

**uWATER:
Ubiquitous WebGIS Analysis Toolkit for Extensive Resources
Version 1.1**

User's Manual

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<http://www.isws.illinois.edu/gws/sware/agreement.asp?pkg=uws&sp=pg1>



I L L I N O I S

1. Introduction

uWATER is a tool developed for non-technically minded citizens and decision-makers to access scientific modeling results and spatial datasets through an interactive online Geographic Information System (WebGIS). This tool permits convenient access to computer model results that quantify the impacts of water resource development and climate change within a study area and facilitates use of these data for water management policy formulation. The objective of uWATER is to bridge the gap between scientific research results and general public understanding.

Because GIS software allows spatial and tabular display and processing of data, it provides unparalleled opportunities for assessment and improved management of natural resources. ArcGIS Desktop, developed by the Environmental Systems Research Institute (ESRI), is currently one of the most popular commercial GIS software packages in the field. ArcGIS Explorer (AGX), ESRI's free web-based GIS tool, can display a variety of GIS data. However, many of the analytical capabilities of ArcGIS Desktop, including spatial and attribute queries, are not available in AGX. uWATER is an AGX plug-in program that adds GIS calculation and query functions to the functions native to AGX, thus providing for a range of applications in environmental resources management.

2. System Requirements

uWATER was developed using AGX SDK with Microsoft Visual Basic 2008. It was designed to work in the environment of AGX (Build 1500 or later). Hardware and software requirements include:

- Microsoft Windows XP Service Pack 2 or later version (32 bit, 64 bit)
- Microsoft .NET Framework 3.5 or later version
Free download at: <http://www.microsoft.com/downloads/details.aspx?FamilyId=5b2c0358-915b-4eb5-9b1d-10e506da9d0f&displaylang=en>
- Microsoft XML Core Services (MSXML) 4.0 Service Pack 2 or later version
Free download at: <http://msdn.microsoft.com/en-us/data/bb190600.aspx>
- Internet Explorer 7.0 or later version
Free download at: <http://www.microsoft.com/windows/internet-explorer/default.aspx>
- ArcGIS Explorer (Build 1500 or later)
Free download at: <http://www.esri.com/software/arcgis/explorer/download.html>
- Hardware
CPU Speed: 2.2 GHz or higher recommended
Processor: Intel Core Duo, Pentium 4, Xeon Processors or later

Memory/RAM: 1 GB minimum, 2 GB or higher recommended

Display Properties: 24 bit color depth

Screen Resolution: 1024 x 768 or higher recommended at normal size (96dpi); the best resolution is **1680 x 1050**

Swap Space: Determined by the operating system, 500 MB minimum

Disk Space: 300 MB or more

Bandwidth Connection Speed: Minimum 380 Kbps, 1500 Kbps, or higher recommended

Video/Graphics: 24-bit capable graphics accelerator, video card OpenGL 2.0 or higher compliant, video memory 256 MB or higher

3. Installation of uWATER

Installation of uWATER is simplified because it does not require a conventional executable file (e.g., .exe or .dll) on the destination computer. Instead, uWATER uses an AGX *Application Configuration* file (.ncfg) that installs automatically on any computer on which AGX is properly installed. To begin installing uWATER, one must download the .ncfg file (Figure 1) from the program Web page:

<http://www.isws.illinois.edu/gws/sware/uwater/>

Double-clicking the *uWATER1.1.ncfg* icon opens AGX and adds a customized tab, *uWATER*, to the default AGX interface. The *uWATER* tab includes a single control button that, when clicked, launches uWATER (Figure 2), the interface of which is designed as a dockable window in AGX.

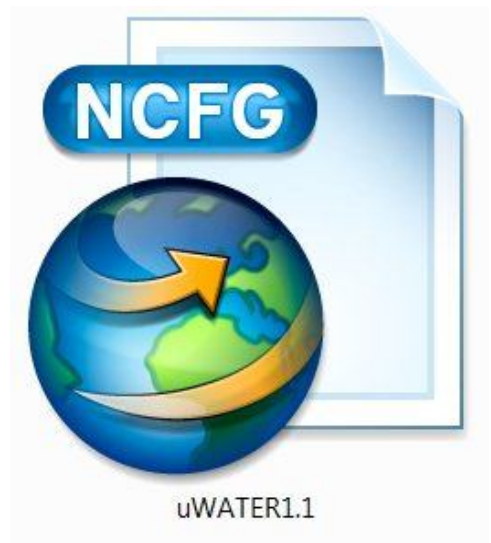


Figure 1. The uWATER ArcGIS Explorer Application Configuration file

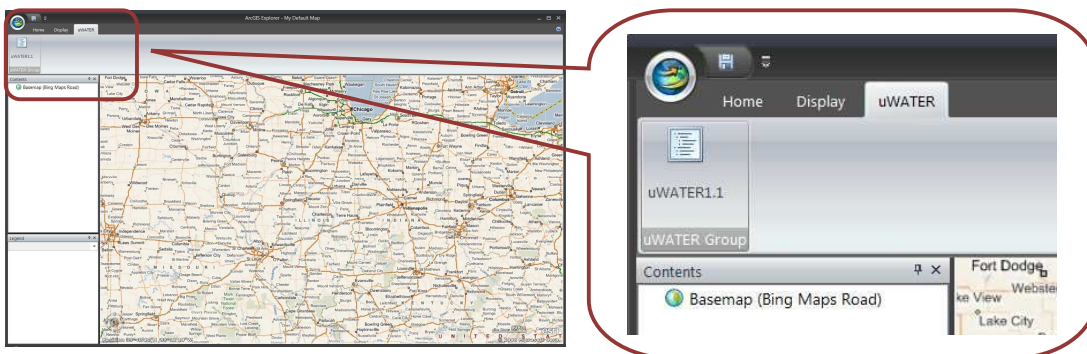


Figure 2. The uWATER tab in ArcGIS Explorer

4. uWATER Interface

The uWATER interface is organized into two tabs: (1) **Complex Query** and (2) **About uWATER**. The **Complex Query** tab allows combined spatial and attribute queries of a user-imported shapefile. After loading the shapefile into ArcGIS Explorer, the user can click the **Refresh** button in the uWATER interface (Figure 3) and use the cursor to highlight the layer to be queried.

The user selects the desired spatial relationship for the spatial query from six options (Table 1): *contains*, *crosses*, *intersects*, *overlaps*, *touches*, and *within*. The user then uses the dropdown list to select the query criteria layer. Two different query options are provided by uWATER. First, the user can use the entire query criteria layer to select a feature by checking the box: **use entire spatial domain**. Or the user can use another dropdown list to select the attribute in the query criteria layer and type in the minimum and maximum value of that attribute. The uWATER will use the selected attribute within the selected range for a spatial query. A summary of the query process will be provided at the bottom of the uWATER interface. A click of the **Identify Features** button executes the query. The feature layer that resulted from the attribute query will be created first if the user uses the second option. One folder of notes (the *spatial query notes*) is created. This folder contains one note for each feature identified through the spatial query. Since ArcGIS Explorer cannot generate or edit a shapefile, the

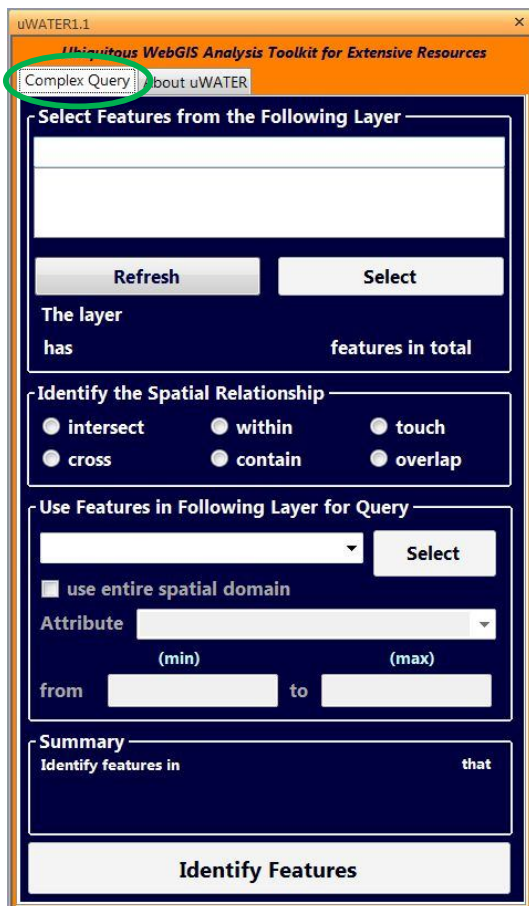


Figure 3. The **Complex Query** tab



Figure 4. The **About uWATER** tab

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spatial query results of uWATER are stored as notes and grouped in folders. By default, the names assigned to these notes begin with the string *SQNote*.

The **About uWATER** tab indicates the software version number and the developers' contact information (Figure 4). uWATER was developed under the Illinois Non-Exclusive Research License Agreement. Since the program is still under development, comments and questions are appreciated.

Table 1. Spatial query methods in uWATER (Modified from ESRI AGX-SDK HELP file)

Methods	Description
Contains	Searches for occurrences when the input geometry completely contains any of the geometries stored in the table. Valid for all shape type combinations.
Crosses	Searches for occurrences when the input geometry intersects any of the geometries stored in the table, but only when they share points in common, at least one of which is not an endpoint. A polyline and a polygon cross if they share a polyline in common on the interior of the polygon that is not equivalent to the entire polyline. Valid for Polyline/Polyline, Polyline/Polygon, and Polygon/Polyline shape type combinations.
Intersects	Searches for any type of spatial relationship between the input geometry and the geometries stored in the table. Valid for all shape type combinations.
Overlaps	Searches for occurrences when the input geometry intersects any of the geometries stored in the table, but also when the region of their intersection is of the same dimension as the geometries involved and is not equivalent to either of the geometries (i.e., the shapes cannot be completely on top of each other). Applies to Polygon/Polygon, Polyline/Polyline, and MultiPoint/MultiPoint shape type combinations.
Touches	Searches for occurrences when the input geometry shares a common boundary with any of the geometries stored in the Table, but also when the intersection of the interiors of the searched shapes is empty. In the Point/Polyline case, the point may only touch an endpoint of the line. Applies to all combinations except Point/Point.
Within	Searches for occurrences when the input geometry is completely within any of the geometries stored in the Table. Valid for all shape type combinations.

5. Examples

Three examples are provided in this section to demonstrate the functionality of uWATER and ArcGIS Explorer. The first example demonstrates computation of groundwater drawdown from a hypothetical water table (groundwater level) in Kane County, Illinois using the default “Query” function in ArcGIS Explorer. The second example identifies streams located in large drawdown areas (from the previous example) using the “Complex Query” function in uWATER. The third example demonstrates identification of fish sample sites located within a certain range of the census block in McHenry County, Illinois also using the “Complex Query” function in uWATER.

5.1 Calculate attributes from a shapefile using “Query” in ArcGIS Explorer

- a) Launch the uWATER main program. Under “Home” tab, use the **Add Content** button to browse and add the shapefile *Kane_GW.shp* in the *uWATERtest/Kane* folder downloaded with the program. The shapefile contains groundwater modeling results for Kane County, Illinois, including head values (groundwater levels) for each model cell (Figure 5).

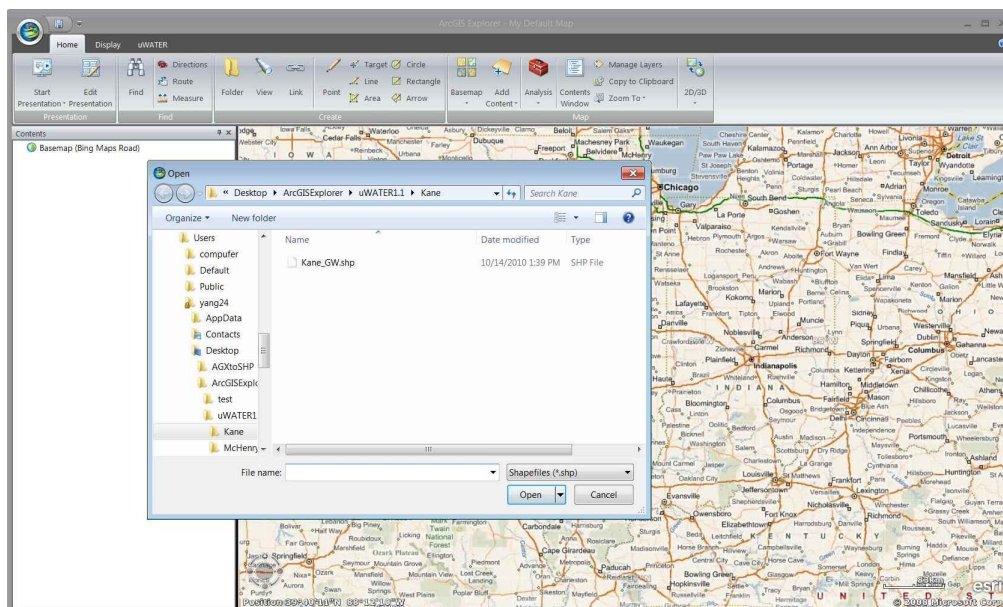


Figure 5. Add shapefiles for ArcGIS Explorer process

b) Use cursor to highlight the *kane_gw* layer in the Table of Contents (left of map), and under “Tools” tab, click **Query** button (Figure 6).

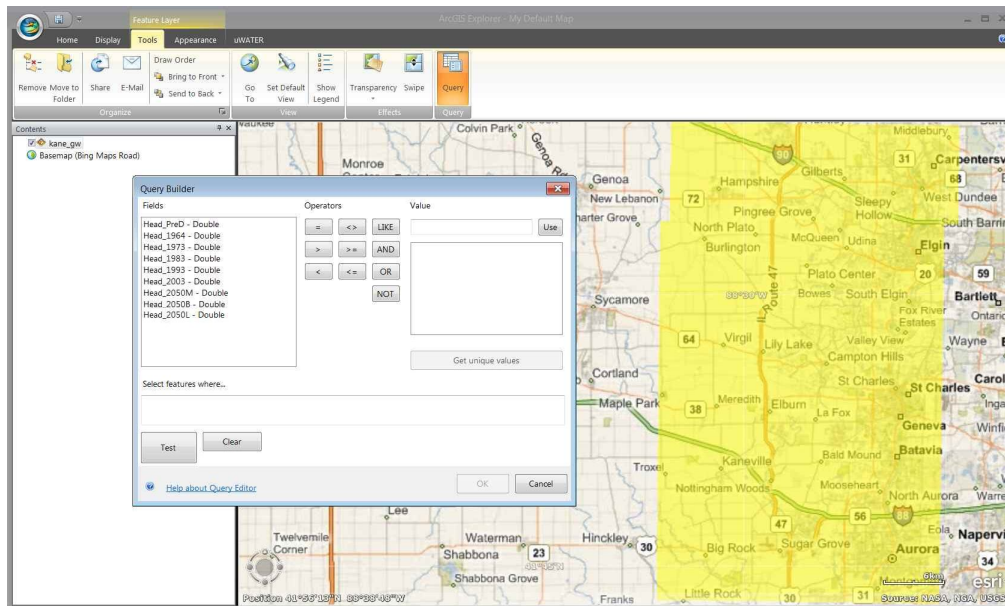


Figure 6. Open **Query** window in “Tools” tab

c) The drawdown is computed by calculating the difference between two water surfaces(heads). In the “Query Builder” window, first use cursor to select (by double-clicking) the head in pre-development condition (Head_PreD). Key in a “-” sign by keyboard and select the head in 2050 with less water resource intensive scenario (Head_2050L). Key in “> 5” by keyboard. This query criterion will show up at the bottom text box in the “Query Builder” window (Figure 7).

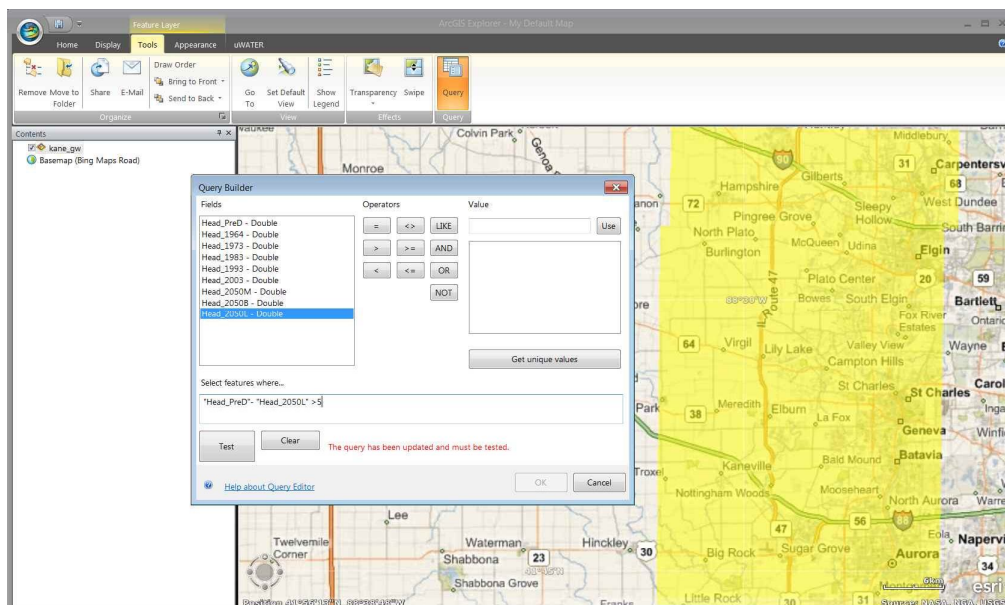


Figure 7. Type in attribute query criteria

d) Click on the **Test** button first and the “Query Builder” window will show how many features are identified by this query; click **OK** button and ArcGIS Explorer will conduct the query (Figure 8).

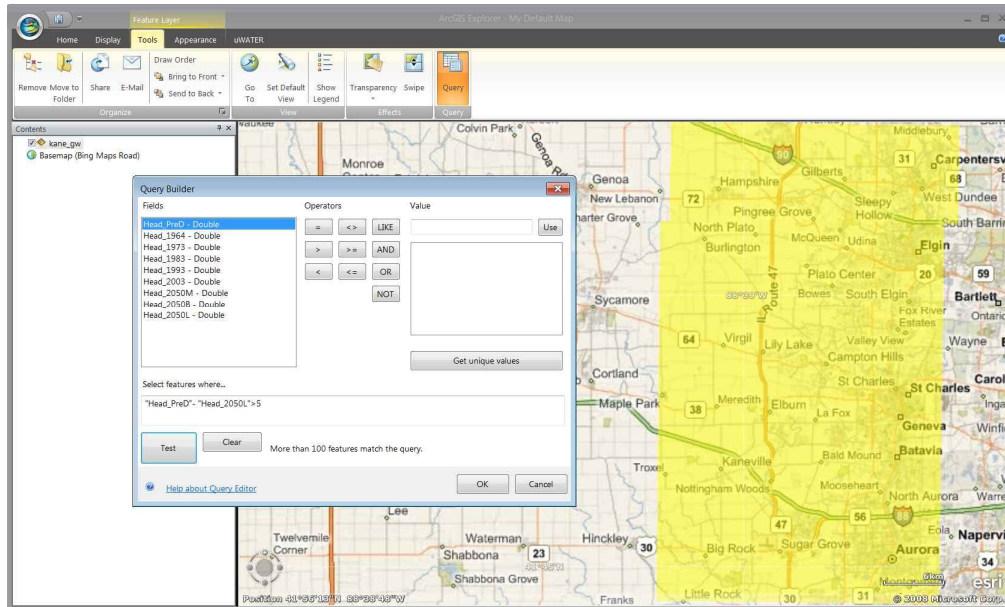


Figure 8. Confirm query criteria

e) This procedure results in a new feature layer with the name “kane_gw (“Head_PreD”-“Head_2050L” > 5)” shown in red by the default setting of ArcGIS Explorer. This feature layer is the projected drawdown larger than 5 ft in 2050 under the less water resource intensive scenario (Figure 9).

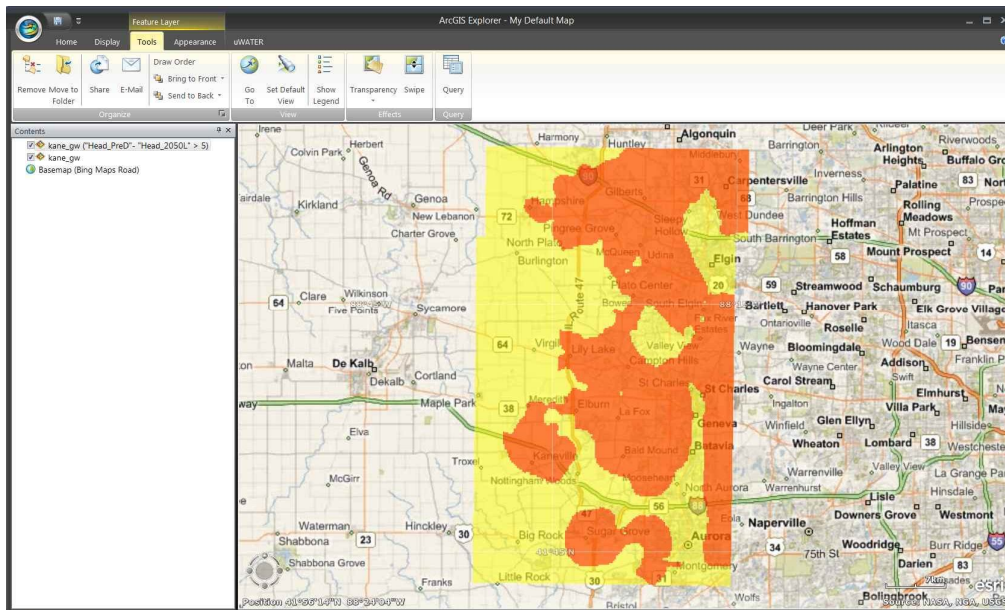


Figure 9. ArcGIS Explorer displays query result in the map

f) Repeating this procedure several times with different drawdown query criteria will result in several layers that overlap each other. The user can change the color of the resulting layers and put them into an appropriate sequence to create a graduated color scheme map of different degrees of drawdown. For example, as shown in Figure 10, green is drawdown less than 5 ft, blue is between 5 and 10 ft, yellow is between 10 and 20 ft, orange is between 20 and 30 ft, and red is greater than 30 ft.

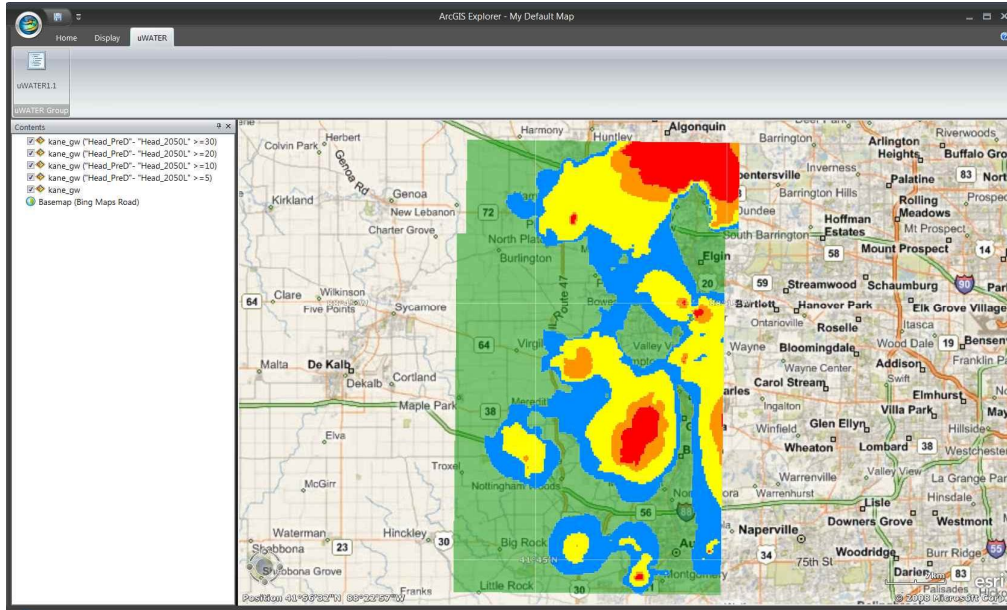


Figure 10. Multiple queries result in colored drawdown map for different degrees of drawdown

5.2 Query a shapefile based on another shapefile

a) Launch the uWATER main program. Under “Home” tab, use the **Add Content** button to browse and add the shapefile *Kane_GW.shp* and *Kane_Rivers.shp* in the *uWATERtest/Kane* folder downloaded with the program (Figure 11).

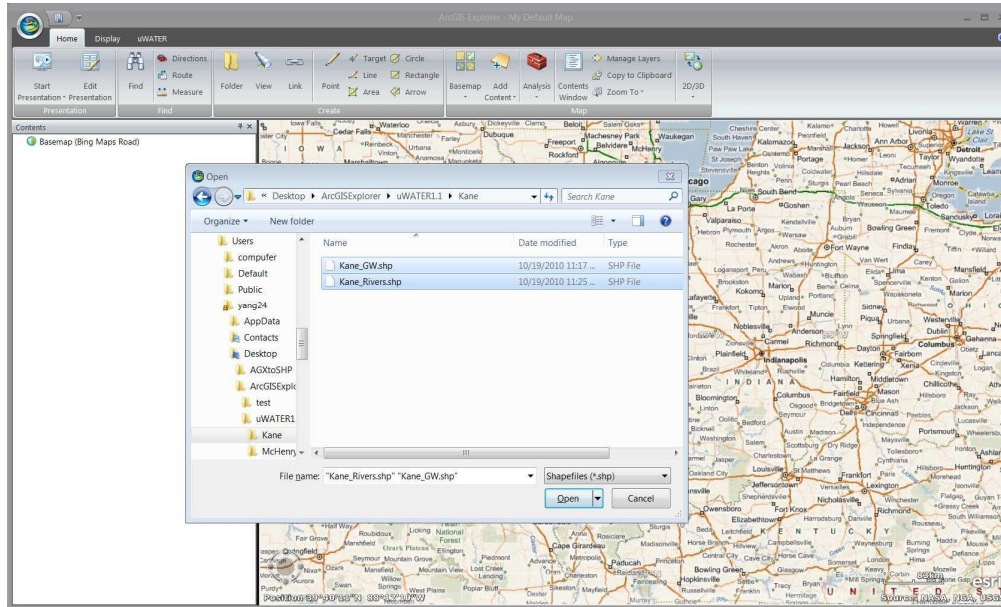


Figure 11. Add shapefiles for uWATER process

b) Following the instructions in 5.1, create a new feature layer with the name *kane_gw* ("*Head_PreD*" - "*Head_2050L*" > 5). This feature layer is the projected drawdown larger than 5 ft in year 2050 with less water resources scenario (Figure 12).

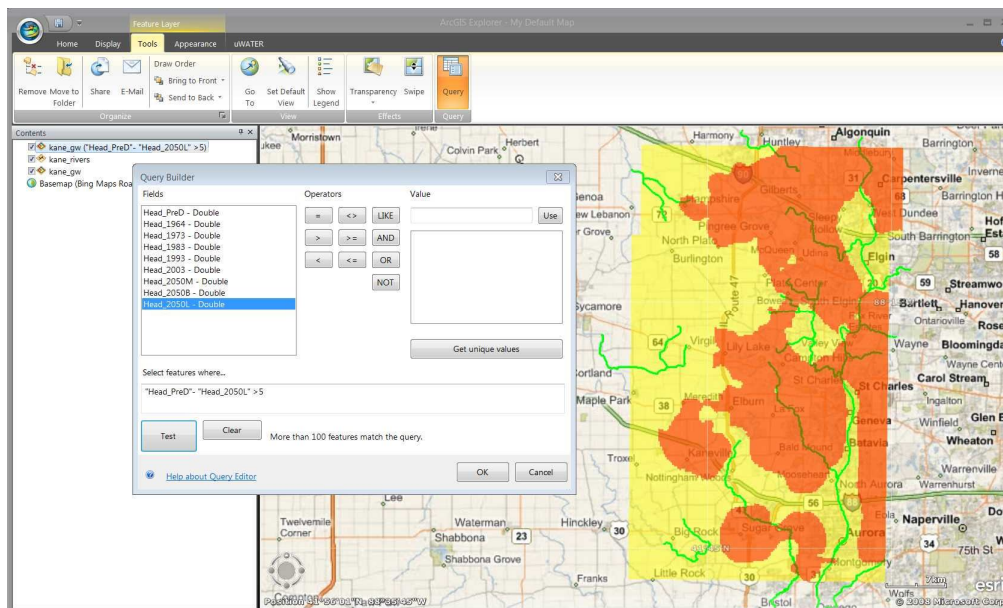


Figure 12. Conduct attribute query on groundwater levels

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c) Under “uWATER” tab, click the **uWATER1.1** button to open the uWATER interface. The interface is designed to be docked along with “Contents.” Click the **Refresh** button in the uWATER interface. The list of feature layers in the “Contents” will show up in the listbox. (Figure 13).

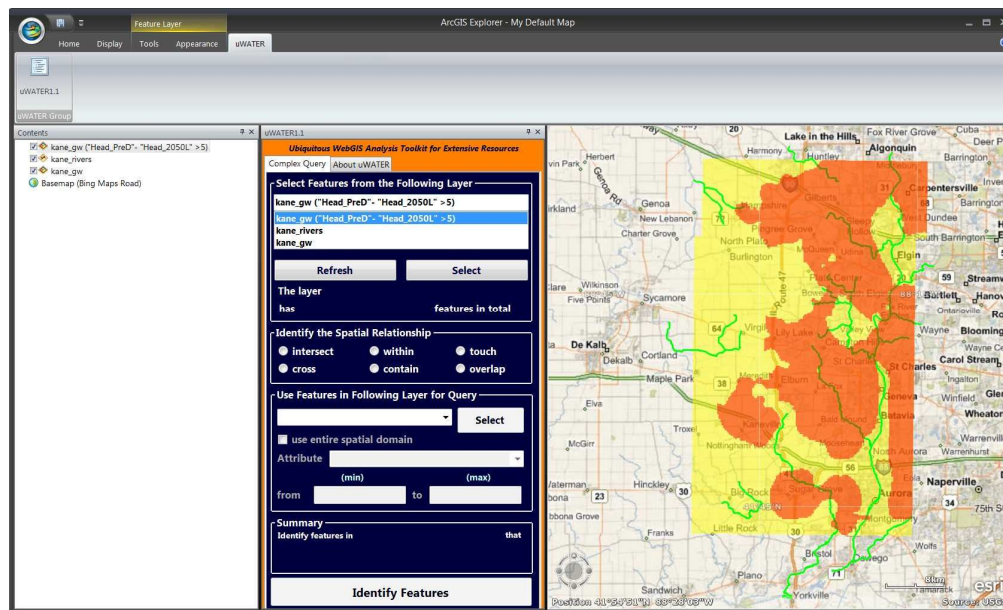


Figure 13. Open uWATER interface and get feature layers in the “Contents” by clicking **Refresh**

d) Use the cursor to highlight *kane_rivers* layer and click the **Select** button in the uWATER interface. The information about the selected layer will show. Use the ratio buttons to select the spatial relationship as “intersect” (Figure 14).

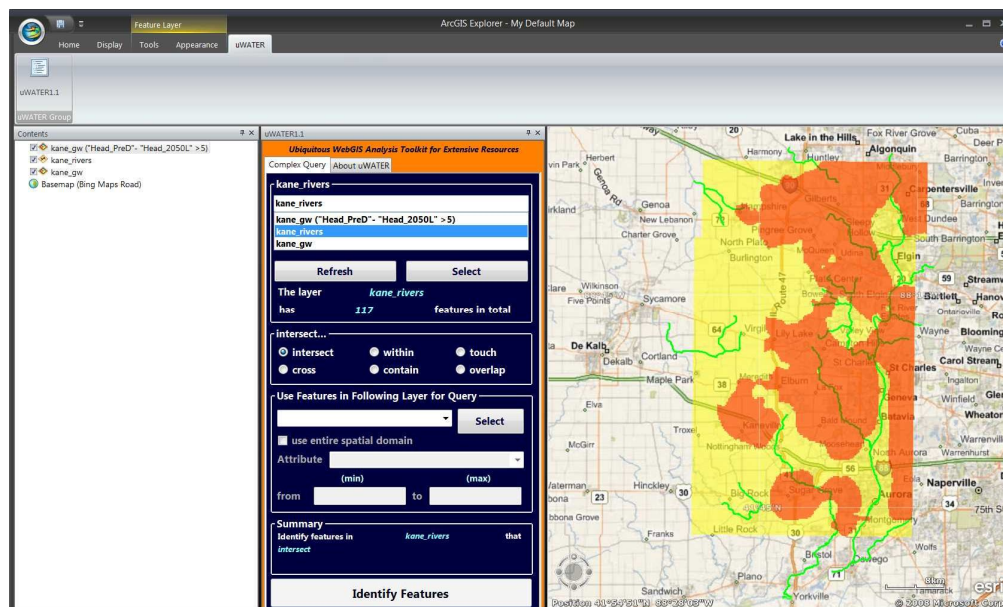


Figure 14. Highlight the *kane_rivers* layer by cursor and choose spatial relationship: “intersect”

e) Select feature layer: *kane_gw* ("*Head_PreD*"- "*Head_2050L*" > 5) in drawdown list (Figure 15).

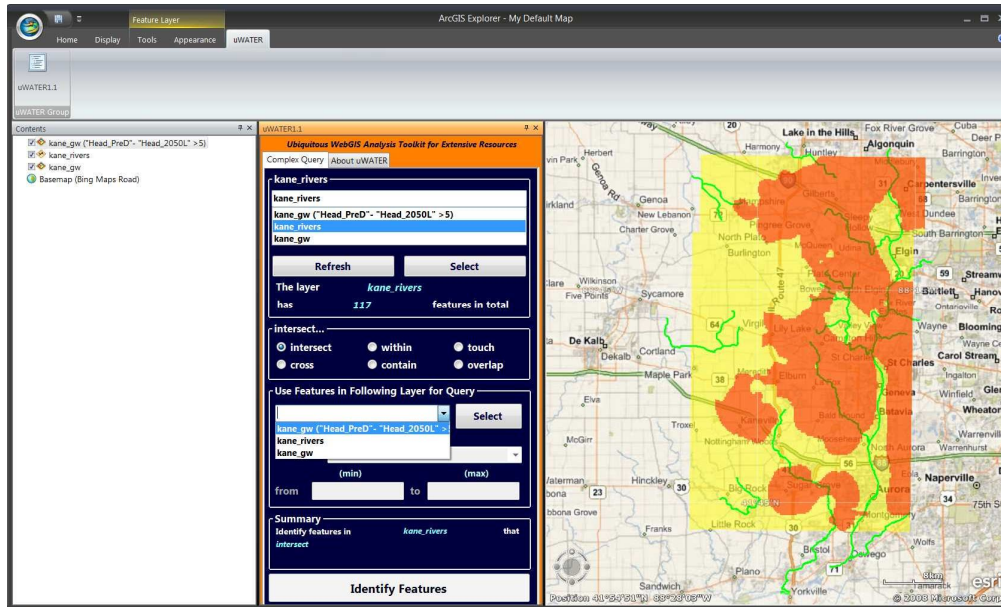


Figure 15. Select *kane_gw* ("*Head_PreD*"- "*Head_2050L*" > 5) as spatial query criteria

f) Check the "use entire spatial domain" checkbox, which means uWATER will select the features in the *kane_rivers* layer that intersects with the entire *kane_gw* ("*Head_PreD*"- "*Head_2050L*" > 5) layer. A summary is also given at the bottom of the uWATER interface. Click **Identify features** button after verifying the accuracy of the summary. One folder named "*Spatial Query: intersect kane_gw ("Head_PreD"- "Head_2050L" >5)*" is created for the resulted SQNotes, which are the river features intersecting with *kane_gw* ("*Head_PreD*"- "*Head_2050L*" > 5) layer (Figure 16).

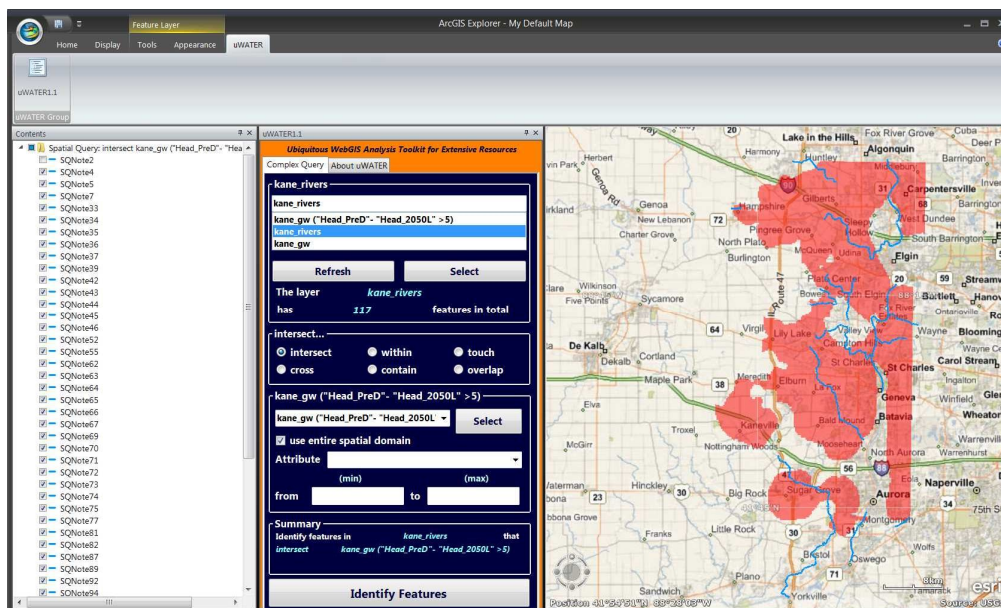


Figure 16. Click **Identify Features** and spatial query results display in the map

5.3 Query a shapefile based on attributes of another shapefile

a) Launch the uWATER main program. Under “Home” tab, use the **Add Content** button to browse and add the shapefile *McHenry_Census.shp* and *McHenry_fish.shp* in the *uWATERtest/McHenry* folder downloaded with the program (Figure 17).

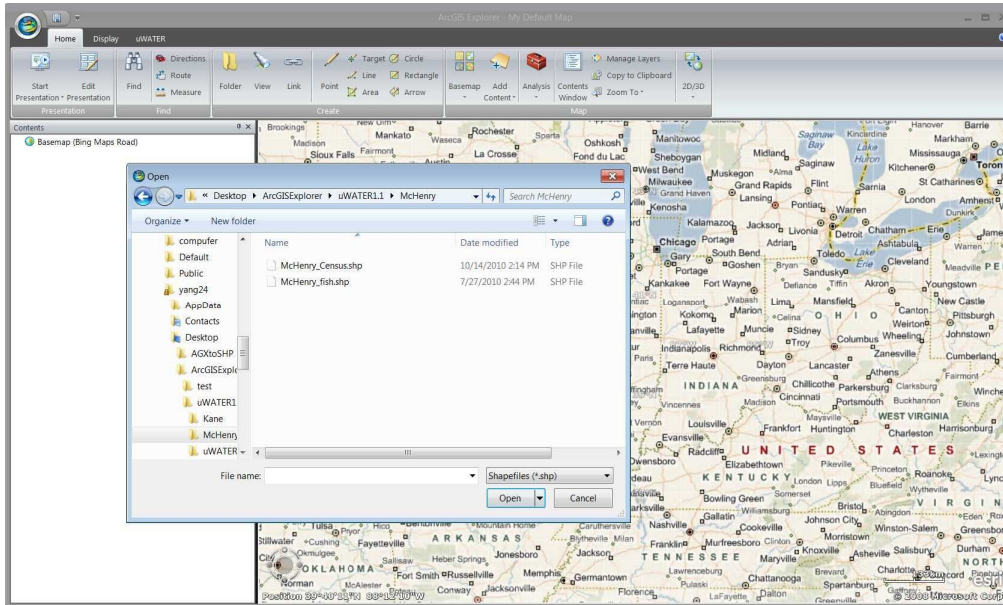


Figure 17. Add shapefiles for uWATER process

b) Under “uWATER” tab, click the **uWATER1.1** button to open the uWATER interface. The interface is designed to be docked along with “Contents.” Click the **Refresh** button in the uWATER interface, and the list of feature layers in the “Contents” will show up in the listbox. (Figure 18).

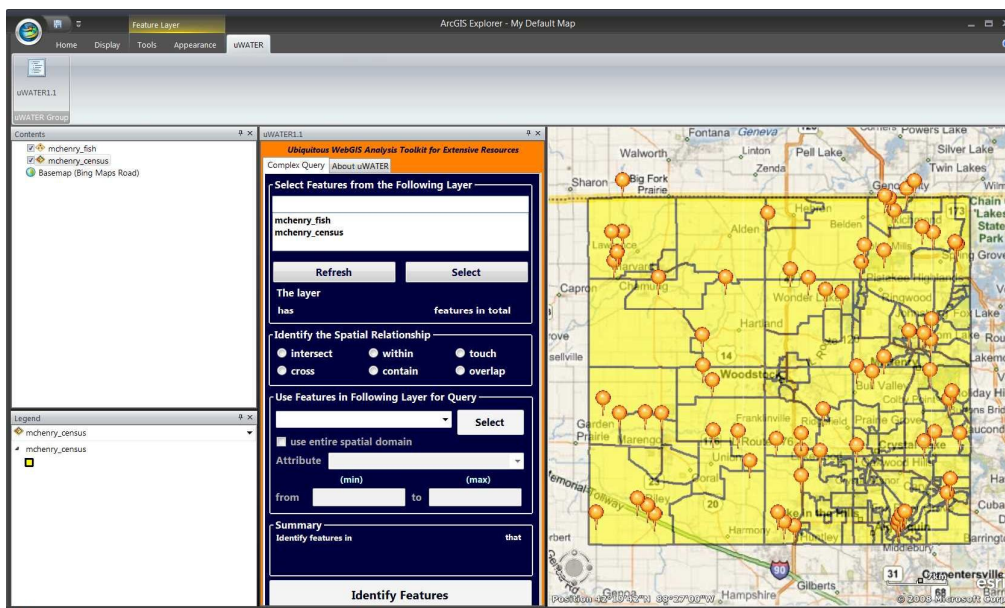


Figure 18. Open uWATER interface and get feature layers in the “Contents” by clicking **Refresh**

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c) Use cursor to highlight *mchenry_fish* layer and click **Select** button in the uWATER interface. The information about the selected layer will show. Use the ratio buttons to select the spatial relationship as “within” (Figure 19).

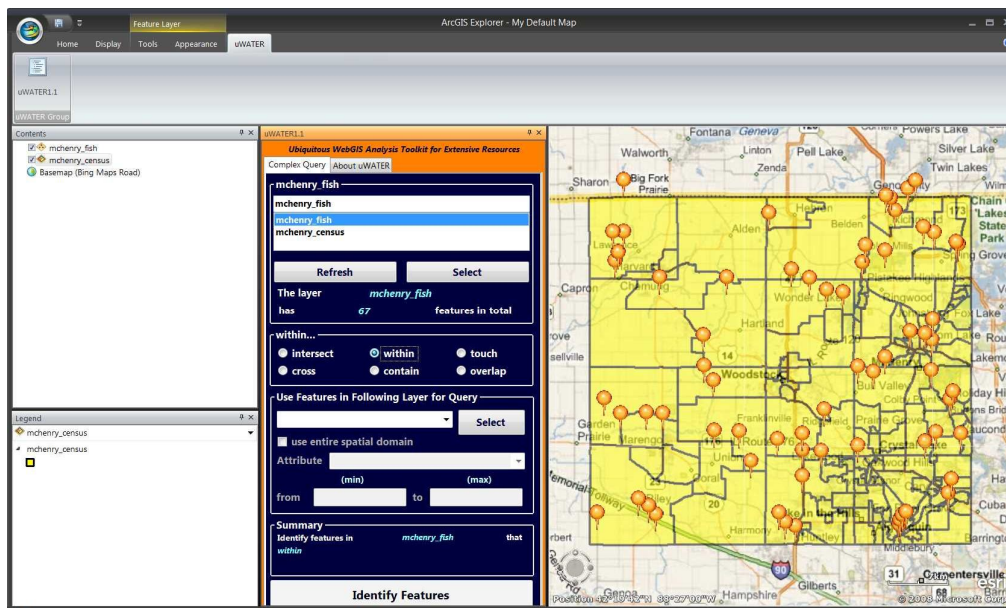


Figure 19. Highlight the *mchenry_fish* layer by cursor and choose spatial relationship “within”

d) Use dropdown list to select feature layer *mchenry_census* (Figure 20).

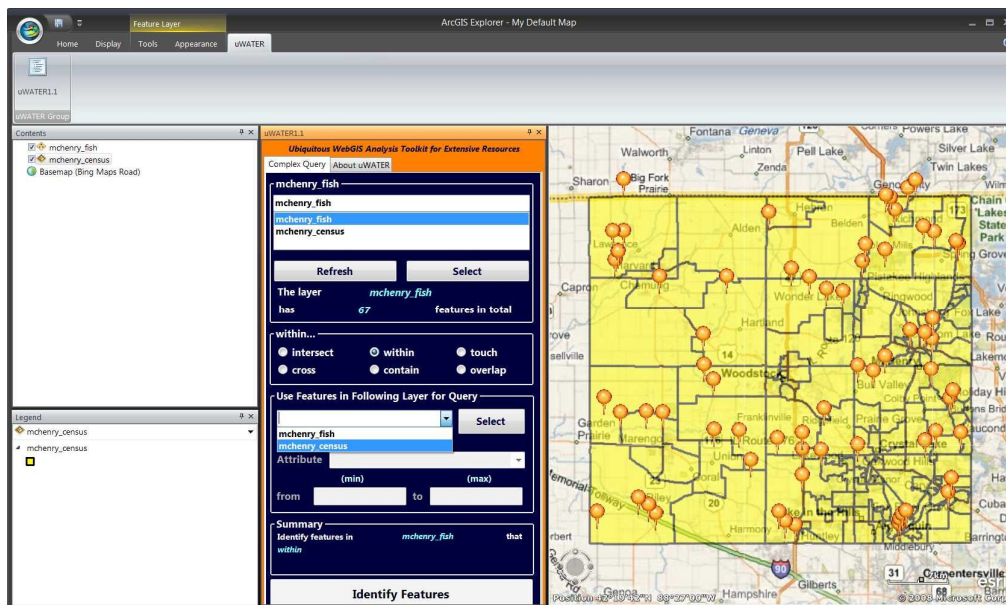


Figure 20. Select *mchenry_census* as spatial query criteria

e) Use dropdown list to select attribute *Urban_Tot* (urban population divided by total population), and key in *0.5* in the minimum textbox, *0.9* in the maximum textbox. (Figure 21).

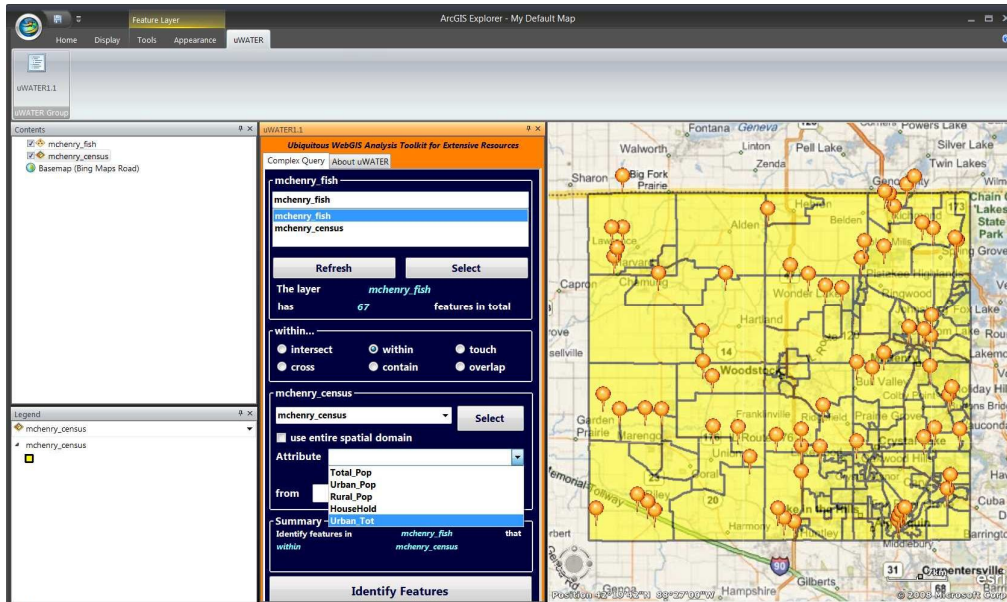


Figure 21. Select *Urban_Tot* as attribute query criteria and type in min and max value

f) This setting means that uWATER will select the features in the *mchenry_fish* layer that are within the *mchenry_census* layer with the attribute *Urban_Tot* from 0.5 to 0.9. A summary is also given at the bottom of the uWATER interface. Click **Identify features** button after verifying the accuracy of the summary. uWATER will first finish a query based on the attribute setting: *Urban_Tot* from 0.5 to 0.9. It will result in a new feature layer named *mchenry_census (Urban_Tot > 0.5 AND 0.9 > Urban_Tot)*. The default setting is in blue outline (Figure 22). Next, uWATER will conduct the spatial query *mchenry_fish* layer within the new layer. One folder named "*Spatial Query: within Urban_Tot from 0.5 to 0.9*" is created for the resulting SQNotes, which are the fish sample features within the *mchenry_census* layer with the attribute *Urban_Tot* from 0.5 to 0.9 (red pushpin in Figure 22).

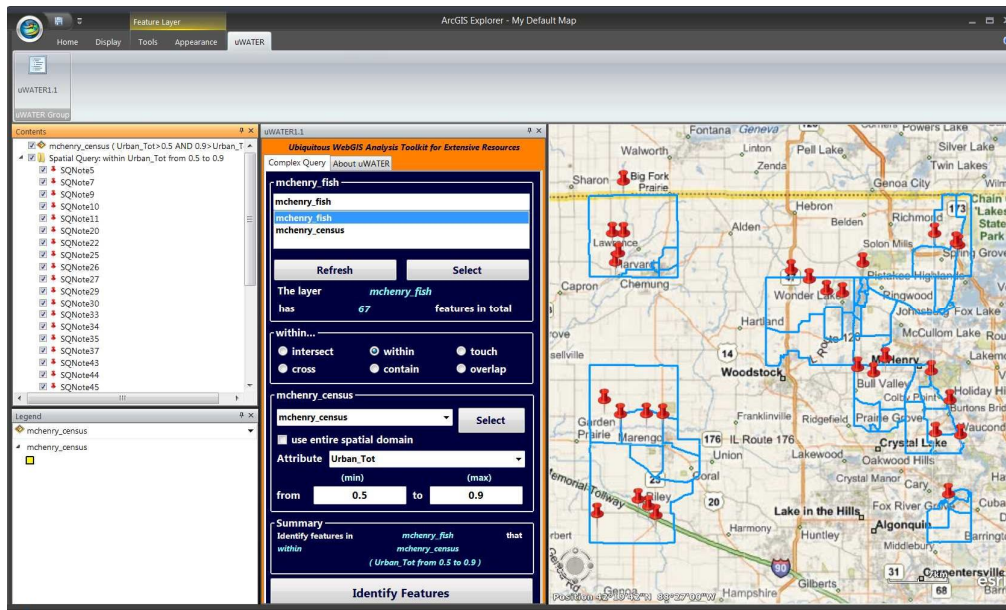


Figure 22. Click **Identify Features** and spatial query results display in the map

6. Acknowledgements, Availability, and References

Support for development of uWATER was provided by McHenry County, Illinois, USA and the State of Illinois. The uWATER package (program, example files, and users' manual) is free to download at <http://www.isws.illinois.edu/gws/sware/uwater/>.

Please contact Yi-Chen Ethan Yang (yang24@illinois.edu) or Yu-Feng Forrest Lin (yflin@illinois.edu) for questions or comments.

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