CHAPTER FOUR

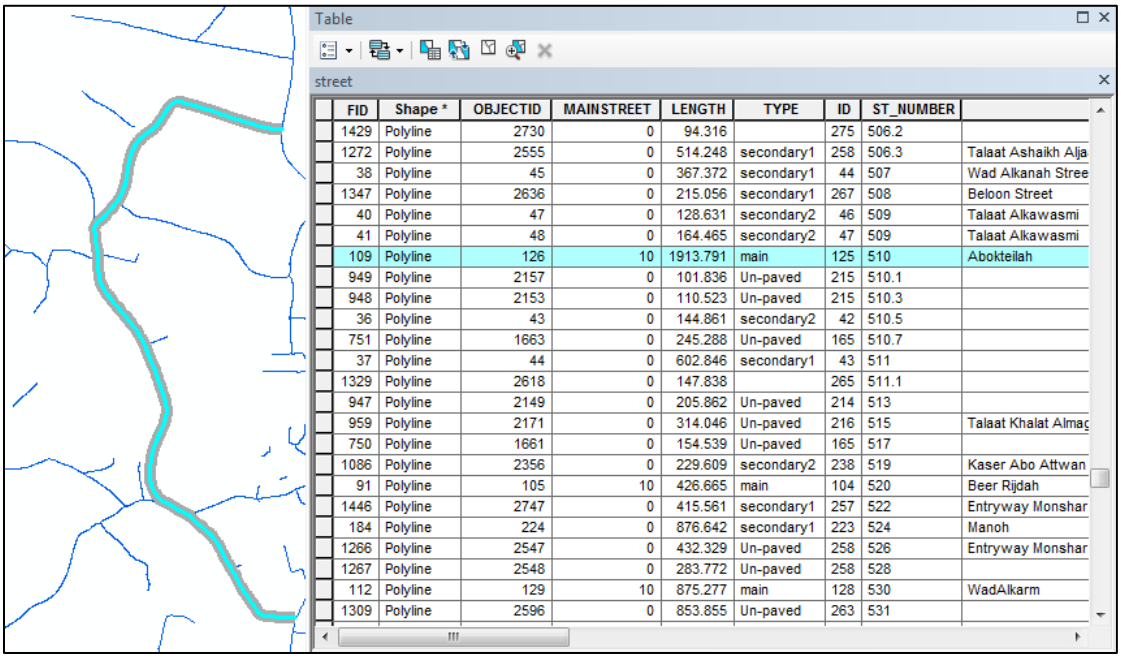
CONSTRUCTION OF ROADS MAINTENANCE MANAGEMENT SUPPORT SYSTEM USING LINEAR REFERENCING METHOD

This chapter contains:

Construction of Roads Maintenance Management Support System Using Linear Referencing Method

4.1 View the Data and Locate Abu Ktelah Street

From street map database of Hebron city, Abu Ktelah Street is located and start working and processing the required data of the street, figure (4.1).

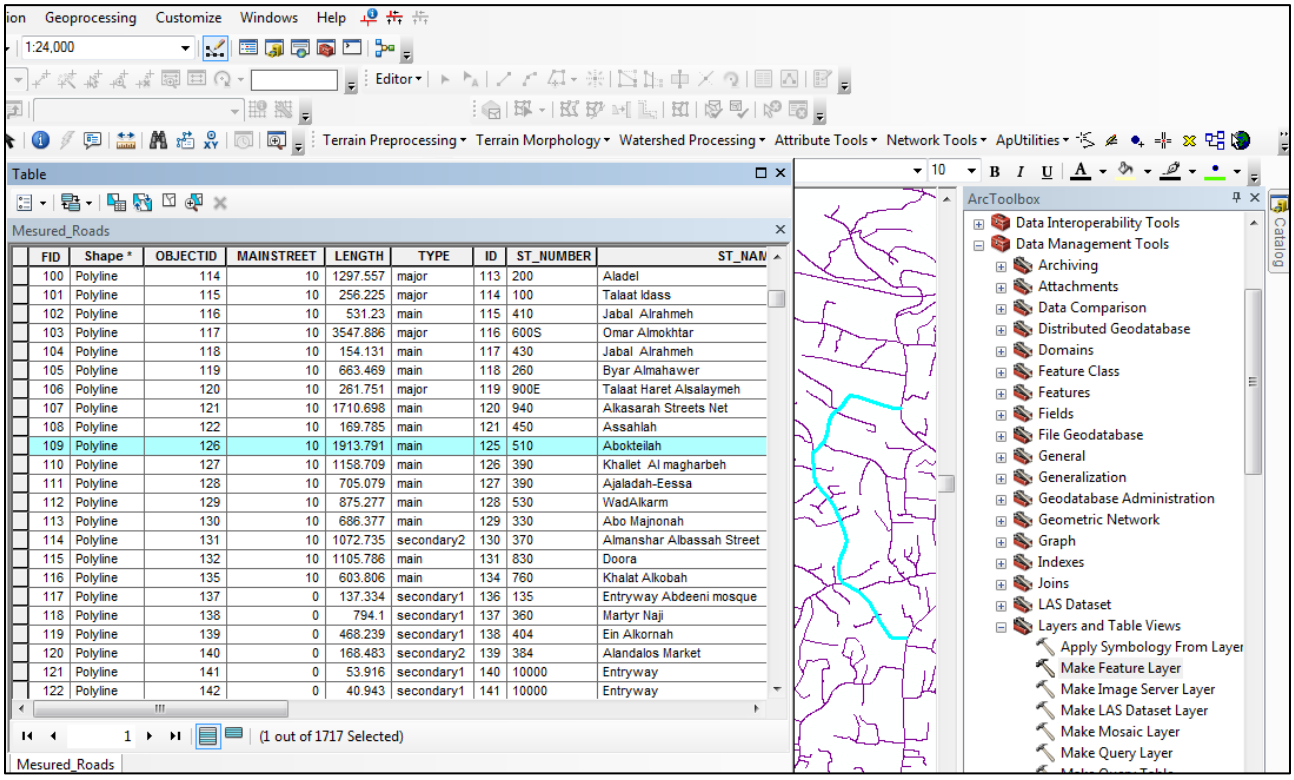


FID	Shape *	OBJECTID	MAINSTREET	LENGTH	TYPE	ID	ST_NUMBER	
1429	Polyline	2730	0	94.316		275	506.2	
1272	Polyline	2555	0	514.248	secondary1	258	506.3	Talaat Ashaikh Alja
38	Polyline	45	0	367.372	secondary1	44	507	Wad Alkanah Stree
1347	Polyline	2636	0	215.056	secondary1	267	508	Beloon Street
40	Polyline	47	0	128.631	secondary2	46	509	Talaat Alkawasmi
41	Polyline	48	0	164.465	secondary2	47	509	Talaat Alkawasmi
109	Polyline	126	10	1913.791	main	125	510	Abokteilah
949	Polyline	2157	0	101.836	Un-paved	215	510.1	
948	Polyline	2153	0	110.523	Un-paved	215	510.3	
36	Polyline	43	0	144.861	secondary2	42	510.5	
751	Polyline	1663	0	245.288	Un-paved	165	510.7	
37	Polyline	44	0	602.846	secondary1	43	511	
1329	Polyline	2618	0	147.838		265	511.1	
947	Polyline	2149	0	205.862	Un-paved	214	513	
959	Polyline	2171	0	314.046	Un-paved	216	515	Talaat Khalat Almaç
750	Polyline	1661	0	154.539	Un-paved	165	517	
1086	Polyline	2356	0	229.609	secondary2	238	519	Kaser Abo Attwan
91	Polyline	105	10	426.665	main	104	520	Beer Rijdah
1446	Polyline	2747	0	415.561	secondary1	257	522	Entryway Monshar
184	Polyline	224	0	876.642	secondary1	223	524	Manoh
1266	Polyline	2547	0	432.329	Un-paved	258	526	Entryway Monshar
1267	Polyline	2548	0	283.772	Un-paved	258	528	
112	Polyline	129	10	875.277	main	128	530	WadAlkarm
1309	Polyline	2596	0	853.855	Un-paved	263	531	

Figure (4.1): Hebron City Street Database, GIS Department Hebron Municipality,2017.

4.2 Select Abu Ktelah Route and Put it in Layer

Creating a temporary layer allows you to do things, such as make selections, without affecting the original data source.



FID	Shape *	OBJECTID	MAINSTREET	LENGTH	TYPE	ID	ST_NUMBER	ST_NAM
100	Polyline	114	10	1297.557	major	113	200	Aladel
101	Polyline	115	10	256.225	major	114	100	Talaat Idass
102	Polyline	116	10	531.23	main	115	410	Jabal Alrahmeh
103	Polyline	117	10	3547.886	major	116	600S	Omar Almokhtar
104	Polyline	118	10	154.131	main	117	430	Jabal Alrahmeh
105	Polyline	119	10	663.469	main	118	260	Byar Almahawer
106	Polyline	120	10	261.751	major	119	900E	Talaat Haret Alsalaymeh
107	Polyline	121	10	1710.698	main	120	940	Alkasarah Streets Net
108	Polyline	122	10	169.785	main	121	450	Assahlah
109	Polyline	126	10	1913.791	main	125	510	Abokteilah
110	Polyline	127	10	1158.709	main	126	390	Khallet Al magharbeh
111	Polyline	128	10	705.079	main	127	390	Ajaladah-Eessa
112	Polyline	129	10	875.277	main	128	530	WadAlkarm
113	Polyline	130	10	686.377	main	129	330	Abo Majnonah
114	Polyline	131	10	1072.735	secondary2	130	370	Almanshar Albassah Street
115	Polyline	132	10	1105.786	main	131	830	Doora
116	Polyline	135	10	603.806	main	134	760	Khalat Alkobah
117	Polyline	137	0	137.334	secondary1	136	135	Entryway Abdeeni mosque
118	Polyline	138	0	794.1	secondary1	137	360	Martyr Naji
119	Polyline	139	0	468.239	secondary1	138	404	Ein Alkornah
120	Polyline	140	0	168.483	secondary2	139	384	Alandalos Market
121	Polyline	141	0	53.916	secondary1	140	10000	Entryway
122	Polyline	142	0	40.943	secondary1	141	10000	Entryway

Figure (4.2): Take out the Street in the Layer

Choose the path of Abu Ktelah and put it in a layer to start applying the orders of linear referencing application on it and separate it from the rest of the Hebron city streets, figure (4.2).

4.3 Creates Routes.

A route feature class is a line feature class that has a defined measurement system. These measurement values can be used to locate events, assets, and conditions along its set of linear features.

The Create Routes tool is used to specify the input line features, the route identifier field, the method used to set the route measures, and the output feature class.

Creates routes from existing lines. The input line features that share a common identifier are merged to create a single route, figure (4.3).

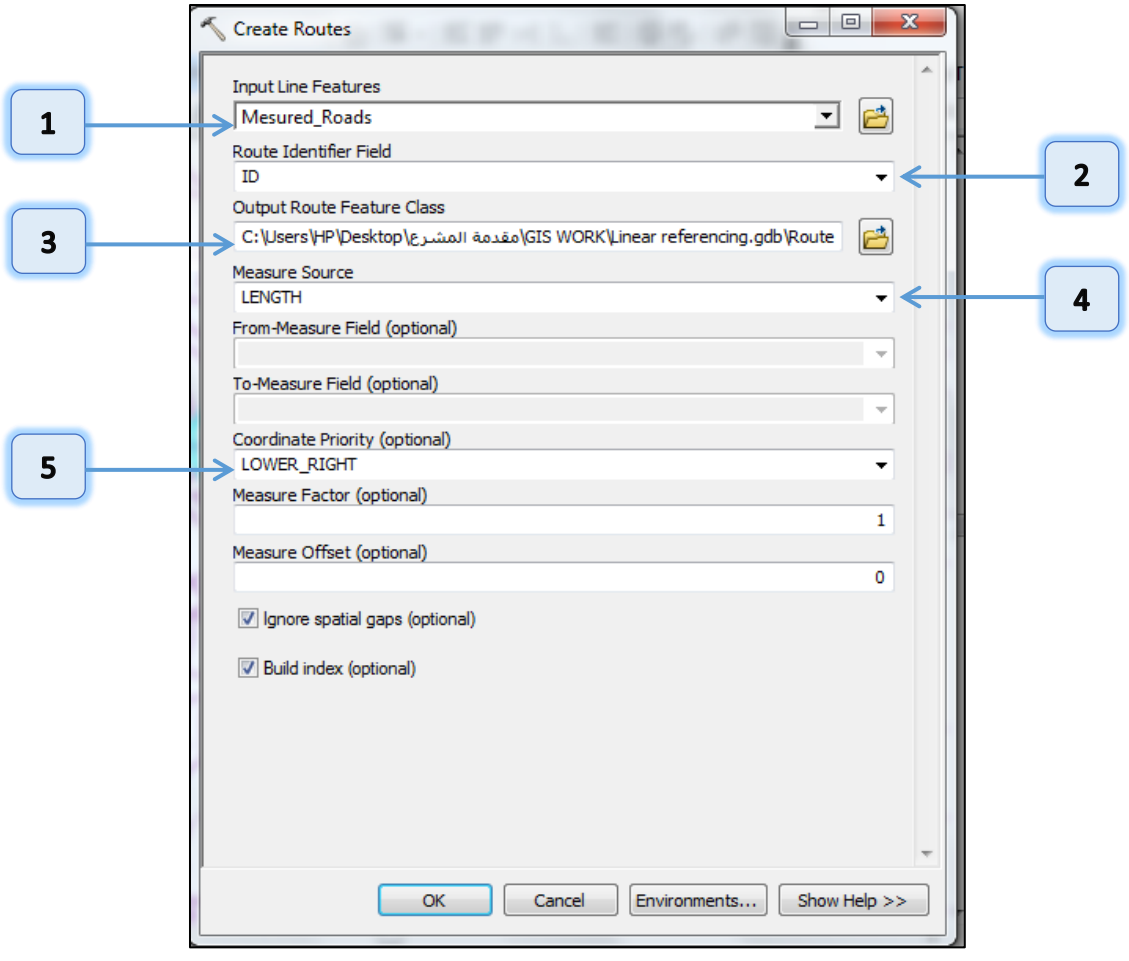


Figure (4.3): Creates Routes

As illustrated in figure (4.3), the

1. Measured_Roads layer is input line feature.
2. ID field is Abu Ktelah route identifier.
3. Street _Route the output feature class.
4. Length is measure source.
5. Lower right is coordinate priority.

4.4 Abu Ktelah Route

Figure (4.4) shows the Abu Ktelah route feature and its attribute table, which contains the ID, Shape and Shape_Length fields, which is created using create routes tool.

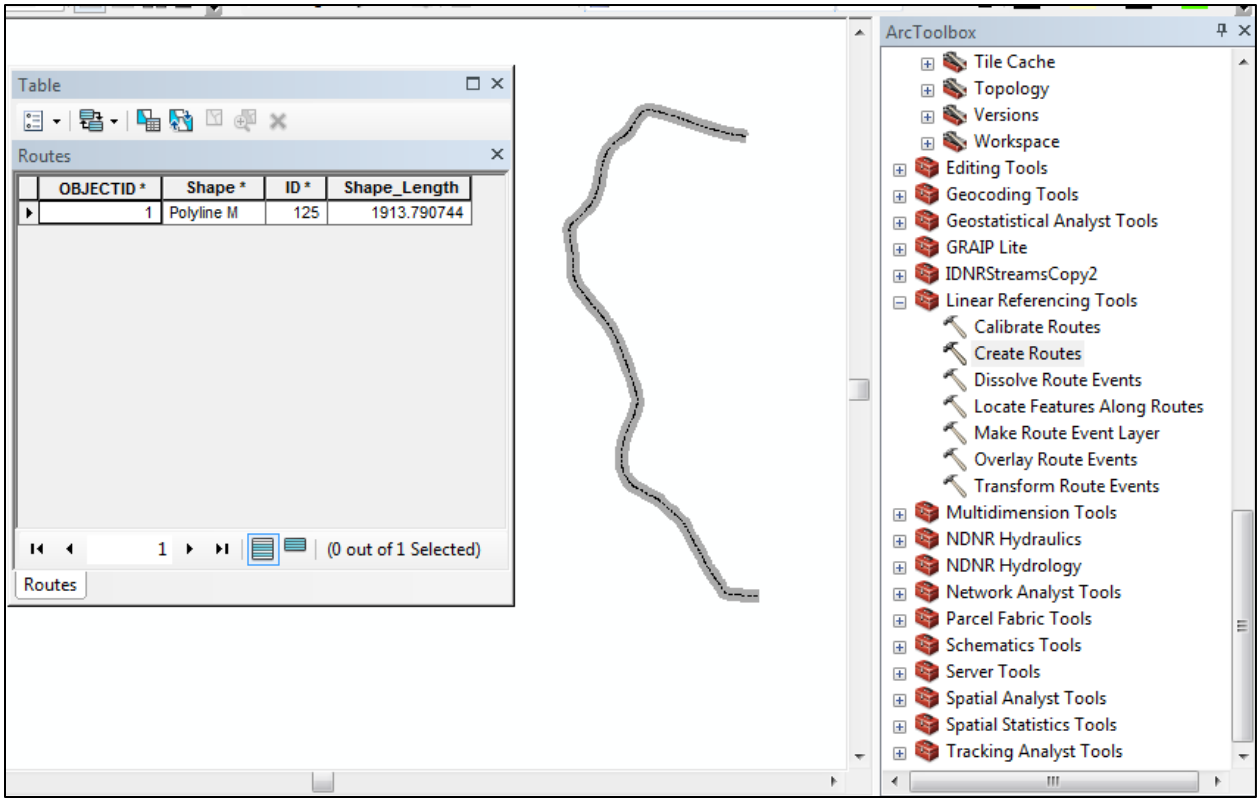


Figure (4.4): Abu Ktelah Route

4.5 Line and Point Event Tables

Event tables contain information about assets, conditions, and events that can be located along route features. Each row in the event table references an event and its location is expressed as measurements along named (identifiable) linear features.

Line event: Line events define a portion of a route. Both from- and to-measure fields must be specified. Figure (4.5) shows the surveyed line event table of Abu Ktelah street

Line Events

OBJE	OID	R_ID	Fmp	Tmp	ITEM	MATERIAL	CONDITION	status	LENGTH_	WIDTH_	OFFSET_M	NOTE
10	10	125	112.18	116.02	Trench	Asphalt	Poor	Need to repair	3.99	1.14	_	Null
79	79	125	1802.14	1807.16	Trench	Asphalt	Poor	Need to repair	29.2	0.89	_	Null
46	46	125	1060.83	1074.32	Crack	Asphalt	Poor	Need to fill	13.79	0	_	Longitudinal crack
69	69	125	1658.86	1658.9	Crack	Asphalt	Poor	Need to fill	5.81	0	_	cross track
36	36	125	925.05	935.18	Retaining wall	Concrete	Does not exist	Need to set	9.61	0	_	4.5 m height
41	41	125	986.41	993.29	Trench	Asphalt	Poor	Need to repair	6.85	1.5	_	Null
64	64	125	1606.96	1616.62	Crack	Asphalt	Poor	Need to fill	11.55	0	_	Longitudinal crack
31	31	125	650.52	805.05	Trench	Asphalt	Poor	need to repair	51.04	1.74	_	Null
17	17	125	221.83	280.57	Trench	Asphalt	Poor	Need to repair	58.72	0.71	_	Null
87	87	125	1212	1215	Crosswalk	paint	Dose not exist	Need to set	3	7	_	Null
19	19	125	259.53	272.54	Trench	Asphalt	Poor	Need to repair	12.8	0.46	_	Null
59	59	125	1477.63	1506.14	Crack	Asphalt	Poor	Need to fill	28.97	0	_	Longitudinal crack
4	4	125	61.39	62.25	Trench	Asphalt	Poor	Need to repair	1.12	4.86	_	Null
82	82	125	400	403	Crosswalk	paint	Dose not exist	Need to set	3	6	_	Null
49	49	125	1025.22	1025.5	Crack	Asphalt	Poor	Need to fill	4.14	0	_	cross track
54	54	125	1263.95	1273.17	Trench	Asphalt	Poor	Need to repair	9.22	1.5	_	Null
20	20	125	281.32	281.57	Trench	Asphalt	Poor	Need to repair	0.27	4.38	_	Null
8	8	125	101.41	102.59	Trench	Asphalt	Poor	Need to repair	0.77	4.22	_	Null
77	77	125	1782.32	1782.35	Crack	Asphalt	Poor	Need to fill	4.2	0	_	cross track
44	44	125	1051.07	1051.87	Trench	Asphalt	Poor	Need to repair	0.8	5.83	_	Null
72	72	125	1738	1752.77	Trench	Asphalt	Poor	Need to repair	14.72	0.86	_	Null
39	39	125	942.79	964.36	Crack	Asphalt	Poor	Need tofill	21.58	0	_	Longitudinal crack
62	62	125	1547.91	1548	Crack	Asphalt	Poor	Need to repair	4.58	0	_	cross track
29	29	125	661.34	709.37	Crack	Asphalt	Poor	Need to fill	46.88	0	_	Longitudinal crack
67	67	125	1635.6	1645.44	Trench	Asphalt	Poor	Need to repair	11.3	3.44	_	Null

0 (0 out of 83 Selected)

Line Events

Figure (4.5): Line Event Table

Point event: Point events occur at a precise location along a route. Only a from-measure field must be specified, figure (4.6).

Table

Point Events

OBJECTID *	OID	R_ID	Measurment	ITEM	MATERIAL	CONDITION	Status	LENGTH_M	WIDTH_M	DIAMETER_M
86	86	125	1350.36	TP	Wood	good	_	0	0	0.1
53	53	125	783.4	TP	Wood	good	_	0	0	0.1
148	148	125	1206.35	Patch	Asphalt	Poor	Need to repair	7.87	0.73	0
102	102	125	1528.31	TP	Wood	good	_	0	0	0.1
9	9	125	87.56	Hole	Asphalt	Poor	Need to fill	0	0	0.2
76	76	125	1214.38	Manhole	Steel	good	_	0	0	0.5
2	2	125	5	EP	Wood	good	_	0	0	0.1
43	43	125	617.64	Hole	Asphalt	Poor	Need to fill	0	0	0.4
138	138	125	1831.9	TP	Wood	good	_	0	0	0.1
125	125	125	1689.12	EP	Steel	good	_	0	0	0.1
143	143	125	1877.4	EP	Steel	good	_	0	0	0.1
130	130	125	1746.51	EP	steel	good	_	0	0	0.1
13	13	125	133.26	TP	Wood	good	_	0	0	0.1
71	71	125	976.33	Patch	Asphalt	Poor	Need to repair	0	0	3
38	38	125	489.59	TP	Wood	good	_	0	0	0.1
133	133	125	1781.61	EP	Steel	good	_	0	0	0.1
120	120	125	1669.25	Hole	Asphalt	Poor	Need to fill	0	0	0.5
94	94	125	1433.88	TP	Wood	good	_	0	0	0.1
61	61	125	886.32	EP	Steel	good	_	0	0	0.1
99	99	125	1495.96	S-MH	Steel	good	_	0	0	_
66	66	125	960.61	TP	Wood	good	_	0	0	0.1
33	33	125	451.56	EP	Steel	good	_	0	0	0.1
115	115	125	1649.41	EP	Steel	good	_	0	0	0.1
89	89	125	1367.57	EP	Steel	good	_	0	0	0.1
56	56	125	839.44	EP	Steel	good	_	0	0	0.1

0 (0 out of 157 Selected)

Figure (4.6): Point Event Table

4.6 Add Route Event to Abu Ktelah Route

Adding route events from the ArcMap Tools menu

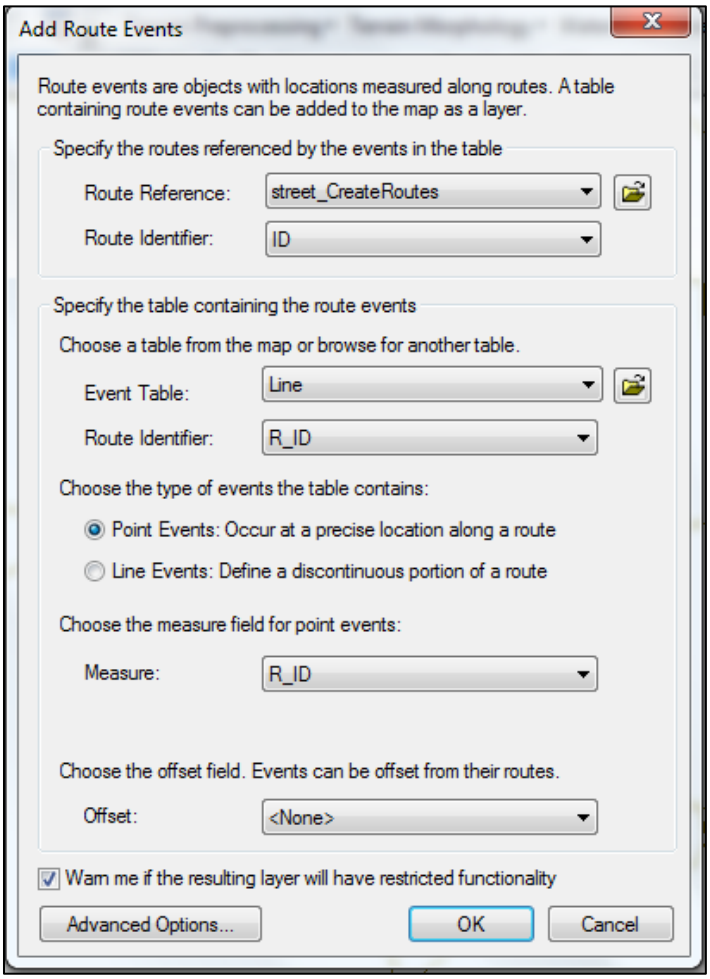


Figure (4.7): Add Route Event to Abu Ktelah Street

Add Route Events tool transforms the measures of events from one route reference to another and writes them to a new event table.Figure (4.8) and (4.9) represent the Abu Ktelah Route and its added line and point events ,respectively .

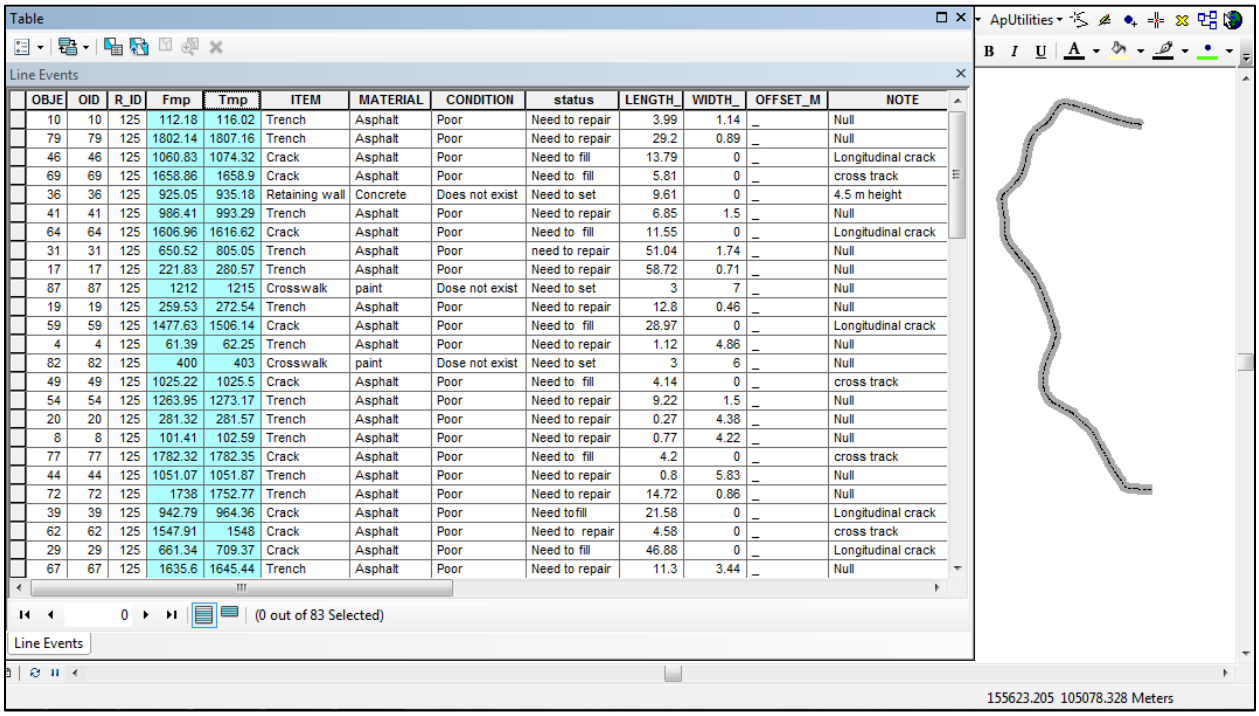


Figure (4.8): Abu Ktelah Route and its Line Event Table

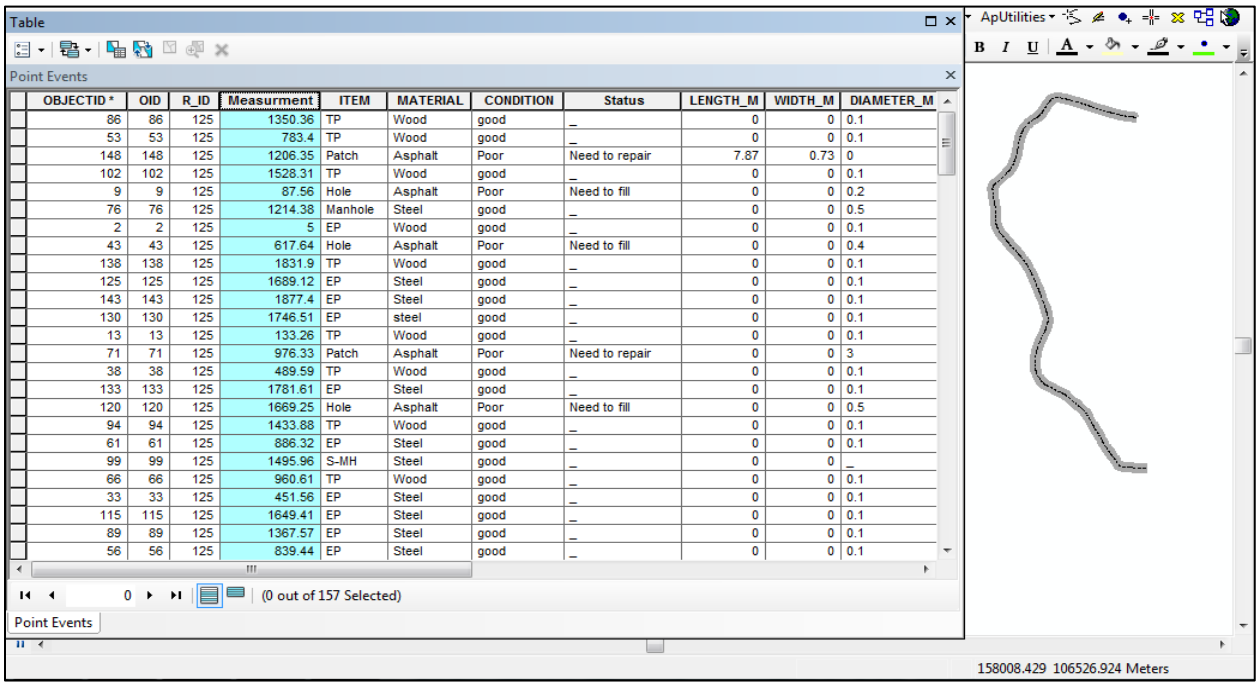


Figure (4.9): Abu Ktelah Route and its Point Event Table

4.7 Calculate the Maintenance Total Cost

Maintenance cost is calculated to give an initial idea to the concerned authorities such as municipalities, contractors or companies about the estimated cost of maintenance.

Table (4.1) shows the unit cost of maintenance for each event located on Abu Ktelah Street, Hebron Municipality.

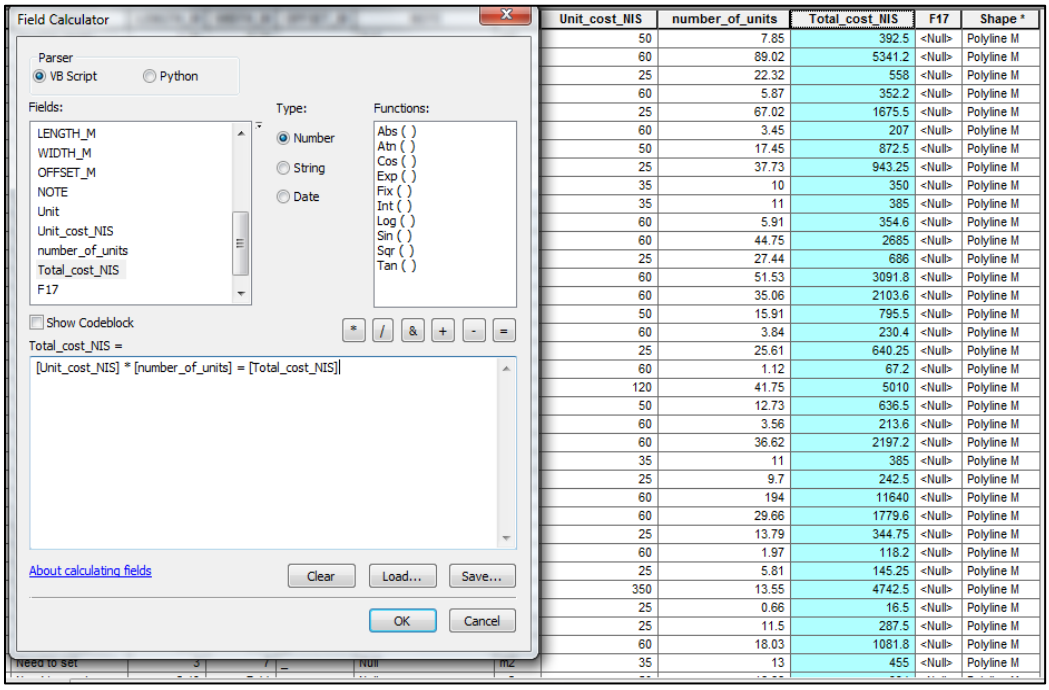
ITEM	Unit	Unit cost (NIS)
Crack	m	25.00
Trench	m2	60.00
Guardrail	m	350.0
Pump	m2	50.00
Retaining wall	m2	1500
Widening	m2	120
Paint	m2	35
Hole	m2	40
Patch	m2	60
Cat eye	-	45

Table (4.1): Events Maintenance Cost, Street Department, Hebron Municipality 2017.

Unit cost: The cost of maintaining every event on the street such as Crack, Pump, Hole, Patch….etc.

Total cost = Unit cost * Number of units.

The cost of maintenance was calculated for all events on Abu Ktelah Street using GIS field calculator from point and line event tables as shown in figure (4.10).



Unit_cost_NIS	number_of_units	Total_cost_NIS	F17	Shape *
50	7.85	392.5	<Null>	Polyline M
60	89.02	5341.2	<Null>	Polyline M
25	22.32	558	<Null>	Polyline M
60	5.87	352.2	<Null>	Polyline M
25	67.02	1675.5	<Null>	Polyline M
60	3.45	207	<Null>	Polyline M
50	17.45	872.5	<Null>	Polyline M
25	37.73	943.25	<Null>	Polyline M
35	10	350	<Null>	Polyline M
35	11	385	<Null>	Polyline M
60	5.91	354.6	<Null>	Polyline M
60	44.75	2685	<Null>	Polyline M
25	27.44	686	<Null>	Polyline M
60	51.53	3091.8	<Null>	Polyline M
60	35.06	2103.6	<Null>	Polyline M
50	15.91	795.5	<Null>	Polyline M
60	3.84	230.4	<Null>	Polyline M
25	25.61	640.25	<Null>	Polyline M
60	1.12	67.2	<Null>	Polyline M
120	41.75	5010	<Null>	Polyline M
50	12.73	636.5	<Null>	Polyline M
60	3.56	213.6	<Null>	Polyline M
60	36.62	2197.2	<Null>	Polyline M
35	11	385	<Null>	Polyline M
25	9.7	242.5	<Null>	Polyline M
60	194	11640	<Null>	Polyline M
60	29.66	1779.6	<Null>	Polyline M
25	13.79	344.75	<Null>	Polyline M
60	1.97	118.2	<Null>	Polyline M
25	5.81	145.25	<Null>	Polyline M
350	13.55	4742.5	<Null>	Polyline M
25	0.66	16.5	<Null>	Polyline M
25	11.5	287.5	<Null>	Polyline M
60	18.03	1081.8	<Null>	Polyline M
35	13	455	<Null>	Polyline M

Figure (4.10): Calculate the Total Cost of Maintenance

Total rehabilitation cost for Abu Ktelah street = 192,200 NIS.

4.8 Made a Symbology

At its simplest level of representation, spatial data exists as points, lines, areas, or rasters. You encode meaning into these basic shapes through a process of symbolization. Symbols allow you to illustrate a unique difference between features, some difference in magnitude between features, or another characteristic. Symbolization can take on a range of functions on a map but should be clear, concise, and easily understood by the user. In many ways, symbolization can be regarded as the coding of map features to communicate meaning.

Figure (4.11) shows the symbology for line event table using ITEM field to display various line events.

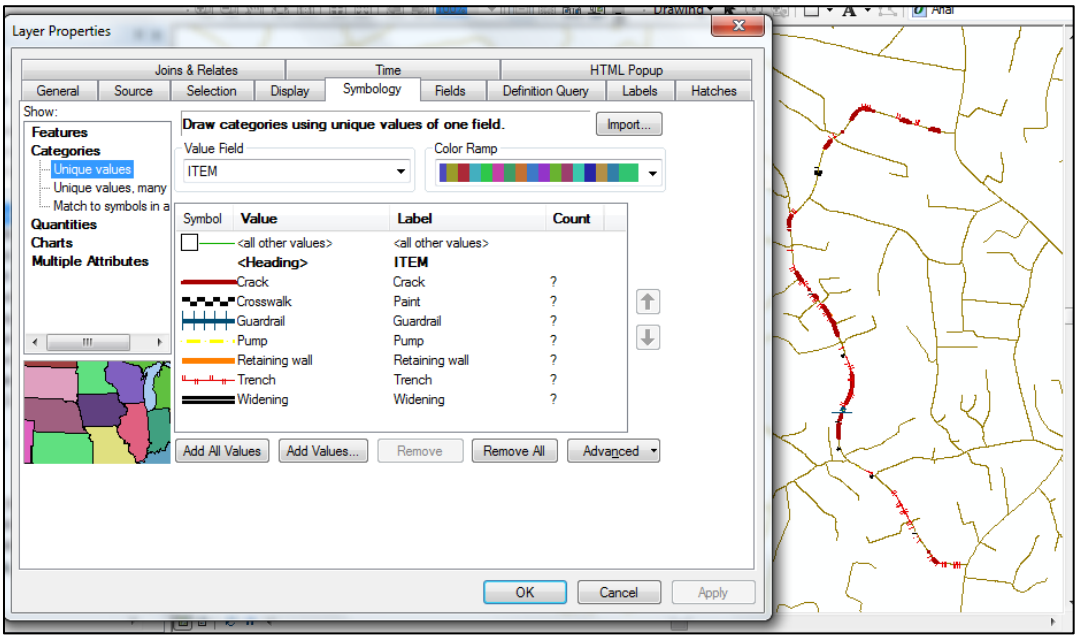


Figure (4.11): Line Event

Map1 in appendix I show the distribution of line event in the study area.

Figure (4.12) shows the symbology for point event table using ITEM field to display various point events.

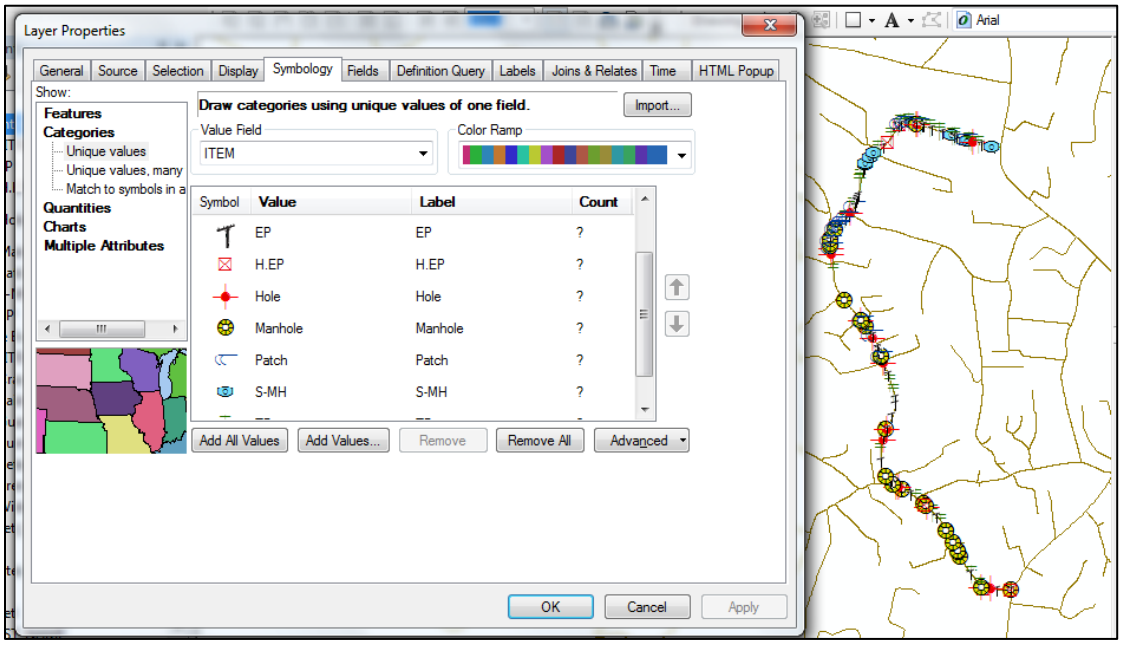


Figure (4.12): Point Event

Map2 in appendix I show the distribution of point events in the study area.

4.9 Linear Referencing and online ArcGIS Server (ArcGIS web map)

What is ArcGIS Server?

ArcGIS Server is software that makes your geographic information available to others in your organization and optionally anyone with an Internet connection. This is accomplished through web services, which allow a powerful server computer to receive and process requests for information sent by other devices. ArcGIS Server opens your GIS to tablets, smartphones, laptops, desktop workstations, and any other devices that can connect to web services.

ArcGIS Server opens your GIS to many types of devices through web services. You can take the resources you're familiar with through ArcGIS, such as map documents and geoprocessing models, and publish them to your server to create GIS web services. The services can be consumed in any application or device that can make a web service call using HTTP.

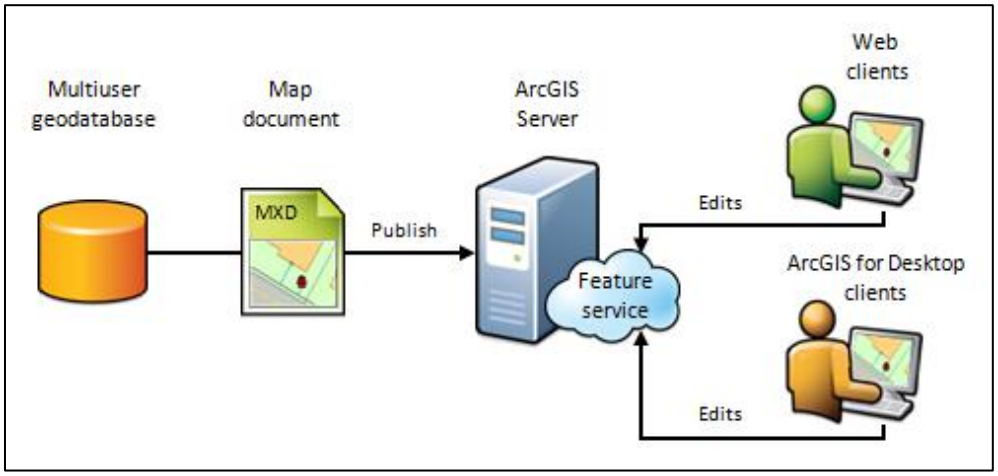


Figure (4.13): ArcGIS Server

ArcGIS Server components

- **GIS server—**Hosts and runs services. The GIS server consists of a server object manager (SOM) and one or more server object containers (SOCs).
- **Web server—**Hosts Web applications and Web services that use the objects running in the GIS server.
- **Clients**—Web browsers can be used to connect to Web applications running in the Web server. Desktop applications can connect either through HyperText

  Transfer Protocol (HTTP) to ArcGIS Web services running in the Web server, or connect directly to the GIS server over a LAN or WAN.

Advantages of using ArcGIS server

- **Get an online ArcGIS web map**.

  ArcGIS web map is an interactive display of geographic information that you can use to tell stories and answer questions.

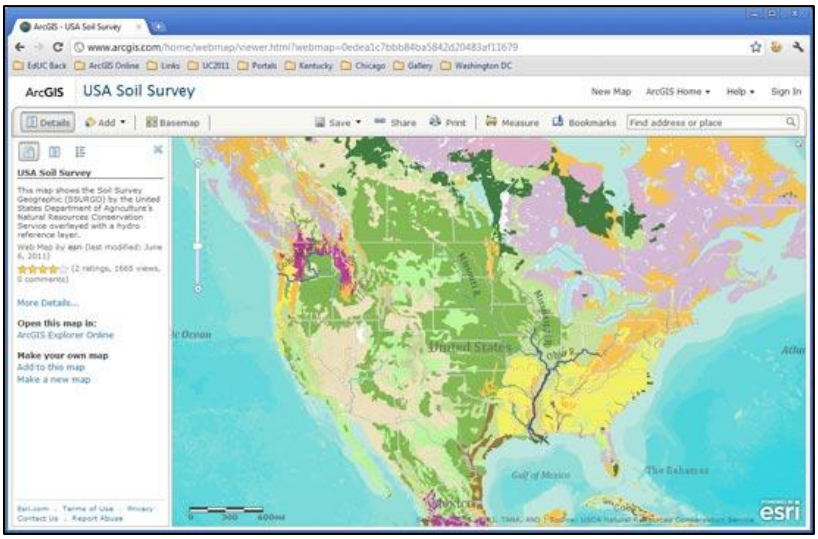


Figure (4.14): Online ArcGIS Web Map

- **No need to using ArcGIS Desktop**

- **Facilitate work in the field using GIS collector**

  Collector for ArcGIS is a great tool to get started on field data collection with a mobile phone or tablet computer. For the experienced desktop GIS user, Collector provides a mechanism for field data gathering and populating

  GIS attributes tables. For the individual in the field, Collector offers easy to complete template based forms that require no GIS experience. Collector is integrated with ArcGIS Online for Johns Hopkins, the library's supported web

GIS portal for sharing and making available geospatial data. Data gathered using a mobile device is automatically uploaded to a private section of ArcGIS Online. For areas that lack mobile connectivity, gathered data can be temporarily stored on the device and then easily uploaded when service is available.

ArcGIS server usage constraints

- Cost is very high about 100,000$.
- The system requires a committee of IT experts, server, domain and Board.