بسم الله الرحمن الرحيم

# Palestine Polytechnic University

**College of Engineering**
**Civil and Architecture Engineering Depratment**

**Graduation Project**

## Building a roads network for Yatta City using GIS

**Team**

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**Abstract**

The project aims to build a roads network for" Yatta City" using network analyst on ArcGIS software to use the results in Planning and build services in the city and planning travel paths between city services centers such as hospitals , emergency , police stations.

The project requires three stages , starts with digitizing roads network, then create a database for roads networks contains ( traffic volumes ,directions , speed limits , roads conditions and services centers addresses ). Then, we are going to build and analyze the network. Finally, tests will be applied to check the functionality of the network.

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## الملخص

يهدف المشروع لبناء شبكة طرق لمدينة يطا بحيث يتم الاستفادة منه في عملية التخطيط في بناء الخدمات وتوزيعها داخل المدينة وكذلك في عملية تخطيط مسارات السفر من وإلى مراكز خدمات مُعينة مثل المستشفيات ، الطوارئ ، الشّرطة وغيرها .

ويتم عمل هذا المشروع على عدة مراحل ، أولها هو رسم شبكة لطرق وتحديثها ثم ادخال معلومات عن كل طريق مثل سعته والإتجاهات عليه والسرعة المسموحة وطبيعة الطريق ، كما يتم ادخال مراكز الخدمات وعناوينها ، بعدها يتم بناء الشبكة وتحليلها . وأخيراً ، اجراء اختبارات لدور هذه الشبكة .

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# CHAPTER ONE

## INTRODUCTION

### 1.1 Problem definition

The recent fast development of Yatta city, which affects the public sector economic activities, educational sector and human resources, impose a huge stress on the street network within the city and between the city and the surrounding cities and towns .

This increasing demand on Yatta city streets network make it very important to establish a digital network streets network model as part of integrated planning strategy for Yatta city development plan. This will help in finding the shortest of the fastest path from point to point in some critical conditions or cases.

The recent development in information technology facilitate the management of different sectors of our life. The GIS system is one of these modern database technologies, which proved its ability in many applications .

The Idea of project came into mind by realizing the importance of building roads network for Yatta city, because of delaying of civil services such as ambulances and fire trucks to reach accident position; this will be an attempt to use GIS to solve these problems .

### 1.2 Objectives

#### 1.2.1 Main objective

The main Objective is to build streets network of Yatta city using ArcGIS.

#### 1.2.2 Specific Objectives

1. Optimize routes for civil services department in Yatta city (Ambulance, Police, Fire trucks, electricity emergency).
2. To prepare network that can be determine the best route between two points and closes services .
3. Calculation of driving time for first responder planning.

## 1.3 Study Area

### 1.3.1 Location and Topography

Yatta city is located 9 km south of Hebron city, in the southern part of the West Bank. It is bordered by Zif and Khallet al Maiyya to the East, Ar Rihiya, Al Fawwar Camp and Wadi as Sada to the North, Beit 'Amra to the West, and As Samu' to the South. The total area of Yatta town estimated to be 270,000 dunums, of which 14,000 dunums are classified as 'built up' area; whilst 115,000 dunums are agricultural area, 141,000 is forest, uncultivated, or public land. Yatta municipality has a master plan for 24,500 dunums of town lands. Yatta city is located on the mountainous area south of Hebron city at an elevation of 793 m above the sea level, with a mean rainfall 303 mm, an average annual temperature of 18 °C, and average annual humidity at 61%, the total population of Yatta city, is estimated to be 100,000 according to the growth rate of Yatta city which is 4.7 % .

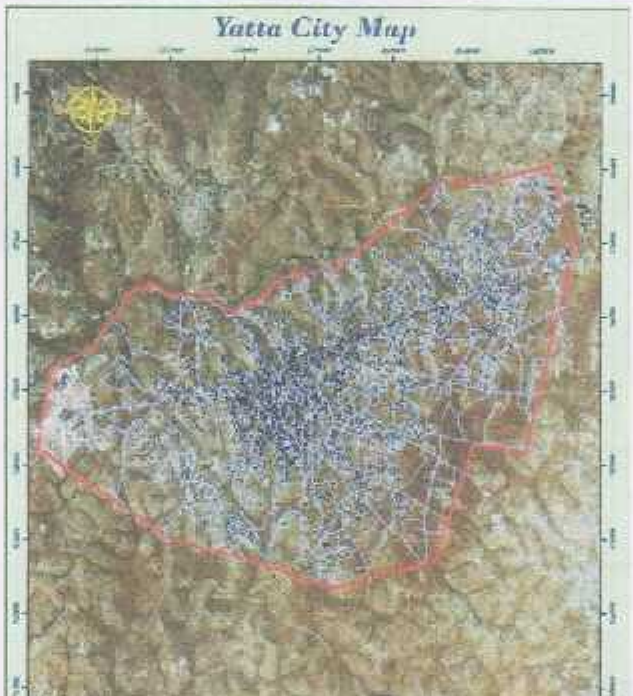



Figure 1.1 : Yatta City Borders

### 1.3.2 Streets

The plan of existing and proposed streets of Yatta city has been obtained from Yatta Municipality.

## 1.4 Time Table

The time schedule shows the stages for achieving our work and the process of project growth that include choosing the project, problem definition, literature review, collecting data, office works, primary preparation of introduction and final preparation of project.

Time Table for first semester (1.1)

| Week / Stage | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Choosing the project** | ■ | ■ | ■ | | | | | | | | | | | | | |
| **Problem Definition** | | | ■ | ■ | ■ | | | | | | | | | | | |
| **Literature Review** | | | | | ■ | ■ | ■ | | | | | | | | | |
| **Collecting Data** | | | | | | | | ■ | ■ | ■ | | | | | | |
| **Office works** | | | | | | | | | | ■ | ■ | ■ | ■ | | | |
| **Primary Report of introduction** | | | | | | | | | | | | | ■ | ■ | ■ | |
| **Final report of introduction** | | | | | | | | | | | | | | | ■ | ■ |

Time Table for Second semester (1.2)

| Week / Stage | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Coding the streets** | ■ | ■ | ■ | | | | | | | | | | | | | |
| **Determining Speeds** | | | ■ | ■ | | | | | | | | | | | | |
| **Updating the existing network** | | | | | ■ | ■ | ■ | | | | | | | | | |
| **Writing and Editing the report** | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |

**1.5 Methodology**

The methodology of this project can summarized in the following phases :

**First Phase**

Data collection, this includes collection of information about Yatta streets network as a digital master plan. The data were obtained from the engineering department of Yatta municipality and by field survey to determine directions, and number of paths of each street segment.

**Second Phase**

Digitizing the buildings of Yatta city and services centers such as Police centers, Civil defense, hospitals, Pharmacies and centre of each street in Yatta city.

**Third phase**

Using the Network analysis extension and it's applications; including finding the best route for the time needed to reach and point from others.

**1.6 Project Scope**

The project consists of five chapters as follows :

**Chapter One (Introduction)**

This chapter gives a general view, objectives, literature review and importance of the project.

**Chapter Two (Geographic Information System)**

This chapter covers the history of GIS, components of GIS, Tasks of GIS, Applications of GIS.

**Chapter Three ( Network)**

This chapter covers the principles of Network Analysis.

**Chapter Four ( Network Analyst in ArcGIS 10.0)**.

This chapter covers the types of networks that can be done in ArcGIS.

**Chapter Five ( Data Preparation )**

This chapter covers field works, office operations, and data preparation, digitzing , topology map and creating attribute tables.

**Chapter Six ( Test and Results )**

This Chapter test network dataset and applying spatial analysis such as routing, finding closest facility and define service area .

**Chapter Seven ( Conclusion and Recommendations )**

This chapter contain conclusion and recommendations project.

# CHAPTER TWO

## GEOGRAPHIC INFORMATION SYSTEM

2.1 Introduction to GIS

2.2 Components of GIS

2.3 GIS Data Input

2.4 Coordinate Systems

2.5 Map Scale

## 2.1 Introduction to GIS

GIS stands for Geographic Information Systems, often defined as a computerized database management system for capture, storage, retrieval, analysis, and display of spatial data. Any data that includes information about location be it a street address, zip code, census tract, or longitude and latitude coordinates can be considered spatial. Many different types of data can be integrated into GIS and represented as a map layer. When these layers are drawn on top of each other, spatial patterns and relationships often emerge. The most common GIS product is a map, but GIS can be used to generate answers to queries or as part of spatial statistical analysis. (1)

GIS is not new. Since the 1960s computers have been used to store and process geographic data . early examples of GIS-related work include the following : (2)

- Computer mapping at the university of Edinburgh (Cppock 1988 ) , the Harvard laboratory for computer graphics (Chrisman 1988 ) and the experimental Cartography Unit (Rehind 1988 ) .
- Canada Land Inventory and the subsequent development of the Canada Geographic Information System (Tomlinson 1984).
- Publication of Ian McHarg's Design with Nature (McHarg 1969 0 and the map overlay method .
- Introduction of an urban street network with topology in the U.S. Bureau of the Census DIME ( Dual Independent Map Encoding ) system ( Broome and Meixler 1990).

For many years, through . GIS has been considered to be too difficult , expensive and proprietary. The advent of the graphical user interface (GUI), powerful and affordable hardware and software and public digital data has broadened of the range of GIS applications and brought GIS to mainstream use.

### 2.2 Components of GIS

GIS consists of five key components (3)

1- Hardware
2- Software

3- Data
4- People
5- Methods

### 2.2.1 Hardware

Hardware comprises the equipment needed to support the many activities needed for geospatial analysis ranging from data collection to data analysis. The central piece of equipment is the workstation, which runs the GIS software and is the attachment point for ancillary equipment. Data collection efforts can also require the use of a digitizer for conversion of hard copy data to digital data and a GPS data logger to collect data in the field. The use of handheld field technology is also becoming an important data collection tool in GIS.

### 2.2.2 Software

Different types of software are important. Central to this is the GIS application package. Such software is essential for creating, editing and analyzing spatial and attribute data. Extensions or add-ons are software that extends the capabilities of the GIS software package. Component GIS software is the opposite of application software. Component GIS seeks to build software applications that meet a specific purpose and thus are limited in their spatial analysis capabilities.

### 2.2.3 Data

Data is the core of any GIS. There are two primary types of data that are used in GIS: vector and raster data. A geodatabase is a database that is in some way referenced to locations on the earth. Geodatabases are grouped into two different types: vector and raster. Vector data is spatial data represented as points, lines and polygons. Raster data is cell-based data such as aerial imagery and digital elevation models. Coupled with this data is usually data known as attribute data. Attribute data generally defined as additional information about each spatial feature housed in tabular format. Documentation of GIS datasets is known as metadata.

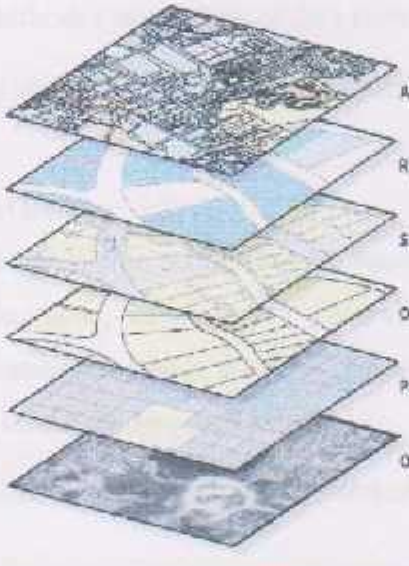



Figure (2.1) :Data themes as layers [4] (Esri website, visited on 10 Oct 2013)

### 2.2.4 People

Well-trained GIS professionals knowledgeable in spatial analysis and skilled in using GIS software are essential to the GIS process. There are three factors to the people component: education, career path, and networking. The right education is key; taking the right combination of classes. Selecting the right type of GIS job is important. A person highly skilled in GIS analysis should not seek a job as a GIS developer if they haven't taken the necessary programming classes. Finally, continuous networking with other GIS professionals is essential for the exchange of ideas as well as a support community.

### 2.2.5 Methods

A neatly conceived implementation plan and business rules are the models and operating practices, are unique to each organization .

## 2.3 GIS Data Input

The two basic types of data are : [5]

- Geometrical data ( vector data, raster data, topology )
- Attribute data ( qualitative data , quantitative data )

The methods of data acquisition are classified by Bill and Fritsch :

- Primary methods ( acquisition of data from the object itself )
- Secondary methods ( data acquisition from existing analogue or digital sources )

### 2.3.1 Geometrical data

The primary methods of data acquisition are usually more exact and more up to data than the secondary methods, but they are generally more expensive than the secondary methods. The secondary methods are usually less accurate and less actual as the primary methods but they tend to be less expensive.

The primary methods of acquisition of geometrical data are the following:

- Surveying
- Satellite positioning methods (GPS).
- Photogrammetry
- Remote sensing

The secondary methods of acquisition of geometrical data are the followings :

- Manual digitizing of analogue maps.
- Scanning of analogue maps.
- Using existing digital databases.

### 2.3.2 Attribute Data

The primary methods of acquisition of attribute data are :

- Measurements of various kind (e.g. geophysical ).
- The remote sensing
- Interviews .

The secondary methods of acquisition of attribute data are :

- Using of conventional documents in registers and files .
- Compilations in scientific reports .

- Data acquisition from existing digital databases .

### 2.4 Coordinate systems

A basic principle in GIS is that map layers to be used together must align spatially. Obvious mistakes can occur if they do not. GIS users typically work with map features on a plane . These maps features represent spatial features on the Earth's surface. The locations of map features are based on a plane coordinate system expressed in x- and y-coordinates, whereas the locations of spatial features on the Earth's surface are based on a geographic coordinate values. A map projection bridges the two types of coordinate systems. The process of projection transforms the Earth;s surface to a plane, and the outcome is a map projection, ready to be used for a plane or projected coordinate system. (6)

#### 2.4.1 Geographic coordinate system

The geographic coordinate system is the location reference system for spatial features on the Earth's surface ( Figure ). The geographic coordinate system is defined by longitude and latitude. Both longitude and latitude are angular measures : longitude measures the angle east or west from the prime meridian, and altitude measure the angle north or south of equatorial plane . (6)

Figure (2.2) : Geographic representation (6)(A gentle introduction to GIS, visited on 16 Oct 2013 )

#### 2.4.2 Projected coordinate systems

A projected coordinate systems, also called a plane coordinate system , is built on a map projection. Projected coordinate systems and map projections are often used interchangeably. For example, the Lambert conformal conic is a map projection but it can also refer to a coordinate system. In practice, however, projected coordinate systems are designed for detailed calculations and positioning, and are typically used in large-scale mapping such as at scale of 1:50000. Accuracy in a feature's location and its relative position to other features is therefore a key consideration in the deisgn of a projected coordinate system. [6]

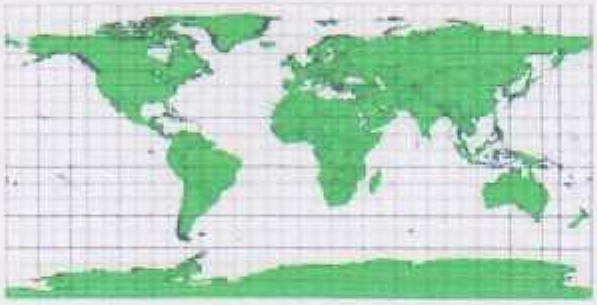


Figure (2.3) : Projected representation [6] (A gentle introduction to GIS, visited on 16 Oct 2013)

**2.5 Map Scale**

Map scale is the ration of the map distance to the corresponding ground distance. This definition applies the different measurements units. A 1:24000 scale map can mean that a map distance of 1 cm represents 24,000 cm (240 m) on the ground . A1:24000 scale map can also mean that a map distance of 1 inch represents 24,000 inches (200 feet) on the ground. Regardless of its measurement unit, 1 :24000 is a larger map scale than 1:100,000 and a 1:24000 scale map shows more details in a smaller area than a 1:100,000 scale map. Some cartographers considers maps with a scale of 1:24000 or larger as large-scale maps.

Map scale should not be confused with spatial scale, a term commonly used in natural resource management. Spatial scale refers to the size of area or extent. Unlike map scale, spatial scales is not rigidly defined. A large spatial scale simply means that it covers a larger area than a small spatial scale. A large spatial scale to an ecologist is therefore a small map scale to a cartographer. Map scale can be expressed in many forms : words (a), as a ratio (b), or as graphic or bar scale (c), ( figure 2.4) [6]

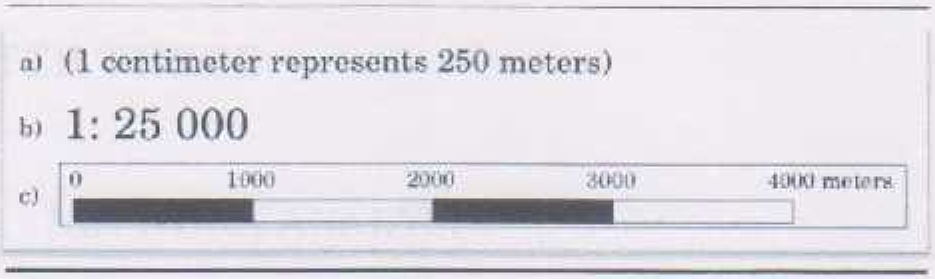



Figure (2.4) : Map Scale Types [6] (A gentle introduction to GIS , visited on 16 Oct 2013)

# CHAPTER THREE

## NETWORK ANALYSIS

**3.1 Introduction**

**3.2 Optimal Routing**

**3.3 Network Attribute**

**3.3.1 Cost**

**3.3.2 Descriptors**

**3.3.3 Restrictions**

**3.3.4 Hierarchy**

### 3.1 Introduction

Network analysis is a special type of line analysis involving a set of interconnected lines. Typical networks include themes such as roads, streams, hiking trails, and pipelines. Network Analysis can be used to answer at least four types of questions :

1. **Address Geocoding**. Address geocoding is the process of taking addresses and estimating their locations in your GIS coordinate system. This is done by relating an house address on a GIS street view for delivery of some product, generating driving directions to a given address, or displaying customer locations in a GIS view from a list of customer addresses. Address Geocoding is not not available in Palestine.
2. **Optimal Routing.** Optimal routing is the process of delineating the best route to get from one location to one or more locations. The " best route " could be the shortest, the quickest, or the most esthetic ,depending on the GIS user's preference for defining "best".
3. **Finding Closest Facilities.** This is a special type of optimal routing problem where you are trying to find the closet points to a given location. Typically the points are called facilities and the given location is called an event location.
4. **Resource Allocation**. Resource allocation is the allocation of the resources from supply centers to customers on a network. (7)

### 3.2 Optimal Routing

Optimal routing is the process of delineating the best route (or path) to get from one location to one or more locations. It is not usually feasible to test all possible paths that exist in a network. Instead, a path finding algorithm is used.

To find the quickest path of the following network of hiking trails to get from node 1 (trailhead) to node 7 (tent site). The time to hike each trail varies depending upon trail conditions. Trails 3,5,and 6 are relatively quick hikes.

Table (3.1): Trails names and their estimated time

| Trail Name | Estimated Hiking Time (Minutes) |
|---|---|
| **Moose Trail** | 15 |
| **Lower Meadow** | 20 |
| **Upped Meadow** | 20 |
| **Taiga Trail** | 10 |
| **Upper Tundra** | 5 |
| **Lower Tundra** | 5 |
| **Eagle Pass** | 30 |
| **Rocky Trail** | 40 |
| **Fire Line** | 10 |
| **Duck Trail** | 30 |
| **Glacier Trail** | 30 |
| **Becky's Trail** | 10 |

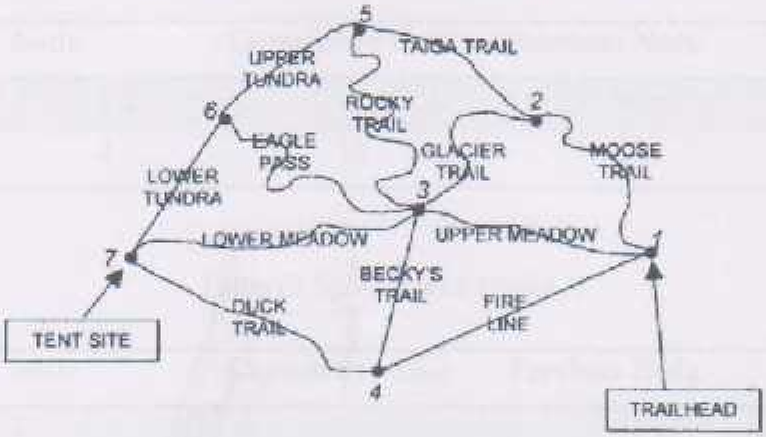



Figure (3.1): Trails distribution [7] (Practical GIS analysis)

**Step 1**

Building two tables, one of nodes that have already been processed, and one of adjacent nodes to process. We start at the trailhead, node#1:

Table (3.2): Processed Nodes 1

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 1 | 0 | none |

Table(3.3) :Adjacent Nodes 1

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 2 | 15 | 1 |
| 4 | 10 | 1 |

**Step 2**

Pick the adjacent node with the least cumulative cost which is hiking to node#4. and add it to the processed nodes list.

Table (3.4): Processed Nodes 1

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 1 | 0 | none |
| 4 | 10 | 1 |

Table (3.5): Adjacent Nodes 2

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 2 | 15 | 1 |

**Step 3**

Scan the nodes adjacent to your latest processed node (4), and add them to the Adjacent Nodes list. There are 3 nodes adjacent to node#4 and they're: 1, 3, and 7. Node#1 is already in the processed nodes list, we exclude it from the adjacent nodes list. The cumulative cost for node#3 is the cost of hiking to node#4 (10 minutes), plus the cost of hiking from node#4 to node#3 (10 minutes). The cumulative cost to get to node#7 is 10 minutes + 30 minutes.

Table (3.6): Adjacent Nodes 3

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 2 | 15 | 1 |
| 3 | 20 | 4 |
| 7 | 40 | 4 |

**Step 4**

We then pick the adjacent node with the least cumulative cost (node#2 with a cost of 15), and add it to the processed nodes list.

Table (3.7): Processed Nodes 2

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 1 | 0 | None |
| 4 | 10 | 1 |
| 2 | 15 | 1 |

**Step 5**

Scan the nodes adjacent to your latest processed node (2) and add them to the Adjacent Nodes list. The nodes adjacent to node#2 are nodes 1,3, and 5. Node#1 is already in the processed nodes list, so it is excluded from the adjacent nodes list. The cumulative cost for node 3 is the cost to hike to node#2 (15 minutes) plus the cost to hike from node#2 to node#3 (30 minutes). The cumulative cost to get to node#5 is the time to hike to node#2 (15 minutes) plus the time to hike from node#2 to node#5 (10 minutes).

Table (3.8) : Adjacent Nodes 4

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 3 | 20 | 4 |
| 7 | 40 | 4 |
| 3 | 45 | 2 |
| 5 | 25 | 2 |

**Step 6**

Pick the adjacent node with the least cumulative cost, and add it to the processed nodes list.

Table (3.9) :Processed Nodes 3

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 1 | 0 | none |
| 4 | 10 | 1 |
| 2 | 15 | 1 |
| 3 | 20 | 4 |

**Step 7**

Scan the nodes adjacent to latest processed node (3), and add them to the Adjacent Nodes list. The nodes adjacent to node#3 include 1,2,4,5,6,and 7. Nodes 1,2,3, and 4 are already in the processed nodes list and are therefore excluded from the adjacent nodes list. The cumulative cost to hike to node#3 is 20 minutes. To go all the way to node#5 will take 20 + 40 = 60 minutes. To go to node# 3 and then node#6 will take 20 + 30 = 50 minutes. And to hike to node#3 and then node#7 will take 20 + 20= 40 minutes.

Table (3.10): Adjacent Nodes 5

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 5 | 25 | 2 |
| 7 | 40 | 4 |
| 5 | 60 | 3 |

| | | |
|---|---|---|
| 6 | 50 | 3 |
| 7 | 40 | 3 |

**Step 8**

Pick the adjacent node with the least cumulative cost, and add it to the processed nodes list.

Table (3.11) : Processed Nodes 4

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 1 | 0 | None |
| 4 | 10 | 1 |
| 2 | 15 | 1 |
| 3 | 20 | 4 |
| 5 | 25 | 2 |

**Step 9**

Scan the nodes adjacent to your latest processed node (5) , and add them to the Adjacent Nodes list. The nodes adjacent to node#5 include 2,3, and 6, Nodes 2 and 3 are already in the processed nodes list and therefore are excluded from the adjacent nodes list. The cumulative cost to hike to node 6 is 25 minutes to hike to node#5 and then 5 minutes to hike to node#6, totaling 30 minutes.

Table (3.12) : Adjacent Nodes 6

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 7 | 40 | 4 |
| 6 | 50 | 3 |
| 7 | 40 | 3 |
| 6 | 30 | 5 |

**Step 10**

Pick the adjacent node with the least cumulative cost, and add it to the processed nodes list.

Table (3.13) : Processed Nodes 5

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 1 | 0 | None |
| 4 | 10 | 1 |
| 2 | 15 | 1 |
| 3 | 20 | 4 |
| 5 | 25 | 2 |
| 6 | 30 | 5 |

**Step 11**

Scan the nodes adjacent to your latest processed node (6) . . . and add them to the Adjacent Nodes list. The nodes adjacent to node 6 include nodes 3,5, and 7. Nodes 3 and 5 are already in the processed nodes list and are therefore excluded from the adjacent nodes list. The cumulative cost to hike to node#7 through node#6 is 5 + 30 = 35 minutes.

Table (3.14) : Adjacent Nodes 7

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 7 | 40 | 4 |
| 7 | 40 | 3 |
| 7 | 35 | 6 |

**Step 12**

Pick the adjacent node with the least cumulative cost and add that to the processed nodes list.

Table (3.15) : Processed Nodes 6

| Node | Cumulative Cost | Previous Node |
|---|---|---|
| 1 | 0 | None |
| 4 | 10 | 1 |
| 2 | 15 | 1 |
| 3 | 20 | 4 |
| 5 | 25 | 2 |
| 6 | 30 | 5 |
| 7 | 35 | 6 |

All nodes are now in the processed nodes list, therefore the processing stops. The quickest route to get to node#7 will take 35 minutes and from the processed nodes list, it is

**Node#7 ← Node#6 ← Node#5 ← Node#2 ← Node#1**

We can ask the GIS to display this optimal route in our hiking trail network view.


Figure (3.2) : Optimal Route

We could starting at Trail Head hike Moose Trail, straight to Taiga Trail I( 15 minutes ), straight to Upper Tundra (10 minutes ), straight to lower tundra (5 minutes ) ending at Tent Site (5 minutes ).

Once the nodes have been processed, all the optimal routes to node#1 from any node are solved. However, there may also be more than one optimal route that is not reflected in the analysis. For example, from the processed nodes list, the optimal route to hike from node#3 is :

**Node#3 ← Node#4 ← Node#1**

which would take 20 minutes. The direct Node#1 → Node#3 route would also take 20 minutes. In this simple example, there are relatively few possible routes, so as a check you could try all possible routes. This is generally not possible with complex networks typical of real-life applications.

Table (3.16 ): Some Of Possible Routes

| Route | Time ( Minutes ) |
|---|---|
| 1 ➔ 2 ➔ 5 ➔ 6 ➔ 7 | 35 |
| 1 ➔ 3 ➔ 7 | 40 |
| 1➔4 ➔ 3 ➔ 7 | 40 |
| 1 ➔ 4 ➔ 7 | 40 |
| 1 ➔ 4 ➔ 3 ➔ 6➔ 7 | 55 |
| 1 ➔3 ➔ 6 ➔7 | 55 |
| 1➔3 ➔ 4 ➔ 7 | 60 |

### 3.3 Network Attributes

Network attributes are properties of the network elements that control traversability over the network. Examples of attributes include the time to travel a given length of road, which streets are restricted for which vehicles, the speeds along a given road, and which streets are one-way.

#### 3.3.1 Cost

Certain attribute are used to measure and model impedances and model impedances, such as travel time ( transit time on a street ) or demand ( the volume of garbage picked up on a street ).

These attributes are apportioned able along an edge; that is, they are divided proportionally along the length of an edge. For example, if travel time is modeled as a cost attribute , then traversing half an edge will take half the time as traversing the whole edge. This means that if the travel time to traverse the edge is 3 minutes, it take 1.5 minutes to traverse half the edge. If you are looking for a 1.5 minutes route along this edge, the route feature will be created from the first half of the edge feature .

### 3.3.2 Descriptors

Descriptors are attributes that describe characteristics of the network or its element. Unlike costs, descriptors are not apportioned. This means that the value does not depend on the length of the edge element. For example, the number of lanes is an example of a descriptor on a street network. Speed limit of streets is another descriptor attribute for a street network.

### 3.3.3 Restrictions

Restrictions can be identified for particular elements, such that during an analysis, restricted elements cannot be traversed. For example, one-way streets can be modeled with a restriction attribute, so they can only be traversed from one end to another and not in the reverse direction. In all cases, a restriction attribute is defined using a Boolean data type .

### 3.3.4 Hierarchy

Hierarchy is the order or rank assigned to network elements. A street network might have an attribute on the source features that breaks the roads down into three (or more) classes, such as local, secondary, and primary. You can use this attribute on the source features to build a hierarchy attribute on the network dataset.

Once a hierarchy attribute is present, you can choose whether to use or ignore it when solving a network analysis.

# CHAPTER FOUR

## NETWORK ANALYST IN ArcGIS

## 4.1 Introduction

Network analyst extension in ArcGIS provides a variety of maps for best routes, closest facility and many other useful data that can be utilized in producing many hardcopy or digital maps.

## 4.2 Types of Networks in ArcGIS

ArcGIS provides many types of networks that can be done in network analyst extension and they're :geometric networks, transportation networks, multimodal networks and 3D networks. [9]

### 4.2.1 Geometric Networks (utility and river networks)

River networks and utility networks like electrical, gas, sewer, and water lines allow travel on edges in only one direction at a time. The agent in the network for instance, the oil flowing in a pipeline can't choose which direction to travel; rather, the path it takes is determined by external forces: gravity, electromagnetism, water pressure, and so on. [9]

### 4.2.2 Transportation Networks

Transportation networks like street, pedestrian, and railroad networks can allow travel on edges in both directions. The agent on the network for instance, a truck driver traveling on roads is generally free to decide the direction of traversal as well as the destination. [9]

### 4.2.3 Multimodal Network

A network dataset is capable of modeling a single mode of transportation, like roads, or a multimodal network made up of several transportation modes like roads, railroads, and waterways. [9]

### 4. 2.4 3D network datasets

Three-dimensional network datasets enable you to model the interior pathways of buildings, mines, caves, and so on. [9]

If you have street features with accurate z-coordinate values, you can use them with z-aware features that model pathways inside buildings to create 3D networks of campuses or even cities. This allows you to answer questions like the following:

- What is the best wheelchair-accessible route between rooms in different buildings?
- What floors of a high-rise building can't be reached by a fire department within eight minutes?

## 4.3 Network Elements

Network elements are generated from the source features used to create the network dataset. The geometry of the source features helps establish connectivity. In addition, network elements have attributes that control navigation over the network.

There are three kinds of network elements:

- Edges which Connect to other elements junctions and are the links over which agents travel.
- Junctions which Connect edges and facilitate navigation from one edge to another.
- Turns which store information that can affect movement between two or more edges.

Edges and junctions form the basic structure of any network. Connectivity in a network deals with connecting edges and junctions to each other. Turns are optional elements that store information about a particular turning movement; for instance, a left turn is restricted from one particular edge to another.[10]

## 4.4 Network sources

There are three types of network sources that can participate in the creation of a network dataset:

- Edge feature sources : Line feature classes participate as edge feature sources.
- Junction feature sources : Point feature classes participate as junction feature sources.
- Turn feature sources : Turn feature classes participate as turn feature sources in a network. A turn feature source explicitly models a subset of possible transitions between edge elements during navigation. [10]

Each feature class that participates in a network as a source generates elements based on its assigned role. For example, a line feature class is used as a source for edge elements, and a point feature class is used to generate junction elements. Turn elements are created from a turn feature class. The generated junction, edge, and turn elements form the underlying graph, which is the network.

Geometric network feature classes cannot participate as network dataset sources because they are actively linked to a geometric network. Feature classes that participate as a source in a network dataset can participate in a topology.

Consider the example of a simple transportation network and the sources that participate in its creation. This network has a streets feature class that can act as an edge source, a street intersections feature class acting as a junction source, additional line feature classes that act as edges (rail lines and bus routes), and point feature classes that act as junctions (rail stations and bus stations). [10]


Figure (4.1) : Network simple features

All feature classes that reside in the feature dataset, which contains the network dataset, can participate as network sources. Only two sources can participate in a shapefile network dataset—a line shapefile and a shapefile turn feature class. [10]

### 4.4.1 System Junctions

A junction must exist at each end of an edge in a network dataset. So if we don't create a junction source feature at the end of an edge, a system junction will be created automatically for us when the network dataset is built.

System junctions are stored as points in a source feature class, which is automatically generated during the first build operation. The source feature class is named[network name]_Junctions, where [network name] represents the name of the network dataset. [10]

### 4.4.2 Turns in Network dataset

A turn models a movement from one edge element to another. Often turns are created to increase the cost of making the movement, or prohibit the turn entirely. For example, a turn feature representing a left-hand turn at an intersection could be assigned a cost of 30 seconds to model the average time it takes for the left-turn light to change to green. Similarly, a restriction attribute could read a field value from a turn feature to prohibit it. This is useful when the turning movement is posted as illegal (no left turns).

Turns can be created at any junction where edges connect. There are $n^2$ possible turns at every network junction, where n is the number of edges connected at that junction. Even at a junction with a single edge, it is possible to make one U-turn. [11]

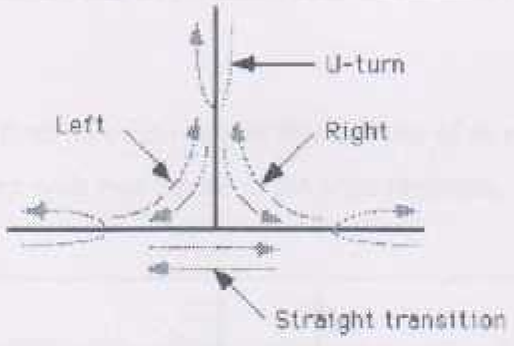



Figure (4.2) : Possible turns

#### 4.4.2.1 Multi-edge turns

A simple turning movement between two edges connected at a junction is referred to as a two-edge turn. The ArcGIS Network Analyst extension supports modeling multi-edge turns. A multi-edge turn is a movement from one network edge element to another through a sequence of connected intermediate edge elements. These intermediate edges are referred to as the interior edges of a turn. In a street network, the interior edges of a turn are typically those edge elements that represent the interior of an intersection of divided roads.

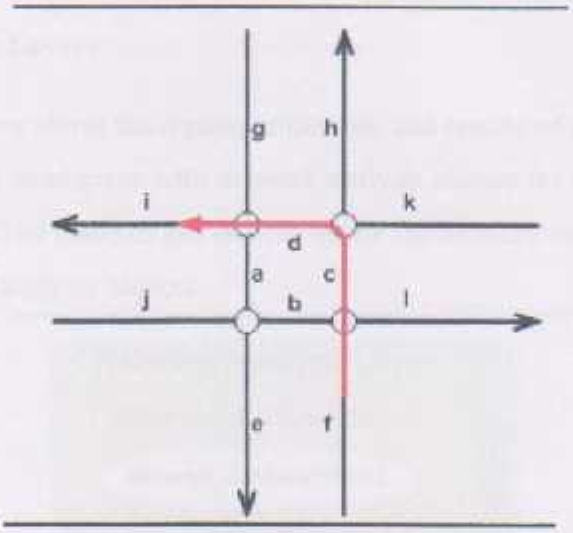


Figure (4.3) : Multi-edge turn

The example shown above depicts a multiedge left turn at an intersection of two divided roads. Edges c and d represent interior edges of the turn, while edges f and i represent the exterior edges.

#### 4.4.2.2 U-Turns

A U-turn is a movement from an edge element through one of its ends back onto itself. It is typically modeled as a turn with two entries in the edge sequence, where both entries are the same edge element.

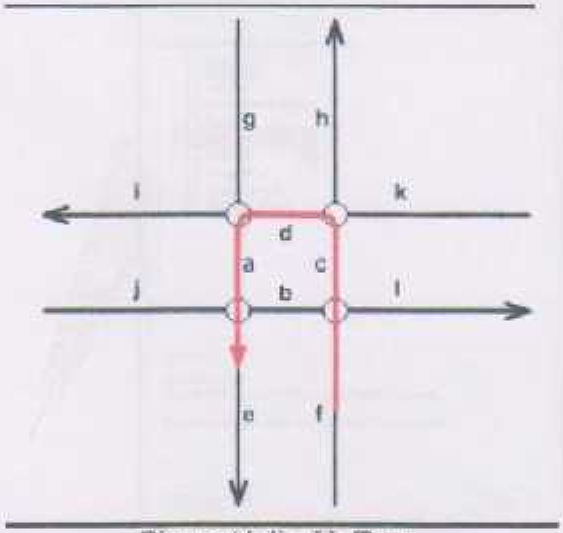


Figure (4.4) : U- Turn

When dealing with divided roads, a U-turn is modeled as a multiedge turn, where edges f and e are exterior edges and c, d, and a are interior edges. [11]

**4.5 Network Analysis Layers**

A network analysis layer stores the inputs, properties, and results of a network analysis. It contains an in-memory workspace with network analysis classes for each type of input, as well as for the results. The features and records inside the network analysis classes are referred to as network analysis objects.

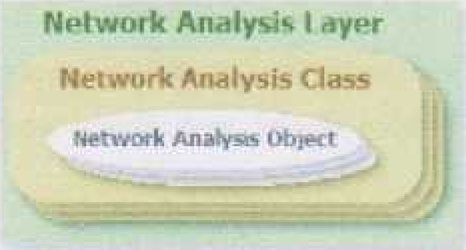



Figure (4.5) : Network Analysis classes

**4.6 Network Analyst Toolbar**

The network analyst toolbar provides the commands for creating new analysis layers, tools for working with those analysis, and tools to work and build network datasets.

To validate network analyst tool extension :

1- From menu toolbar we choose Customize – Extensions
2- Pick on network analyst

Figure(4.6) : Validate network analyst extension

The Figure bellow shows the network analyst toolbar, each command is labeled by number to explain the function of each command.


Figure (7.4) : Network Analyst toolbar

1- Network Analyst type and it contains :new route, new service area , new closest facility, new OD cost matrix, new vehicle routing problem, new location – allocation.
2- To show\Hide network analyst window .
3- Create network location tool.
4- Select/Move network location.
5- To solve network.
6- To show directions window.
7- Network dataset.
8- Network Identify tool.
9- Build network dataset.

# CHAPTER FIVE

## DATA PREPARATION

**5.1 Overview**

**5.2 Yatta Municipality Data**

**5.3 Street Network Attribute Table**

**5.4 Creating a map topology**

**5.5 Calculate Slope Distance**

**5.6 Building Network Dataset**

## 5.1 Overview

The nature of network analysis project, in general, contains field work followed by observations, processing analysis and assessment process " office work ".

This project includes, several operations that were made, starting with obtaining streets data from Yatta Municipality , digitizing and updating streets centre lines, determination of street flow directions, speed limits on streets, streets junctions, creating network attribute tables in GIS, raw field observation entrance to the computer and export of cad drawing to the GIS database

## 5.2 Yatta Municipality Data

The Following data were obtained from the municipaltiy of Yatta :

1. An AutoCAD drawing file containing the streets edges and borders of Yatta city were obtained from Engineering Department of Yatta Municipality, fig (5.1 ).

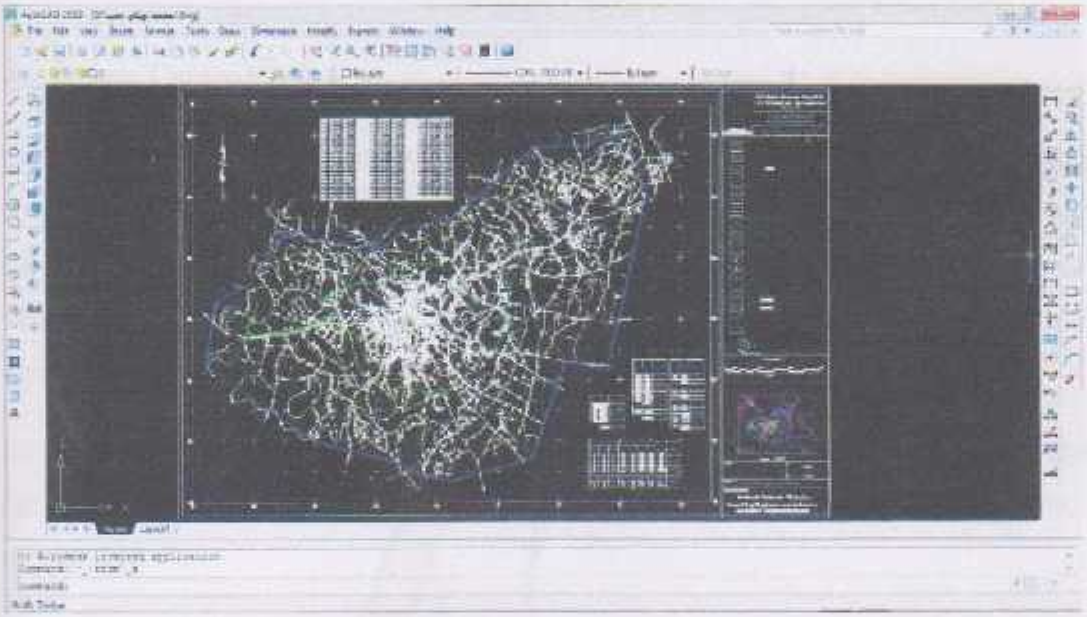


Figure (5.1) : Yatta city cad master plan

2. An Ortho photos of the year 2011 were obtained from Engineering Department of Yatta Municipality with 0.5 meter accuracy ,fig (5.2)

Figure 5.2 : Ortho photos of Yatta City

**5.3 Streets Centre lines**

Centre line definition : A line representing the physical center of a street way between street shoulders, often coinciding with the centre line painted line dividing bi-directional travel lanes, represents both directions of travel. Limited access interstates, highways and boulevards divided by concrete barriers or grassy median strips are modeled by two centerlines one for each direction of travel.

Streets centre line are a framework layer because they can support address matching (geocoding), transportation modeling, street way management, vehicle routing, and cartography.

Street centre lines also frequently define boundaries for emergence dispatch service area, political boundaries, parcels, and zoning so they are a foundation layer in the geometric construction of other layers.

Street centerlines was created by digitizing the mid of exist streets and update streets centre lines and field was built to input data using ArcGIS tools.

## 5. 4 Digitizing of Building

A Feature class named " buildings " was created, then the buildings in Yatta City which are located inside Yatta Municipality borders were degitized including services buildings.

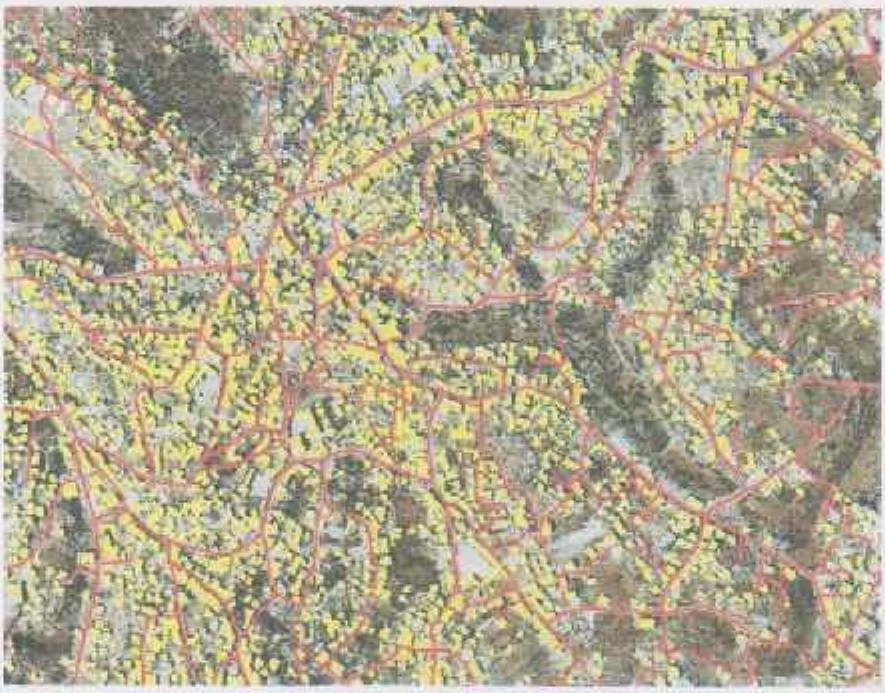


Figure 5.3 : Sample of digitized streets and buildings

## 5. 5 Locate Services Locations

Services Locations such as hospitals, police centre, civil defense centre, fuel stations and pharmacies were mapped " point feature class " as requirements for the network analysis.

## 5.6 Streets Network Attribute Table

Network attributes are the properties of the network elements that the analysis over the network. Example of attribute is the time to travel a given length of street. Which streets are restricted for which vehicles, the maximum speed alowed along a given street, the condition of each street and which streets are two-way or one-way.

Network attributes have a four basic elements: name, usage type, units, and data type. More elements that affects speed were used such as condition of each street and geometry Additionally. These elements have a set of assignments defining the values for the elements.

- The usage type specifies how the attribute will be used during analysis, which is identified as a cost, descriptor, restriction, or hierarchy.
- Units of a cost attribute are either distance or time units such as centimeter, meters, kilometer , miles , minutes and seconds ). Descriptors, hierarchies and restrictions have unknown units
- Data type can be either integar, float or double. Restrictions are always Boolean, whereas a hierarchy is always an integar.

Network attributes are created either in the new network data set wizard ( when defining a new network ) or on the network dataset properties dialog box through preparing the network settings. To create network attributes; first, the name of attribute, its usage, units, and data type are defined. Next, evaluators for each source are assigned this provides the values for the network attribute specifying the right when the network dataset is built. This is done by selecting the proper attribute and clicking Evaluators.

### 5.7 Cost For Yatta Facility

The Maximum speed of each street were obtained from Yatta municipality. The following table summarizes the maximum speed depending on street type.

Table (5.1) Maximum Speed of Streets

| Street type | Max.Speed |
|---|---|
| Unpaved | 30 |
| LOCAL | 60 |
| HIGHWAY | 120 |

Length of each street is automatically given by ArcGIS software, or we can Calculate Length by adding field to attribute table of street then pick " Calculate Geometry ".

Table (5.2): Attribute Data Representation

| Property | Type | Field name,type | Input criterion |
|---|---|---|---|
| **Length** | Cost | METERS, double | Calculated from calculate geometry |
| **Time** | Cost | MINUTES, double | vb expression [MINUTES] = [METERS] *60 / 1000*[KPH] |
| **Speed of travel** | Cost | KPH, Double | Assigned for each class on 90, 80 and 60 km/hr |
| **Street type** | Hierarchy | Func_Class, integer | 1 regional, 2 main street,3 local |
| **Way of travel** | Restriction | OneWay,(string) | FT (Travel is only permitted in the digitized direction of the line feature) TF (Travel is only permitted against the digitized direction of the line feature)N ( Travel is not permitted in either direction) Any other value ( Travel is permitted in both directions) |

The arrangement of data as listed in Table 1 can produce a network dataset for the inquiry about the best route between two or more stops, the time of travel, and distance traveled, after completing the digitizing of the desired streets in the region with a reasonable representation for the cities and towns the building of the network dataset can be performed.

### 5.8 Map Topology

It's important to check that digitized lines are sharing correct geometry between each other.

Using Arc GIS from Catalog window right click on dataset to create and choose a " New Topology " option .

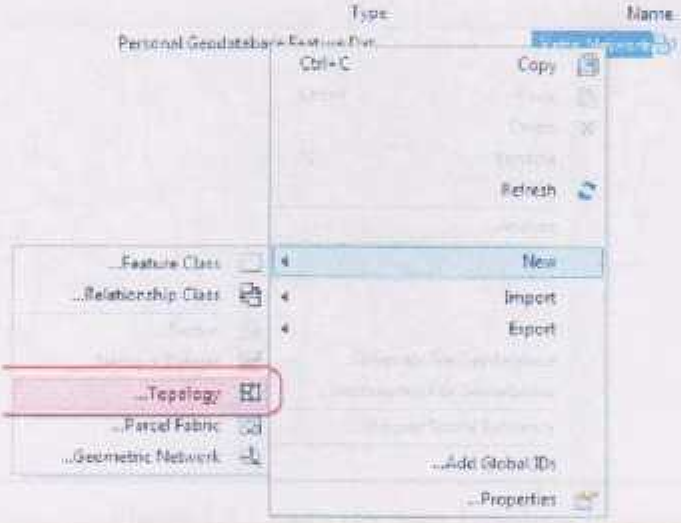



Figure 5.4 : Creating Topology

Layer that will participate in topology is choosen, then we add topology rules for " line feature ": Must not Have Dangles, which is a good way to check for continuity. The orther rule us Must Not Have Psuedo's ; which is a good way to check for intersections . Both rules are shown in figures 5.5 and 5.6.

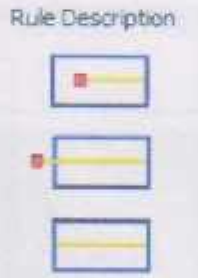



Figure 5.5 : Must Not Have Dangles


Figure 5.6 : Must Not Have Psuedo's

Figure 5.7 shows the topology map of Yatta and all errors appearing in the feature class .

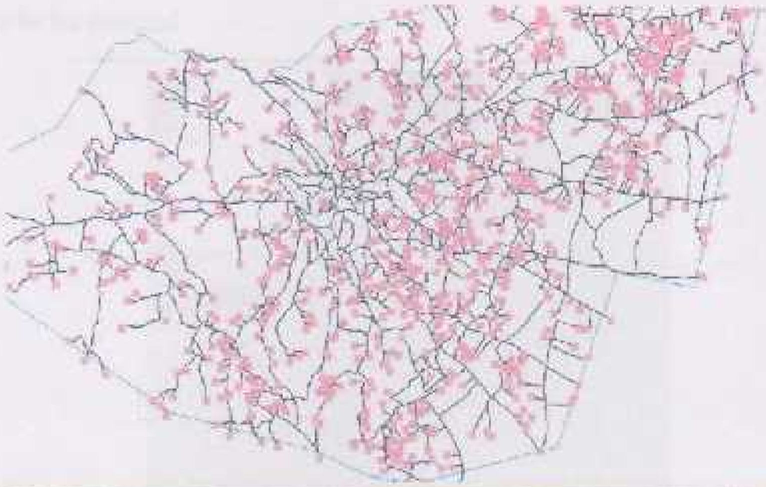


Figure 5.7 : Yatta city map Topology

To delete all topology errors, the topology toolbar in ArcGIS Arc map is used to editing. Errors may have to be merged , trimmed, extended or snapped.

1- Errors to be snapped

Figure below shows an error occurred due to snapping while digitizing, this error could be eliminated by clicking right click on topology error and choose " snap ".

Figure 5.8 : Error to be snapped

2- Errors to be merged

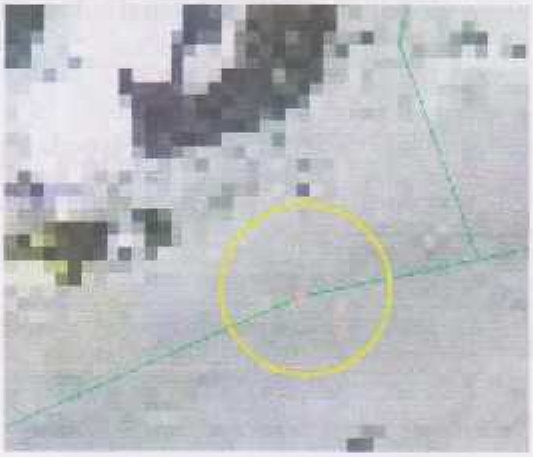


Figure 5.9 : Error to be merged

## 5.9 Calculating slope distance

To calculate slope distance we must have a contour map or a TIN. Using " Global Mapper 13 " software we can generate a contour map of 5 Meters interval and download it online using " STRM digital elevation mode with a resolution of 3 arc seconds ( 91m) .

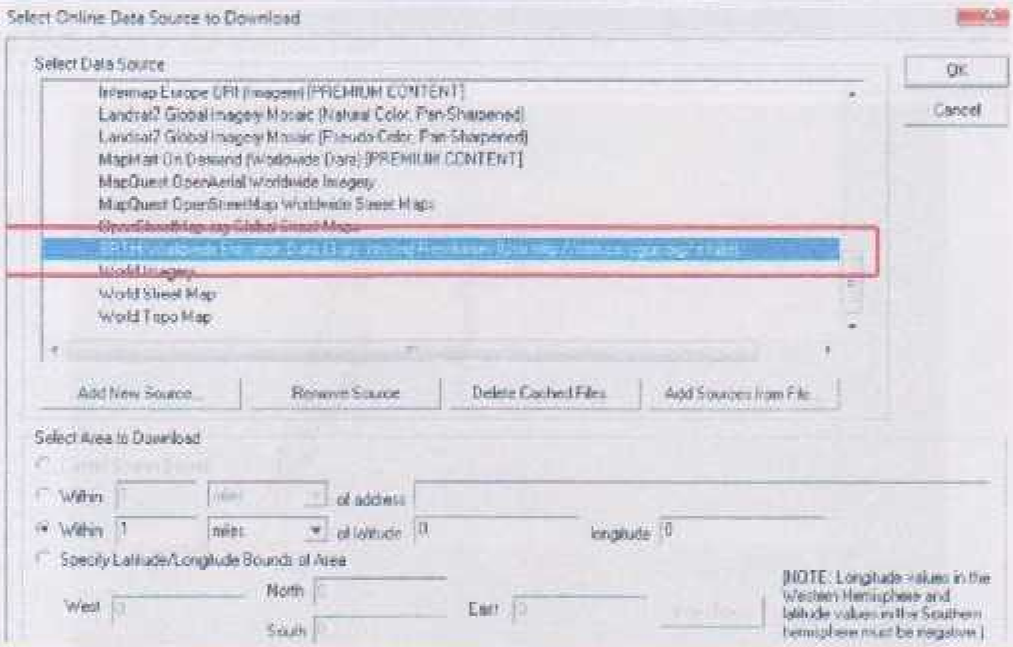



Figure 5.10 : Importing 5m interval contour map from STRM model

Contour map will be exported as " shape file " and will be added to ArcGIS .

In order to calculate slope distance , a TIN has to be created using the contour map generated by " global mapper ", Here, the Extension of 3D analyst has to be activated on the ArcGIS software .

- From ArcTool Box choose 3d Analyst tool → TIN Management → Create TIN.
- A new window will appear and we will choose output coordinate and output file and input shape file which is contour map as shown in figure12.5.

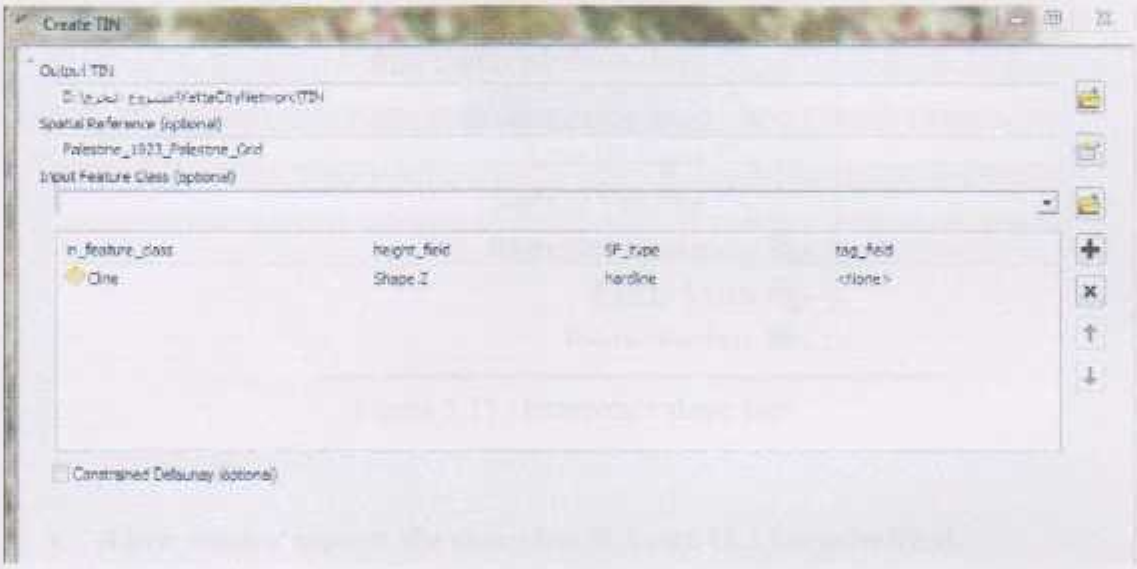



Figure 5.11: Create TIN window

Figure 13.5 shows the created TIN .

Figure 5.12 : Created TIN

- The next step is calculating 3D length for the centre lines using ArcTool Box, from 3D Analyst group → Functional Surface → Interpolate shape .

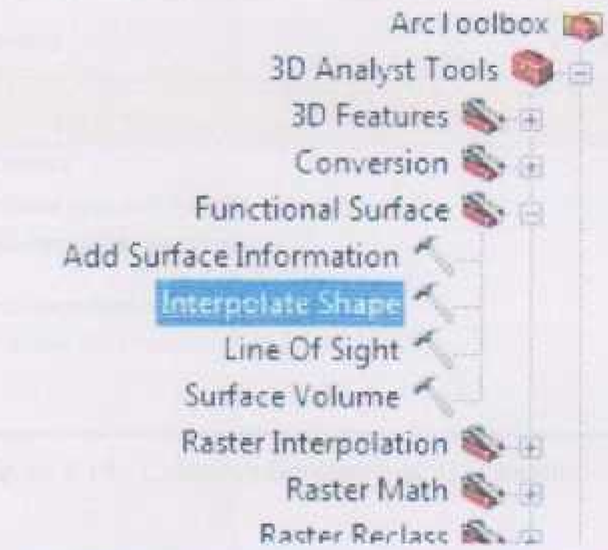



Figure 5.13 : Interpolate shape tool

- A new window appears, the dialog box In figure 14.5 has to be filled .

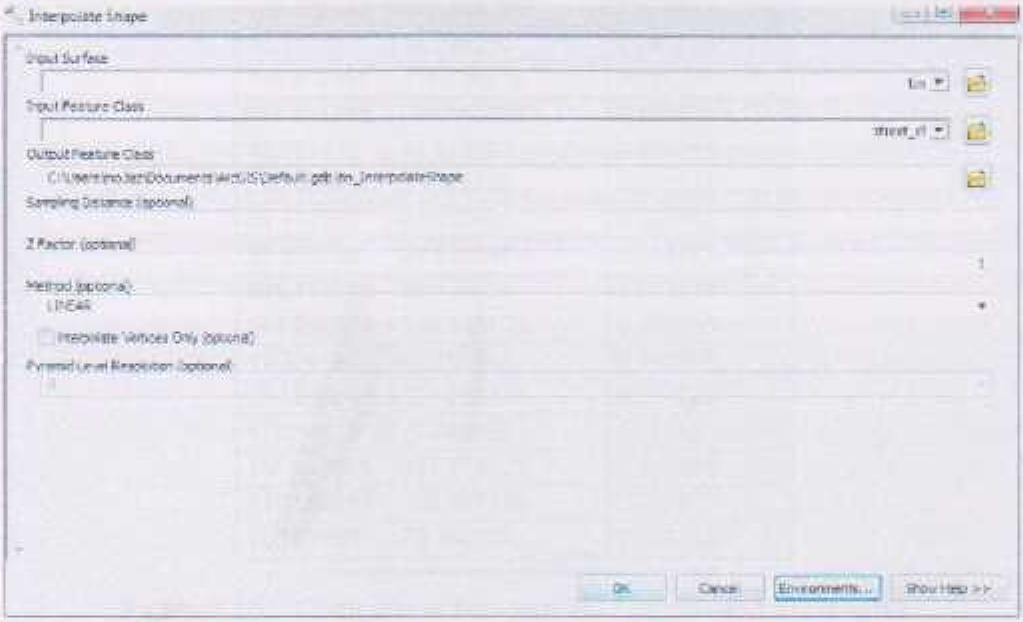



Figure 5.14 : Interpolate Shape window

- Open attribute table of " streets " and right click on " METERS " field the Calculate geometry has to be chosen, the property " 3d Length " shown is figure 5.15 has to be selected :

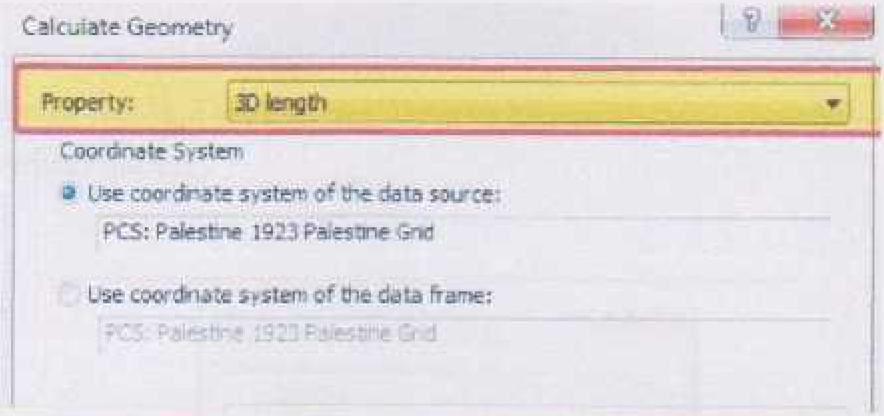



Figure 5.15 : Calculate Geometry of 3D Length

Figure 5.16 shows the comparison between 2d length ( SHAPE_Length) and 3d length ( METERS )

| METERS | Shape_Length | Difference |
|---|---|---|
| 160.130292 | 159.992732 | 0.13756 |
| 127.479241 | 127.358295 | 0.120945 |
| 48.81781 | 48.776235 | 0.041575 |
| 116.810451 | 116.734218 | 0.076233 |
| 114.441248 | 114.317926 | 0.123322 |
| 47.551773 | 47.543522 | 0.008251 |
| 24.100943 | 24.088798 | 0.012145 |
| 64.177902 | 64.139435 | 0.038467 |
| 25.033739 | 25.032997 | 0.000742 |
| 204.318575 | 204.26554 | 0.053034 |
| 140.398864 | 140.313778 | 0.085086 |
| 45.254198 | 45.106399 | 0.147799 |
| 124.519544 | 124.358316 | 0.161229 |
| 47.614979 | 47.498792 | 0.116187 |
| 157.903585 | 157.774921 | 0.128664 |
| 138.662366 | 138.451449 | 0.210917 |
| 73.591593 | 73.383222 | 0.208371 |

Figure 5.16 : Comparison between 3D Lengths and 2D lengths

## 5.6 Building Network Dataset

The following steps are to be followed in order to build network dataset .

**Step 1**

Enable Network Analyst Extension by clicking on customize and choose extensions and check on network analyst .

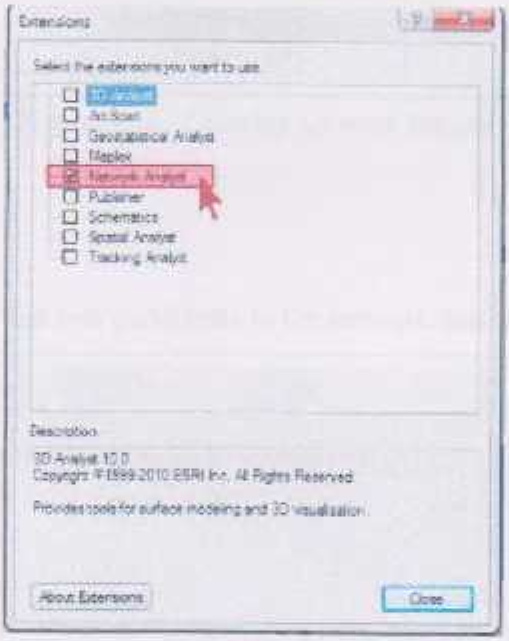



Figure 5.17 : ArcGIS Extensions

**Step 2**

From Arc Catalogue window, right click on data set that we created and choose new Network Dataset . figure 5.18 shows the creation of a new network dataset and the network dataset wizard appears. The name of the network is entered and click next .

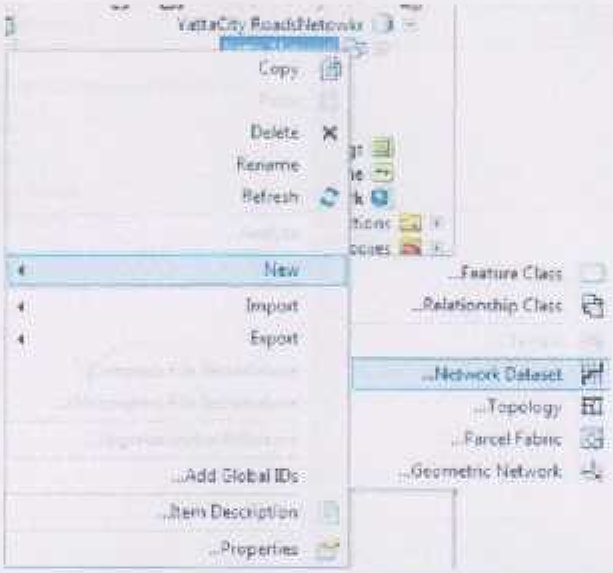



Figure 5.18 : Creating network dataset

**Step 3**

Select the feature classes that will participate in the network dataset and click next

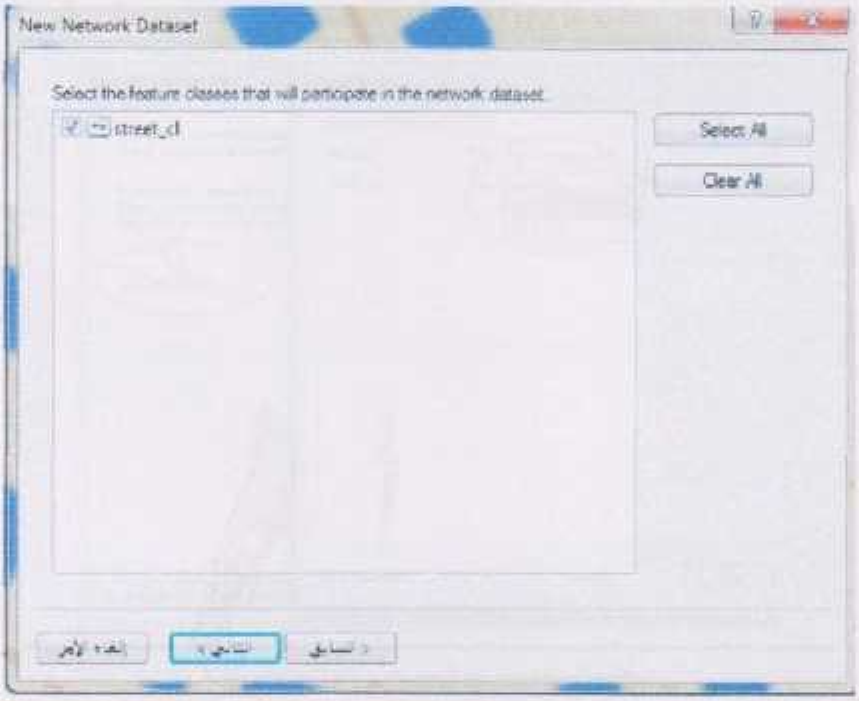



Figure 5.19 : Selecting Feature Classes Participated In Network

**Step 4**

Check on " Yes " to validate turns in the network then click next .

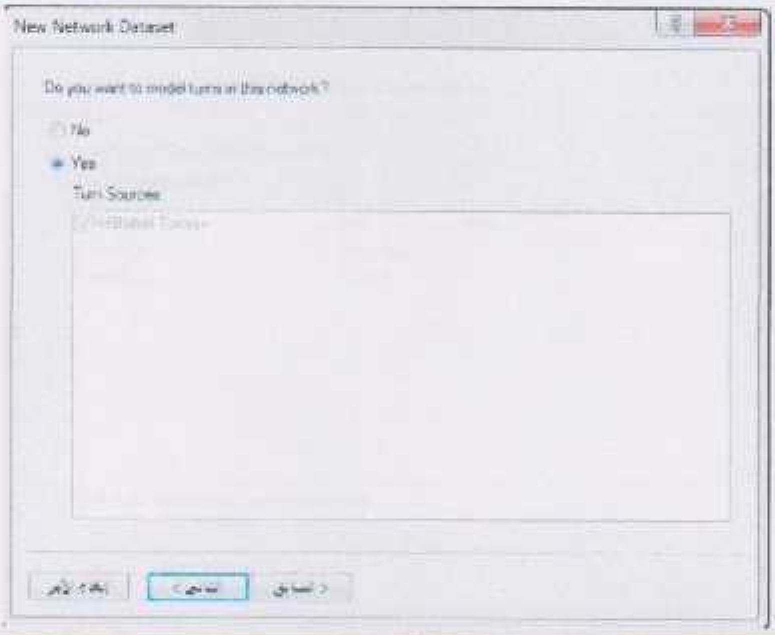



Figure 5.20 : Modeling Turns

**Step 5**

Choosing the style of connectivity, here the chosen type is at any vertex, click next.

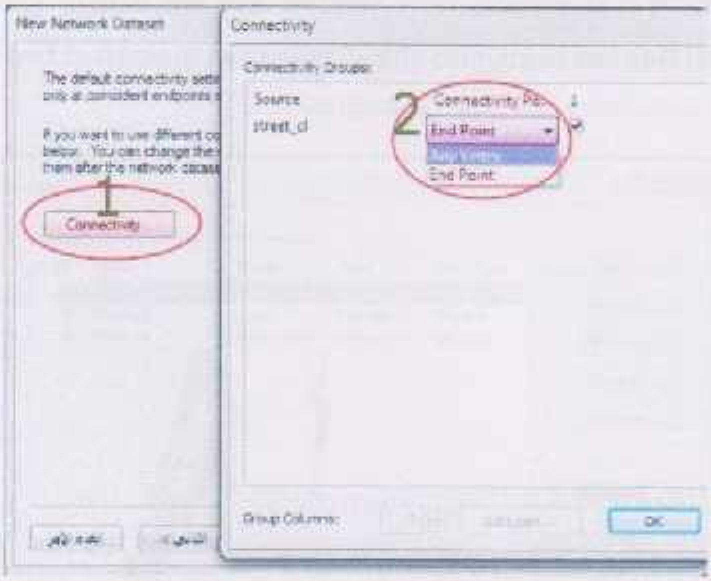



Figure 5.21 : Choosing connectivity

**Step 6**

The figure bellow shows the window asking if elevations of the street are included or not , here the z-elevation are not available, choose none and click next.

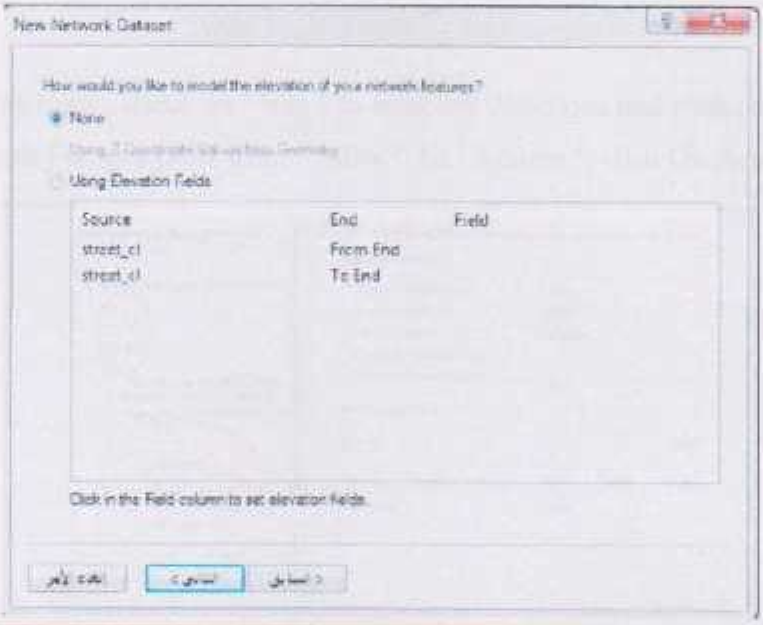



Figure 5.22 Modeling Elevations

**Step 7**

Configure of evaluators, the figure bellow shows the evaluators used in network dataset, and it can be easily used if the past attribute were inserted in a proper way, here the properties of cost and restrictions are automatically configured and analyst figure them out, click next .

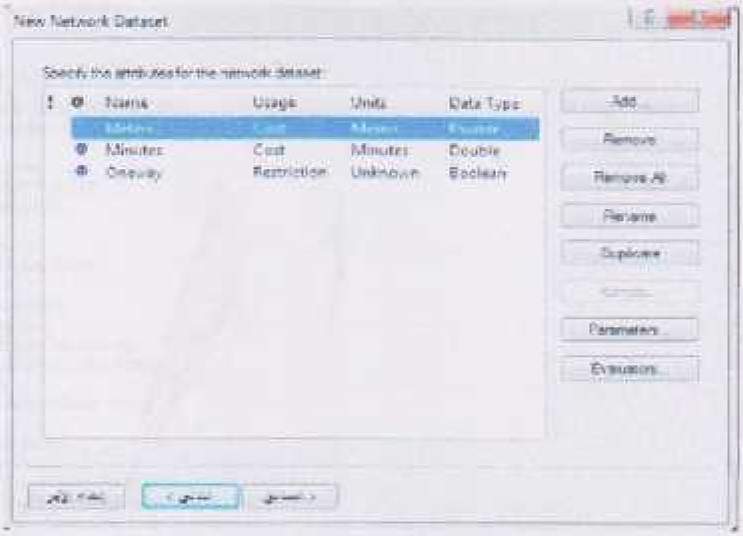



Figure 5.23 : Evaluators of Network

**Step 8**

Establishing directions , check on " Yes " to establish directions and click on Directions and change Display length Units from " Miles " To " Meters ", click Ok then click Next .

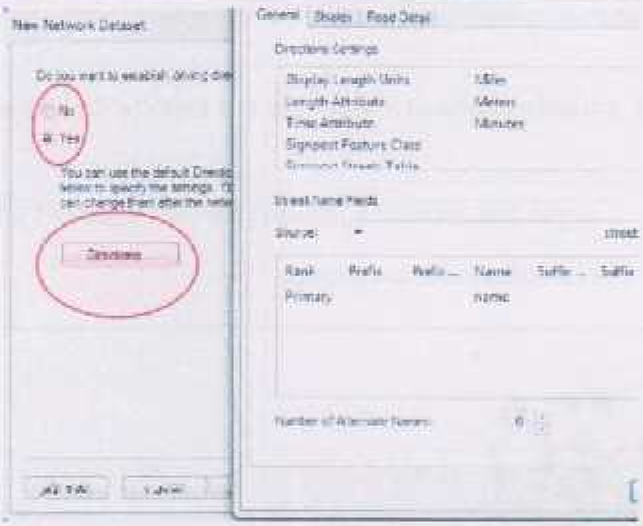



Figure 5.24 : Establishing Directions in Network

**Step 9**

The last window of creating network dataset shows summary for the evaluators and properties of network dataset intended to be built, if the information are correct click finish.


Figure 5.25 : Summary of Network

**Step 10**

this step is a message of whether the user wants to create the dataset or not, ClickYes.

**Step 11**

The last step is a message of whether the user wants to add evaluators, Click Yes .

Figure 15.5 shows the Network that we created, junctions and edges .

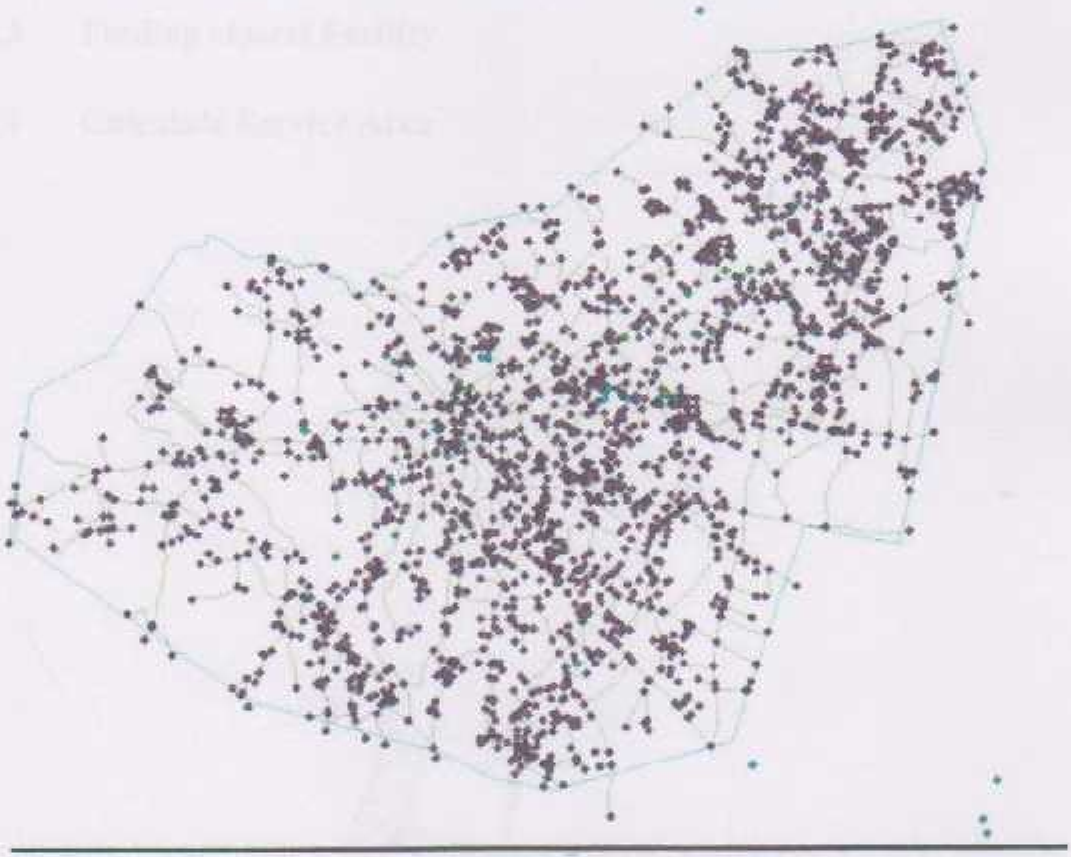


Figure 5.26 : Yatta City Roads Network

# CHAPTER SIX

## TEST AND RESULTS

**6.1 Introduction**

**6.2 Finding Best Route**

**6.3 Finding closest Facility**

**6.4 Calculate Service Area**

## 6.1 Introduction

ArcGIS network analyst provides network spatial analysis, such as routing, finding closest facility and define service area based on travel time or distance .

## 6.2 Finding Best Route

### 6.2.1 Preparing display

On the network Analyst toolbar, click on " network Analyst " and choose "new route".

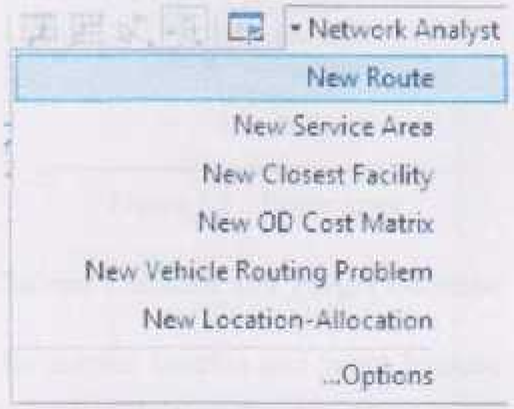



Figure 6.1 : Creating Route model

The network analyst window contains empty list of stops, routes, point barriers, line barriers and polygon barriers .

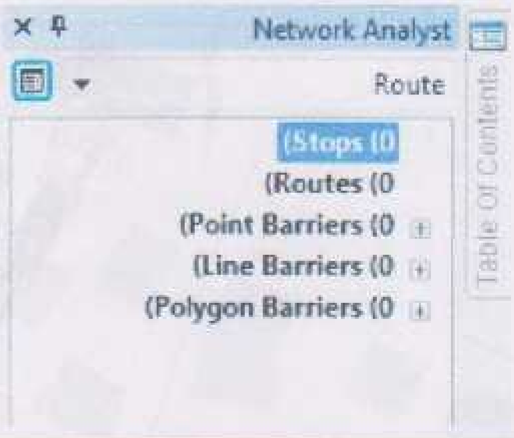



Figure 6.2 : Empty stops, Routes and Bariers

Table of Contents contains a new route Analysis Layer as shown in figure below .


Figure 6.3 : Route layer

### 6.2.2 Adding Stop at a Current Location and Target Location

Now we will add stops for current location and target location by the following steps :
1- Click on Stops(0) on network analyst window .

2- From network analyst toolbar click on create location tool .

3- On streets network map click on current location to define a new stop location .

This stop will remain elected until another stop location( target location ) is placed on streets network map .

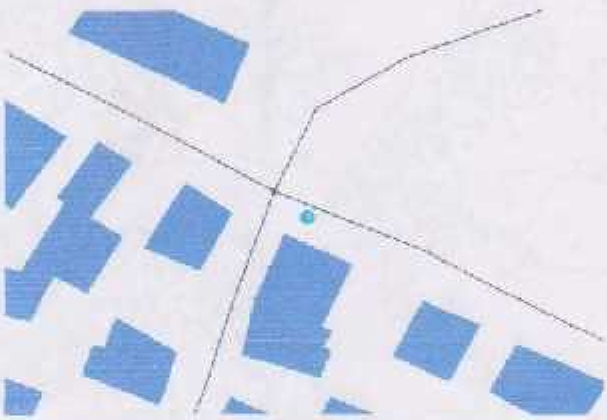


Figure 6.4 : adding a stop location

The located stops also displays number 1. The number represents the order in which the stop will be visited by calculated route. You will also notice that the stops category on the network analyst window now lists 1 stop.

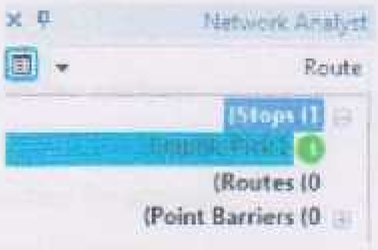



Figure 6.5 : Assigning location as graphic pick 1

4- Now we will add the second stop location which is the target location. The new stop will be numbered. The order of stops can be changed on network analyst window. The first stop is treated as the origin and the last, as the destination .

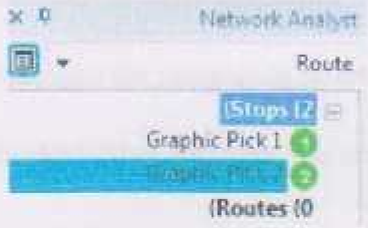



Figure 6.6 : order of stops, graphic 1 is origin, graphic 2 target location

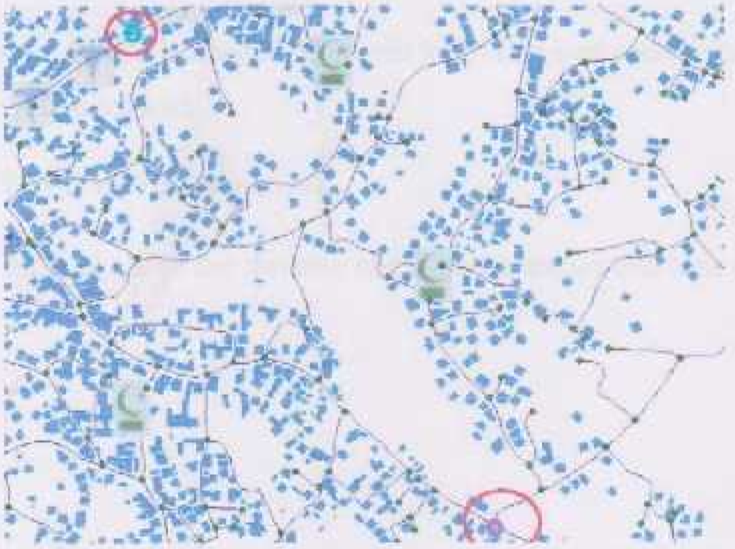


Figure 6.7 : Locations of graphic pick 1 and graphic pick 2 ( target location )

If a stop is not located on the network, it will appear with unlocated symbol, and it can be located by moving it closer to any edge that belongs to the network. On network analyst toolbar, click on Select/Move Network location tool .

### 6.2.3 Setting up the parameters for analysis

we will set the following parameters for analysis :

1- Make sure that route based on time.
2- Make sure that U-turns is allowed .
3- Make sure that OneWay restrictions must be followed.

To ensure these parameters follow the followed steps :

1- From network analyst window click on layer properties .

2- click on layer setting tab. Make sure the impedance selected is Minutes.

3- Leave " reorder stops " unchecked. This preserves the order of stops as decided by you, when you created stops .

4- choose " allowed " from U-turns dropdown box.

5- choose " true shape with measures " from output shape type dropdown box.

6- check on " ignore invalid locations". This will let us find best route using located stops. Unlocated stops will be ignored.

7- check on OneWay in the restrictions list.

8- on directions list, make sure the distance unit is set to meters and time attribut is set to minutes.

9- click ok .

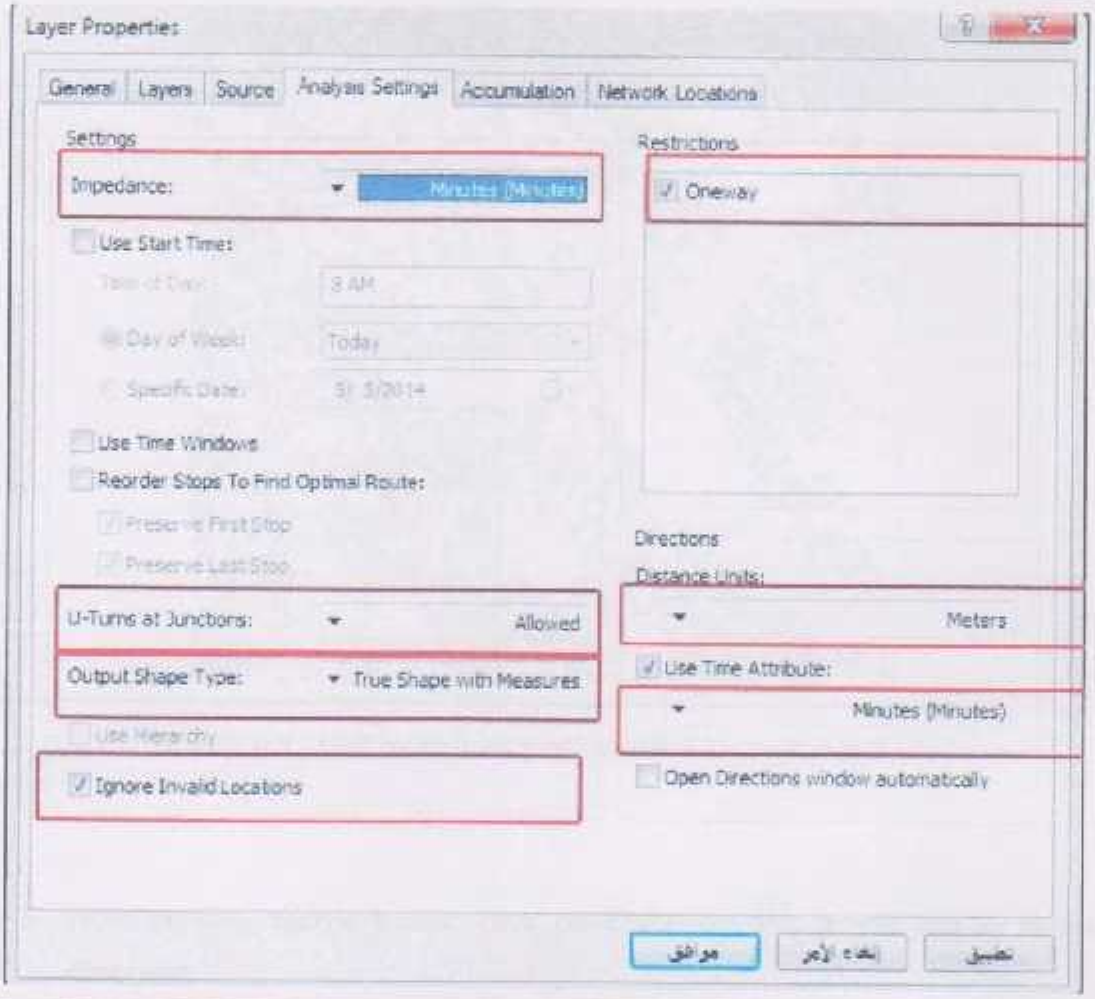



Figure 6.8 : Setting parameters of analysis

### 6.2.4 Solve to compute the best route between location and target location.

1- From network analyst toolbar click on solve button .

2- A polyline route will appear in the map and in route category in network analyst window .

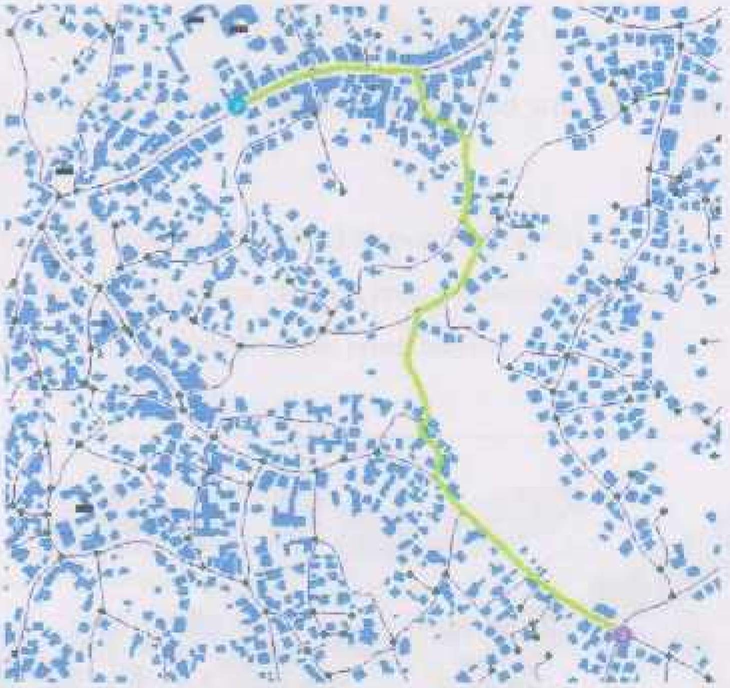


Figure 6.9 : Best route from graphic pick 1 to graphic pick 2

3- From network analyst toolbar click on directions, it will display driving directions.
4- The direction window can also display turn-by-turn maps by click on map link in direction window.


Figure 6.10 : Directions Window of Route 1

### 6.2.5 Adding a Barrier on Yatta Streets Network.

A barrier can be added to represent a roadblock and will find an alternative route to avoid the roadblock.

1- Click on network analyst window, click point barrier(0).
2- From network analyst toolbar click on create location tool.
3- Click on anywhere on route to place point barrier.

Figure 6.11: Adding Barrier on Route 1

4- Click on solve button in network analyst toolbar, a new alternative route will be computed to avoid the barrier as shown in figure below .

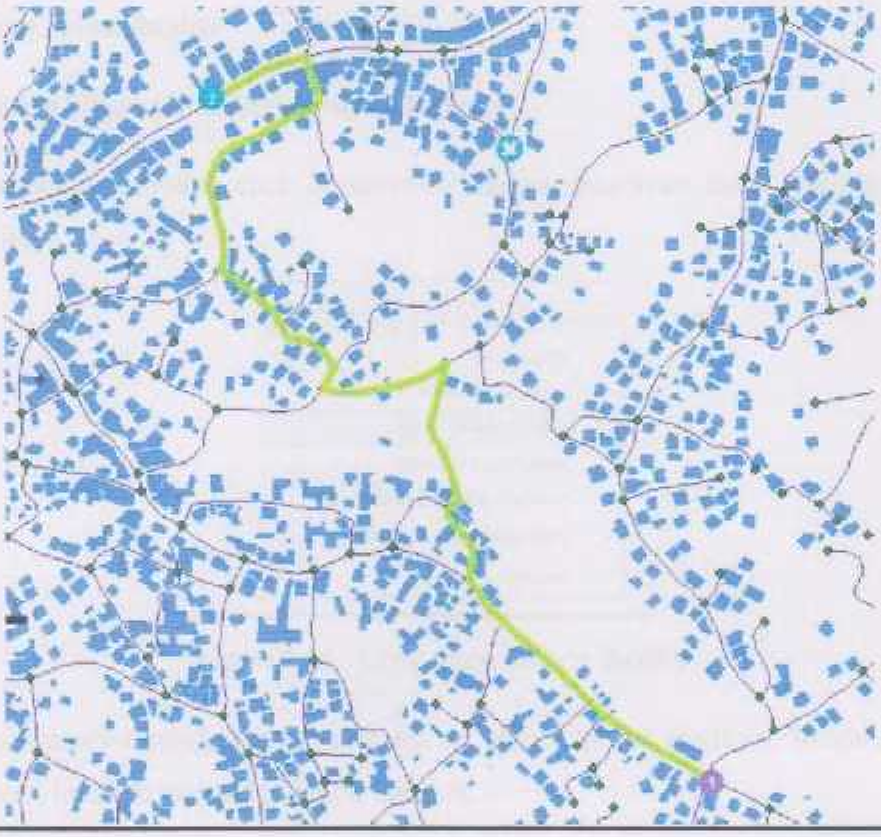


Figure 6.12 : Alternative Route From Graphic Pick 1 to Graphic Pick 2

### 6.2.6 Applications of finding best route in Yatta City .

1- In garbage collection : finding the best route for garbage car to pick up garbage from containers , this is done by locate containers locations on map as shape file this choose containers which should be picked up and solve to find best route.

2- In incidents

   a. Ambulance arrival : finding the best route for ambulance to arrive from its station to accident location.

   b. Fire engine arrival : finding the best route for fire engine to arrive the blaze.

   c. Police car arrival : finding the best route for police car from police centre to any accident location.

3- Finding best route from any location in City to any facility such as schools, mosques, universities, pharmacies ..etc .

## 6.3 Finding Closest facility

### 6.3.1 Creating Closest Facility Analysis Layer

On network analyst toolbar click on network analyst dropdown menu and click on new closest facility .


Figure 6.13 : Create new closest facility

The network analyst window now contains an empty list of facilities, incidents, routes, point barriers, line barriers and polygon barriers.


Figure 6.14 : Network analyst window of closest facility

Also, table of contents contains a new closest facility layer as shown in figure below.


Figure 6.15 : Table of contents with closest facility layer

### 6.3.2 Adding facilities

We will add facilities from a point shape file for which a layer file has been created.

1- In network analyst window, right click on facilities(0) and click on load locations as figure shows below.

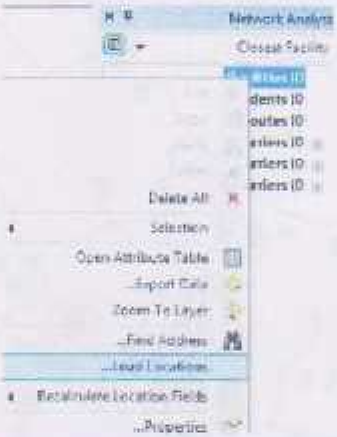


Figure 6.16 : Load facilities locations

2- Select pharmacy from " load from " dropdown list and click ok.


Figure 6.17 : Loading pharmacy as closest facility

### 6.3.3 Adding an incident

1- On network analyst window, click on incident(0) then from network analyst toolbar choose new network location tool and select your location on map. Figure below shows facilities as circles and incident as square.

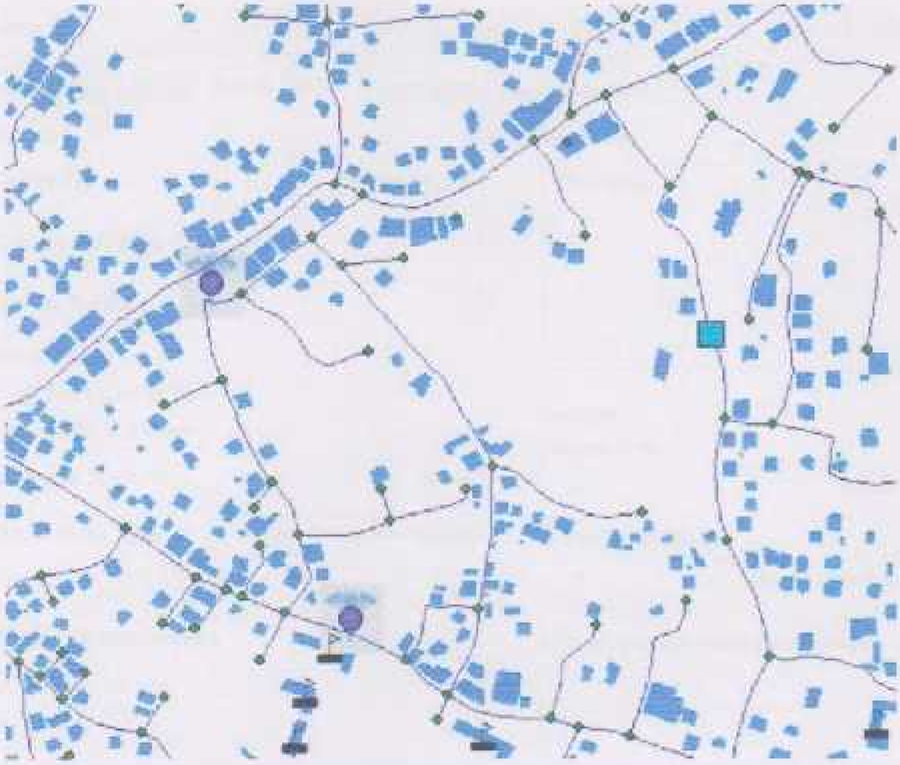


Figure 6.18 : Adding incident on map appears as square

### 6.3.4 Setting up the parameters for analysis

1- Click on the analyst layer properties button in network analyst window
2- In layer properties dialog, click on analysis setting tab.
3- Click on impedance dropdown box and choose Minutes (Minutes).
4- Set the default cutoff to none.
5- Increase facilities to find from 1 to 2 .
6- Choose travel from incident( location) to facility ( pharmacy).
7- Select allowed for U-turns.
8- Select true shape with measures for out shape type.
9- Check on ignore invalid locations.
10- Check on OneWay in restrictions list.
11- Click ok.

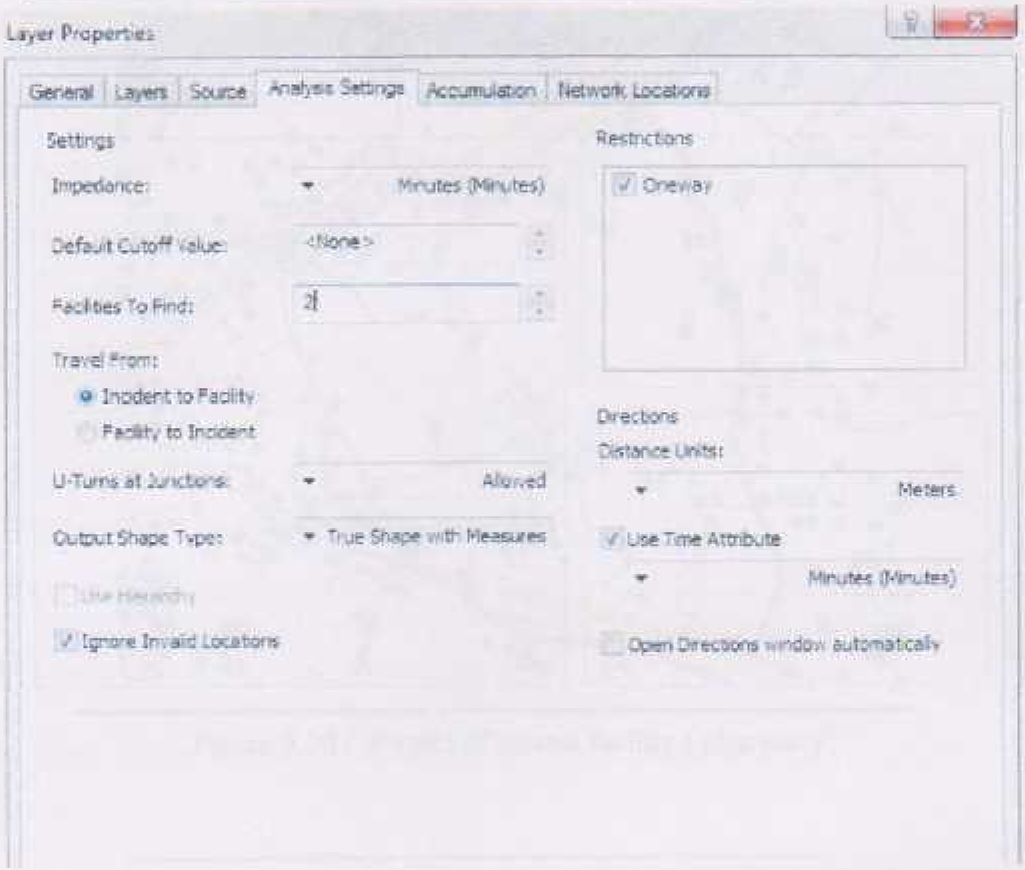



Figure 6.19 : Setting parameters for closest facility layer

### 6.3.5 Solve to compute the closest facility (pharmacy) to your location (incident).

1- From network analyst toolbar click on solve button .
2- A two polyline routes will appear in the map and in route category in network analyst window .
3- Click on directions window button in network analyst toolbar to generate directions for the two routes for pharmacies .

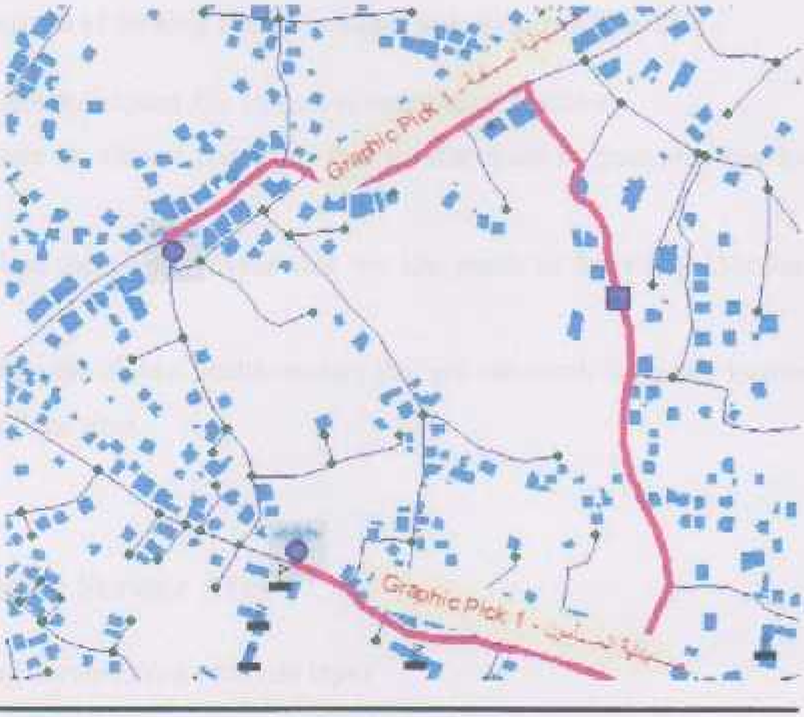



Figure 6.20 : Routes of closest facility ( pharmacy)


Figure 6.21 : Directions of routes of closest facility

### 6.3.6 Applications of finding facilities using network in Yatta City .

1- Calculate the closest fire station to location of accident.

2- Calculate the closest pharmacy that we can reach to from any location in a defined time.

3- Calculate the closest stores that we can reach to from any location in a defined time.

4- Calculate the closest health centers that we can reach from any location of accident in a defined time.

## 6.4 Calculating Service Area

### 6.4.1 Creating service area analysis layer

On network analyst toolbar, click on network analyst drop down menu and choose new service area.

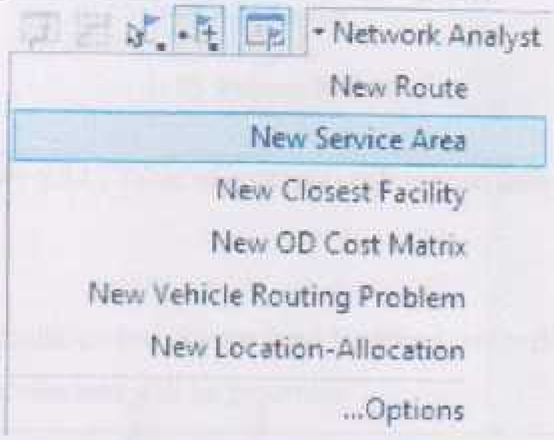



Figure 6.22 : Creating new service area

The network analyst window now contains an empty list of facilities, lines, polygons , line barriers , point barriers and polygon barriers.

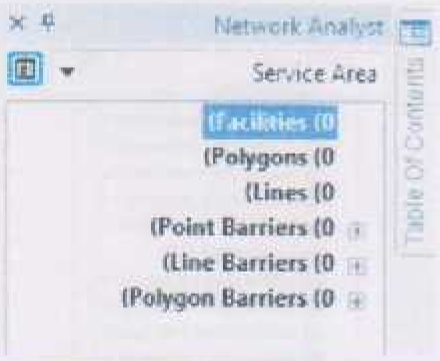



Figure 6.23 : Network analyst window of service area

Also, table of contents contains a new service area analysis layer as shown in figure below .

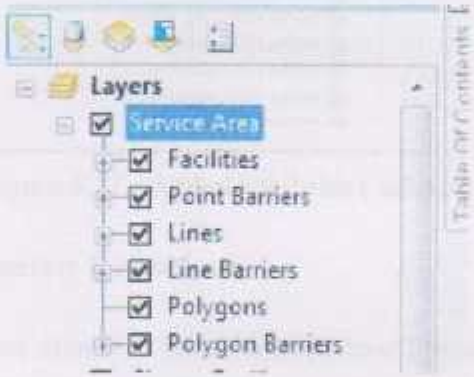



Figure 6.24 : Table of contents with service area layer

### 6.4.2 Adding facilities

1- Right click on facilities and choose load locations, we will add schools as facility for which the service area will be generates.


Figure 6.25 : Loading schools feature class as location of service area

2- Faculties now are visible on the map and in network analyst window


Figure 6.27 : Added Facilities ( schools )

### 6.4.3 Setting up the parameters for analysis

We will specify that service area will be calculated based on distance ( meters ). Three service area polygons will be calculated for each school ( facility), one at 200 meters , one at 400 meters and another at 700 meters. We will specify that direction of travel will be away from facility not toward facility, that no U-turns is allowed and that one way restrictions must be followed.

1- From network analyst window, click on analysis layer properties .
2- From analysis setting tab, click on impedance drop down list and select Meters(meters).
3- Type " 250 500 1000 " in default breaks text box. ( Enter distances as numbers separated by spaces without quotes ).
4- Under directions choose away from facility.
5- From U-turns drop down list choose not allowed .
6- Check OneWay in restrictions list.
7- Check on ignore invalid locations.

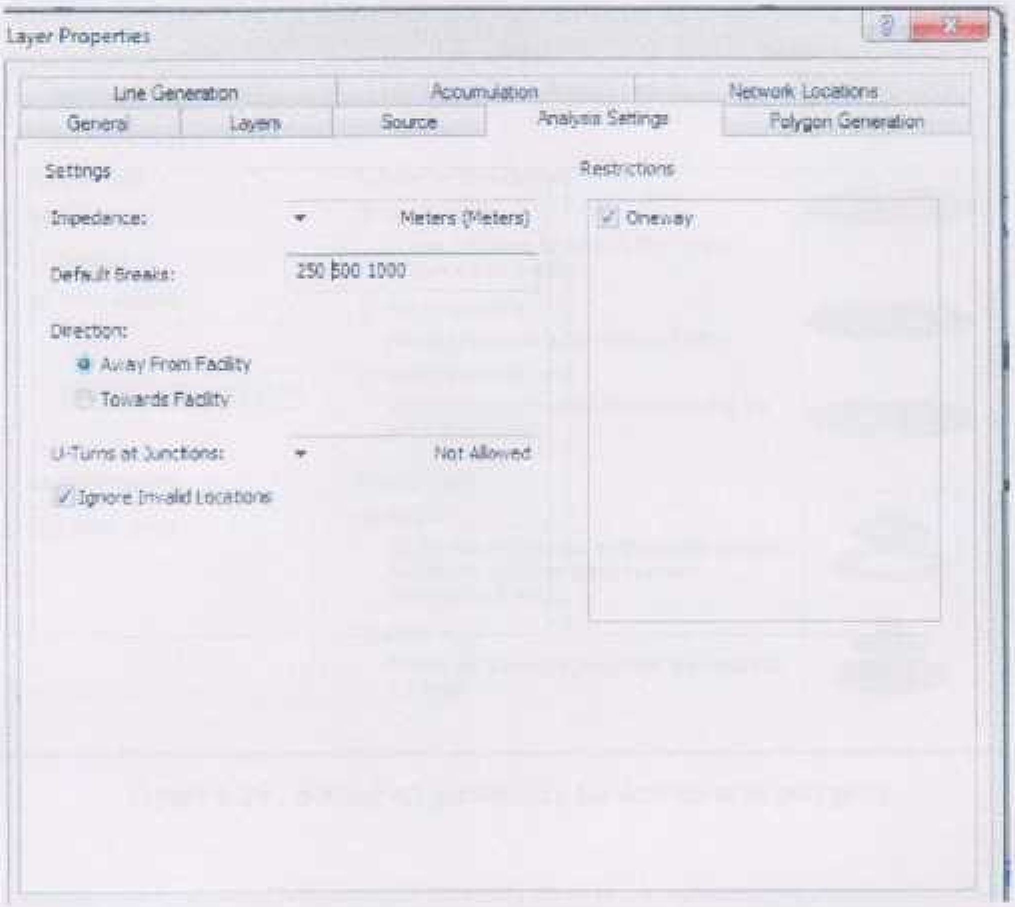



Figure 6.28 : Setting up parameters for service area

8- Click on polygon generation tab and check on generate polygons.
9- Select polygon type generalized, this results in faster analysis. Detailed polygons are much accurate, but need more time to be generated.
10- Select overlapping under multiple facilities options. This results in individual polygons per facility that may overlap.
11- Select Rings for overlap type. This excludes area of smaller breaks from polygons of bigger break.
12- Click apply, then click Ok.

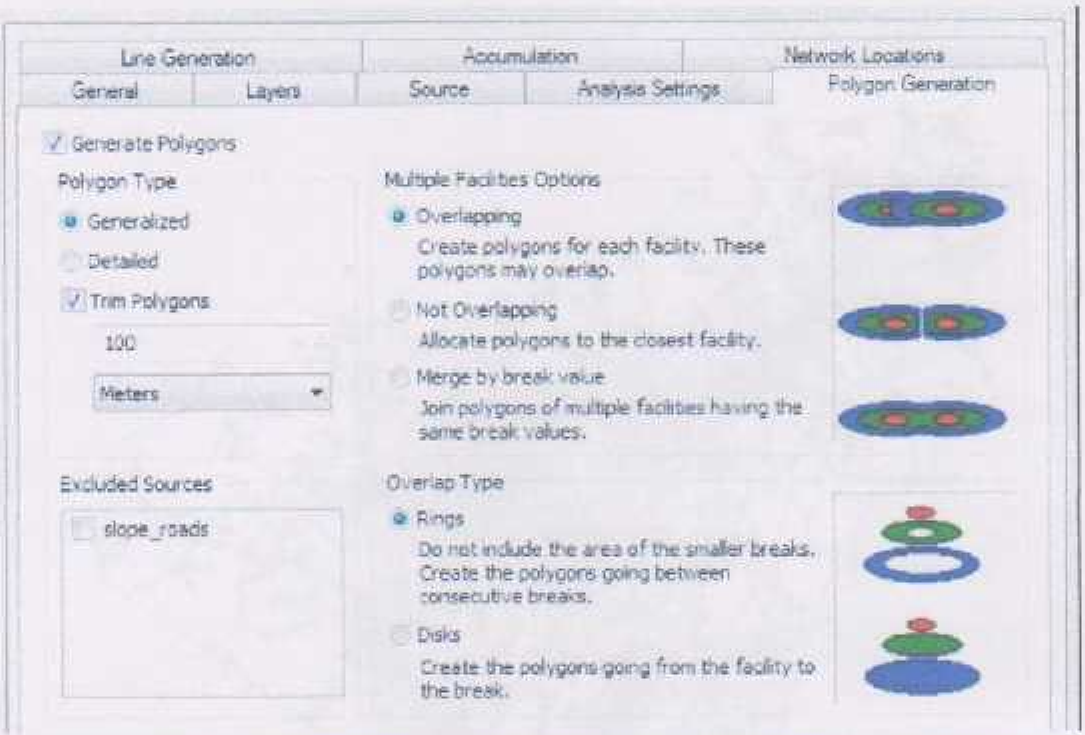



Figure 6.29 : Setting up parameters for service area polygons

### 6.4.4 Solve to compute service area

1- From network analyst toolbar click on solve button .

2- A service area polygons will appear on map and on network analyst window. There is a transparency set by default for polygons layer. This shows the underlying layers and gives ideas of area under polygon with respect to streets network.

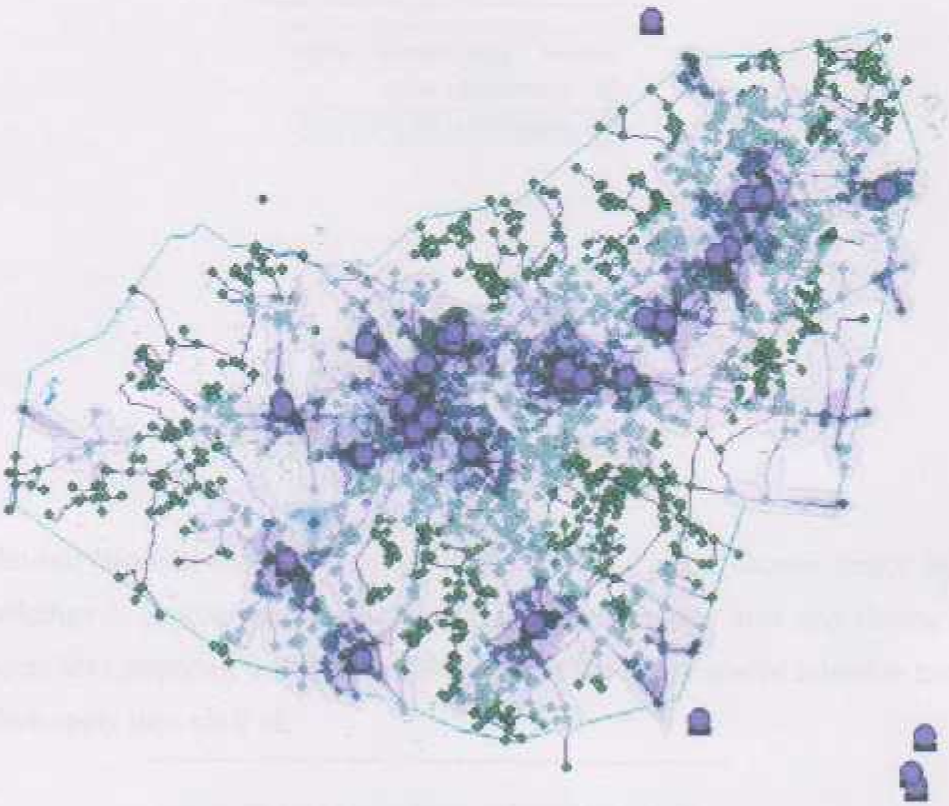


Figure 6.30 : Service area based on 250,500 and 1000 meters

### 6.4.5 Identifying buildings that do not lie with service area polygons .

1- From table of contents select and move buildings feature class to the top to improve visibility .


Figure 6.31 : Moving buildings shape file to the top of layers

2- Choose select by location from selection menu.


Figure 6.32 : Select by location

3- Choose selection method " select features from ", and choose target layers " buildings ", choose target layers " polygons " of service area and choose target layers are completely within the source layer feature from spatial selection method .

4- Click apply then click ok.

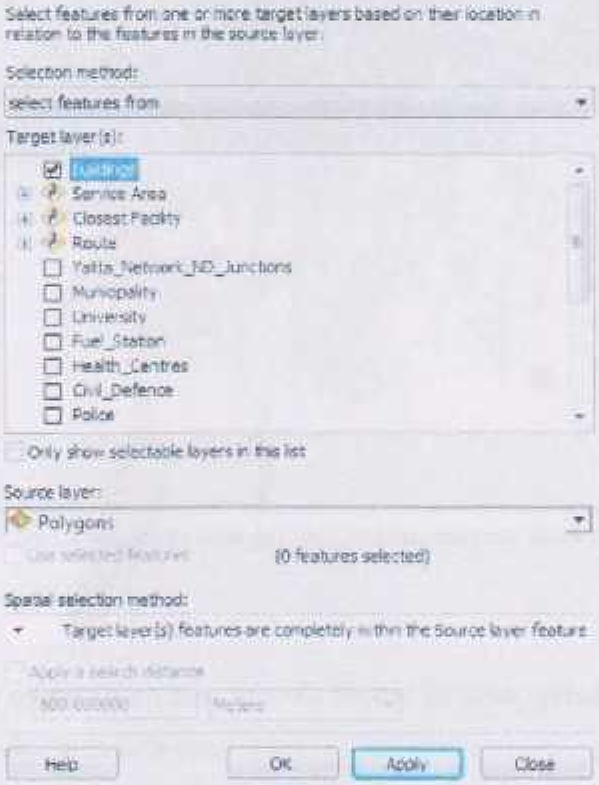



Figure 6.33 : Select buildings that are completely within service area polygons

5- Now all building are within service area are selected, we want to select all buildings that are not within service area polygons and this is done by switch selection.

6- From table of contents right click buildings feature class and open attribute tables.

7- Click on switch selection button  .

8- Now all buildings that are not within service area polygons are selected 2300 out of 8612 .

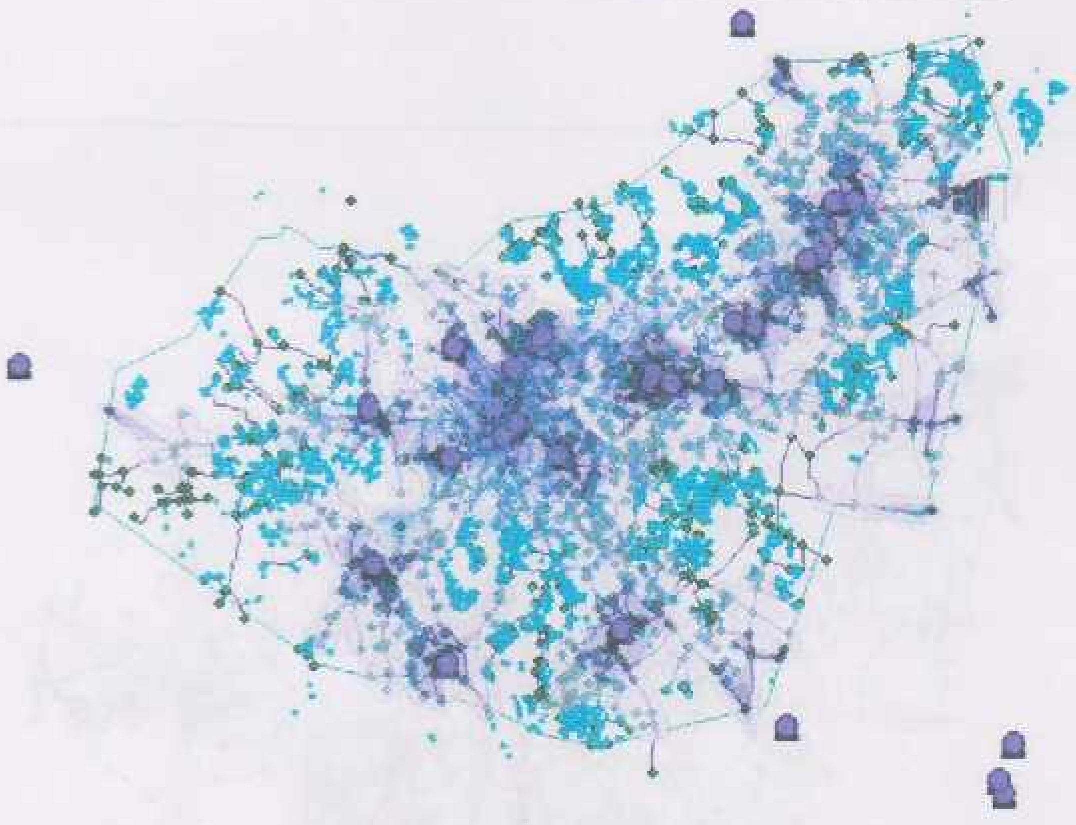


Figure 6.34 : Buildings that are not within service area polygons

9- From figure it seems that a new schools should be constructed for buildings that are not within service area polygons .

### 6.4.6 Suggest a New Schools

In order to make service area contains all building in city we have to add a new facilities ( schools ) .

1- From Network Analyst window click on " Facilities " and from network analyst toolbar click on create new location tool .
2- Add facilities to unserved area .
3- Click Solve .

Figure below shows that the new service area serve most of buildings in Yatta city .

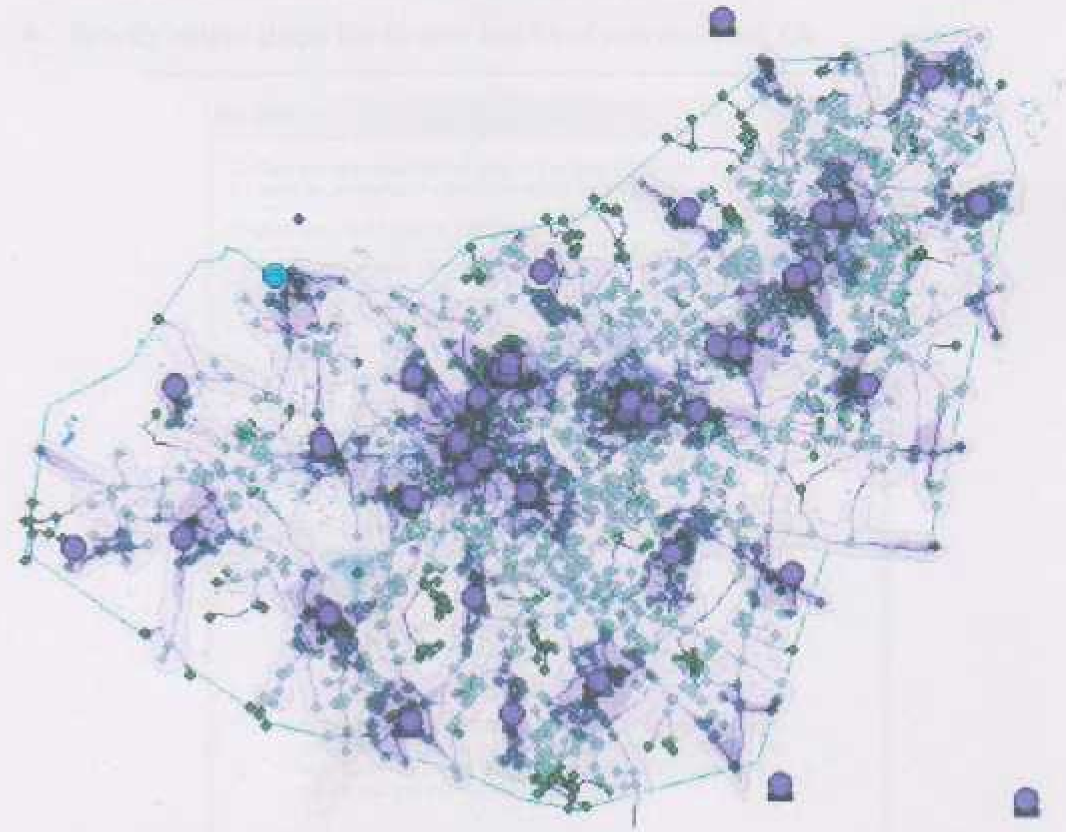


Figure 6.35 : New Service Area after suggest new schools

**6. 4.7 Identifying the service Area polygon that each house lies within**

1- From table of contents right click on polygon of service area feature layer , choose Join and Relates and select Join.

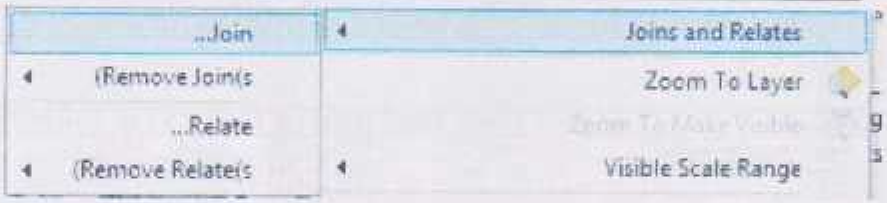



Figure 6.36 : Load the join data panel

2- From " What do you want to join to this layer " dropdown menu select " join data from another layer based on spatial location " .

3- Select Buildings, and select it falls completely inside ...

4- Specify output shape file to save results of join and click Ok .

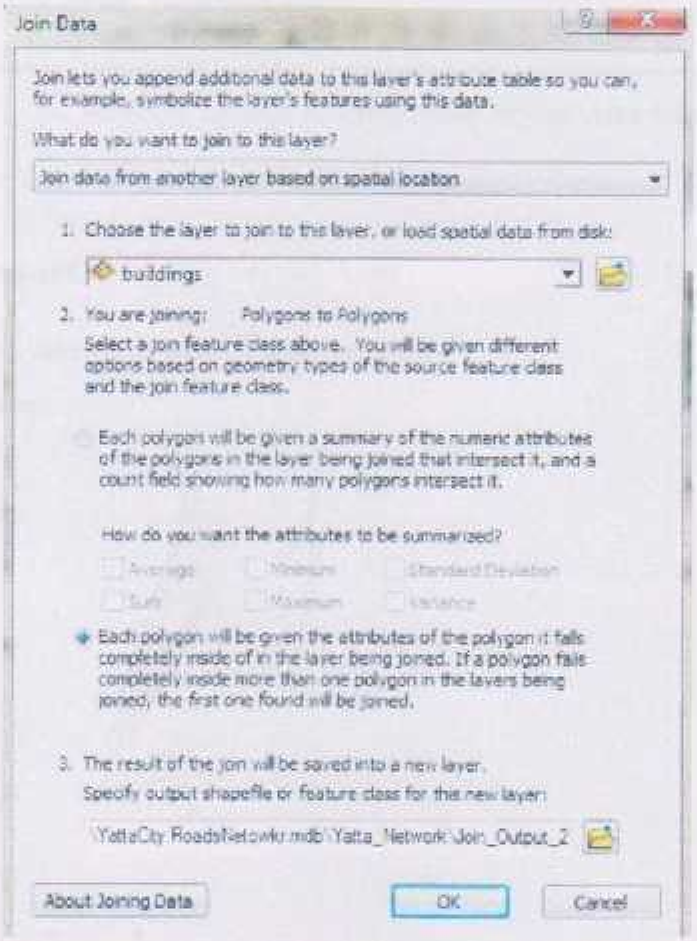
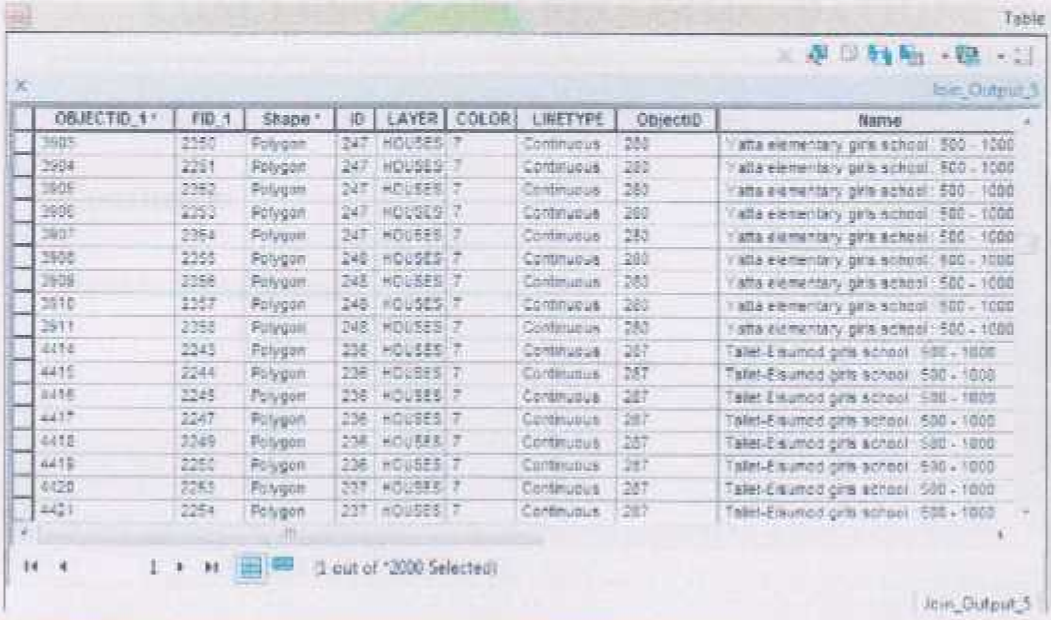



Figure 6.37 : Join data parameters

5- Right click on the new layer added and open attribute table, it will display the name of school and polygon it falls under .



Table

Join_Output_5

| OBJECTID_1 * | FID_1 | Shape * | ID | LAYER | COLOR | LINETYPE | ObjectID | Name |
|---|---|---|---|---|---|---|---|---|
| 3903 | 2250 | Polygon | 247 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3904 | 2251 | Polygon | 247 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3905 | 2252 | Polygon | 247 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3906 | 2253 | Polygon | 247 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3907 | 2254 | Polygon | 247 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3908 | 2255 | Polygon | 248 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3909 | 2256 | Polygon | 248 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3910 | 2257 | Polygon | 248 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 3911 | 2258 | Polygon | 248 | HOUSES | 7 | Continuous | 280 | Yatta elementary girls school : 500 - 1000 |
| 4414 | 2243 | Polygon | 236 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |
| 4415 | 2244 | Polygon | 236 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |
| 4416 | 2245 | Polygon | 236 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |
| 4417 | 2247 | Polygon | 236 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |
| 4418 | 2249 | Polygon | 236 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |
| 4419 | 2250 | Polygon | 236 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |
| 4420 | 2253 | Polygon | 237 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |
| 4421 | 2254 | Polygon | 237 | HOUSES | 7 | Continuous | 287 | Talet-Elsumod girls school : 500 - 1000 |

(1 out of *2000 Selected)

Join_Output_5

Figure 6.38: Attribute table of buildings with service Area information

### 6.4.8 Applications of Calculating Service Area .

1- Calculating service Area for Yatta mosques.

2- Public phones .

3- Schools.

4- Pharmacies .

5- Clinics.

# CHAPTER SEVEN

## CONCLUSION AND RECOMMENDATIONS

**7.1 Conclusion**

**7.2 Recommendations**

## 7.1 Conclusion

In this project the following conclusions are found:

1- This is the first trial to build a street network for Yatta city, which works under ArcGIS network analyst extension.

2- This network will help the Vehicle drivers, Ambulance Vehicle, Police, Ministry of Educations, Ministry of Religious affairs and many others.

3- This network was applied for different spatial analysis methods .

4- The effect of the topography was considered using DEM of Yatta.

5- We had Updated Yatta City Street network up to the year 2014.

## 7.2 Recommendations

In this project the following are recommended :

1- We recommend applying network analysis in different sectors of Palestinian community .

2- Modify the street addresses of Yatta streets to match the universal standards.

3- GPS technology can be applied with Pocket PC to ultimate the using of spatial network vehicles such as police cars and Ambulance .

4- Arc explorer could be used to open and view network .

5- The network, need a daily update for new roads, closed roads, and rush times.

## References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10. ESRI,http://help.arcgis.com/en/arcgisdesktop/10.0/help../index.html#/Network_elements/004700000008000000/
11. ESRI,http://help.arcgis.com/en/arcgisdesktop/10.0/help../index.html#/Turns_in_the_network_dataset/00470000000p000000/