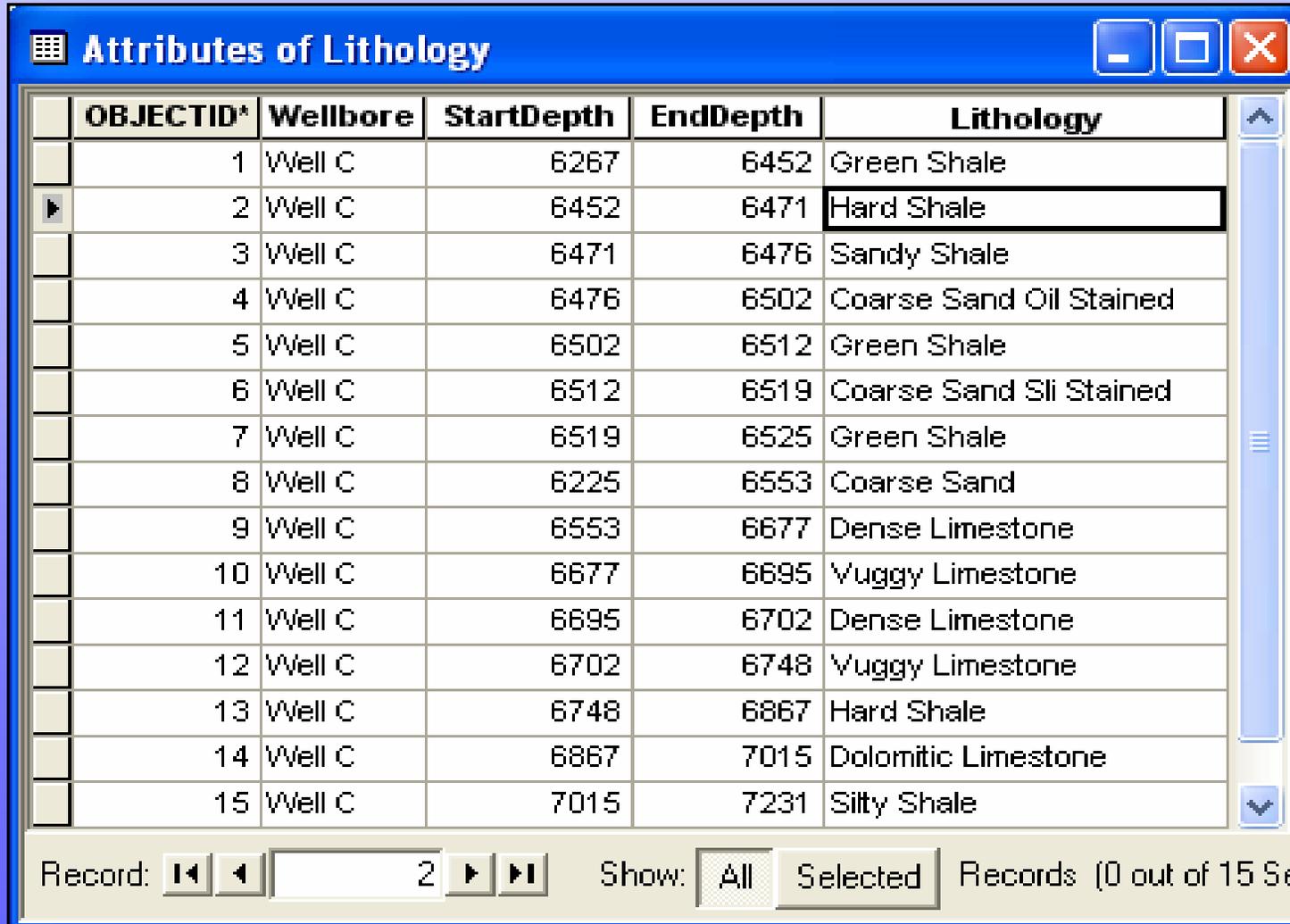


Line Route Events

Line Route Events

Lithologic Units

Example of a table containing wellbore lithology



Attributes of Lithology

OBJECTID*	Wellbore	StartDepth	EndDepth	Lithology
1	Well C	6267	6452	Green Shale
2	Well C	6452	6471	Hard Shale
3	Well C	6471	6476	Sandy Shale
4	Well C	6476	6502	Coarse Sand Oil Stained
5	Well C	6502	6512	Green Shale
6	Well C	6512	6519	Coarse Sand Sli Stained
7	Well C	6519	6525	Green Shale
8	Well C	6225	6553	Coarse Sand
9	Well C	6553	6677	Dense Limestone
10	Well C	6677	6695	Vuggy Limestone
11	Well C	6695	6702	Dense Limestone
12	Well C	6702	6748	Vuggy Limestone
13	Well C	6748	6867	Hard Shale
14	Well C	6867	7015	Dolomitic Limestone
15	Well C	7015	7231	Silty Shale

Record: 2 Show: All Selected Records (0 out of 15 Se

This table of lithologic data was used in the following route event example.

Line Route Events Lithologic Units

Display Route Events

Route events are objects with locations measured along routes. A table containing route events can be added to the map as a layer.

Specify the routes referenced by the events in the table

Route Reference: WellpathC

Route Identifier: Name

Specify the table containing the route events

Choose a table from the map or browse for another table.

Event Table: Lithology

Route Identifier: Wellbore

Choose the type of events the table contains:

Point Events: Occur at a precise location along a route

Line Events: Define a discontinuous portion of a route

Choose the measure fields for line events:

From-Measure: StartDepth

To-Measure: EndDepth

Choose the offset field. Events can be offset from their routes.

Offset: <None>

Advanced Options... OK Cancel

Display the “Display Route Events..” dialog by right clicking on the “Lithologic Unit” table in the ArcMap table of contents.

Specify start and end measure attributes to create a line route event layer .

Line Route Events Lithologic Units

Layer Properties

Labels | Hatches | Joins & Relates

General | Source | Selection | Display | Symbology | Fields | Definition Query

Show: **Draw categories using unique values of one field.** Import...

Value Field: Lithology | Color Scheme: [Color Legend]

Symbol	Value	Label	Count
<input checked="" type="checkbox"/>	<all other values>	<all other values>	
<Heading> Lithology			
[Orange]	Coarse Sand	Coarse Sand	?
[Yellow]	Coarse Sand Oil Stained	Coarse Sand Oil Stained	?
[Light Orange]	Coarse Sand Sli Stained	Coarse Sand Sli Stained	?
[Green]	Dense Limestone	Dense Limestone	?
[Yellow-Green]	Dolomitic Limestone	Dolomitic Limestone	?
[Dark Green]	Green Shale	Green Shale	?
[Brown]	Hard Shale	Hard Shale	?
[Light Brown]	Sandy Shale	Sandy Shale	?
[Orange-Red]	Silty Shale	Silty Shale	?

Add All Values | Add Values... | Remove | Remove All | Advanced ▾

OK | Cancel | Apply

The lithology route layer uses a unique value legend based on the lithology attribute field

Line Route Events Lithologic Units

The screenshot shows the 'Layer Properties' dialog box with the 'Hatches' tab selected. The 'Hatch features in this layer' checkbox is checked. Under 'Hatch Class', 'Hatch Def(1)' is listed. The 'Hatch Interval' section is expanded, showing 'Hatch interval using this field' selected with 'StartDepth' in the dropdown. The 'Hatch Definitions' section has 'Add Hatch Definition' and 'Pre-defined Hatch Style' buttons. The 'Other Options' section has 'Hatch Placement...', 'Scale Range...', and 'SQL Query...' buttons. The 'OK', 'Cancel', and 'Apply' buttons are at the bottom.

Layer Properties

General | Source | Selection | Display | Symbology | Fields | Definition Query

Labels | Hatches | Joins & Relates

Hatch features in this layer

Hatch Class
 Hatch Def(1)

Import...

Hatch Interval
Specify the hatch interval in route measure units

Hatch interval: 0

Hatch interval using this field: StartDepth

Hatch Definitions: Add Hatch Definition

Pre-defined Hatch Style: Hatch Styles...

Add Class...
Remove Class
Remove All

Other Options: Hatch Placement... Scale Range... SQL Query...

OK Cancel Apply

Use an attribute field to specify the hatch interval

Line Route Events Lithologic Units

The image shows two overlapping dialog boxes from ArcGIS. The background dialog is 'Layer Properties' with the 'Hatches' tab selected. It shows a 'Hatch Class' named 'Hatch Def(1)' with a 'Line' hatch style, a length of 4 feet, and a lateral offset of 0 feet. The 'Labels' section is checked, and a font preview is visible. The foreground dialog is 'Hatch Text Expression', which is used to define the text for the hatches. It shows a list of fields including 'OBJECTID', 'Lithology', 'Wellbore', 'StartDepth', and 'EndDepth'. The 'Lithology' field is selected and placed in the expression text area. The 'Parser' dropdown is set to the default.

Layer Properties

General | Source | Selection | Display Hatches | Symbology | Fields | Joins & Relationships

Hatch features in this layer

Hatch Class
Hatch Def(1)

Place these hatches every hatch intervals

Hatch

Line Marker

Line length feet

Lateral offset feet

Labels

Label these hatches

AaBbCcZz

Hatch Text Expression

Expression

Label Fields

To add a field into expression, double-click or drag & drop.

OBJECTID Lithology
Wellbore
StartDepth
EndDepth

Display coded value description

Expression

Write the expression in the language of the selected parser. Advanced

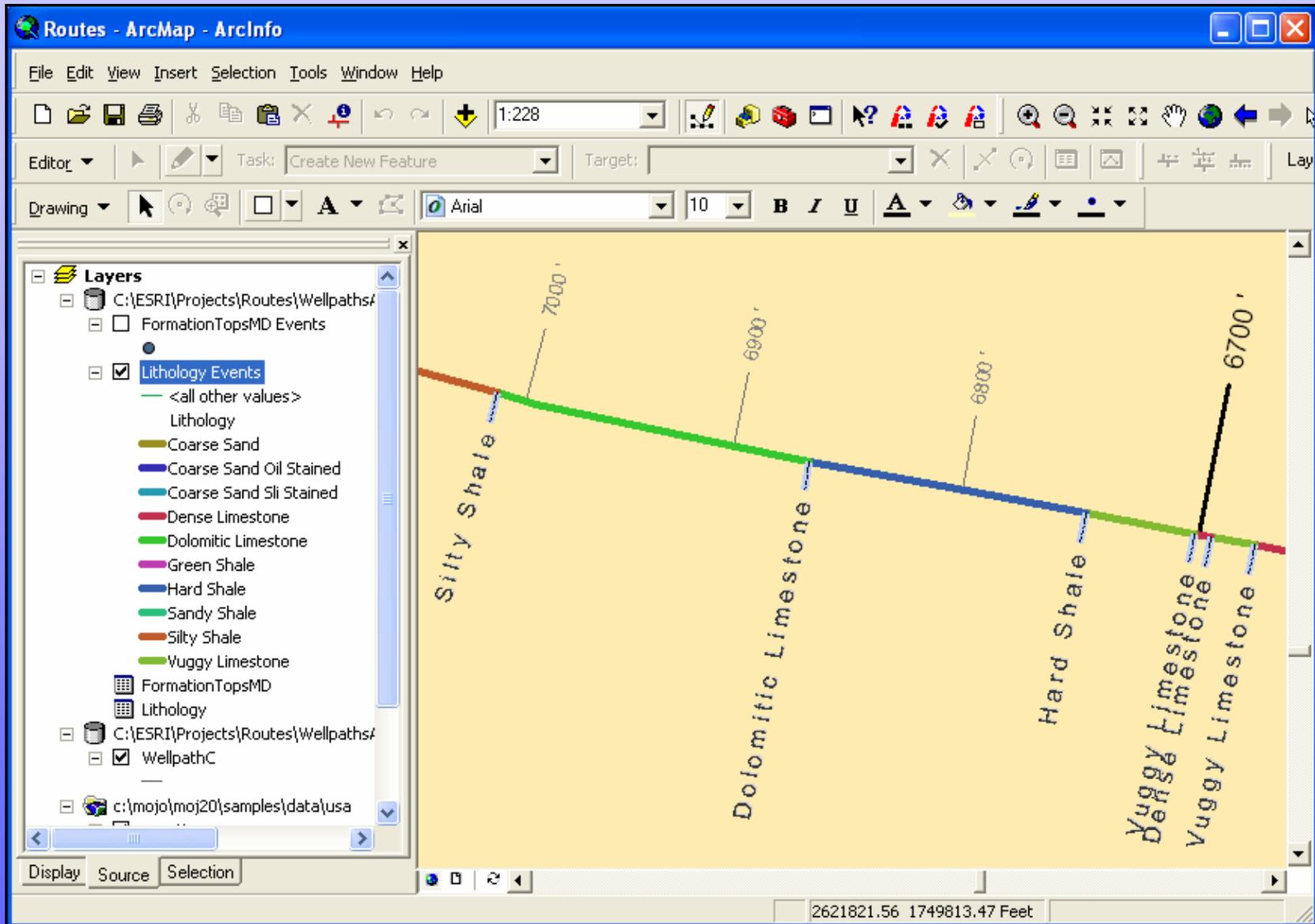
[Lithology]

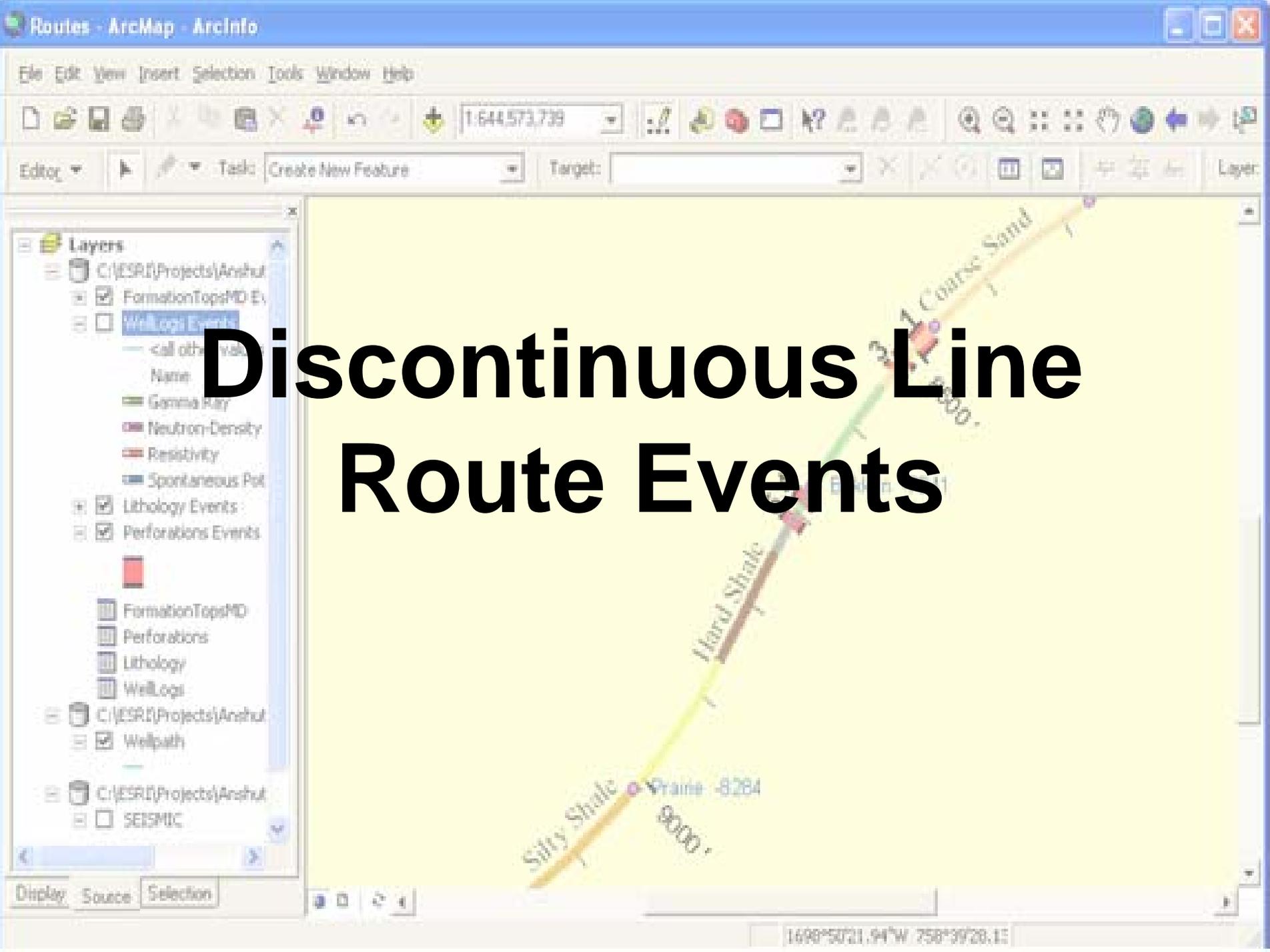
Parser:

Hatches are labeled using the lithology field in an expression

Lithologic Units in ArcMap

Each line event classification has a unique color





Discontinuous Line Route Events

Layers

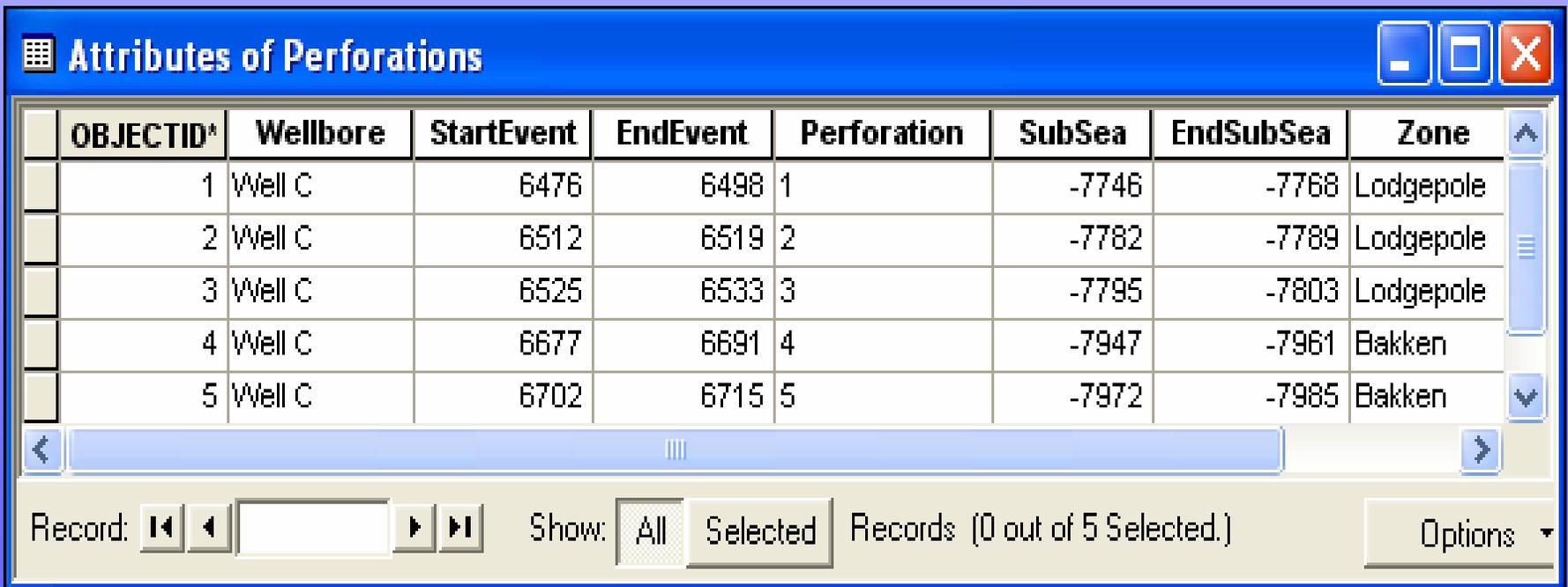
- C:\ESRI\Projects\Anshut
 - FormationTopsMD E
 - WellLog Events**
 - Call other values
 - Name
 - Gamma Ray
 - Neutron-Density
 - Resistivity
 - Spontaneous Pot
 - Lithology Events
 - Perforations Events
 - FormationTopsMD
 - Perforations
 - Lithology
 - WellLog
- C:\ESRI\Projects\Anshut
 - Wellpath
- C:\ESRI\Projects\Anshut
 - SEISMIC

Discontinuous Line Route Events

Perforation Intervals

This table of perforation interval data was used in the following route event example.

Example of a table containing well perforation intervals (could have used drill stem test or core intervals instead)



The screenshot shows a software window titled "Attributes of Perforations" with a table of well perforation intervals. The table has the following columns: OBJECTID*, Wellbore, StartEvent, EndEvent, Perforation, SubSea, EndSubSea, and Zone. The data is as follows:

OBJECTID*	Wellbore	StartEvent	EndEvent	Perforation	SubSea	EndSubSea	Zone
1	Well C	6476	6498	1	-7746	-7768	Lodgepole
2	Well C	6512	6519	2	-7782	-7789	Lodgepole
3	Well C	6525	6533	3	-7795	-7803	Lodgepole
4	Well C	6677	6691	4	-7947	-7961	Bakken
5	Well C	6702	6715	5	-7972	-7985	Bakken

The window also includes a scroll bar and a control bar at the bottom with the following text: "Record: [Navigation icons] Show: All Selected Records (0 out of 5 Selected.) Options [Dropdown arrow]"

Discontinuous Line Route Events

Perforation Intervals

Display Route Events

Route events are objects with locations measured along routes. A table containing route events can be added to the map as a layer.

Specify the routes referenced by the events in the table

Route Reference: WellpathC

Route Identifier: Name

Specify the table containing the route events

Choose a table from the map or browse for another table.

Event Table: Perforations

Route Identifier: Wellbore

Choose the type of events the table contains:

Point Events: Occur at a precise location along a route

Line Events: Define a discontinuous portion of a route

Choose the measure fields for line events:

From-Measure: StartEvent

To-Measure: EndEvent

Choose the offset field. Events can be offset from their routes.

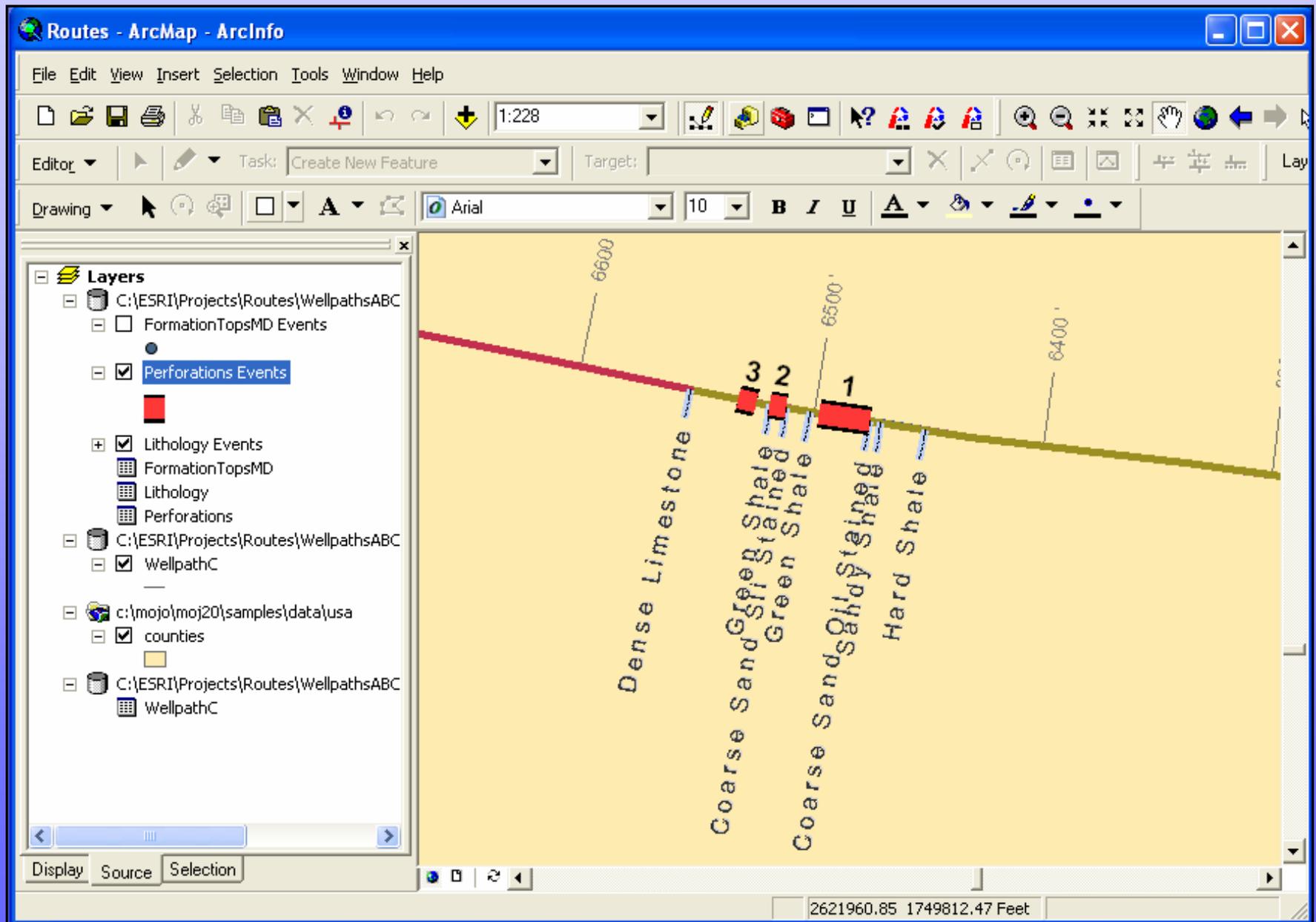
Offset: <None>

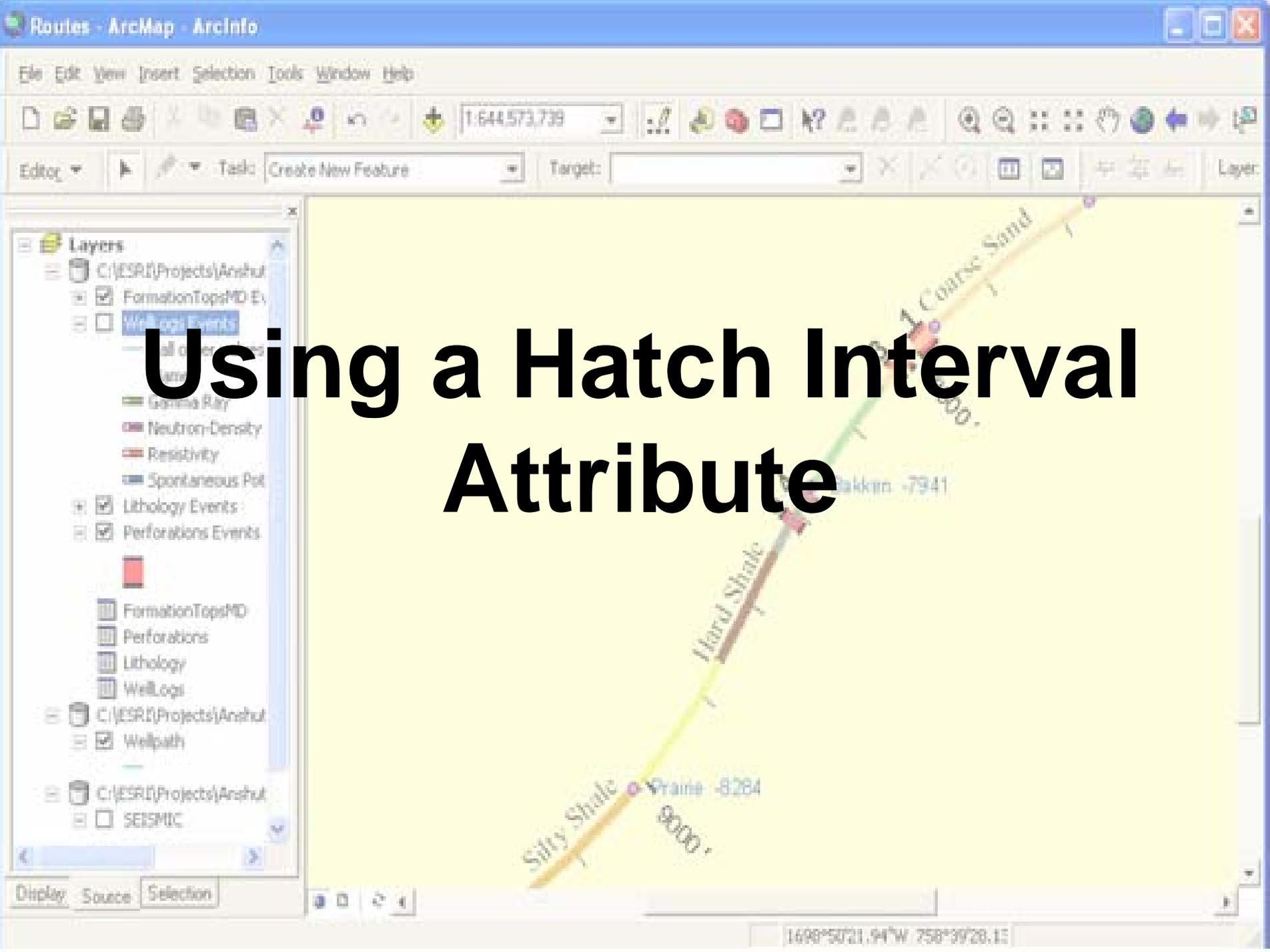
Advanced Options... OK Cancel

Display the “Display Route Events..” dialog by right clicking on the “Perforation Interval” table in the ArcMap table of contents.

Specify start and end measure attributes to create line a line route event layer .

Well Perforations in ArcMap

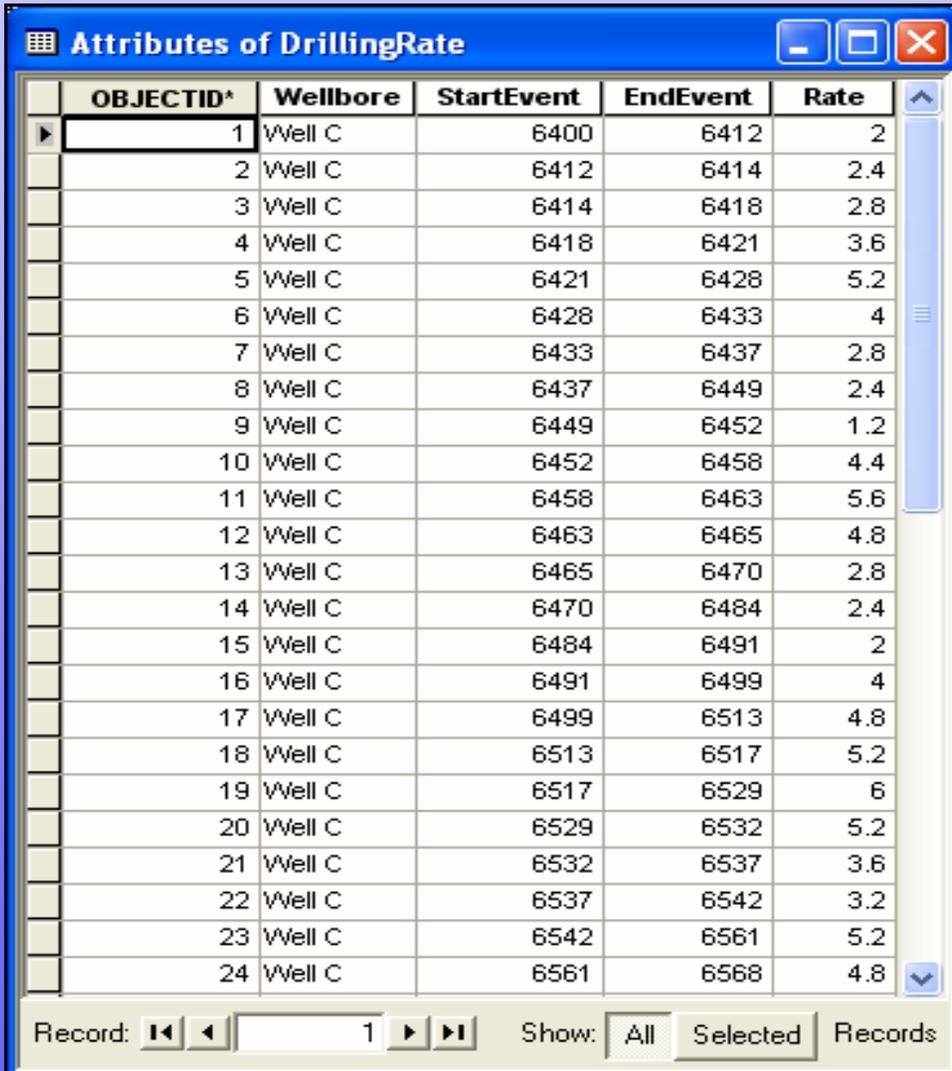




Using a Hatch Interval Attribute

Hatch Interval Attribute Drilling Rates

Example of a table containing drilling rates



OBJECTID*	Wellbore	StartEvent	EndEvent	Rate
1	Well C	6400	6412	2
2	Well C	6412	6414	2.4
3	Well C	6414	6418	2.8
4	Well C	6418	6421	3.6
5	Well C	6421	6428	5.2
6	Well C	6428	6433	4
7	Well C	6433	6437	2.8
8	Well C	6437	6449	2.4
9	Well C	6449	6452	1.2
10	Well C	6452	6458	4.4
11	Well C	6458	6463	5.6
12	Well C	6463	6465	4.8
13	Well C	6465	6470	2.8
14	Well C	6470	6484	2.4
15	Well C	6484	6491	2
16	Well C	6491	6499	4
17	Well C	6499	6513	4.8
18	Well C	6513	6517	5.2
19	Well C	6517	6529	6
20	Well C	6529	6532	5.2
21	Well C	6532	6537	3.6
22	Well C	6537	6542	3.2
23	Well C	6542	6561	5.2
24	Well C	6561	6568	4.8

This table of drilling rate data was used in the following route event example.

Hatch Interval Attribute Drilling Rates

Display Route Events

Route events are objects with locations measured along routes. A table containing route events can be added to the map as a layer.

Specify the routes referenced by the events in the table

Route Reference: WellpathC

Route Identifier: Name

Specify the table containing the route events

Choose a table from the map or browse for another table.

Event Table: DrillingRate

Route Identifier: Wellbore

Choose the type of events the table contains:

Point Events: Occur at a precise location along a route

Line Events: Define a discontinuous portion of a route

Choose the measure fields for line events:

From-Measure: StartEvent

To-Measure: EndEvent

Choose the offset field. Events can be offset from their routes.

Offset: <None>

Advanced Options... OK Cancel

Display the “Display Route Events..” dialog by right clicking on the “Drilling Rate” table in the ArcMap table of contents.

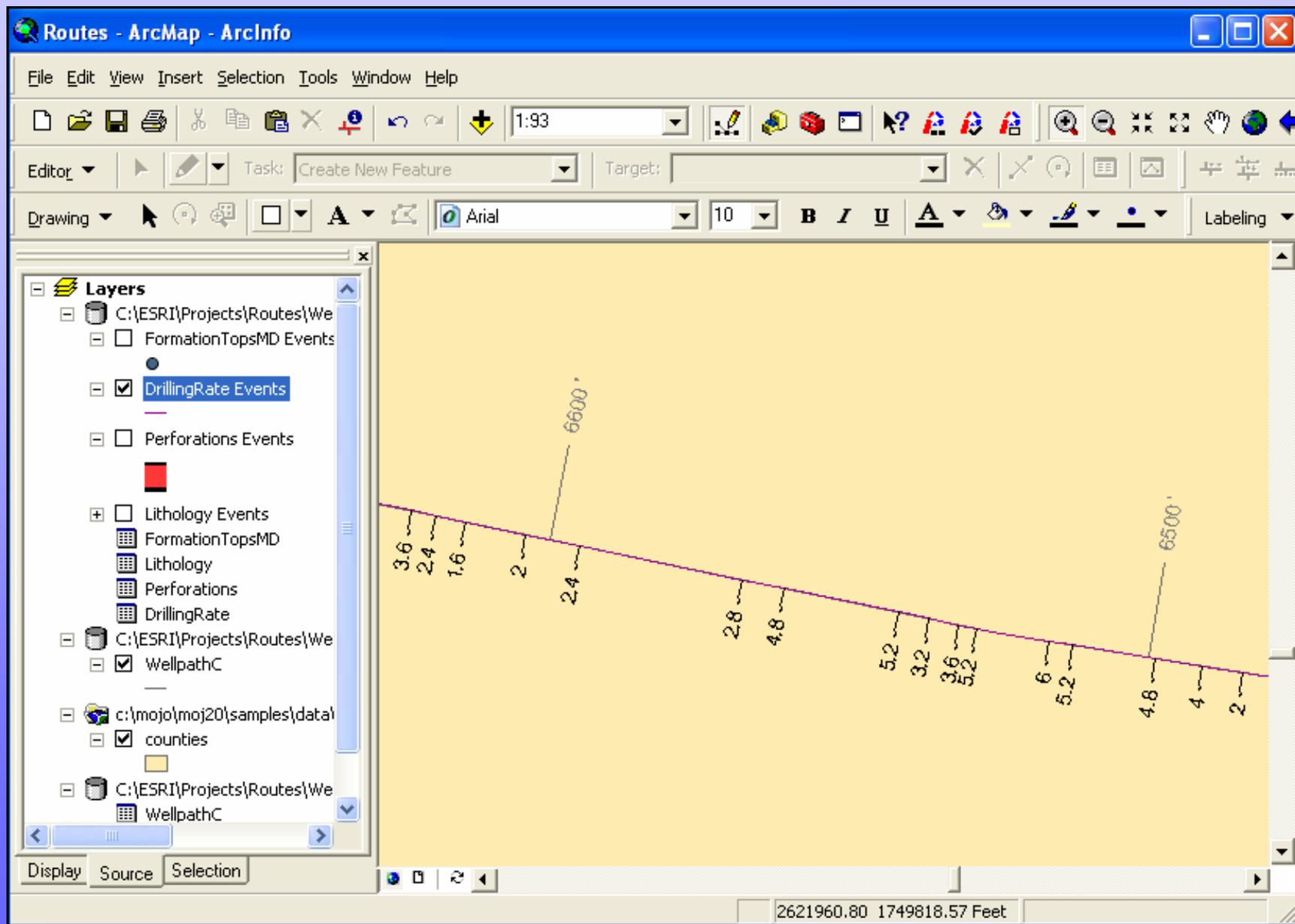
Specify start and end measure attributes to create a line route event layer .

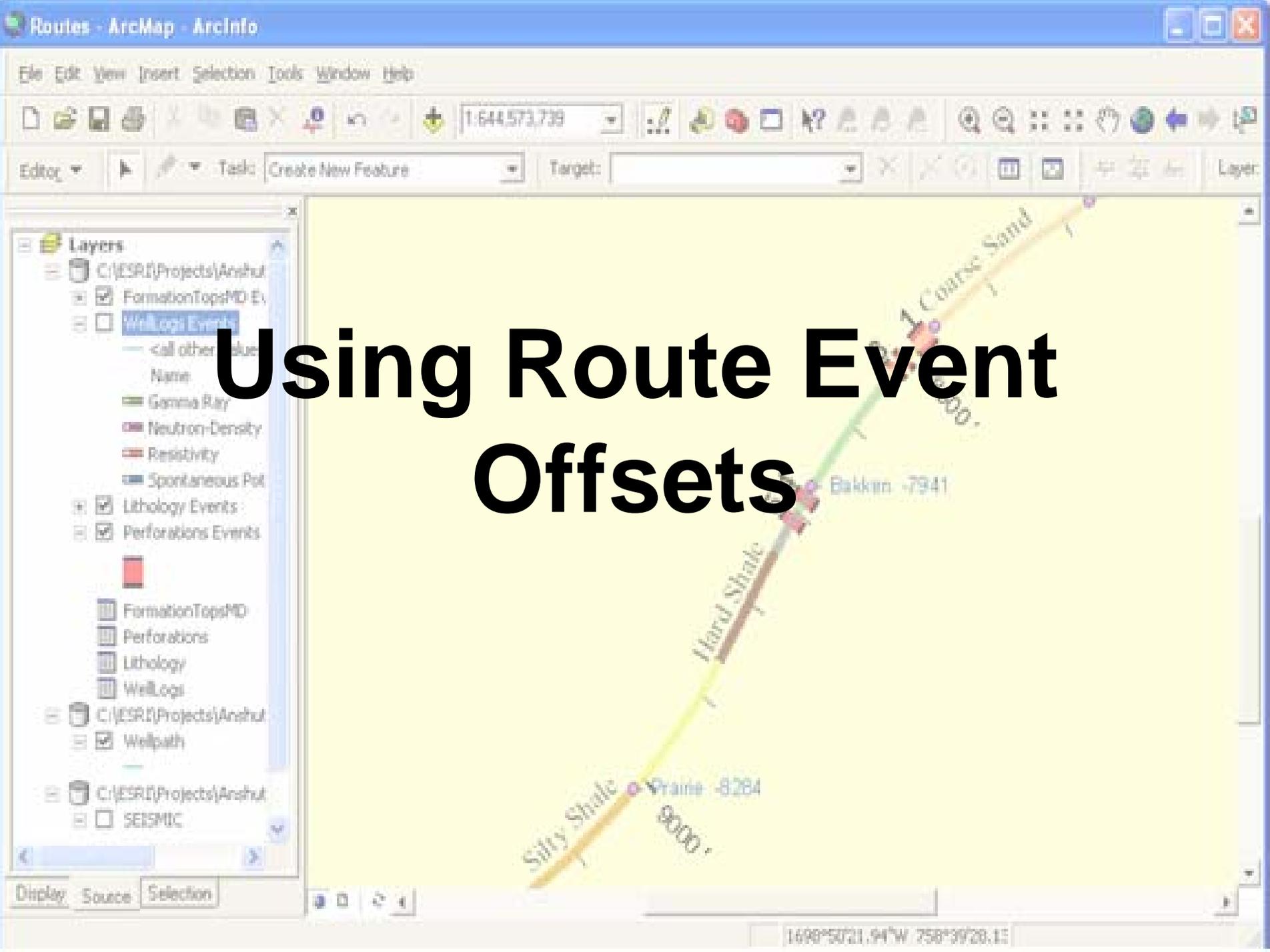
Hatch Interval Attribute Drilling Rates

The screenshot shows the 'Layer Properties' dialog box with the 'Hatches' tab selected. The 'Hatch features in this layer' checkbox is checked. Under the 'Hatch Class' section, 'Hatch Def(1)' is listed. The 'Hatch Interval' section is expanded, showing the option 'Hatch interval using this field' selected, with 'StartEvent' chosen in the dropdown menu. The 'Hatch Definitions' section has 'Add Hatch Definition' and 'Pre-defined Hatch Style' buttons. The 'Other Options' section has 'Hatch Placement...', 'Scale Range...', and 'SQL Query...' buttons. The 'OK', 'Cancel', and 'Apply' buttons are at the bottom.

Use the StartEvent attribute field for the hatch interval.

Drilling Rates Displayed in ArcMap





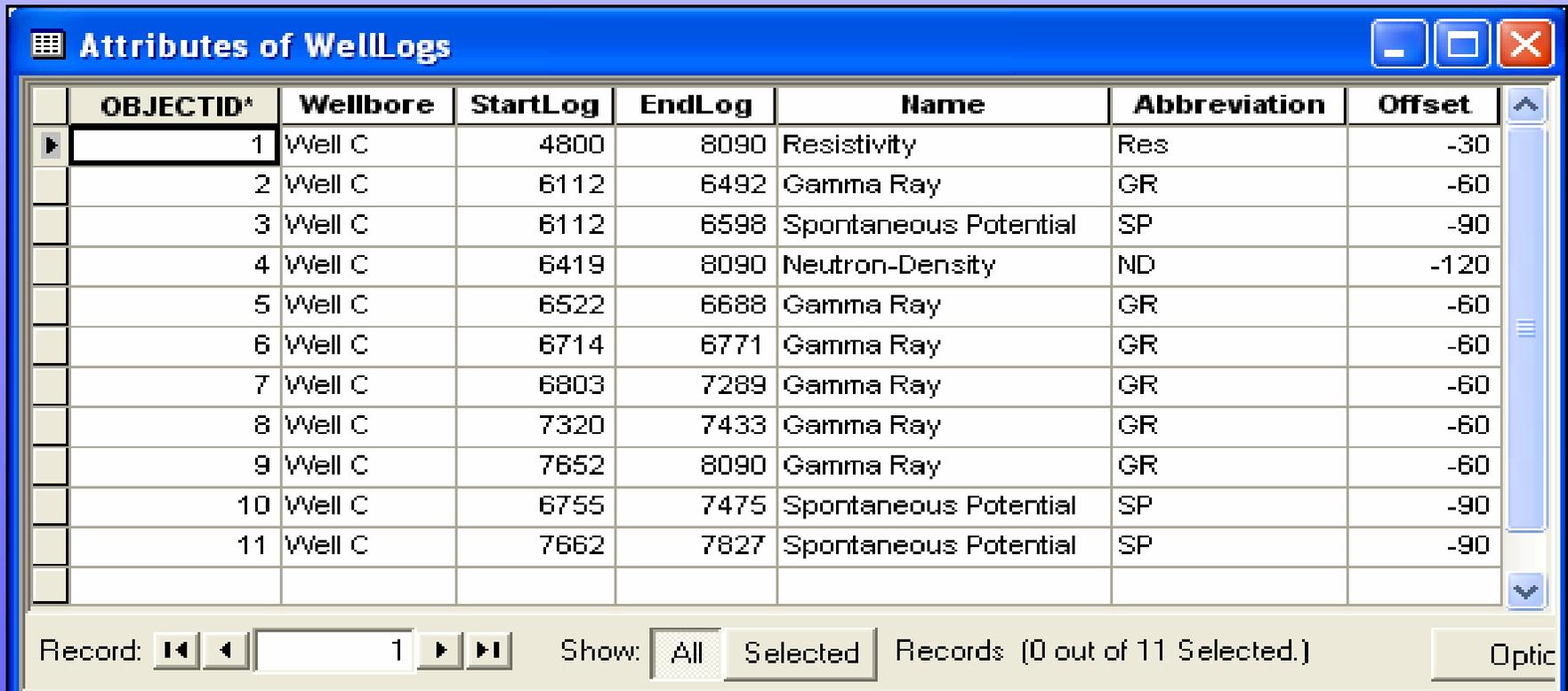
Using Route Event Offsets

Route Event Offsets

Well Logs

This table of well log interval data was used in the following route event example.

Example of a table containing well log intervals



OBJECTID*	Wellbore	StartLog	EndLog	Name	Abbreviation	Offset
1	Well C	4800	8090	Resistivity	Res	-30
2	Well C	6112	6492	Gamma Ray	GR	-60
3	Well C	6112	6598	Spontaneous Potential	SP	-90
4	Well C	6419	8090	Neutron-Density	ND	-120
5	Well C	6522	6688	Gamma Ray	GR	-60
6	Well C	6714	6771	Gamma Ray	GR	-60
7	Well C	6803	7289	Gamma Ray	GR	-60
8	Well C	7320	7433	Gamma Ray	GR	-60
9	Well C	7652	8090	Gamma Ray	GR	-60
10	Well C	6755	7475	Spontaneous Potential	SP	-90
11	Well C	7662	7827	Spontaneous Potential	SP	-90

Record:  1  Show: All Selected Records (0 out of 11 Selected.)

Route Event Offsets

Well Logs

Display Route Events

Route events are objects with locations measured along routes. A table containing route events can be added to the map as a layer.

Specify the routes referenced by the events in the table

Route Reference: WellpathC

Route Identifier: Name

Specify the table containing the route events

Choose a table from the map or browse for another table.

Event Table: WellLogs

Route Identifier: Wellbore

Choose the type of events the table contains:

Point Events: Occur at a precise location along a route

Line Events: Define a discontinuous portion of a route

Choose the measure fields for line events:

From-Measure: StartLog

To-Measure: EndLog

Choose the offset field. Events can be offset from their routes.

Offset: Offset

Advanced Options... OK Cancel

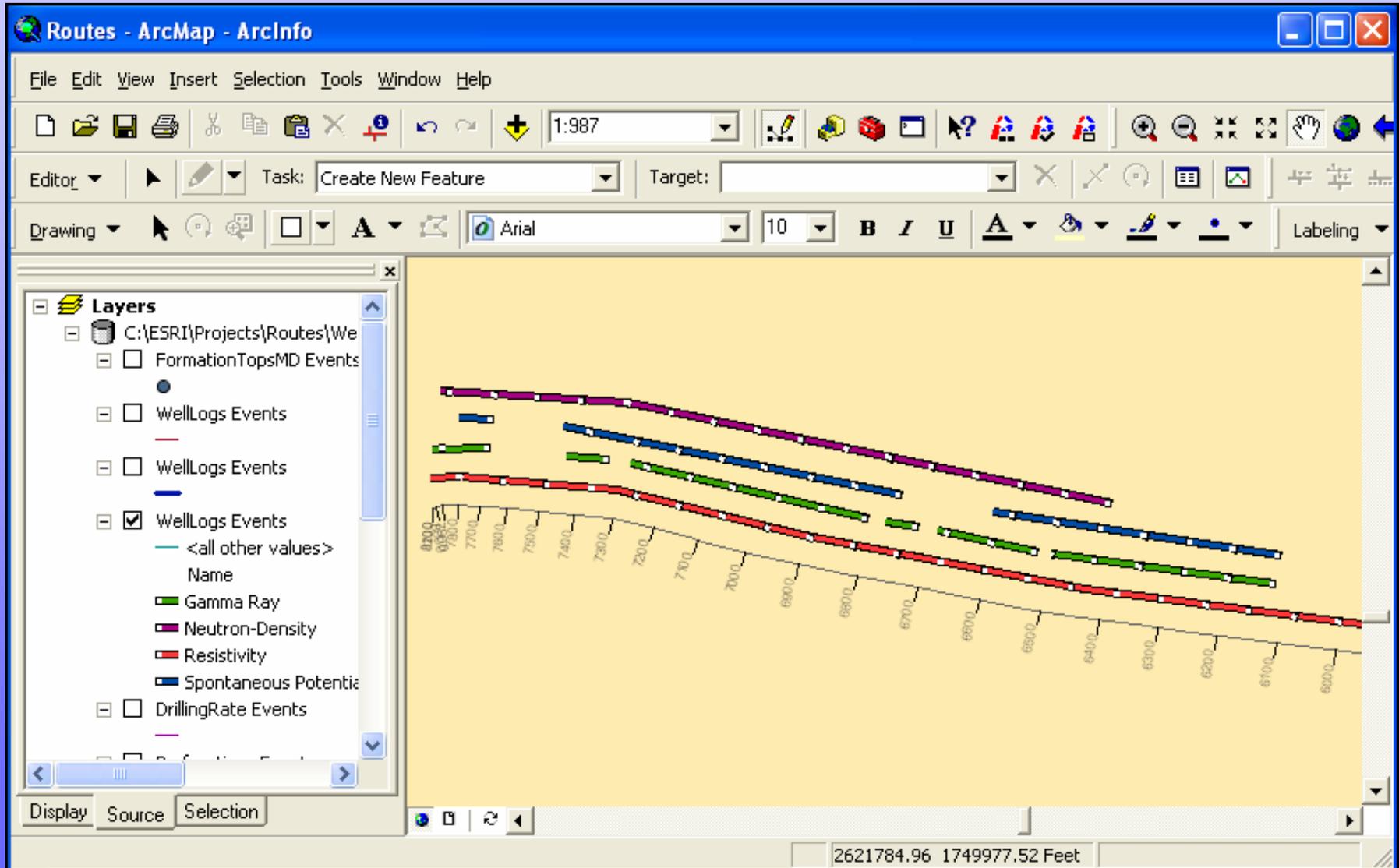
Display the “Display Route Events..” dialog by right clicking on the “Well Log Interval” table in the ArcMap table of contents.

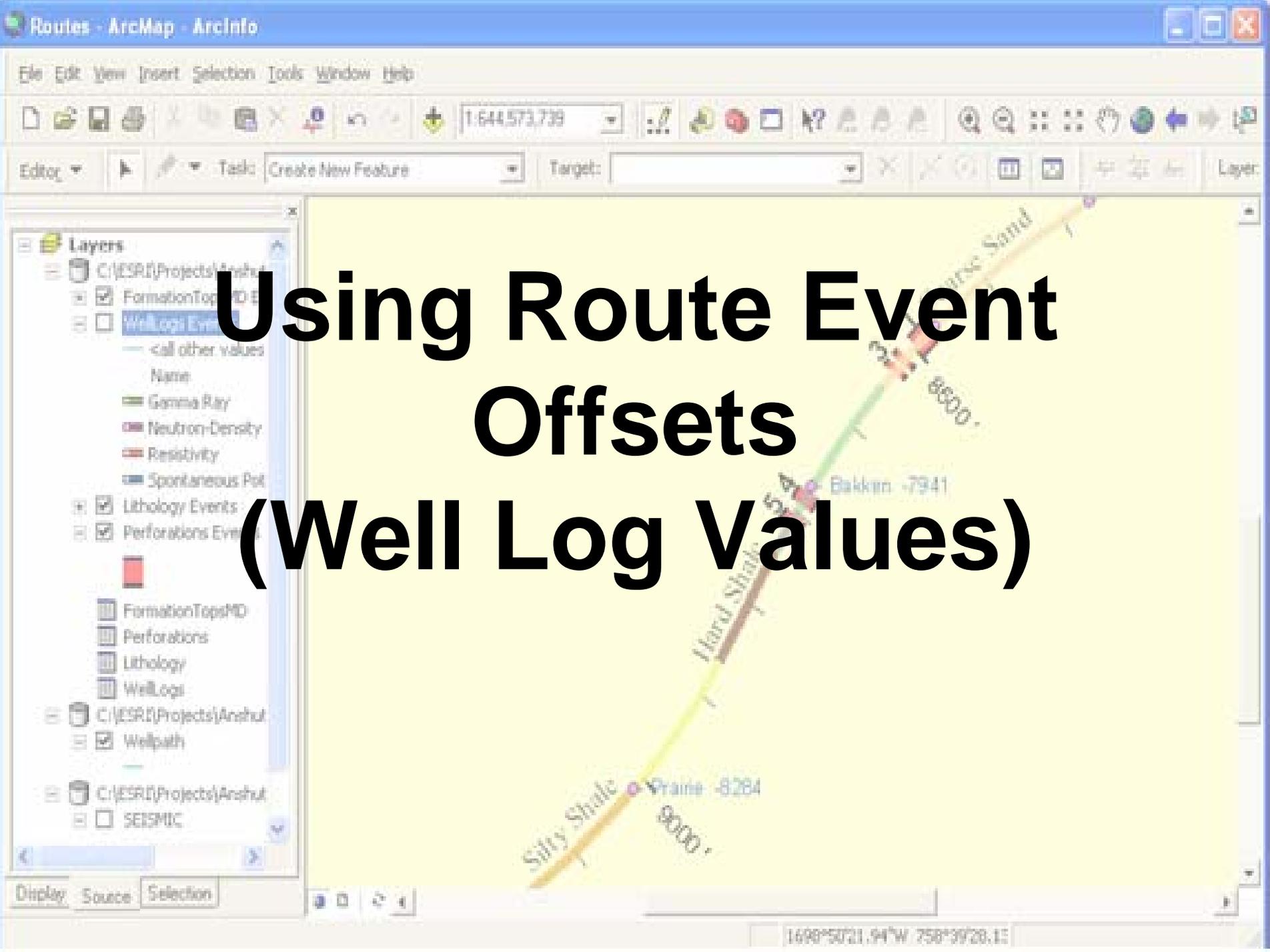
Specify start and end measure attributes to create a line route event layer .

Use an attribute containing offset distances in map units

Well Logs in ArcMap

Well log intervals appear using offsets which overlap along the wellbore





Using Route Event Offsets (Well Log Values)

Route Event Offsets

Well Log Values

Example of a table containing gamma ray values

NAME	DEPTH	GR	SP	GR2	SP2	OBJECTID
WELL E	116.5	39.5322	37.5625	19.7661	43.78125	1
WELL E	117	42.3233	37.5625	21.16165	43.78125	2
WELL E	117.5	40.1438	37.5625	20.0719	43.78125	3
WELL E	118	39.5589	37.5625	19.77945	43.78125	4
WELL E	118.5	34.9209	37.5625	17.46045	43.78125	5
WELL E	119	32.946	37.5625	16.473	43.78125	6
WELL E	119.5	31.2917	37.5625	15.64585	43.78125	7
WELL E	120	35.0027	37.5625	17.50135	43.78125	8
WELL E	120.5	34.1719	37.5625	17.08595	43.78125	9
WELL E	121	34.5027	37.5625	17.25135	43.78125	10
WELL E	121.5	30.7917	37.5625	15.39585	43.78125	11
WELL E	122	33.8863	37.5625	16.94315	43.78125	12
WELL E	122.5	35.3382	37.5625	17.6691	43.78125	13
WELL E	123	38.5085	37.5625	19.25425	43.78125	14
WELL E	123.5	38.3219	37.5625	19.16095	43.78125	15
WELL E	124	38.3219	37.5625	19.16095	43.78125	16
WELL E	124.5	35.675	37.5625	17.8375	43.78125	17
WELL E	125	32.6864	37.5625	16.3432	43.78125	18
WELL E	125.5	25.3015	37.5625	12.65075	43.78125	19

This table of gamma ray data was used in the following route event example.

Route Event Offsets

Well Log Values

Display Route Events

Route events are objects with locations measured along routes. A table containing route events can be added to the map as a layer.

Specify the routes referenced by the events in the table

Route Reference: WellpathE

Route Identifier: Name

Specify the table containing the route events

Choose a table from the map or browse for another table.

Event Table: Well_E_Log_Values

Route Identifier: NAME

Choose the type of events the table contains:

Point Events: Occur at a precise location along a route

Line Events: Define a discontinuous portion of a route

Choose the measure field for point events:

Measure: DEPTH

Choose the offset field. Events can be offset from their routes.

Offset: GR2

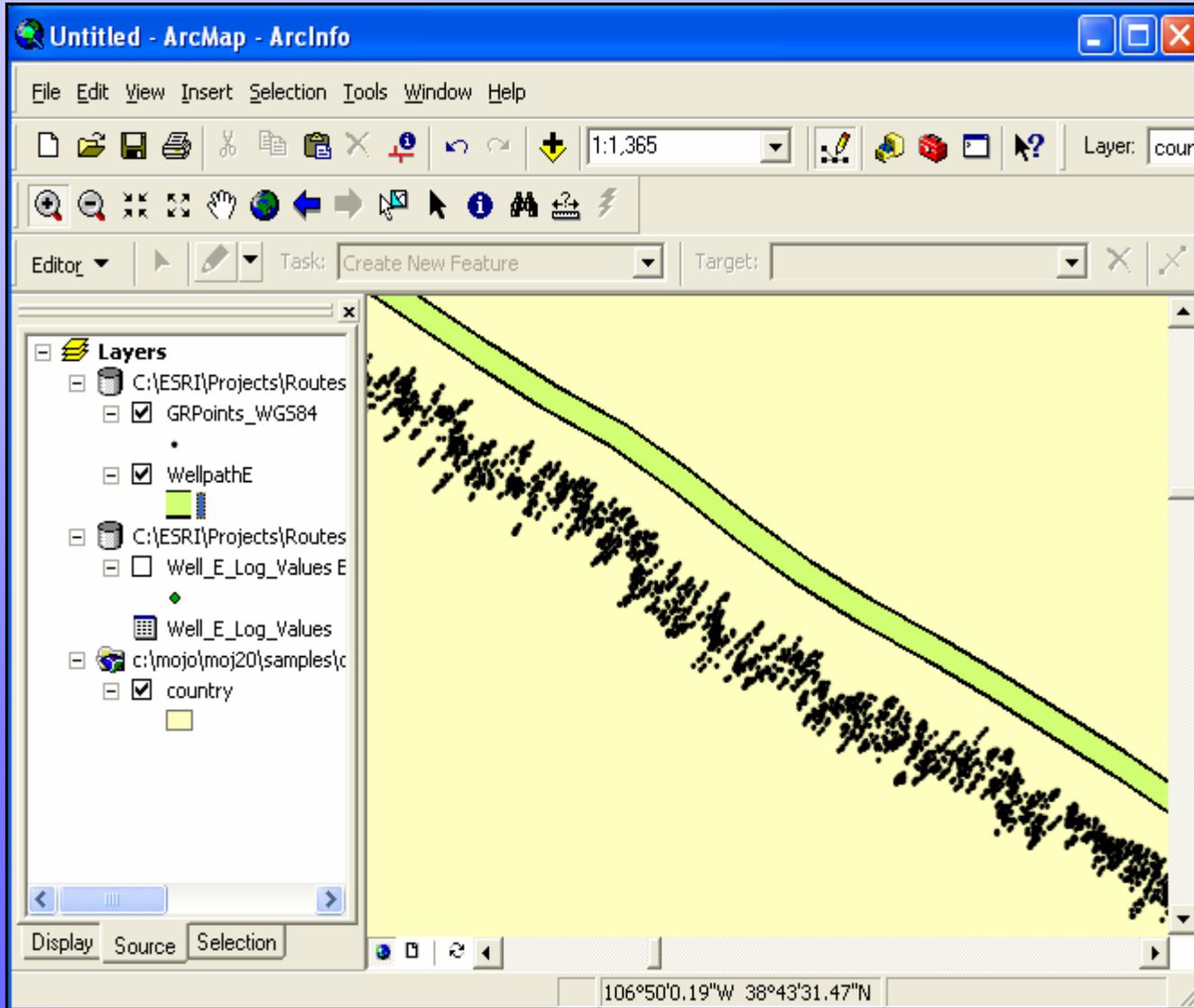
Advanced Options... OK Cancel

Display the “Display Route Events..” dialog by right clicking on the “Well Log Values” table in the ArcMap table of contents.

The measure positions are offset using the gamma ray values

Route Event Offsets

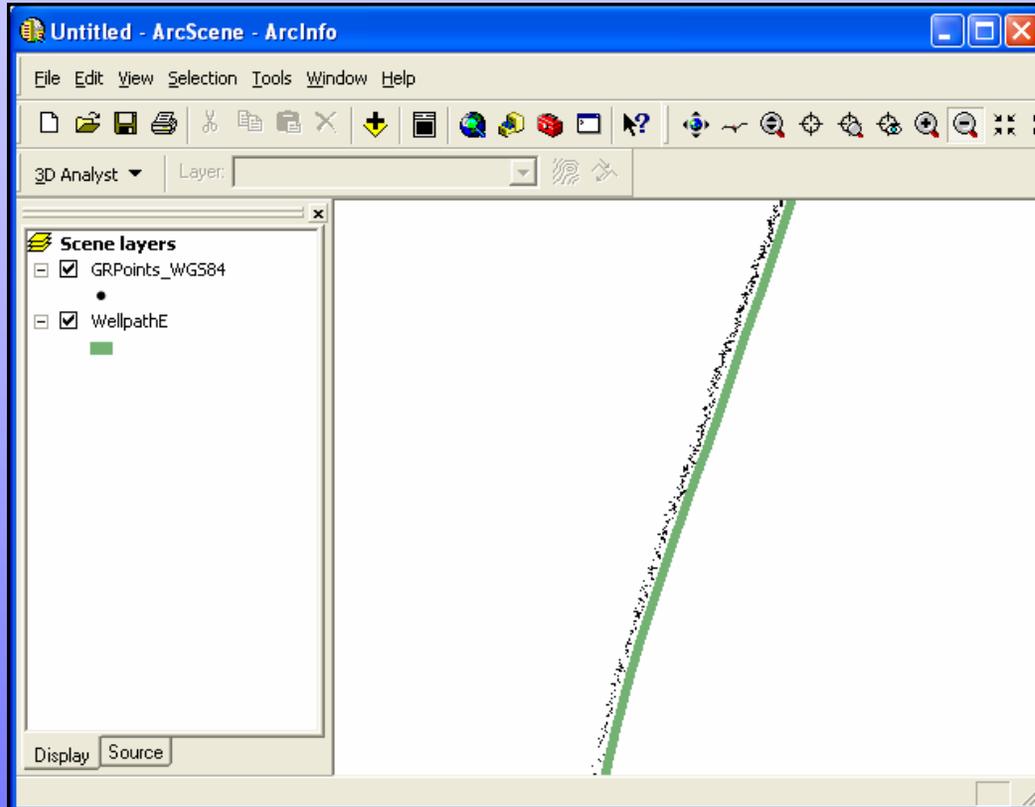
Well Log Values



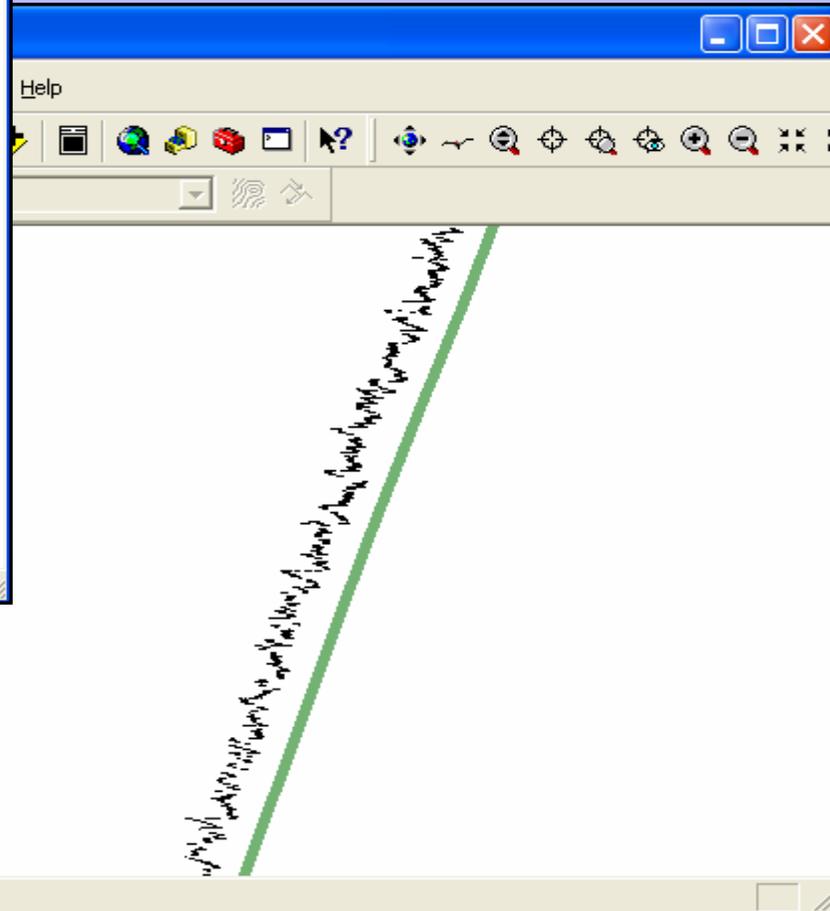
Gamma Ray values displayed spatially, as points. They are offset from the wellbore by the value of the Gamma Ray.

The Gamma Ray measure points can be exported to a geodatabase for use in ArcScene.

Route Event Offsets Well Log Values

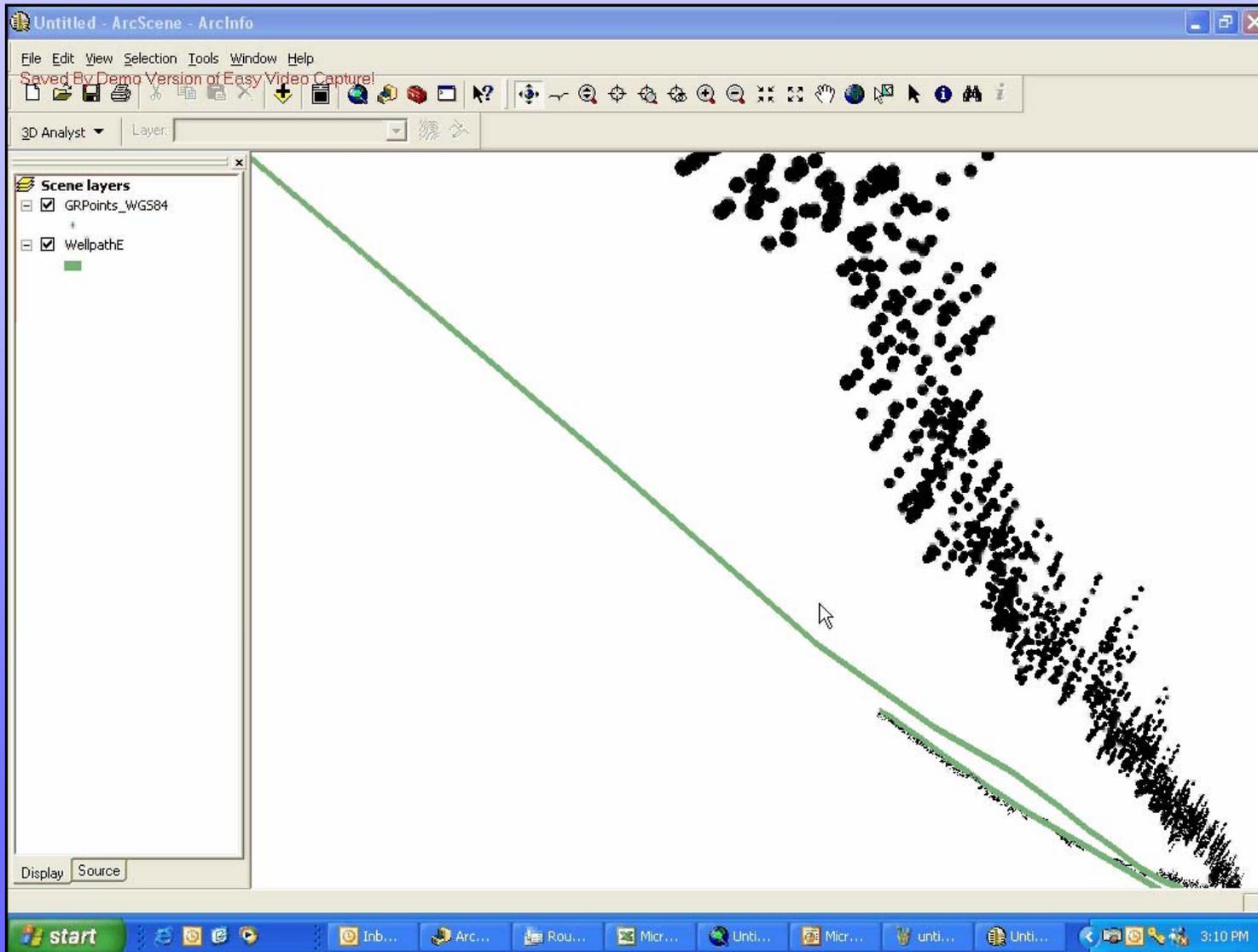


The Gamma Ray data
manipulated in 3D



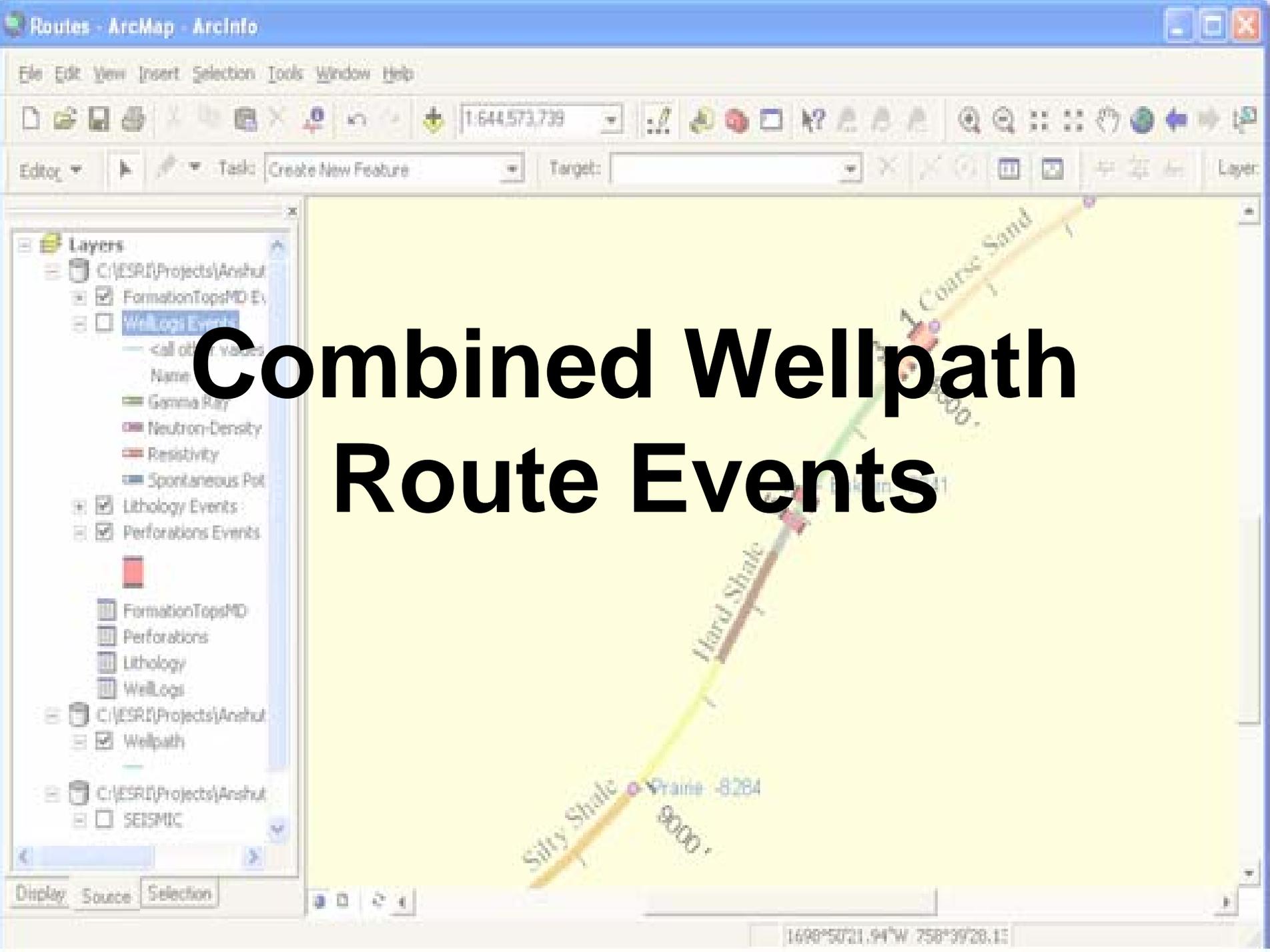
The Gamma Ray data
displayed next to the
wellbore in ArcScene.

Route Event Offsets Well Log Values



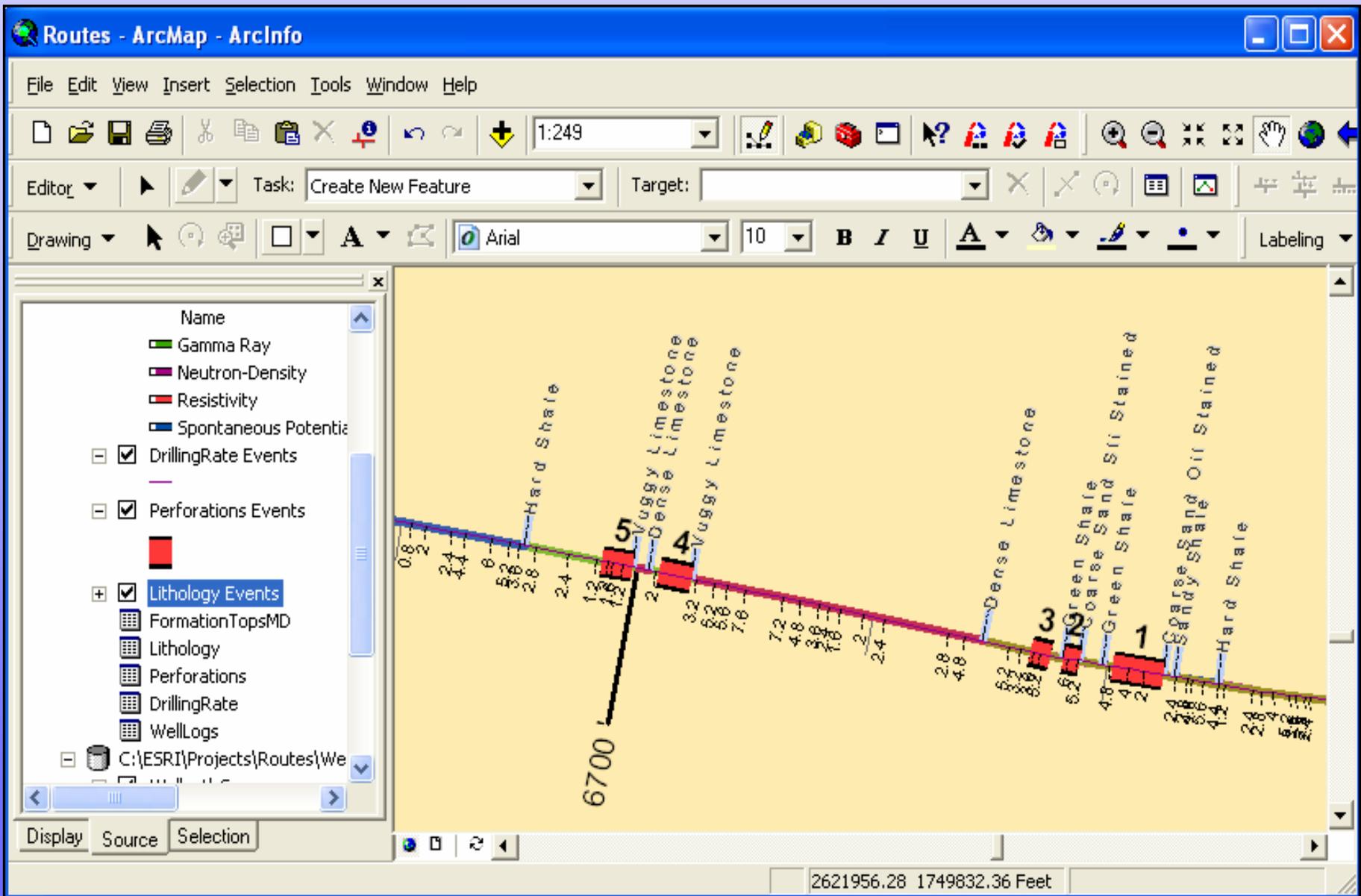
Movie of a
gamma ray
curve
displayed as
3D points

Click on
the picture
to view the
movie

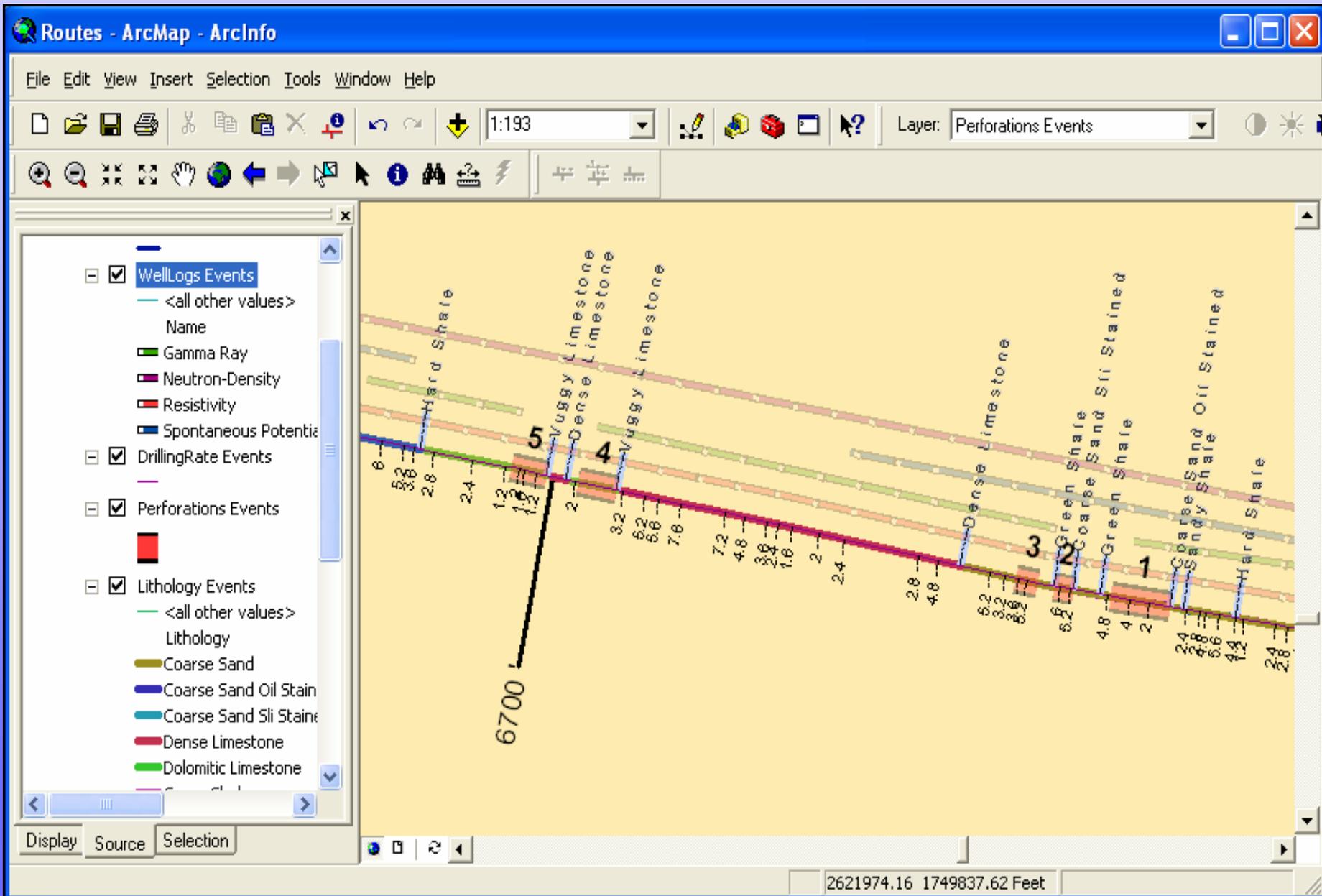


Combined Wellpath Route Events

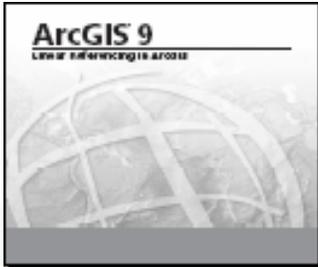
Wellpath Route Events



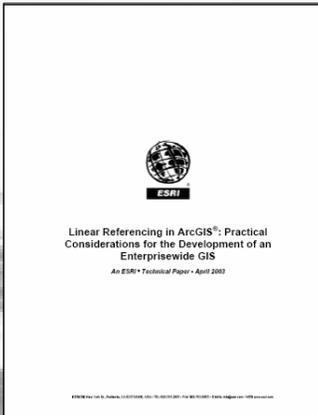
Wellpath Route Events



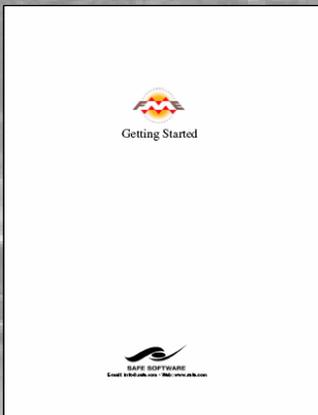
References



ArcGIS 9 Linear Referencing in ArcGIS



Linear Referencing in ArcGIS: Practical Considerations for the Development of an Enterprise GIS

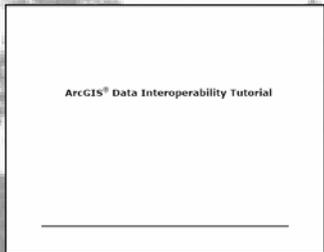


FME Getting Started

References



FME Readers and Writers



ArcGIS Data Interoperability Tutorial