

---

## Introduction

Proximity analysis is an important function in GIS as it covers a wide range of topics that help in answering many spatial questions, such as

1. How close is the observation well to a treatment plant?
2. Do any wells fall within 500 m of a fault system?
3. What are the distances between the wells and the treatment plant?
4. What is the nearest or farthest well from the dam?
5. What is the shortest street network route from the water tower reservoir to the towns?

Proximity tools can be applied in the vector and raster format. The vector-based tools vary in the types of output they produce and can be explained briefly in this chapter.

---

## Proximity Analysis in Vector Format

**Buffer** analysis is used for identifying areas surrounding any type of feature, whether it is point, line or polygon. The buffer polygon is created to a specified distance around an input feature. The output polygon features can be used as an input to overlay tools (union, intersect, erase, and spatial join). **Multi-Ring Buffer** creates a new feature class of buffer features using a set of buffer distances. Buffer function doesn't take into consideration any physical obstacle that might exist in the area of buffering.

**Select by Location:** After generating the buffer, user can use the **select by location** using different relationships between the buffer and the source feature under investigation. The select by location does not draw a boundary, but select the features that are determined by the relationship between the source and target layers.

**Near** function is selecting one feature of a set and then calculating the distance to all other features in the same set. The Near tool adds a new field called "distance" in the attribute table of one of the input layers. The distance will be calculated based on the map unit of the coordinate system of the map document.

**Point Distance** is similar to the Near function, but it generates an independent table. It calculates the distance from each point in one layer to all of the points within a given radius in another layer. The generated table can be used for further statistical analyses.

---

**Electronic Supplementary Material:** The online version of this chapter ([https://doi.org/10.1007/978-3-319-61158-7\\_16](https://doi.org/10.1007/978-3-319-61158-7_16)) contains supplementary material, which is available to authorized users.

**Desire Lines (Spider diagram)** will draw a line from each record to the one selected feature to identify the exact location. The Desire lines tool is part of the business analyst and shows which customers visit which stores. A line is drawn from each customer point to its associated store point, making it easy to see the actual area of influence of each store. This tool can be used in environmental related problems.

**Scenario 1:** The region of Dhuleil-Samra, in Jordan, is considered an arid area and groundwater, which is scarce and has low water quality, is the only source for domestic use. As a hydrogeologist working for Water Authority you have been asked to explore the possibilities of finding two wells with good water quality. One well in each region: Dhuleil and Samra. The selected two wells would be used for water supply in the two regions. The two wells should have the following criteria:

1. The well in the Samra region should be 2.5 km away from the Wastewater Treatment Plant (WWTP) and serve only the towns in the Samra region
2. The well in Dhuleil region should be 2.5 km away from the stream and serve only the towns in the Dhuleil region
3. Both selected wells should have total dissolved solids (TDS) and nitrate ( $\text{NO}_3$ ) less than 1000 mg/L and 20 mg/L respectively

After identifying the two suitable wells, a pipeline will be extended from each selected well to each town in the designated region. In your final report you decided to provide a table and map showing the distance from each selected well to the towns in both regions.

**Scenario 2:** Your boss asked you to work with another scenario, by choosing the “**Hay Arnous**” town and build, in it, a big Water Supply Tower (WST). The water from the two selected wells will be pumped into the WST and then distribute it to the whole regions by gravity. To consider this approach you need to know the number of towns that will be served and their population. To carry the work you should do the following:

1. The **Hay Arnous** town should be buffered into three rings with a radius of 4, 11, and 18 km
2. Find how many towns are located in each ring and their total population

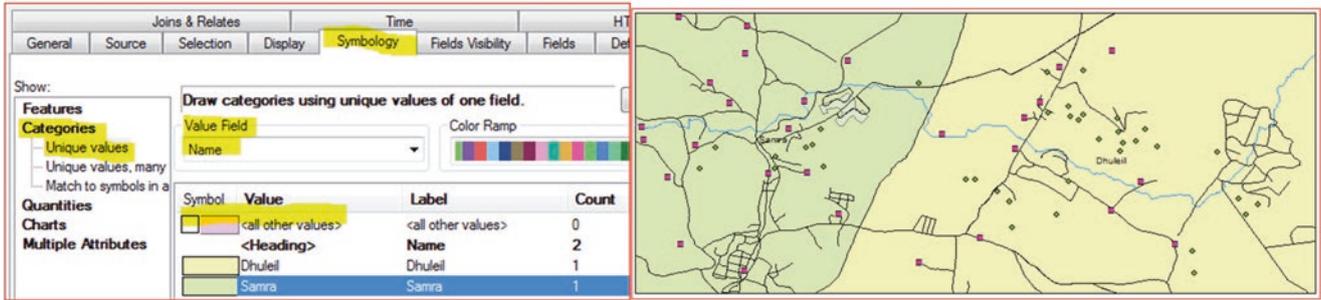
Ring radius (km)	No. of towns	No. of populations
4		
11		
18		

**Scenario 3:** You are working in Dhuleil as a hydrogeologist and you have been given an assignment by your supervisor to verify the argument that the dam in the north-east of the Dhuleil region is playing a role as an artificial recharge. Therefore, the water stored behind the dam in the rainy season will infiltrate into the subsurface aquifer and improve its water quality. The water quality will be checked through two parameters, TDS and  $\text{NO}_3$ , in the wells that are located within 10 km radius from the dam. Low concentration of TDS and  $\text{NO}_3$  in the wells close to the dam means the argument is true, otherwise it is false.

---

## GIS Approach to Solve Scenario 1

1. Start ArcMap and integrate the Region, Road, Stream, Town, Well, and WWTP from \\Ch16\Data01\Q1
2. Click the town symbol select Square 2, Size 7, and the Color = ginger pink/OK
3. Click the symbol of the stream and select the river symbol in the Symbol Selector
4. D-click Region layer/click Symbology tab/Categories, Unique values, Value Field = Name, Uncheck all other values, Click Add All Values, click OK

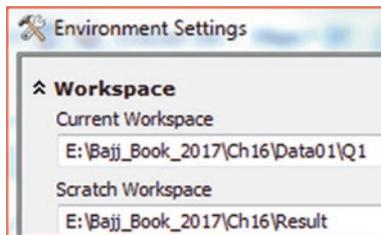


5. In the TOC, r-click Region layer/Label Features

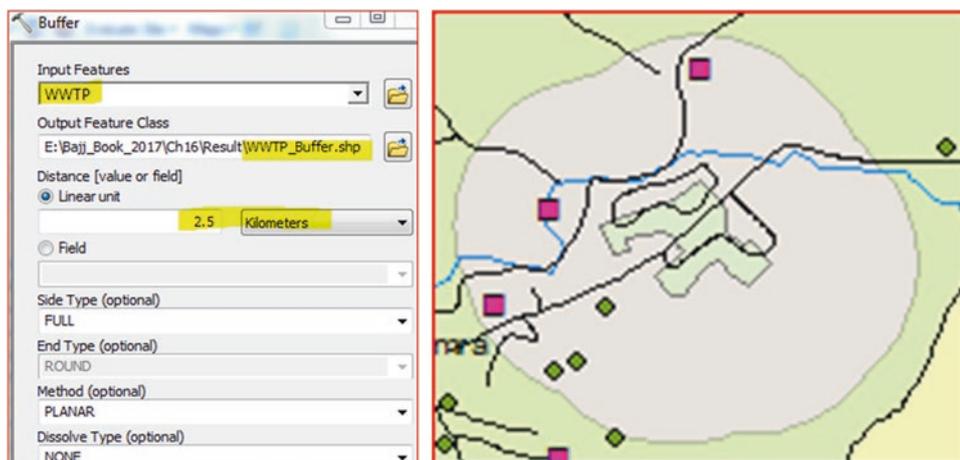
**Question:** How do you make the font of the label Time New Roman, size 14, and place it on the top of the two regions?

**Buffer the WWTP in the Samra Region**

- 6. Click ArcToolbox, r-click empty place/click Environment, then Workspace
- 7. Current Workspace: \\Data01\Q1
- 8. Scratch Workspace: \\Result
- 9. OK



- 10. ArcToolbox/Analysis Tools/Proximity/d-click Buffer
- 11. Input Features: WWTP
- 12. Output Feature Class: \\Result\WWTP\_Buffer
- 13. Linear units: 2.5 km
- 14. Accept the other default
- 15. OK



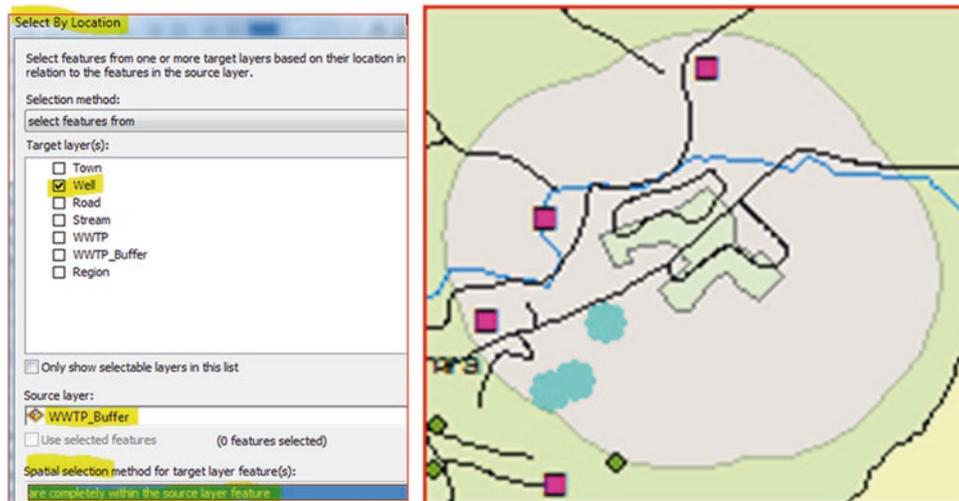
16. R-click WWTP\_Buffer/Properties/Display tab/Transparent 50%

Next step is to find the wells located outside the **WWTP\_Buffer** zone in Samra that have a TDS and NO<sub>3</sub> less than 1000 and 20 mg/L respectively.

### Select By Location

17. Selection menu/Select By Location

- a. Selection Method: Select features from
- b. Target layer(s): Well
- c. Source layer: WWTP\_Buffer
- d. Spatial selection method for target layer: are completely within the source layer feature



**Result:** Three wells have been selected inside the buffer zone of the WWTP.

### SQL Statement

Now we have to find one well that is located outside the buffer zone in the Samra region and has a TDS and NO<sub>3</sub> less than 1000 and 20 mg/L respectively.

18. Open the attribute table of the **Well.shp**

19. Click switch selection button 



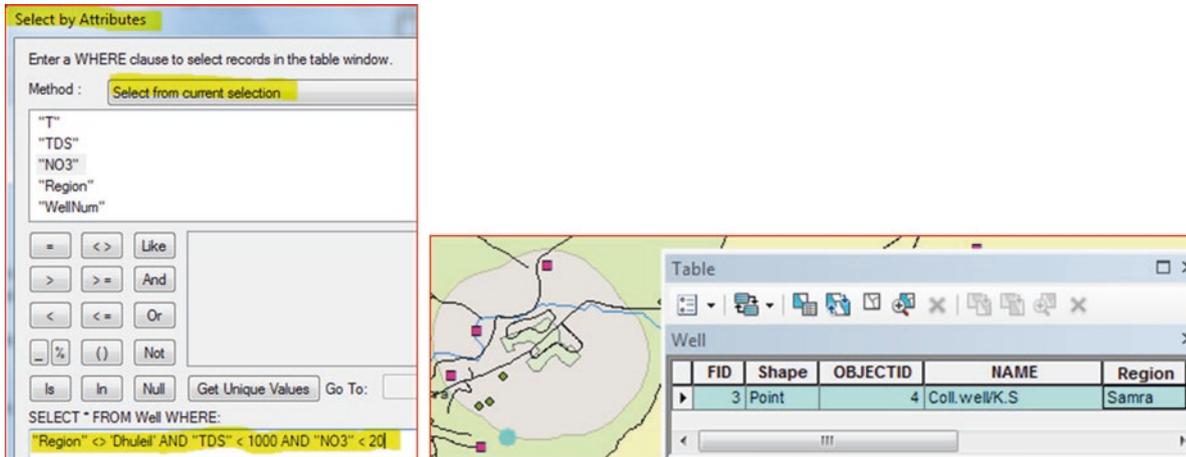
20. Click Table Option drop-down arrow/Select by Attribute/fill the Dialog Box as follow

21. Method: Select from current selection

22. Write the SQL Statement:

**"Region" <> 'Dhuleil' AND "TDS" < 1000 AND "NO3" < 20**

23. Apply/Close

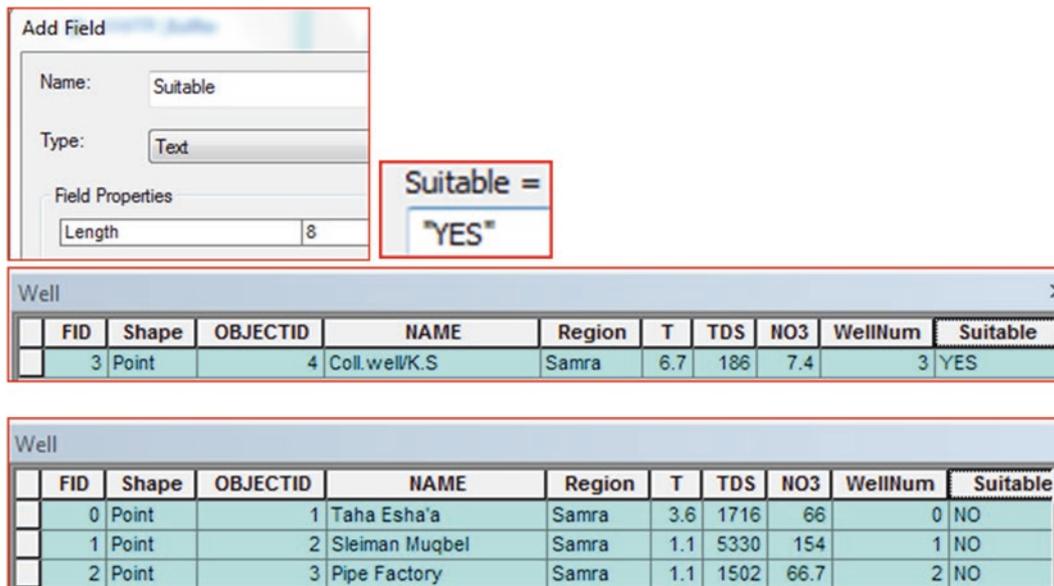


**Result:** One well has been selected in the Samra region.

In order to proceed you have to add a new field in the attribute table of the **Well**

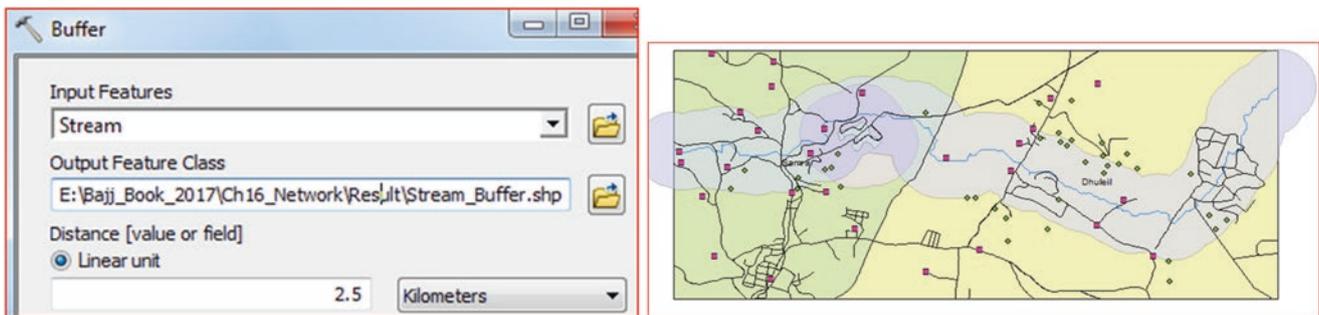
24. Make sure the attribute table of the **Well.shp** is open
25. Table Option/Add Field/Name it **“Suitable”**/Type = Text/Length = 12
26. R-click **“Suitable”** field/Field Calculator/click Yes/
27. In the Field Calculator type **“Yes”** under Suitable, then click OK
28. In the Well attribute table click Switch Selection  button
29. R-click **“Suitable”** field/Field Calculator/click YES/
30. In the Field Calculator type **“No”** under Suitable, then click OK

**Result:** The attribute table of the well that has a TDS and NO<sub>3</sub> less than 1000 and 20 mg/L populated with **“YES”** and the rest with **“NO”** in the **“Suitable”** field.



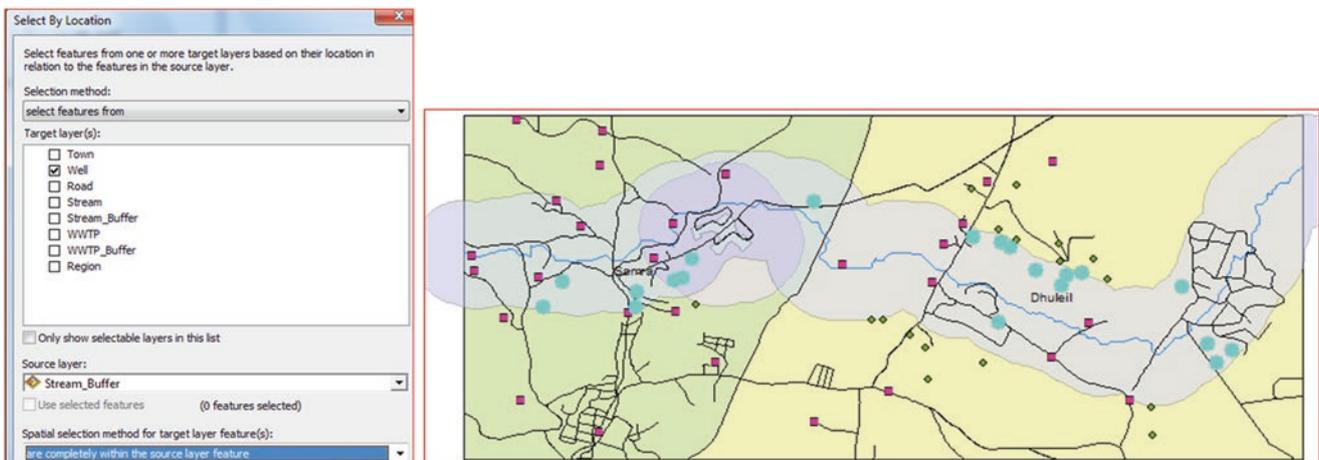
## Buffer the Stream in the Region

31. ArcToolbox/Analysis Tools/Proximity/d-click Buffer
32. Input Features: Stream
33. Output Feature Class: \\Result\Stream\_Buffer
34. Linear units: 2.5 km
35. Accept the other default
36. OK
37. Make the Stream\_Buffer 50% transparent



38. Selection menu/Select By Location
  - a. Selection Method: Select features from
  - b. Target layer(s): Well
  - c. Source layer: Stream\_Buffer
  - d. Spatial selection method for target layer: "are completely within the source layer feature"
39. OK

**Result:** 20 wells from both regions have been selected inside the stream buffer.



Now, we will find the wells located outside the Stream Buffer zone in Dhuleil area that have TDS and  $\text{NO}_3$  less than 1000 and 20 mg/L respectively

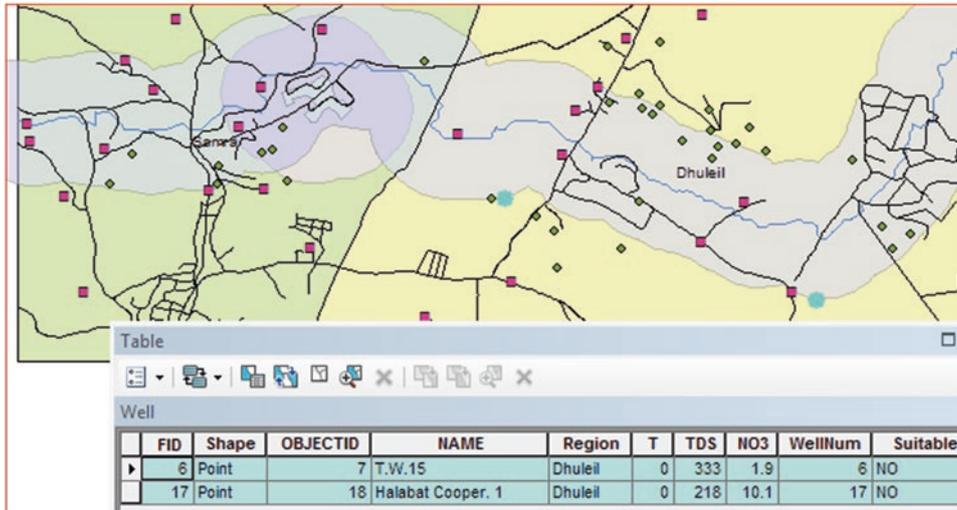
40. Open the attribute table of the **Well** layer
41. Click the Switch Selection  button
42. Table Option/Select By Attribute/
43. Method: Select From Current Selection

44. Write the following SQL statement

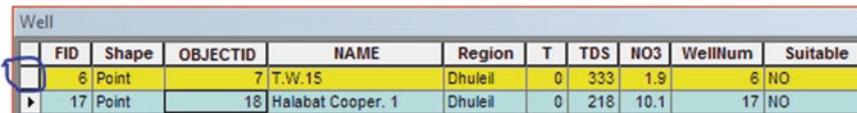
**"Region" <> 'Samra' AND "TDS" < 1000 AND "NO3" < 20**

45. Apply/Close

**Result:** Two wells have been selected outside the buffer, therefore, you are going to choose the well that has lower TDS.

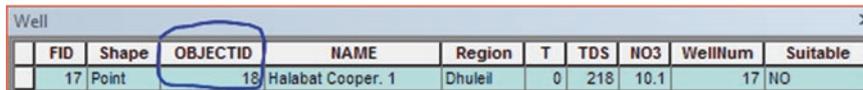


46. In the attribute table of the Well layer click the first cell of the record that has a TDS = 333, the color of the record will turn to yellow color



47. In the attribute table click the Unselect Highlighted  button

**Result:** The well that has TDS 333 will be deselected, and well that has OBJECTID =18 remains selected.



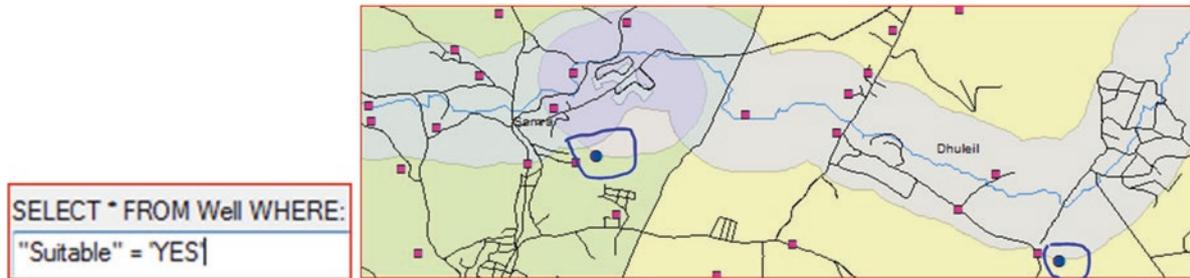
48. R-click Suitable field/Field Calculator/type "YES" under Suitable, then click OK



## Definition Query

To proceed with the analysis we have to hide all the wells and keep only the two selected wells in the Samra and Dhuleil regions.

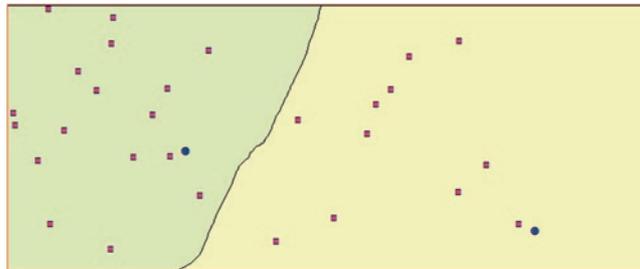
49. R-click Well/Properties/Definition Query tab/click Query Builder/
50. Type the following SQL statement "Suitable" = 'YES'
51. OK/OK
52. Click the symbol of the Well layer, use Circle 2, Size 10, and color = Ultra Blue



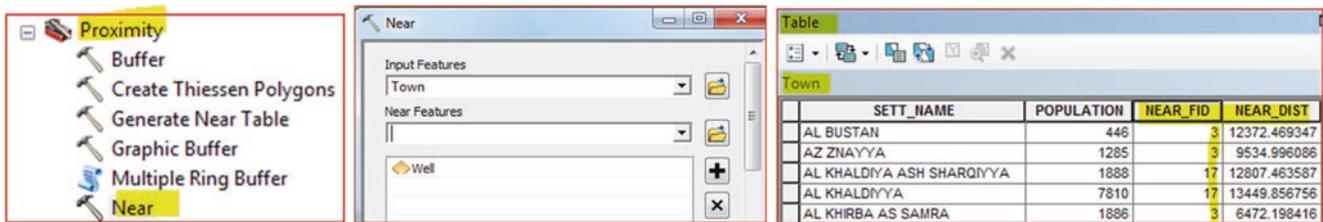
## Near Tool

The Near function determines the distance from each town to the two selected nearest wells in the study area. The Near tool will not generate any output layer, but will add two new fields to the attribute table of the Town layer. The two fields that are added will be called NEAR\_FID and NEAR\_DIST. The NEAR\_FID contain the feature ID (WellNum) of the Well layer. The NEAR\_DIST stores the distance from each well to the nearest town. The value of this field is in meters because the coordinate system of both data is in Palestine\_1923\_Palestine\_Belt (custom UTM).

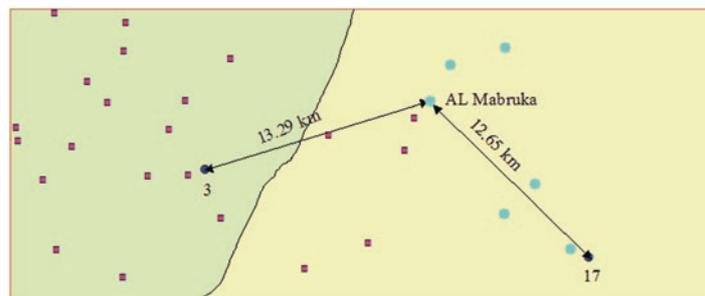
1. Insert New Data Frame and call it Near Proximity
2. Drag the Region, Town, and Well layers from the Dhuleil-Samra data frame into Near Proximity data frame



3. ArcToolbox/Analysis Tools/Proximity/d-click Near
  - a. Input Features: Town
  - b. Near Features: Well
  - c. Accept the rest as a default
4. OK
5. Open the attribute table of the Town (2-fields are added NEAR\_FID and NEAR\_DIST)



**Result Explanation:** In the attribute table of the town two fields were created the **Near\_FID** and **Near\_Dist**. The **Near\_FID** has two variables (3 and 17). Well No 3 is the **WellNum** in the well layer located in Samra area. Well No. 17 is the well that is located in Dhuleil area. The **NEAR\_DIST** field shows the distance between each well and the towns in each region of both Samra and Dhuleil. For example, the distance between well No 17 and Al Mabruka town is 12.65 km, while the distance between well No. 3 and Mabruka town is 13.29 km. Therefore, the Near distance will associate Mabruka town with well No. 17 because the distance is shorter.

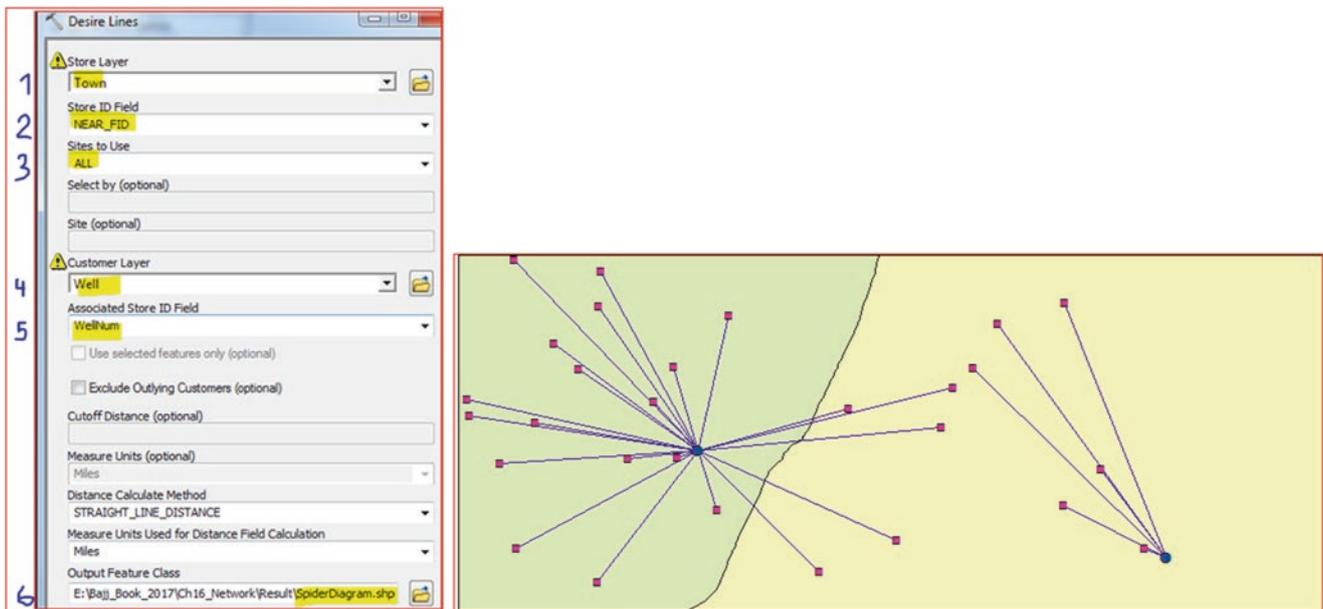


### Desire Lines (Spider Diagram) Tool

**Desire Lines** will draw lines from each well to the closest towns in the two regions. Spider diagram can be performed using the “**Desire Lines**” tool, which is part of the Business Analyst. The tool can be used in environmental related problems to see, for example, the influence of a landfill on the groundwater observation wells. Therefore, a line is drawn from the landfill point to its nearest wells, making it easy to see the actual area of influence of the landfill.

**Note:** To run this function make sure you have the Business Analyst Standard installed and the extension is checked.

6. Insert New Data Frame and call it Spider Diagram
7. Drag the Region, Town, and Well layers from the **Near Proximity** data frame into Spider Diagram data frame
8. ArcToolbox/Business Analyst Tools/Analysis/d-click Desire Lines tool
  - a. Store Layer: Town
  - b. Store ID Field: Near\_FID
  - c. Store to Use: ALL
  - d. Customer Layer: Well
  - e. Customer Layer: WellNum
  - f. Accept the default
  - g. Output Table: \\SpiderDiagram.shp
9. OK

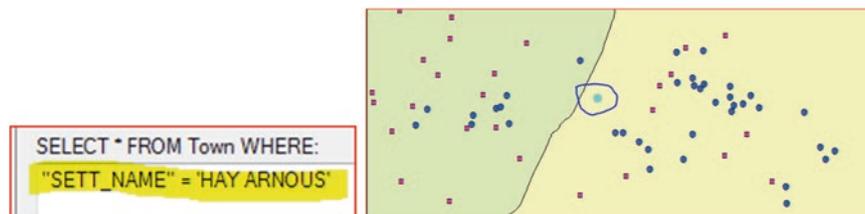


**Result:** A line will be drawn from each well to the closest town.

## GIS Approach to Solve Scenario 2

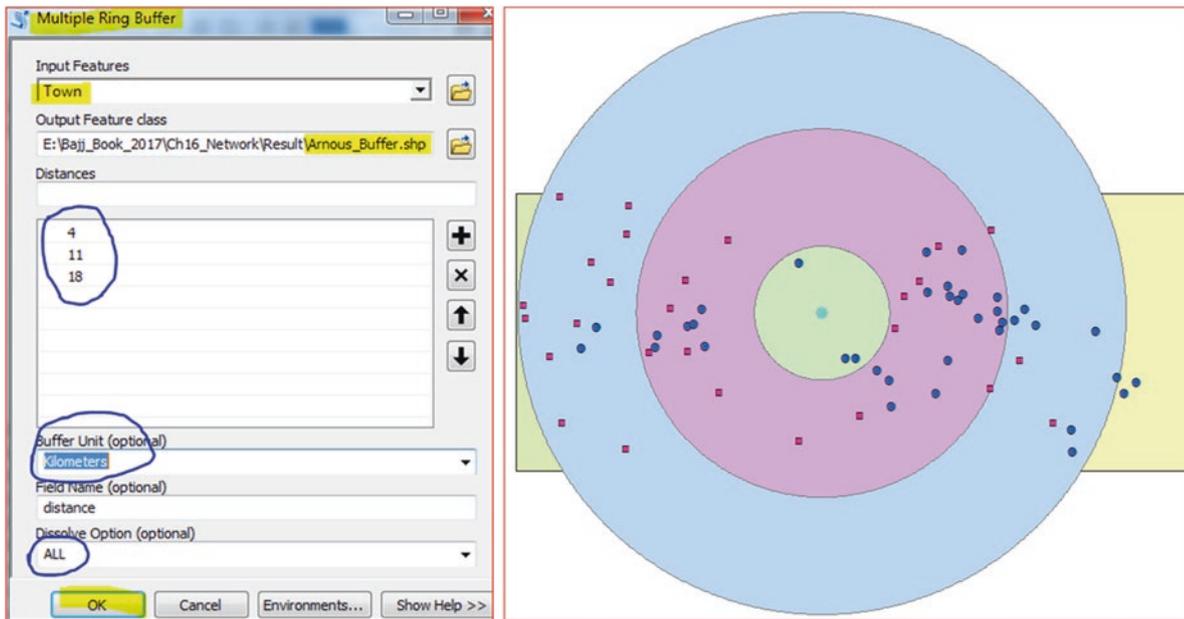
### Use the Multi-Ring Buffer Around the Hay Arnous Town

1. Insert Data Frame and call it Water Reservoir
2. Drag from "Spider Diagram" data frame the region, Town and Well layers into Water Reservoir data frame
3. Open the attribute table of the Town/click Table Options/Select By Attribute
4. Write the SQL statement: "SETT\_NAME" = 'HAY ARNOUS'
5. Apply/Close



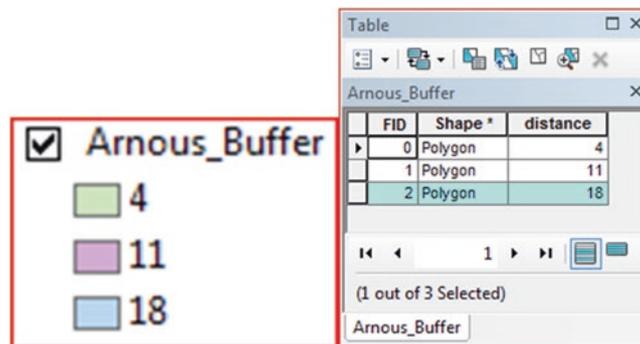
**Result:** The 'HAY ARNOUS' town is selected and is located in the middle of study area.

6. ArcToolbox/Analysis Tools/Proximity/d-click Multiple Ring Buffer
7. Input Features: Town
8. Output Feature Class: Arnous\_Buffer
9. Distance: type 4 click the + sign, Type 11 click the + sign, Type 18 click the + sign
10. Buffer Unit: kilometer
11. Dissolve Option: All
12. OK

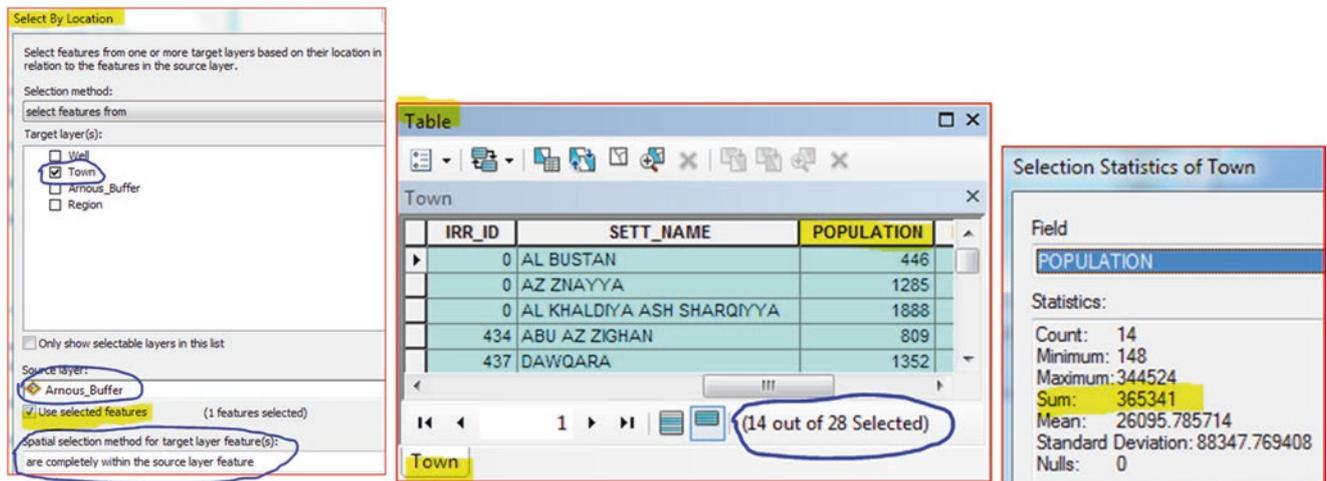


**Result:** A 3 ring buffer is created around the town of ‘HAY ARNOUS’.

13. Open the attribute table of the Arnous\_Buffer/select the third record (18 km distance)



14. Selection/Select By Location/
  - a. Selection method: select feature from
  - b. Target layer(s): Town
  - c. Source Layer: Arnous\_Buffer
  - d. Check “Use selected features”
  - e. Spatial selection within the source layer feature(s): “are completely within the source layer feature”
15. OK



16. Open the attribute table of the Town

**Result:** You will see that there are 14 towns selected.

17. R-click the field Population/Statistics

**Result:** Total Population is 365,341.

18. Repeat the previous steps and write down number of towns and the total population of each Buffer zone in the table below.

Ring radius (km)	No. of towns	No. of populations
4		
11		
18	14	365,341

### GIS Approach to Solve Scenario 3

#### Proximity Analysis in Raster Format

In this section **Euclidean Distance** applications, which are raster based, will be applied. In addition, the vector based application of the **Point Distance** will also be applied to evaluate the effect of the dam on the quality of groundwater.

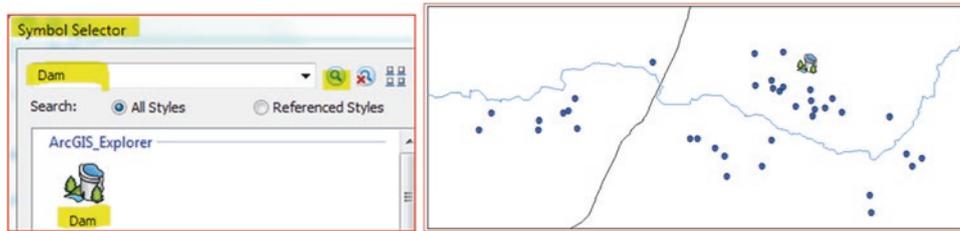
**Euclidean Distance:** The raster-based Euclidean distance tool measures distances from the center of source cells to the center of destination cells. The Spatial Analyst extension can perform analysis where the output layer is in raster format. One of the analysis that can be applied in Earth sciences is the distance surface. This method create a continuous layer from a vector input layer. The vector layer can be point, line, or a polygon such as groundwater well, stream, or a treatment plant.

#### Point Distance Method

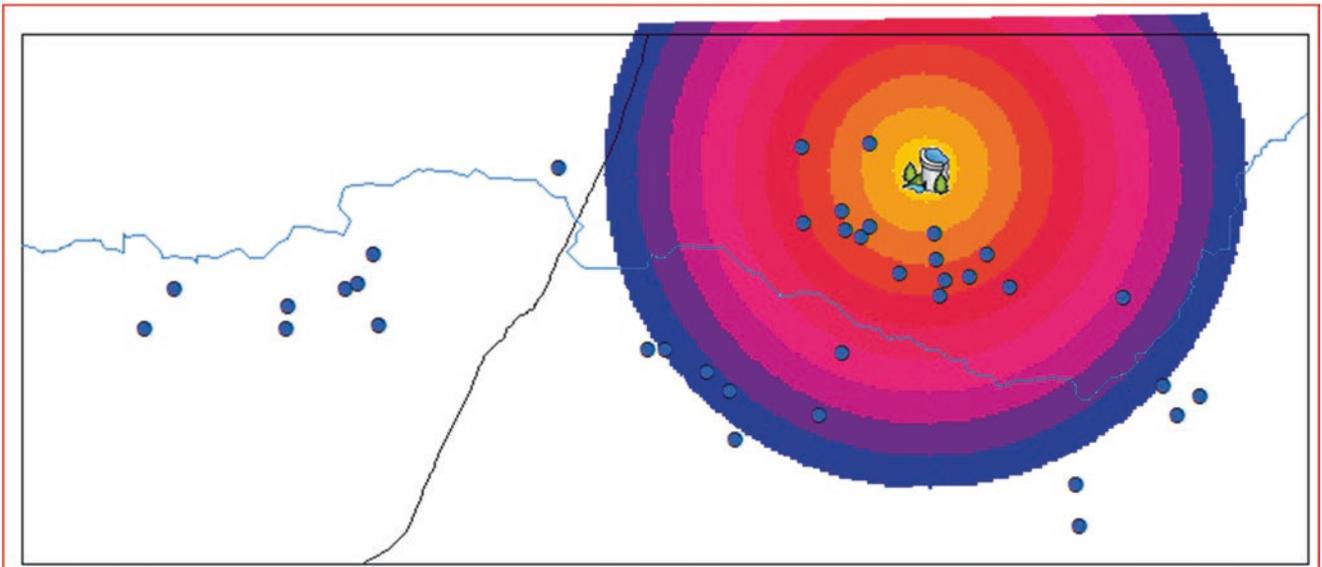
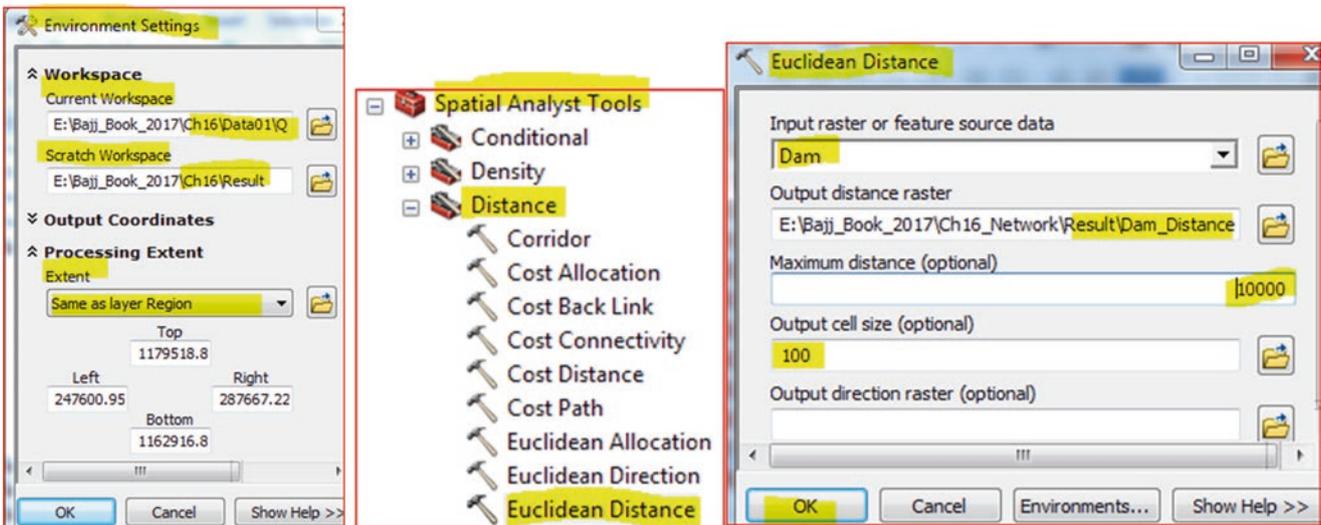
The point distance determines the distances from input point features to all points in the near features within a specified search radius. The tool is similar to the Near tool, but creates a table with distances between the two sets of point layers. If the default search radius is used, distances from all input points to all near points are calculated.

### GIS Approach to Solve Scenario 3

1. Insert Data Frame and call it “**Recharge**”
2. Integrate the **Dam**, **Region**, **Stream**, and **Well** from \\Data01\Q2 folder
3. Click the Dam symbol, type “Dam” in the search window in the Symbol Selector dialog box, and click Search button
4. Click the Dam symbol, then click OK
5. Click the well symbol, select Circle 2, color = blue, and size = 9, then click OK
6. Click the stream symbol, select River symbol, then click OK
7. R-click the Region symbol, change the color to Hollow



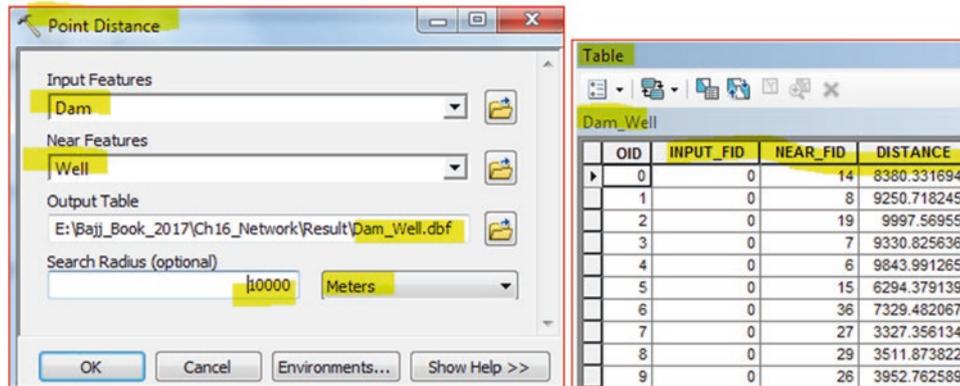
8. At the bottom of ArcToolbox/r-click an empty place
9. Click Environments/Click Workspace
10. Current Workspace: \\Ch16\Data01\Q2
11. Scratch Workspace: \\Ch16\Result
12. Click Processing Extent
13. Extent: Same as layer Region
14. Click OK
15. ArcToolbox/Spatial Analysis Tools/Distance/d-click Euclidian Distance
16. Input raster or feature source data: Dam
17. Output distance raster: \\Result\Dam\_Distance.tif
18. Maximum distance: 10000
19. Output cell size: 100
20. OK



**Result:** The output **Dam\_Distance** raster is classified into 10 classes 1000, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, and 10,000.

### Point Distance Tool

10. ArcToolbox/Analysis Tools/Proximity/d-click Point Distance tool
  - a. Input Features: Dam
  - b. Near Features: Well
  - c. Output Table: \\Dam\_Well.dbf (save as .dbf)
  - d. Search Radius: 10000 m
11. OK



**Result:** The output is a dbf table.

- In the TOC open **Dam\_Well.dbf table**, you will see “DISTANCE” field that show the distance between the dam and the wells located within 10000 m from it
- INPUT\_FID: The Dam feature ID, which has 0 value
- NEAR\_FID: The feature ID of all Wells located within 10000 m from the dam

Next step is to join the **Dam\_Well.dbf** with the **Well** layer based on a common field. The **WellNum** field in the **Well** layer is identical to the **NEAR\_FID** field in the **Dam\_Well**.

12. R-click Well/Join and Relates/click Join
13. What do you want to join to this layer? **Join attributes from a table**
14. Choose the field in this layer that the join will be based on: **WellNum**
15. Choose the table to join to this layer: **Dam\_Well**
16. Choose the field in the table to base the join on: **NEAR\_FID**
17. Join Options: **Keep all records**
18. Click Validate Join
19. Click Yes to create an index for the join field
20. Click Close
21. Ok

**Result:** The **Dam\_Well.dbf** is joined to the **Well** layer.

22. Open the attribute table of the Well layer

The Distance field in the Well layer is populated with zero <NULL> and number larger than zero. The zeros are the wells that are located more than 10,000 m from the dam. The wells that are located within 10,000 m from the dam, their distance from the dam are listed in the Distance field.

**Join Data**

Join lets you append additional data to this layer's attribute table so you can, for example, symbolize the layer's features using this data.

What do you want to join to this layer?

Join attributes from a table

1. Choose the field in this layer that the join will be based on:  
WellNum

2. Choose the table to join to this layer, or load the table from disk:  
Dam\_Well

Show the attribute tables of layers in this list

3. Choose the field in the table to base the join on:  
NEAR\_FID

Join Options

Keep all records  
All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.

Keep only matching records  
If a record in the target table doesn't have a match in the join table, that record is removed from the resulting target table.

Validate Join

**Table**

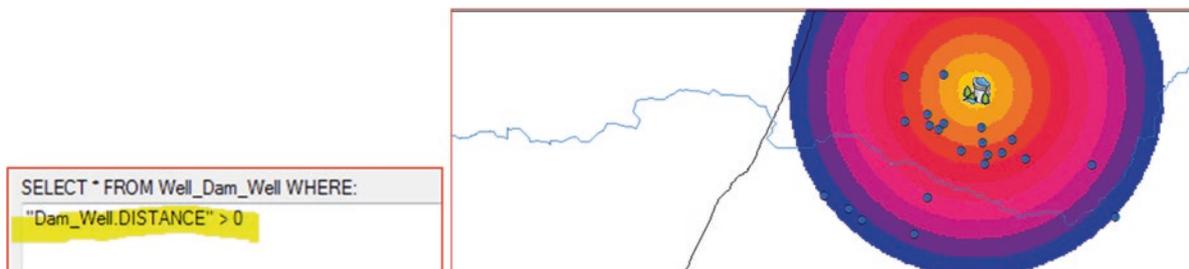
**Well**

	INPUT_FID	NEAR_FID *	DISTANCE
▶	<Null>	<Null>	<Null>
	0	6	9843.991265
	0	7	9330.825636
	0	8	9250.718245
	<Null>	<Null>	<Null>
	<Null>	<Null>	<Null>

## Definition Query

23. R-click Well layer/Properties/Definition Query/click Query Builder
24. Type SQL statement "Dam\_Well.DISTANCE" > 0
25. OK/OK

**Result:** All the wells located farther than 10,000 m will disappear.

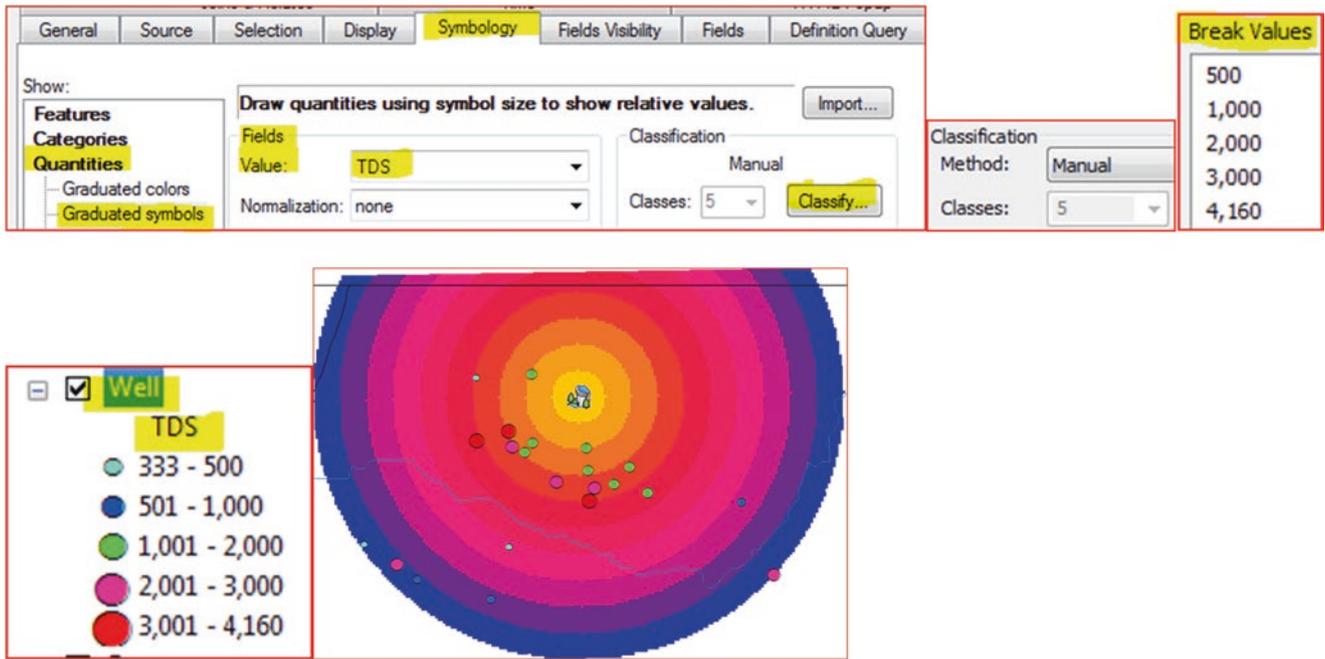


## Well Classification

To verify the effect of the dam, the TDS (salinity) and nitrate concentration of the wells will be classified.

### Salinity (TDS) Classification

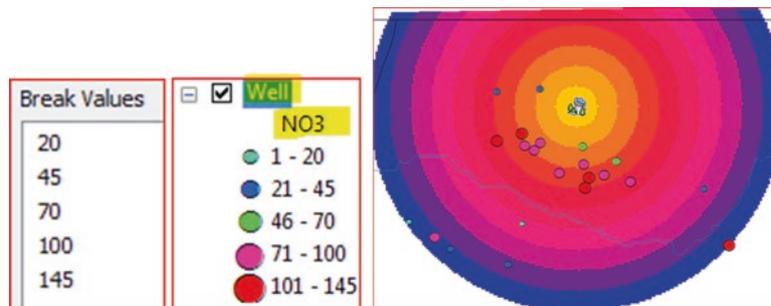
26. D-click Well Layer/click the Symbology tab/click Quantities/click Graduated symbols
27. Field Value: TDS, click Classify/Method Manual/Under Break Value
28. Type, 500, 1000, 2000, 3000, and keep the last value 4160/click an empty place
29. Click OK/click Label Header/check Show thousands separator/OK
30. Change the highest TDS symbol to red, pink, green, blue, then cyan/OK



**Result:** The closest wells to the dam are the ones that have salinity between 1000 and 2000 mg/L. Wells that are located further away from the dam have higher salinity.

**Nitrate (NO<sub>3</sub>) Classification**

31. D-click Well Layer/click the Symbology tab/click Quantities/click Graduate symbols
32. Field Value: NO<sub>3</sub>/click Classify/Method Manual/Under Break Value
33. Type, 20, 45, 70, 100, and keep the last value 145/click an empty place
34. Click OK/click Label header/click Format Label/Number of decimal places = 0
35. Click OK
36. Change the NO<sub>3</sub> symbol (highest to lowest) to red, pink, green, blue, then cyan/OK
37. OK
38. File Save as \\Result\Recharge.mxd
39. Exit your ArcMap



**Result:** The lowest concentration of nitrate are the wells that are located in close proximity to the dam.

**Conclusion:** The wells are located in an agricultural area, where the groundwater is mainly used for irrigation. The high salinity and nitrate concentration are attributed mainly to return flow and application of chemical fertilizers. Despite the high concentration of salinity and nitrate, the closest wells to the dam have less concentration. This indicates that the stored water behind the dam leaks downgradient and improves the quality of water.

## Network Analyst

This section will perform different GIS functions in environmental related problems using the Network Analyst. The Network Analyst is a powerful tool in a way that it is different than the proximity analysis performed in the previous section. The applications will overcome the concept of the straight distance related to some application such as buffering and Euclidian distance calculation. The network analyst will overcome any natural barrier such as hills, lakes, or where there is absolutely no network of a street system. The network analyst will use the actual distance that is associated with the street feature, which is an important feature in the application. This approach is more accurate than using the near function or spider diagram model.

To use the Network Analyst you need to have a line feature that has connectivity such as a street, pipe, railroad, etc. If, for example, you have a street, you need to calculate the time from the length of the street and the speed of each segment of the street ( $\text{Distance} = \text{speed} * \text{time}$ ). The time will be used as the cost in the Network Analyst.

You will perform two scenarios in the Dhuleil-Samra region related to the water supply problem. The data includes a street feature class that has a Shape\_Length and Speed field in its attribute table. A new field “MINUTES” will be added to the Street feature class, which will allow network routing.

**Scenario 1:** Samra - Dhuleil region has a shortage of water supply in summer time. The Water Authority decided to use two good quality water wells to supply the towns in the region with potable water using water trucks. Your duty is to find how long time it requires the truck to supply the towns in the study region with water.

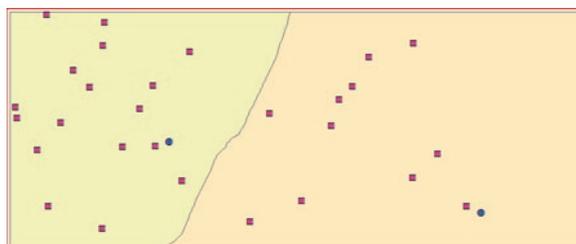
**Scenario 2:** After finding the time required to cover the towns in the region, you want to find the actual path and time that the water truck will take from each individual well to each town.

Your duty to solve scenario 1 by doing the following:

1. Create Network Dataset (SupplyTravelTime)
2. Build NetworkDataset in Network Analyst
3. Run the “Add Location Function”
4. Calculate the True Path and Total Time between Wells and Towns

## GIS Approach

1. Launch ArcMap and rename the Layer Data Frame and call it **Service Area**
2. Integrate Region, Town, and Well\_Supply feature classes from \\Data02\Q4\Region.mdb
3. Classify the Region based on the Name field
4. Symbolize the Town layer (Square 2, size 7, and ginger pink color)
5. Symbolize the Well\_Supply layer (Circle 2, size 10, and blue color)



6. Open Catalog window/r-click Result/New/Personal Geodatabase
7. Rename the geodatabase “**Water Supply.mdb**”
8. R-click Water Supply.mdb/New/Feature Dataset/call it **SamraDhuleil**
9. Click Next



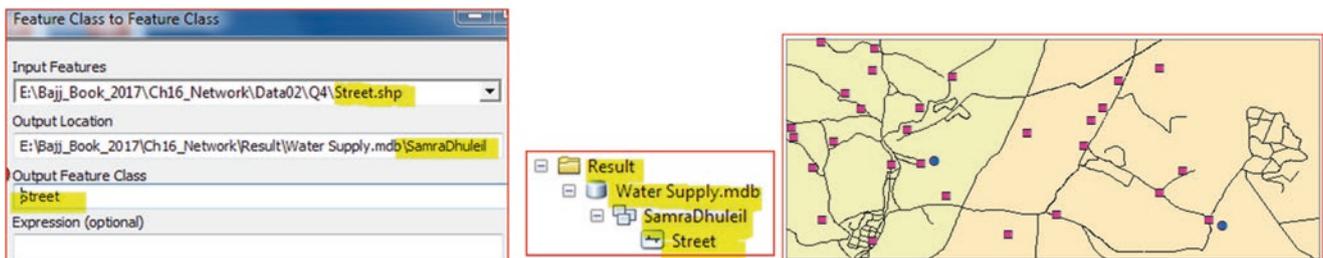
10. Click the Add Coordinate System button drop-down arrow



11. Click Import/browse to \\Q4\Region.mdb\click Well\_Supply/Add/Next/Next/Finish

**Note:** The coordinate of the Well\_Supply feature class is Palestine\_1923\_Palestine\_Belt and this coordinate system is now assigned to the **SamraDhuleil** Feature Dataset.

12. R-click SamraDhuleil Feature dataset/Import/Feature Class (single)
13. Input Features: \\Data02\Q4\Street.shp
14. Output Location: \\Result\Water Supply.mdb\SamraDhuleil
15. Output Feature Class: Street
16. OK



**Result:** The **Street** feature class will be added to the TOC.

17. Open the attribute table of the Street feature class, see that the table has two fields “Shape\_Length” and “Speed”

**Note:** The Speed is in kilometer per hour, and the Shape\_Length is in meter.

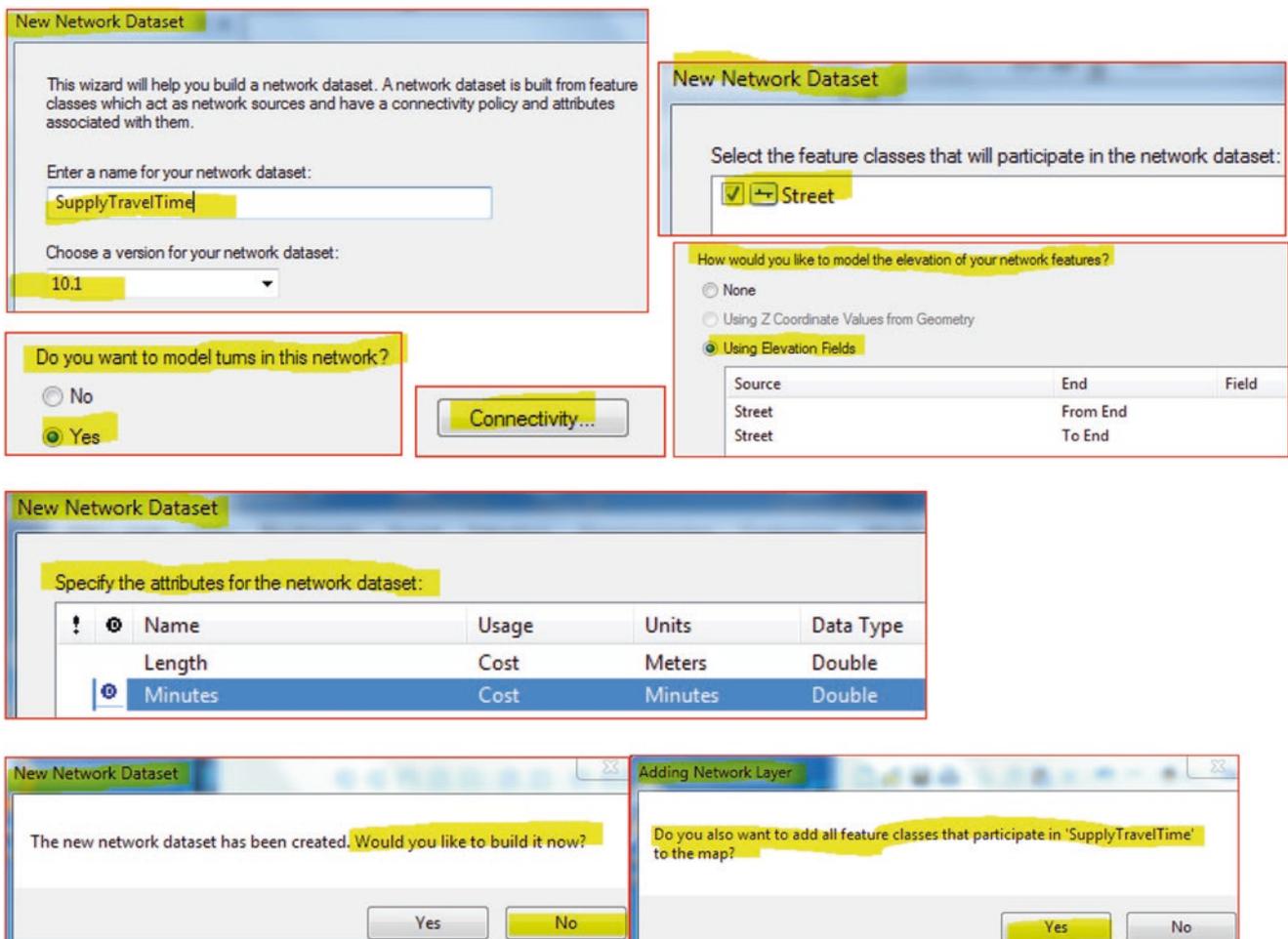
Next step is to add a new field “**MINUTES**” to the **Street** feature class in order to calculate the time from the “Shape\_Length” (length of the street) and “Speed” fields. The “**MINUTES**” field allows user to perform network routing.

18. R-click street feature classes in the Catalog window/Properties/click Field tab
19. Under **Field Name** write “MINUTES” Data Type “Double”
20. Click OK



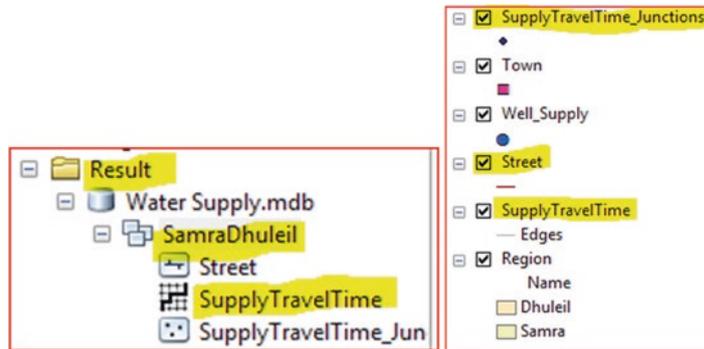
### Create Network Dataset

24. In Catalog window/r-click **SamraDhuleil** Feature Dataset in **WaterSupply.mdb**/click New/Network Dataset
25. Name: **SupplyTravelTime** (choose 10.1 version) and click Next
26. Check the Street and click Next
27. Do you want to model turns in this network? Check “Yes” and click Next
28. Accept the default “Connectivity” and click Next
29. How would you like to model the elevation of your network features? Check “Using Elevation Field” and click Next
30. Specify the attributes for the network dataset, accept the default and click Next
31. Accept the default/click Next
32. Do you want to establish driving setting for this network dataset? check Yes, and click Next
33. Click Finish
34. A dialog box will display “The new network dataset has been created. Would you like to build it now?” Click No
35. Click Yes to add all feature classes that participate in “SupplyTravelTime” to the map



**Result:** The new network dataset SupplyTravelTime is created and SupplyTravelTime\_Junction, Street, and SupplyTravelTime feature classes are added to the TOC.

**Note:** If you open the attribute table of the “SupplyTravelTime\_Junctions”, you will find that it is empty.



## Build the Network

To work with the Network Analyst, the extension of Network Analyst should be checked.

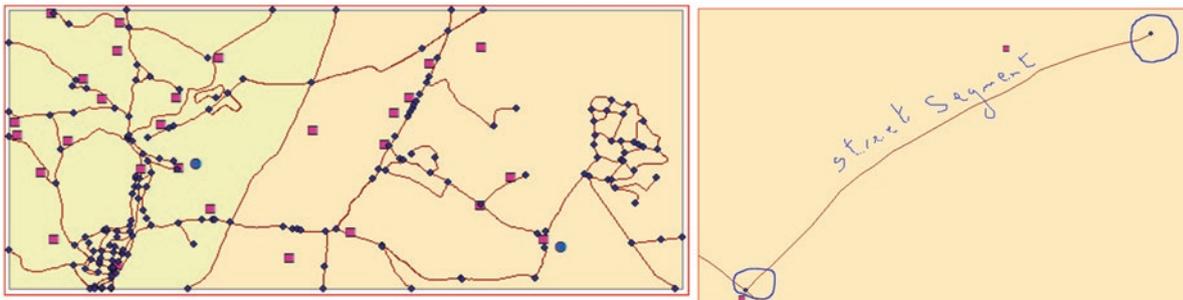
36. Click Customize menu/Toolbar/check Network Analyst



**Note:** The Network Analyst displays the SupplyTravelTime network as the default because it is in the TOC.

37. Click the Build Network Dataset button on the Network Analyst 

**Result:** The SupplyTravelTime\_Junction will be populated with nodes, two nodes for each street segment, one node at the beginning of the segment, and the second node at the end of segment. This will allow you to run several types of network analysis, such as New Service Area and New Closest Facility.



## New Service Area

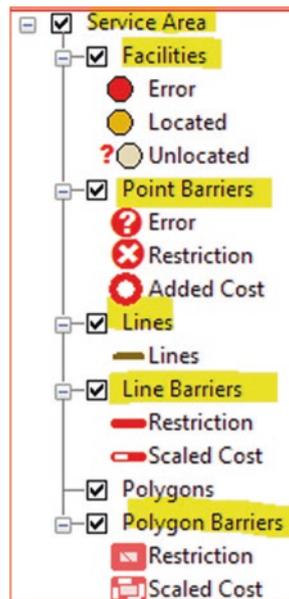
The Network Service Area is a region that covers all accessible streets in the study region. The tool show, for example, within 10 min the water truck will travel from the water supply well along the street network and will include all the streets that can be reached within 10 min time.

Service areas created by Network Analyst also help evaluate accessibility. Concentric service areas show how accessibility varies with impedance. Once service areas are created, you can use them to identify how much land, how many people, or how much of anything else is within the neighborhood or region.

38. From Network Analyst Drop Arrow/Choose New Service Area

**Result:** Service Area is added to the TOC and has the following feature classes:

1. Facilities
2. Point Barrier
3. Line
4. Line Barrier
5. Polygon
6. Polygon Barrier

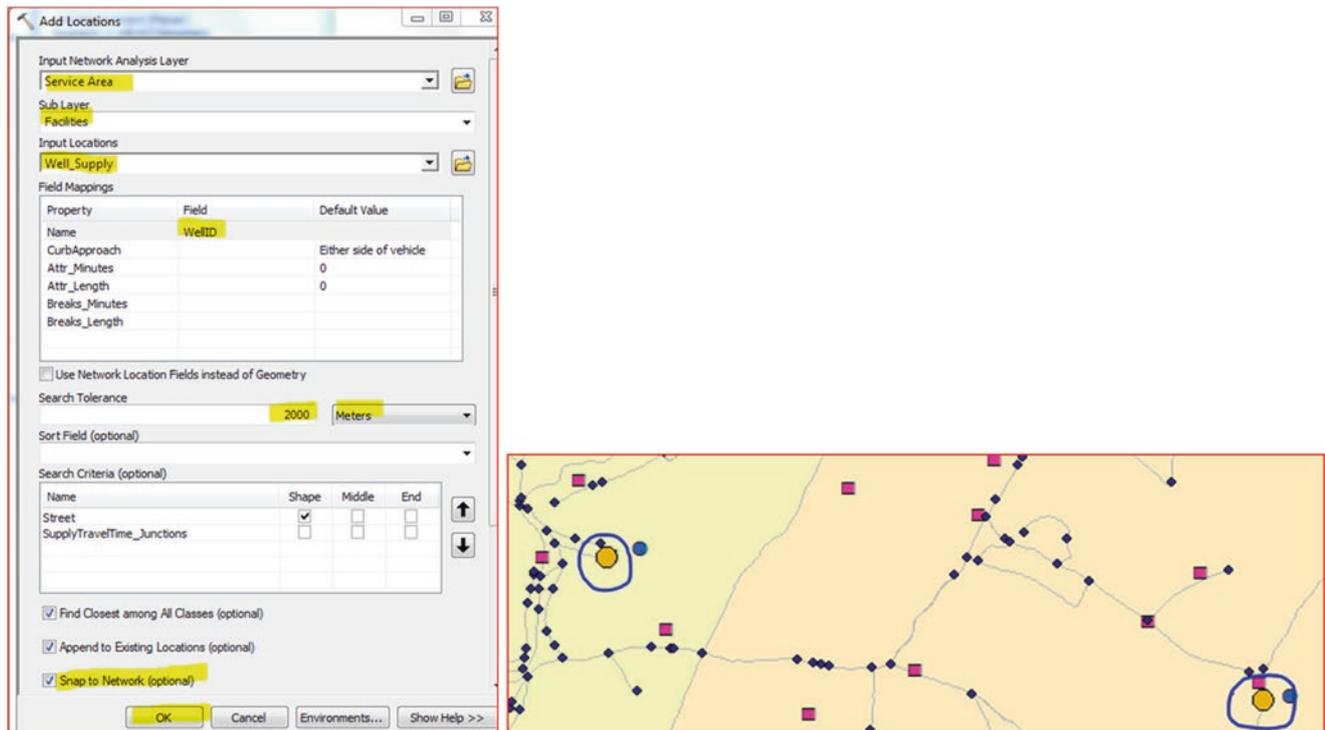


**Note:** The attribute table of all these feature classes are empty.

## Add Locations Tool

This **Add Locations** tool is used to add the **Well\_Supply** to the **Network Dataset** so the Well\_Supply feature class can be used in the Network Service Area analysis

39. ArcToolbox/Network Analyst Tools/Analysis and d-click Add Locations
  - a. Input network Analysis Layer: Service Area
  - b. Sub Layer: Facilities
  - c. Input Locations: Well\_Supply
  - d. Name: WellID
  - e. Search Tolerance 2000 m
40. Check Snap to Network
41. OK



**Result:** The “Located” that is under the Facilities of the Service Area TOC is now created with two features that represent the two wells (Well\_Supply). The located are now snapped to the SupplyTravelTime, which indicate that they have now become part of the Network Dataset and can participate in Network Analysis.

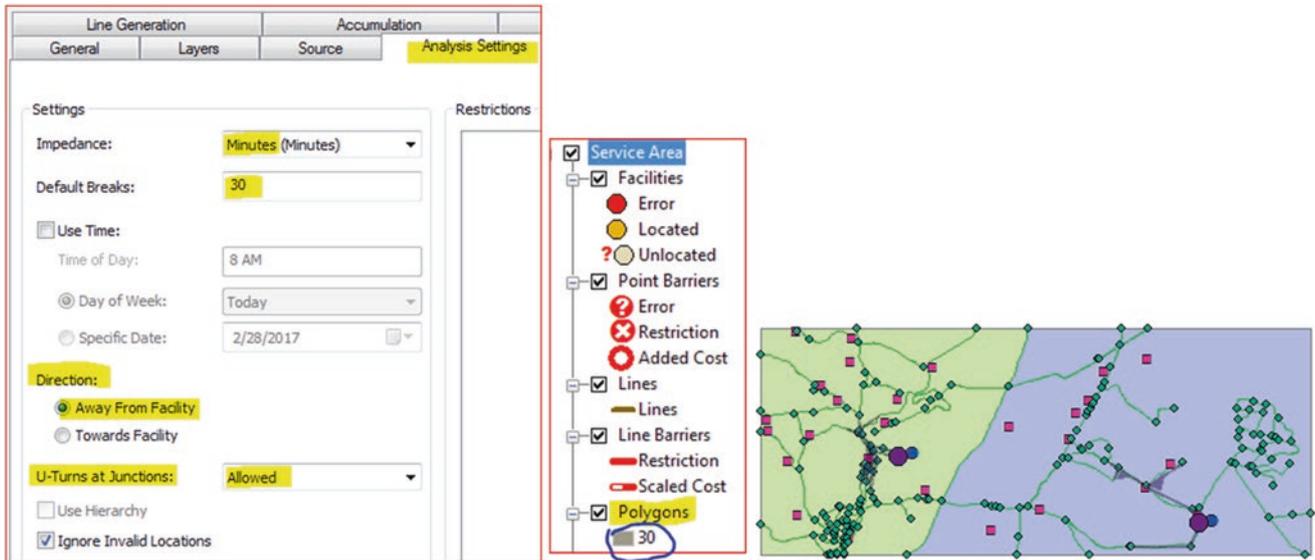
## Calculate the Service Area with Certain Travel Time

### Ten Minutes Travel Time

The Water Authority now wants to see the areas that will be served with water supply within 10 and then within 30 min by the water truck and to see which would be more sufficient.

42. R-click Service Area/Properties/Analysis Setting tab
  - a. Impedance: Minutes (Minutes)
  - b. Default Breaks: 10
  - c. Direction: check “Away from Facility”
  - d. U-Turns at Junctions: Allowed
43. OK

44. On the Network Analyst toolbar click the Solve button  (4<sup>th</sup> icon from left)



**Result:** The Polygons under the Service Area have been populated showing the service area that has been covered. The polygon represents the distance along the street network that can be covered in 10-min drive. It is clear that 10 min is not a sufficient time to cover a wider area with water supply by the water truck.

### 20-Minutes Travel Time

45. R-click Service Area/Properties/Analysis Setting tab

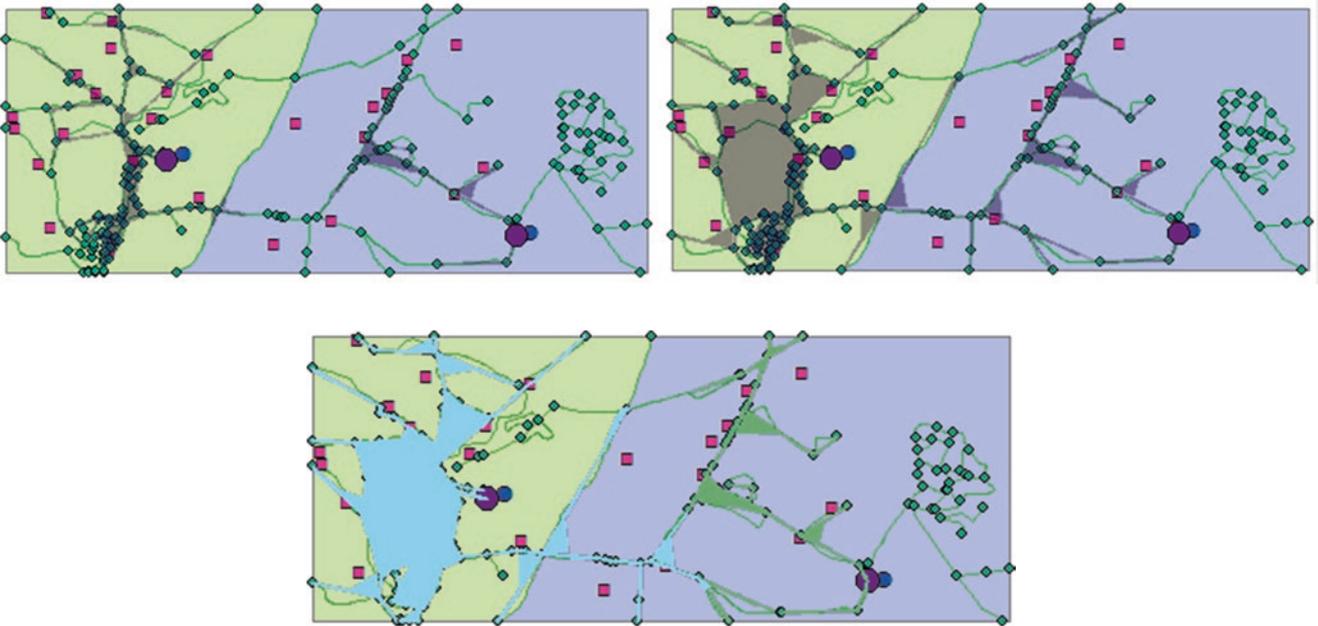
- a. Impedance: Minutes (Minutes)
- b. Default Breaks: 20
- c. Direction: check “Away from Facility”
- d. U-Turns at Junctions: Allowed

46. OK

47. On the Network Analyst toolbar click the Solve button  (4<sup>th</sup> icon from left)

**Result:** 20-minutes is not a sufficient time to cover the whole region with water supply.

**Question:** Can you run 30-min travel time to see if the water truck can cover the whole region with water supply? Do you think 30-min is sufficient?



48. R-click the Polygon under Service Area/Data/Export Data
49. Save it in \\Result\ServiceArea\_30.shp
50. “Yes” to add it into the TOC
51. D-Click **ServiceArea\_30m**/Symbology/Categories/Unique values/Value Field = Facility ID/Add All Value/change the colors of 1 to blue and 2 to green/OK
52. Save your map in the Result folder \\Result\ServiceArea.mxd

**Conclusion:** It is clear that a 30-min travel time is sufficient in order to distribute the water from the two wells to all of the communities in the both regions.

### Calculate the True Path and Total Time between the Wells and Each Town

**Scenario 2:** After finding the time required to cover the towns in the region, you want to find the actual path and time that the water truck will take from each individual well to each town. The actual path can be carried out using the “Closest Facility” tool on the Network Analyst.

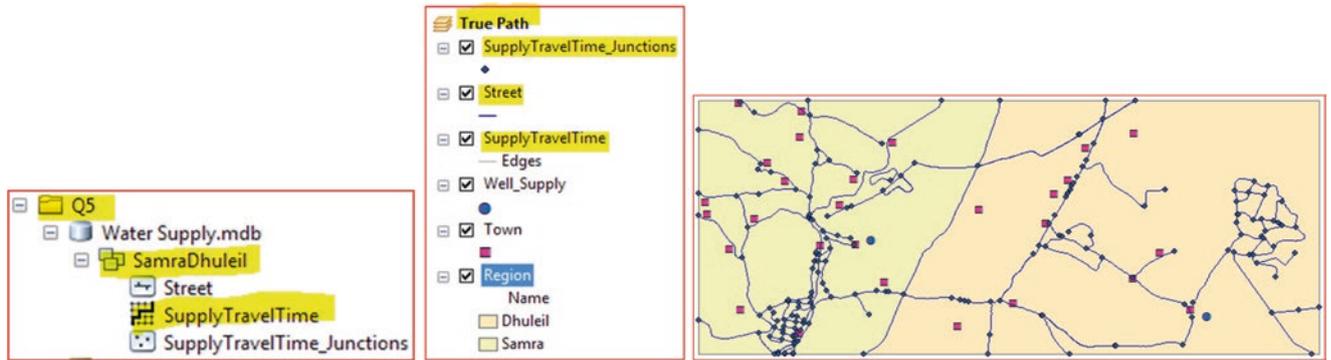
The “Closest Facility” tool is similar to the “Near” tool that have been used earlier as both measure the distance between two locations. But they are different as the “Near” tool measures the straight line distance, while the “Closest Facility” tool measures the distance along a network.

To solve Scenario 2 you have to do the following:

- a) Use the SupplyTravelTime network dataset
- b) Calculate the True Path and Total Time between Wells and Towns

## GIS Approach

53. Insert Data Frame call it True Path
54. Drag Region, Town, and Well\_Supply from Service Area data frame
55. Open Catalog window, drag the **SupplyTravelTime** into the top of TOC from \\Data02\Q5\Water Supply.mdb\SamraDhuleil
56. Click “YES” to add all feature classes that participate in “SupplyTravelTime”

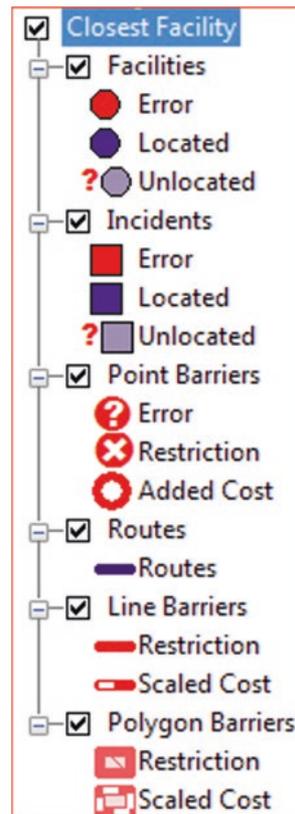


**Result:** SupplyTravelTime\_Junction, Street, and SupplyTravelTime feature classes are now added to the TOC of the True Path data frame.

57. On the Network Analyst toolbar/click the Network Analyst drop-down arrow/click New Closest Facility

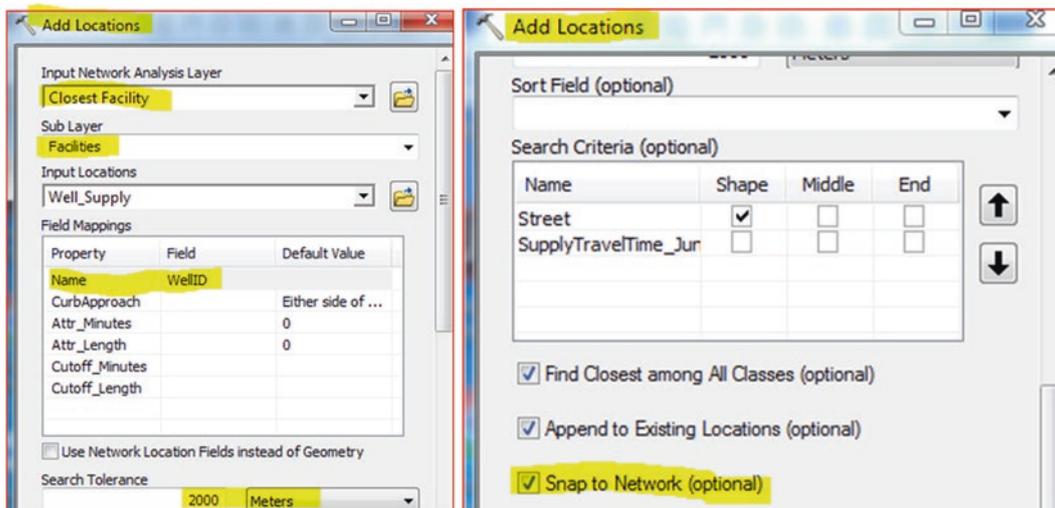
**Result:** A set of layers are added to the TOC of the Closest Facility layer needed for the analysis and they are:

- a) Facilities
- b) Incidents
- c) Point Barrier
- d) Routes
- e) Line Barriers
- f) Polygon Barriers



### Run Add Locations Tool Between Facilities and Well\_Supply

58. ArcToolbox/Network Analyst Tools/Analysis and d-click Add Locations
  - f. Input network Analysis Layer: Closest Facility
  - g. Sub Layer: Facilities
  - h. Input Locations: Well\_Supply
  - i. Name: WellID
  - j. Search Tolerance 2000 m
59. Check Snap to Network
60. OK



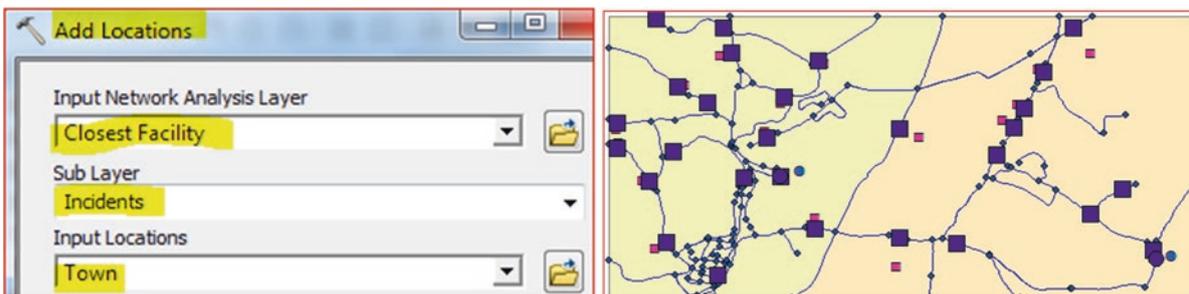
**Result:** The Located that are under the Facilities of the Closest Facility in the TOC is now created with two features that represent the two wells (Well\_Supply). The located are now snapped to the SupplyTravelTime, which indicate that they are now part of the Network Dataset and the can participate in network analysis.



## Run Add Location Tool Again

Run “Add Location” tool to relate the town layers to the network

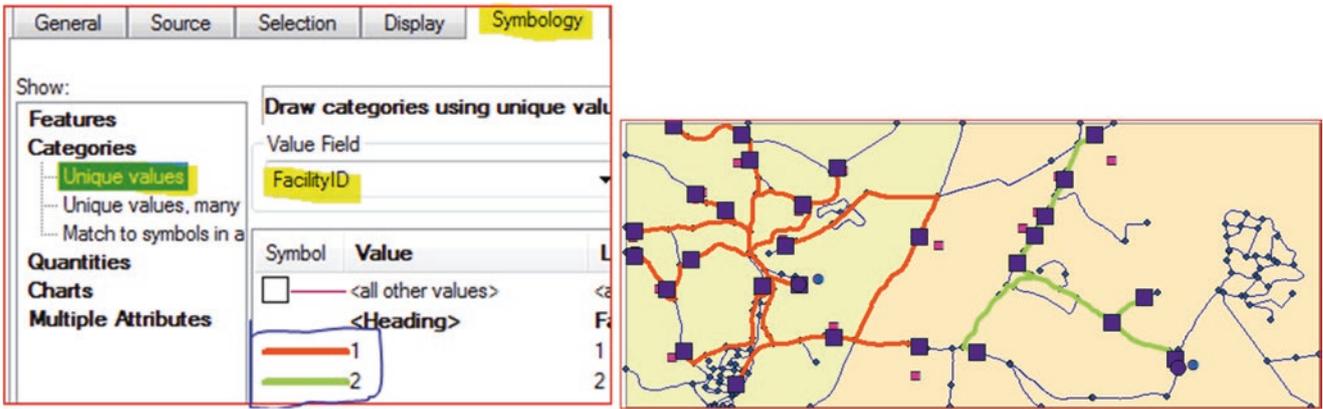
61. ArcToolbox/Network Analyst Tools/Analysis and d-click Add Locations
  - k. Input network Analysis Layer: Closest Facility
    - l. Sub Layer: Incidents
  - m. Input Locations: Town
  - n. Search Tolerance 2000 m
62. Check Snap to Network
63. OK



64. On the Network Analyst toolbar click **Solve** button (4<sup>th</sup> icon from left)

**Result:** The Routes path is built and it connects the two wells to each city.

65. D-click Routes feature class under Closest Facility
66. Click Symbology tab/Categories/Unique Value/Value Field = FacilityID
67. Add All Values
68. Change the color of 1 to Fire Red and line width 3, change 2 to green and width 3
69. OK



- 70. Open the attribute table of the Routes
- 71. You see a field called FacilityID and a field called Total Minutes

**Explanation:** This shows how much time it takes the truck to travel from each well to each town.

Routes			
	FacilityID	IncidentID	Total_Minutes
▶	1	1	228.497833
	1	2	172.206103
	2	3	248.928952
	2	4	208.976134
	4	5	175.065000

(0 out of 28 Selected)

### Show Route Direction

The direction button on the Network Analyst tool shows the direction from each well to the towns.

- 60. Click the direction button  (4<sup>th</sup> from left)

**Result:** A Directions (Closest Facility) Dialog Box display shows the route running from the two wells to the towns in the region.



- 61. Save your map as **Closest Facility.mxd** in the \\Result folder