

MODULE 4

PLANNING FOR WATER RESOURCES

SUMMARY:	Students will assess the locations of critical water features and learn the importance of maintaining and improving water quality and water quantity.
ACTIVITIES:	Identify watershed basins and primary river systems. Evaluate the location and distribution of important water features. Use geospatial tools to delineate areas of hydrologic protection.
SCIENCE STANDARDS:	Utah Science Core 9-12 - Earth Science: Standard 4, Objectives 1a, 2c, and 2d Utah Science Core 9-12 - Earth Science: Standard 5, Objectives 2a, 2b, 2c, and 2d Utah Social Studies Core 9-12: Utah Studies Strand 5, Standard 5.2
MODULE LINK:	https://arcg.is/1W8P9z

GLOSSARY

Buffer:	An area surrounding a geographic object measured in units of distance.
Filter:	A method of sorting data to display specific records.
Floodplain:	An area of land adjacent to a stream or river which experiences flooding during periods of high discharge.
Lake:	A natural body of water surrounded by land.
Reservoir:	An enlarged natural or artificial lake, storage pond, or impoundment formed by constructing a dam across a flowing river.
Riparian Buffer:	A vegetated area near a stream or river that protects water resources from adjacent land uses and pollution.
River:	A large natural waterway that flows into another river, lake, or sea.
Spatial Analysis:	The systematic examination of a geographic question or problem.
Spatial Query:	A statement or logical expression that selects geographic features based on location or spatial relationship.
Stream:	A small narrow waterway that flows into another stream or river.
Water Pollution:	The contamination of water bodies by harmful substances and chemicals.
Watershed:	An area of land that separates waters flowing to different rivers or basins.
Wetlands:	Lands that are covered with shallow water or have saturated soils.

INTRODUCTION

Water is one of the most vital and essential natural resources on the Earth. All living organisms, including humans, depend on plentiful and clean water sources to survive. In the arid and semi-arid Intermountain West of the United States, water resources are scarce due to seasonal and climatic patterns. The majority of precipitation occurs during the winter and early spring months. Little precipitation occurs during the hot and dry summer and fall months. Therefore, waters from rivers, streams, lakes, reservoirs, and springs provide sources of clean water.

In Utah, the historical settlement of communities was largely determined by the availability and proximity to vital water resources. Today, the availability of clean and abundant water resources continues to play a significant role in maintaining thriving communities. Therefore, it is critically important that water resources and supplies remain clean. However, urban and industrial development has impacted water quality and quantity. Several surface and ground

water resources have become polluted. **Water pollution**, or the contamination of water bodies by harmful substances and chemicals, has made many sources of water unsuitable for human use and has degraded aquatic ecosystems and habitat.

In this module, several important water resources will be evaluated in relation to population centers and urban development in Cache County, Utah. **Watersheds**, or drainage basins that are defined by topographic features, will be assessed. Surface water features, including **rivers, streams, lakes**, and **reservoirs**, will be examined. Other hydrological features, such as **wetlands**, will be analyzed.

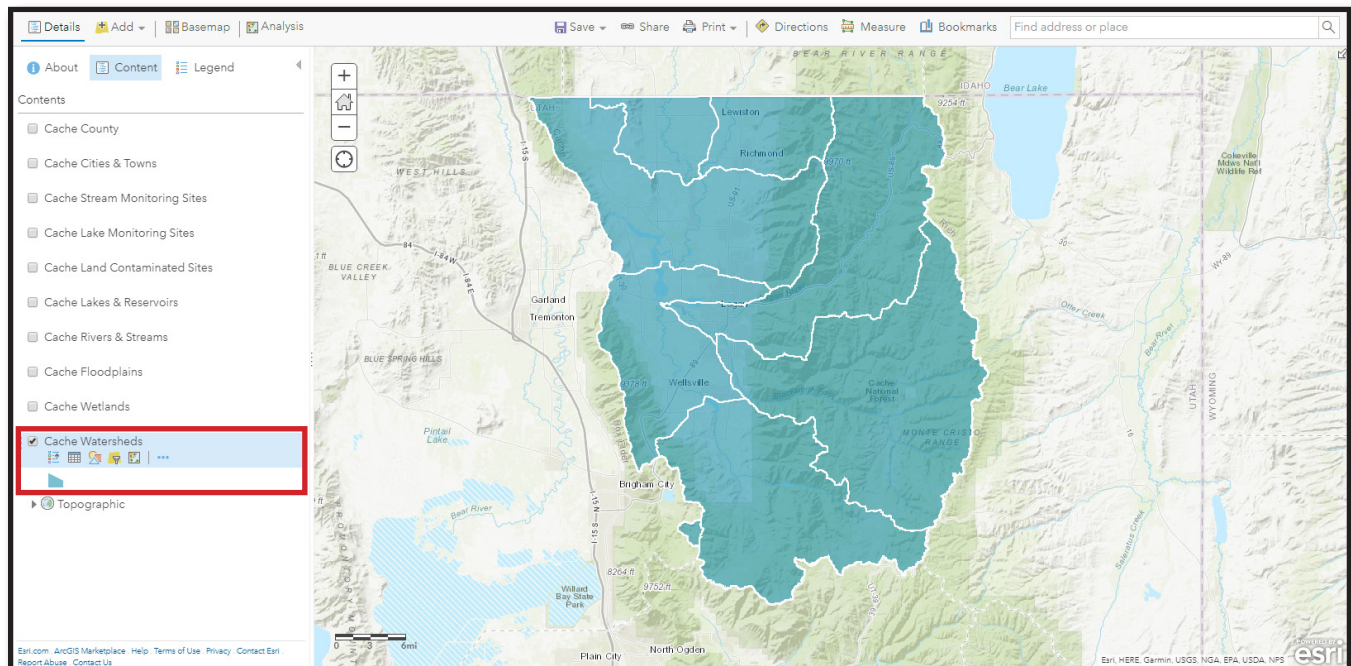
INTERACTION

Open the map titled *Module 4 - Planning for Water Resources* (<https://arcg.is/1W8P9z>). This ArcGIS Online map contains 10 data layers: *Cache County*, *Cache Cities & Towns*, *Cache Stream Monitoring Sites*, *Cache Lake Monitoring Sites*, *Cache Land Contaminated Sites*, *Cache Lakes & Reservoirs*, *Cache Rivers & Streams*, *Cache Floodplains*, *Cache Wetlands*, and *Cache Watersheds*. While some of these data layers will be evaluated in detail, others have been added to this ArcGIS Online map for observation and independent exploration.

The *Cache County* data layer depicts the Cache County boundary. The *Cache Cities & Towns* data layer depicts the city and town boundaries. The *Cache Stream Monitoring Sites* data layer shows the geographic locations of water quality monitoring sites along rivers and streams. The *Cache Lake Monitoring Sites* data layer shows the geographic locations of water quality monitoring sites in lakes. The *Cache Land Contaminated Sites* data layer represents the geographic locations of contaminated sites, such as solid waste facilities and hazardous materials storage sites. While these sites are located on land, they have the potential to pollute water resources through infiltration and runoff.

The *Cache Lakes & Reservoirs* data layer depicts the locations of major lakes and reservoirs in Cache County. The *Cache Rivers & Streams* data layer depicts the locations of the primary waterways in Cache County. The *Cache Floodplains* data layer represents the locations of lands susceptible to flooding during periods of high precipitation and discharge. The *Cache Wetlands* data layer shows the locations and distribution of wetland types in Cache County. The *Cache Watersheds* data layer shows the extent and boundaries of watersheds in Cache County.

When you open the map, the *Cache County* data layer and the *Cache Watersheds* data layer should be the only layers that are turned on. To familiarize yourself with the map and the spatial data layers, feel free to turn the other data layers on and off to identify any general patterns or relationships. After you have introduced yourself to the data, turn all the data layers off with the exception of the *Cache Watersheds* data layer.



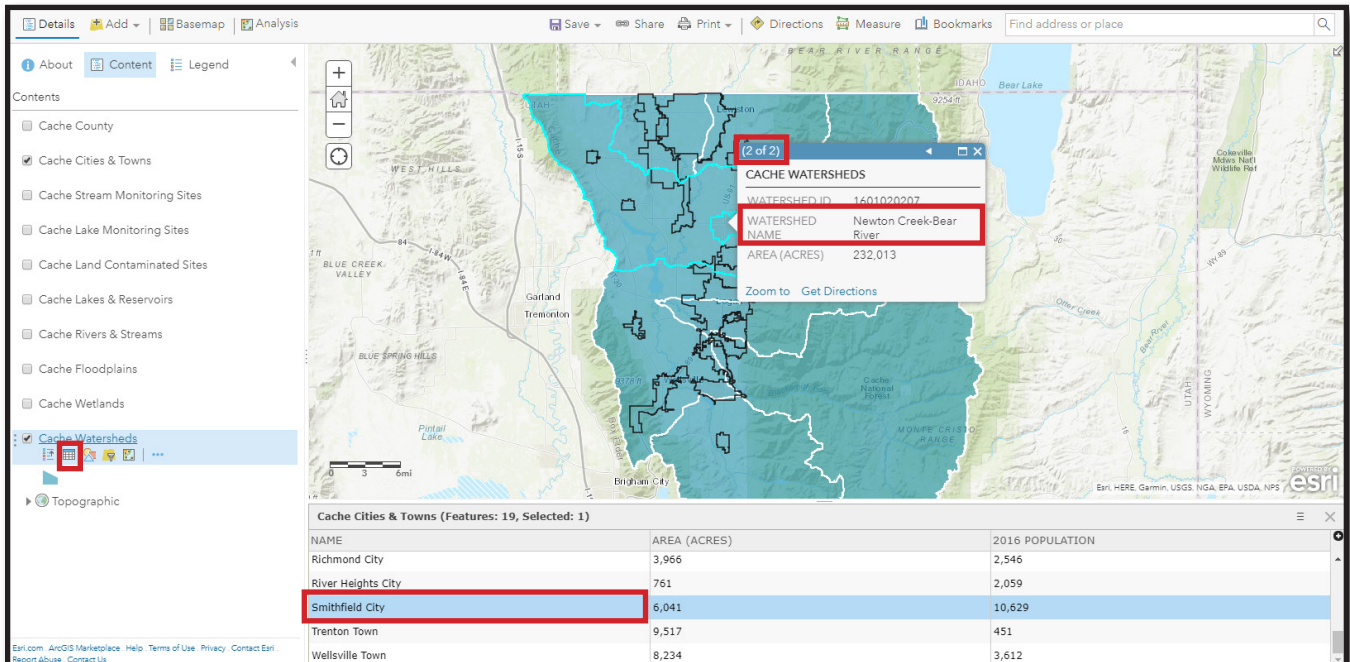
The *Cache Watersheds* data layer depicts the 14 watersheds in Cache County, Utah. Many of these watersheds extend into adjacent counties in Utah and Idaho, such as Box Elder County to the west and Rich County to the east; however, they were subset to the Cache County boundary to improve map legibility. It is important to remember that watersheds are defined by natural and topographic features, not political boundaries.

In your previous studies, you may have learned about watersheds and drainage basins. One of the most well known examples of hydrologic drainage is the Continental Divide. The Continental Divide is the principal hydrological divide of the Americas and it separates the watersheds that drain into the Pacific Ocean from those that drain into the Atlantic Ocean. The 14 watersheds in Cache County are located a few hundred miles west of the Continental Divide and they drain waters from the Wasatch and Bear River mountain ranges. These waters flow into the Great Salt Lake in the Great Basin via major river systems, including the Logan, Blacksmith Fork, and Bear rivers.

Watersheds provide an appropriate geographic extent for studying and planning for water resources. The water quantity and quality of a region may often be better understood by evaluating water resources and issues at these extents. For example, urban or regional planners may be interested in understanding how urban and industrial development within a city or town impacts the quantity and quality of water resources within a specific watershed.

If you were hired to help a planner or administrator in Cache County identify which watershed was impacted by urban and industrial development in Smithfield City, you could use some different tools in ArcGIS Online. First, turn on the *Cache Cities & Towns* data layer. Select the polygon that represents Smithfield City. If you are not certain where Smithfield City is located, open the attribute table associated with the *Cache Cities & Towns* data layer by clicking on the *Show Table* button. Under the *NAME* attribute, scroll down until you see Smithfield City. Left click on Smithfield City in the attribute table. Once selected, the polygon that represents Smithfield City should be highlighted with a blue line. Now that you know the location of Smithfield City, you can identify the watershed that Smithfield City is located within.

To identify the watershed, click on the polygon that represents Smithfield City. A pop-up window will appear that shows the attributes associated with Smithfield City. If you recall from the previous module (*Module 3 - Understanding Population Dynamics*), the pop-up window will contain information for overlapping features. In the upper left corner, you will see result (1 of 2). Right click on the arrow in the upper right until you see result (2 of 2). This will identify and highlight the watershed that Smithfield City is located within. Smithfield City is located within Newton Creek-Bear River Watershed.



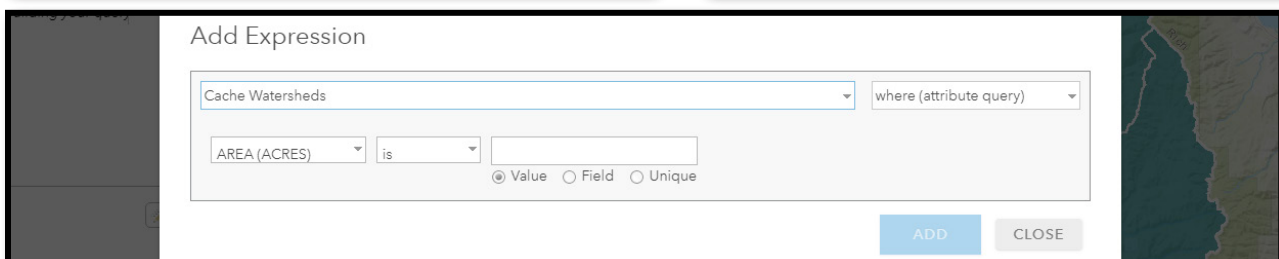
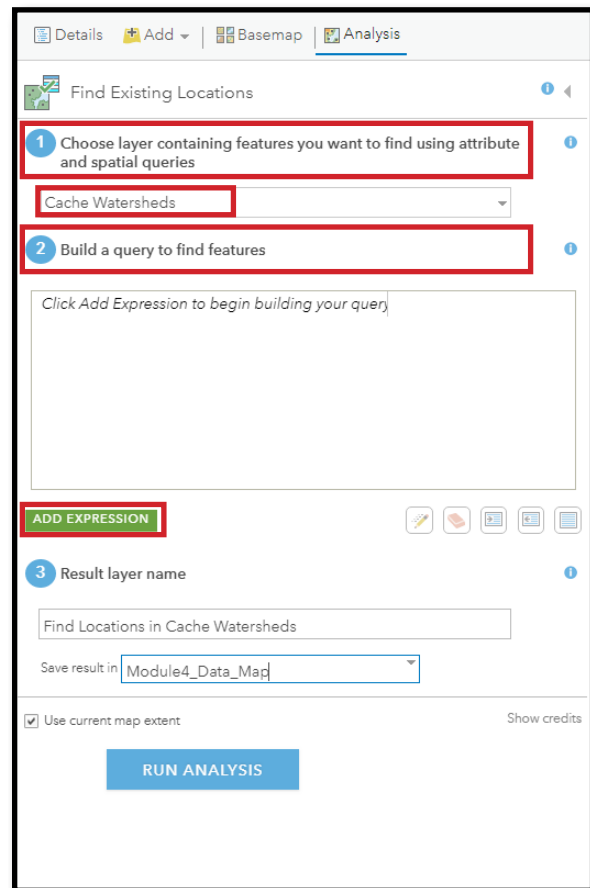
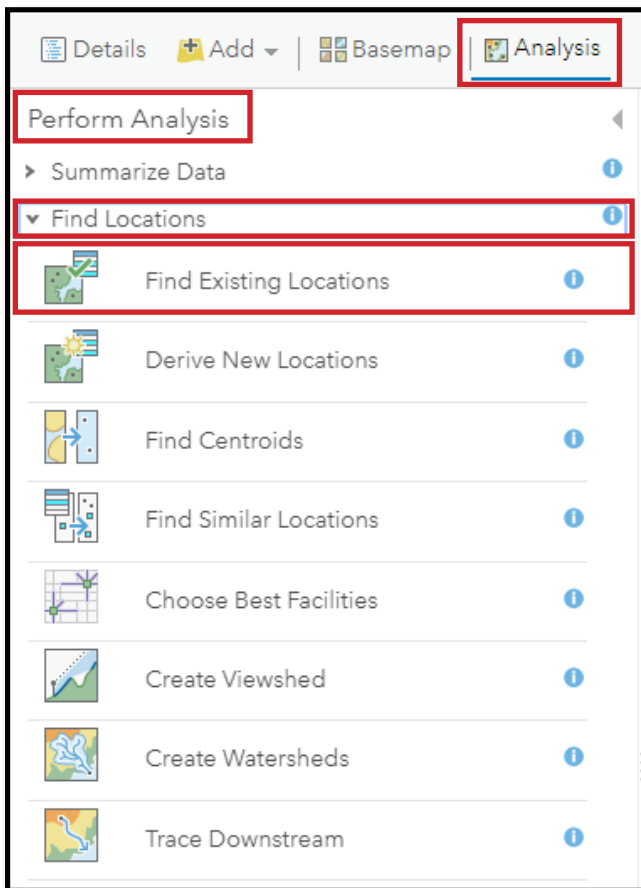
As previously noted, watersheds are defined by natural and topographic boundaries, not political boundaries. Therefore, it may be common for a city or town to be located within multiple watersheds. How would you help a planner or administrator identify multiple watersheds? As with the previous exercise, you can visually identify watersheds by

clicking on the *Cache Cities & Towns* data layer and the *Cache Watersheds* layer. While this can be done, it may be tedious, and it is possible that one or more watersheds may not be identified. Additionally, if you needed to make a map of the results, this method would not work well.

ArcGIS Online has some specific tools that allows users to develop **spatial queries**, or statements that select geographic features based on geographic location or spatial relationship. In simple terms, you can tell ArcGIS Online to identify all the watersheds that a city or town is located within. For instance, if you needed to identify all the watersheds that Logan City is located within, you would begin by selecting the *Analysis* button.

Under the *Analysis* button menu, you will see a series of options under *Perform Analysis*. Click on *Find Locations* and then click on *Find Existing Locations*. Several options are available within the *Find Existing Locations* tool. To begin, you will need to identify the data layer that contains the features you want to identify. In the input field (1) *Choose layer containing features you want to find using attribute and spatial data*, click the dropdown menu and select *Cache Watersheds*.

The most difficult part of developing a spatial query is building a statement that ArcGIS Online can understand. If the goal is to identify all of the watersheds that Logan City is located within, you would want to come up with a simple statement, such as "If Logan City occurs in a watershed, then select that watershed." This statement can then be translated into a spatial query or code that ArcGIS Online understands. Below (2) *Build a query to find features*, click on the green *ADD EXPRESSION* button. A new window will appear that will allow you to begin building your spatial query.



The spatial query to select all of the watersheds that Logan City is located within is a two-step process. First, ArcGIS Online must be told to locate features from the *Cache Watersheds* data layer that intersect with the *Cache Cities & Towns* data layer. In the first box, select *Cache Watersheds*. In the field on the right that currently states *where (attribute query)*, click on the dropdown menu and select *intersects*. To complete the expression, in the bottom box, click on the dropdown menu and select *Cache Cities & Towns*. Click *ADD*.

Add Expression

Cache Watersheds intersects Cache Cities & Towns

ADD CLOSE

The first part of the query will show up in the (2) *Build a query to find features* box. If the expression is left with only this input, any feature from the *Cache Watersheds* data layer that intersects with any feature from the *Cache Cities & Towns* data layer will be identified. This result would be only partially correct because the desired result is to select only those watersheds that intersect with Logan City. The spatial query needs to be refined to tell the program to select the watersheds that Logan City is located within.

Click the *ADD EXPRESSION* button again. In the *Add Expression* window, click the dropdown menu in the first box and select the *Cache Cities & Towns* data layer. Next, in the second box, select *where (attribute query)*. The final step is to identify the specific attribute that the program should be searching for. In the first of the three bottom boxes, click the dropdown menu and select *NAME*. In the second box, choose *is*. Below the third box, there are three options. Select the button next to *Unique*. Click on the dropdown menu to select *Logan City*. Click *ADD*.

Add Expression

Cache Cities & Towns where (attribute query)

FULL NAME is Logan City
 Value Field Unique

ADD CLOSE

There will now be two statements in the (2) *Build a query to find features* box. The final step in building a spatial query is to provide the program with a name for the new data layer. In the (3) *Results layer name*, type *Logan City Watersheds*. Make sure to save the output to your ArcGIS Online account. Click *RUN ANALYSIS*. This will take a minute to run.

2 Build a query to find features

Cache Watersheds intersects Cache Cities & Towns

and

Cache Cities & Towns where FULL NAME is 'Logan City'

ADD EXPRESSION

3 Result layer name

Logan City Watersheds

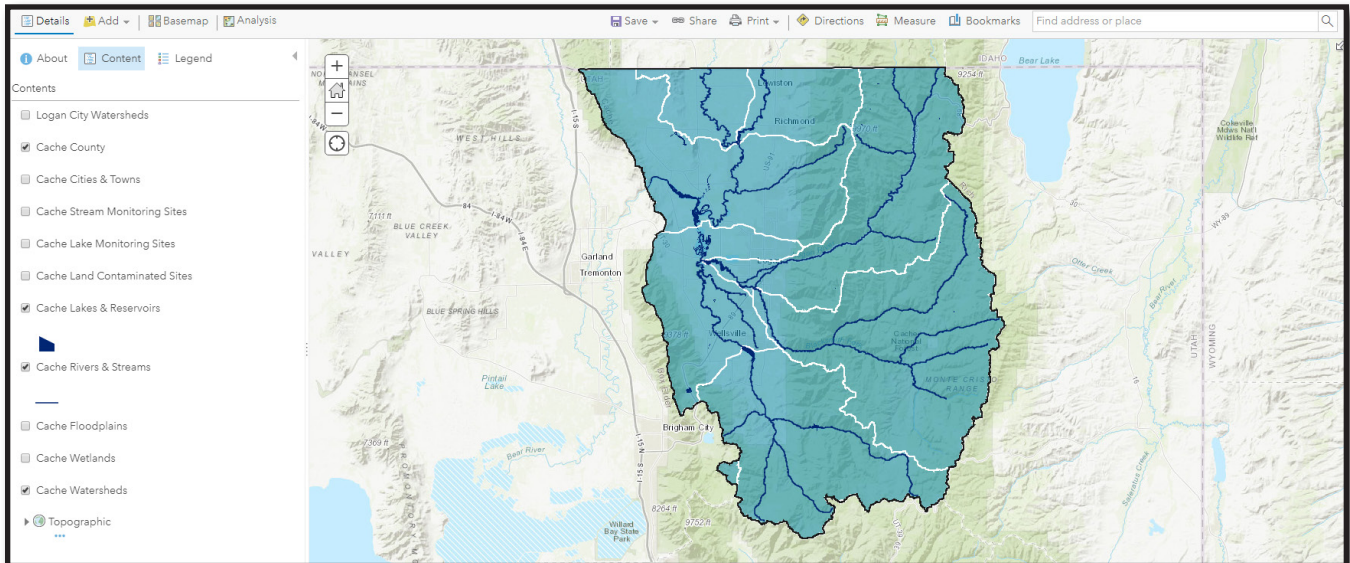
Save result in Module4_Data_Map

Use current map extent Show credits

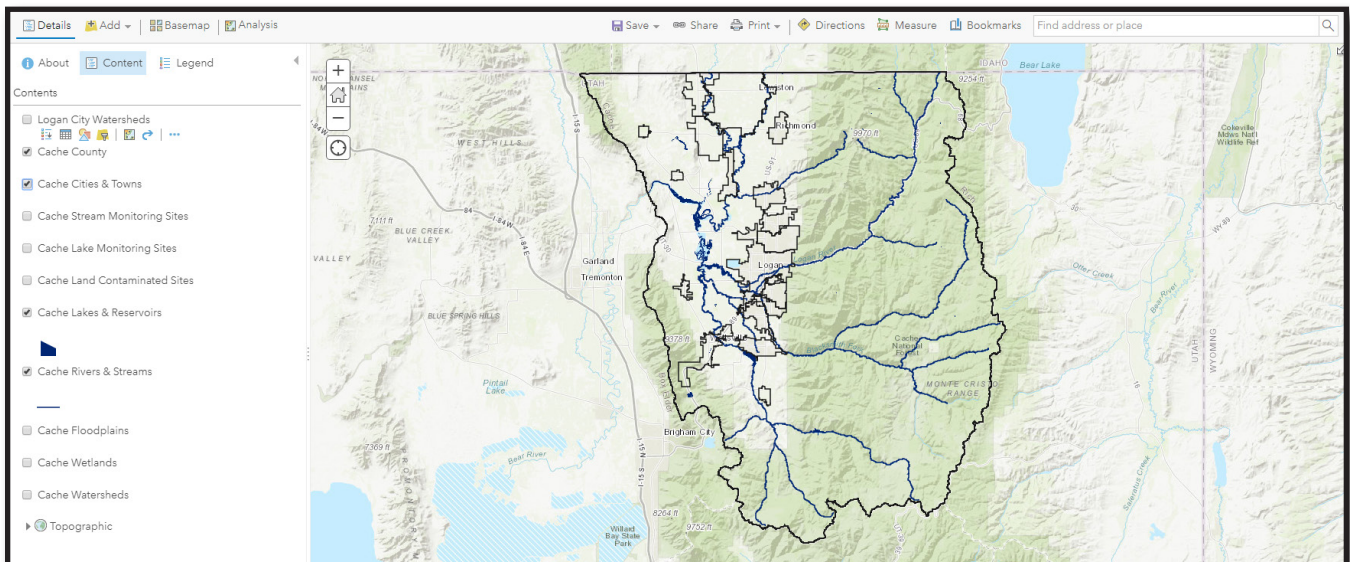
RUN ANALYSIS

The new data layer shows that Logan City occurs within the Blacksmith Fork, Logan River, Newton Creek-Bear River, and Outlet Little Bear River watersheds. The attribute table associated with the new data layer can be inspected to learn more about the four watersheds.

Rivers, streams, lakes, and reservoirs are important components of local and regional environments. In Cache County, the largest river is the Bear River, which enters the northern end of Cache Valley from Oneida Narrows Reservoir in Idaho and exits through Cutler Reservoir in Cache County. Other major rivers in Cache County include the Logan, Blacksmith Fork, and Little Bear rivers. To learn more about the primary surface water features in Cache County, turn on the *Cache Rivers & Streams* data layer and the *Cache Lakes & Reservoirs* data layer. Turn off the *Logan City Watersheds* data layer that you just created and turn back on the *Cache Watersheds* data layer. Do you notice any patterns or relationships between the watersheds and surface water features? You might observe that the rivers and streams exit the watersheds at their lowest elevation points.



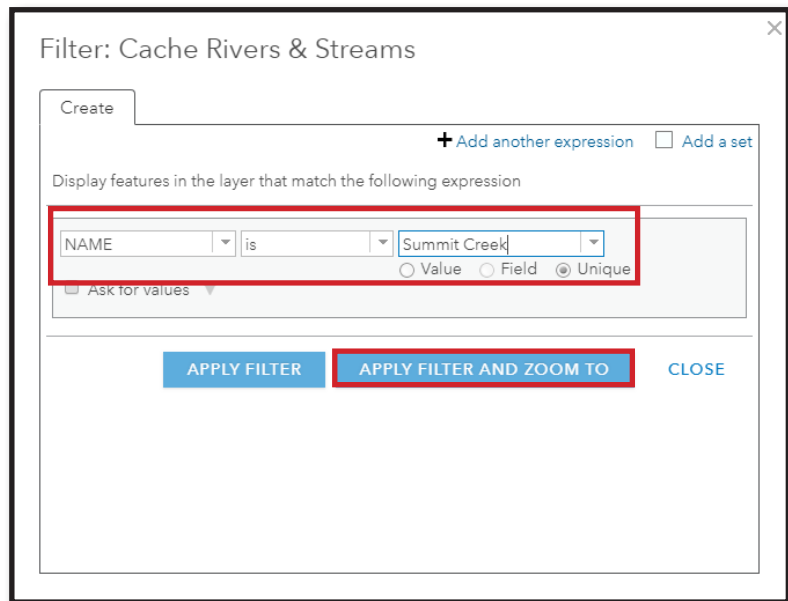
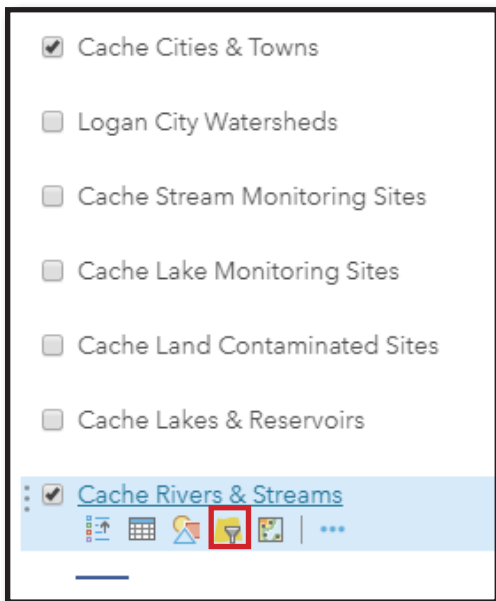
Turn off the *Cache Watersheds* data layer and turn on the *Cache Cities & Towns* data layer. What relationships between major waterways and urban development can you identify? You should notice that many of the cities and towns have a major river or streams running through them. What do cities and towns without a major waterway do to ensure that residents have sufficient water for drinking and irrigation? Urban planners, city managers, and county administrators are consistently interested in securing water supplies and maintaining water quality for all residents. Often times, it is their responsibility to keep these resources clean, functioning, and safe.



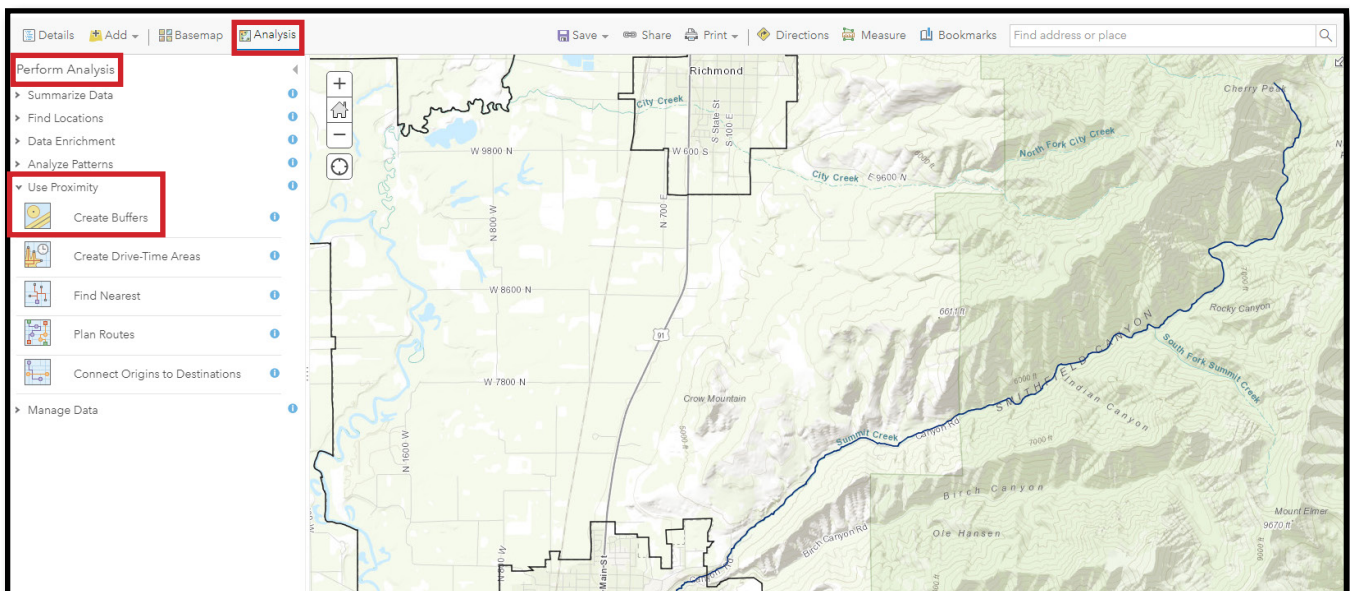
To protect rivers and streams from urban and industrial development, planners and administrators can use **riparian buffers** around rivers and streams to protect them from pollution. Riparian buffers, which often include **floodplains**, not only protect valuable surface water features from pollution, but they can minimize flood-related damage and destruction.

If you wanted to assist the planners in Smithfield City in developing a data layer that identified a 100-foot riparian buffer around Summit Creek, you could use the tools in ArcGIS Online. As with the previous exercise, this is a two-step process. You will first need to select Summit Creek from the *Cache Rivers & Streams* data layer and then you will create a 100-foot buffer around Summit Creek.

To select Summit Creek, hover over the *Cache Rivers & Streams* data layer and click on the *Filter* button. The *Filter* tool allows you to select specific features from a data layer. In the *Filter* window, click on the first box that is presently displaying *FID*. Click the dropdown menu and select *NAME*. In the second box, select *is*. Below the third box, select the button next to *Unique*. Click on the dropdown menu and scroll down to select *Summit Creek*. Click *APPLY FILTER AND ZOOM IN*. ArcGIS Online will now only display the feature in the *Cache Rivers & Streams* data layer called Summit Creek.



Now that you have selected Summit Creek, you can create a 100-foot buffer around it. To do this, click the *Analysis* button. Under *Perform Analysis*, click on *Use Proximity*, and then select *Create Buffers*.



In the *Create Buffers* tool, there are three steps that must be completed to place a buffer around Summit Creek. Below (1) Choose layer containing features to buffer, select the *Cache Rivers & Streams* data layer. Below (2) Enter buffer size, choose *Distance*. Below Enter the buffer distance, type in *100*. In the second box, use the dropdown menu to select *Feet*. Below (3) Result layer name, give the new data layer a new name. You may name it *Summit Creek Buffer*. Lastly, at the bottom of the menu, uncheck the box next to *Use current map extent*. Click *RUN ANALYSIS*. This analysis will take a few minutes to run.

After the analysis has been completed, you can open up the attribute table associated with the new data layer called *Summit Creek Buffer*, to identify the length of the river and the area of the buffer. The length of the river is 15.18 miles and the area of the buffer is 0.57 square miles.

The screenshot shows the 'Create Buffers' tool interface on the left and a map of Summit Creek on the right. The tool interface has three main steps: 1. Choose layer containing features to buffer (Cache Rivers & Streams), 2. Enter buffer size (Distance, 100 Feet), and 3. Result layer name (Summit Creek Buffer). The 'Use current map extent' checkbox is unchecked. The 'RUN ANALYSIS' button is highlighted. The map shows Summit Creek with a buffer around it. Below the map is the attribute table for 'Summit Creek Buffer (Features: 1, Selected: 0)'. The table has columns: NAME, LENG_MILES, Buffer distance in Feet, ORIG_FID, and Area in Square Miles. The row for Summit Creek shows LENG_MILES: 15.18, Buffer distance in Feet: 100.00, ORIG_FID: 18, and Area in Square Miles: 0.57.

NAME	LENG_MILES	Buffer distance in Feet	ORIG_FID	Area in Square Miles
Summit Creek	15.18	100.00	18	0.57

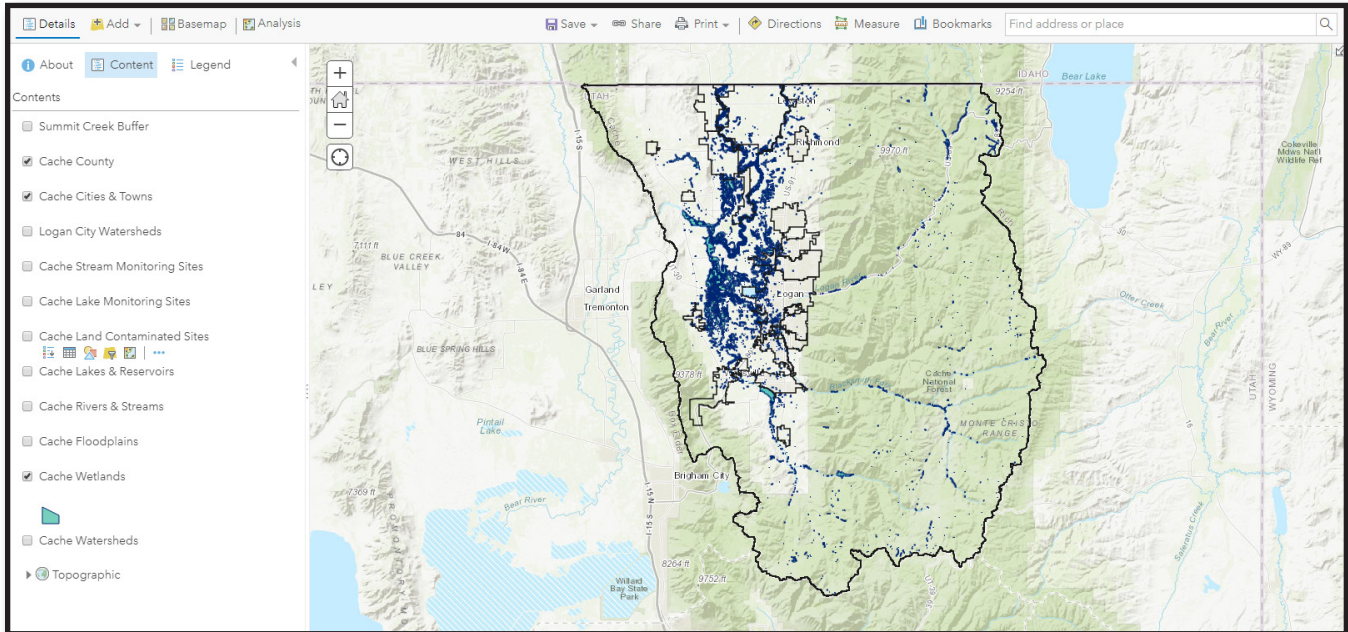
Before proceeding, the filter imposed on the *Cache Rivers & Streams* data layer must be removed. To remove the filter, hover over the *Cache Rivers & Streams* data layer, click on the *Filter* button. The *Filter* window will appear. Select *REMOVE FILTER*. To zoom to the extent of the all rivers and streams, you can zoom out using the *Navigation* buttons or you can select the *More Options* button under the *Cache Rivers & Streams* data layer and select *Zoom to*.

The screenshot shows the 'Filter: Cache Rivers & Streams' dialog box. It has 'View' and 'Edit' buttons. Below, it says 'NAME is 'Summit Creek''. There are two buttons: 'REMOVE FILTER' and 'CLOSE'.

The screenshot shows the 'Contents' pane in the software. The 'Cache Rivers & Streams' layer is selected. A context menu is open over this layer, and the 'Zoom to' option is highlighted. The map on the right shows the extent of the rivers and streams.

Turn off the *Cache Rivers & Streams* data layer and the *Cache Lakes & Reservoirs* data layer. Turn on the *Cache Wetlands* data layer. Wetlands are critically important aquatic features that support several functions. They serve as wildlife habitat, they control flood waters, they filter water pollution, and they provide recreation and hunting areas. Visually inspect where wetlands occur within Cache County. Wetlands occur mainly in the valley bottom and along riparian corridors.

Turn on the *Cache Cities & Towns* data layer to identify relationships between urban development and wetlands. It appears that many of the larger communities in Cache County are located east of the wetlands. It should be noted that historical settlements were established on well-drained soils near the valley edges, as seen by Logan, Smithfield, and Providence. As communities have grown, wetlands have been drained and filled to provide more area for urban and industrial development.



Since wetlands are vitally important, planners and administrators should closely monitor wetlands. One aspect of wetland monitoring is wetland inventories. Wetland inventories can be created by calculating the area of wetlands within a state, county, city, or town. For example, if you wanted to help the urban planner in Lewiston City develop a wetland inventory, you could use ArcGIS Online to calculate the total area of wetlands and the area of different types of wetlands within their city boundary.

If you open up the attribute table associated with *Cache Wetlands*, you will see that there are six different categories of wetlands: herbaceous, playa, riverine, shore, waterbody, and wooded. These categorizations are based on the location of the wetland as well as the type of vegetation and soil that occurs within the wetland. For instance, playa wetlands are shallow depressions that are formed in arid and semi-arid environments. They are generally composed of salty, or saline, soils and may have very little vegetation. While there may be minimal vegetation, playa wetlands can serve as critical bird habitat.

Cache Wetlands (Features: 6, Selected: 0)	
WETLAND TYPE	AREA (ACRES)
Herbaceous	19,659.20
Playa	802.09
Riverine	785.92
Shore	1,011.51
Waterbody	9,713.78
Wooded	3,477.69

To create an inventory of wetlands for Lewiston City, you will first need to select Lewiston City from the *Cache Cities & Towns* data layer. As with the previous exercise involving Summit Creek, you will need to create a filter. To do this, hover over the *Cache Cities & Towns* data layer and click on the *Filter* button. In the first box, select the attribute *NAME*. In the second box, select *is*. Below the third box, select the button next to *Unique*. Click on the dropdown menu and scroll down to select *Lewiston City*. Click *APPLY FILTER AND ZOOM IN*. ArcGIS Online will now only display the feature in the *Cache Cities & Towns* data layer called Lewiston City.

Filter: Cache Cities & Towns

Create + Add another expression Add a set

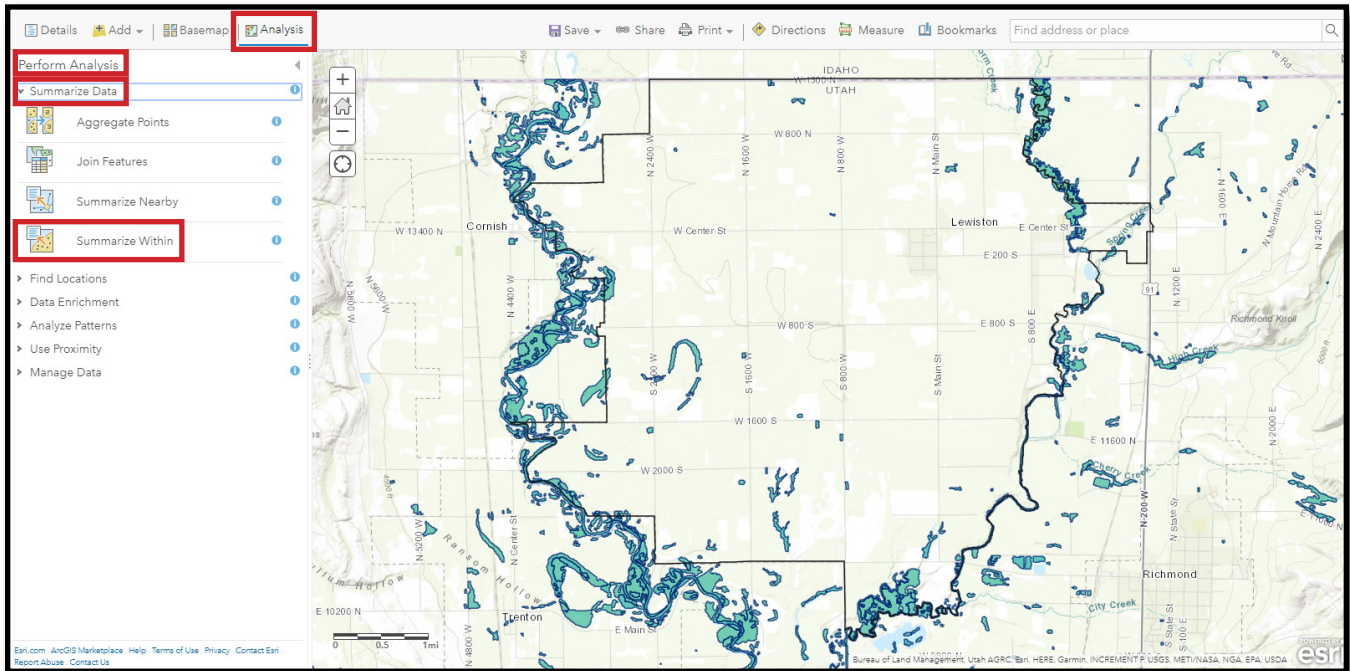
Display features in the layer that match the following expression

FULL NAME is Lewiston City

Ask for values Value Field Unique

APPLY FILTER
APPLY FILTER AND ZOOM TO
CLOSE

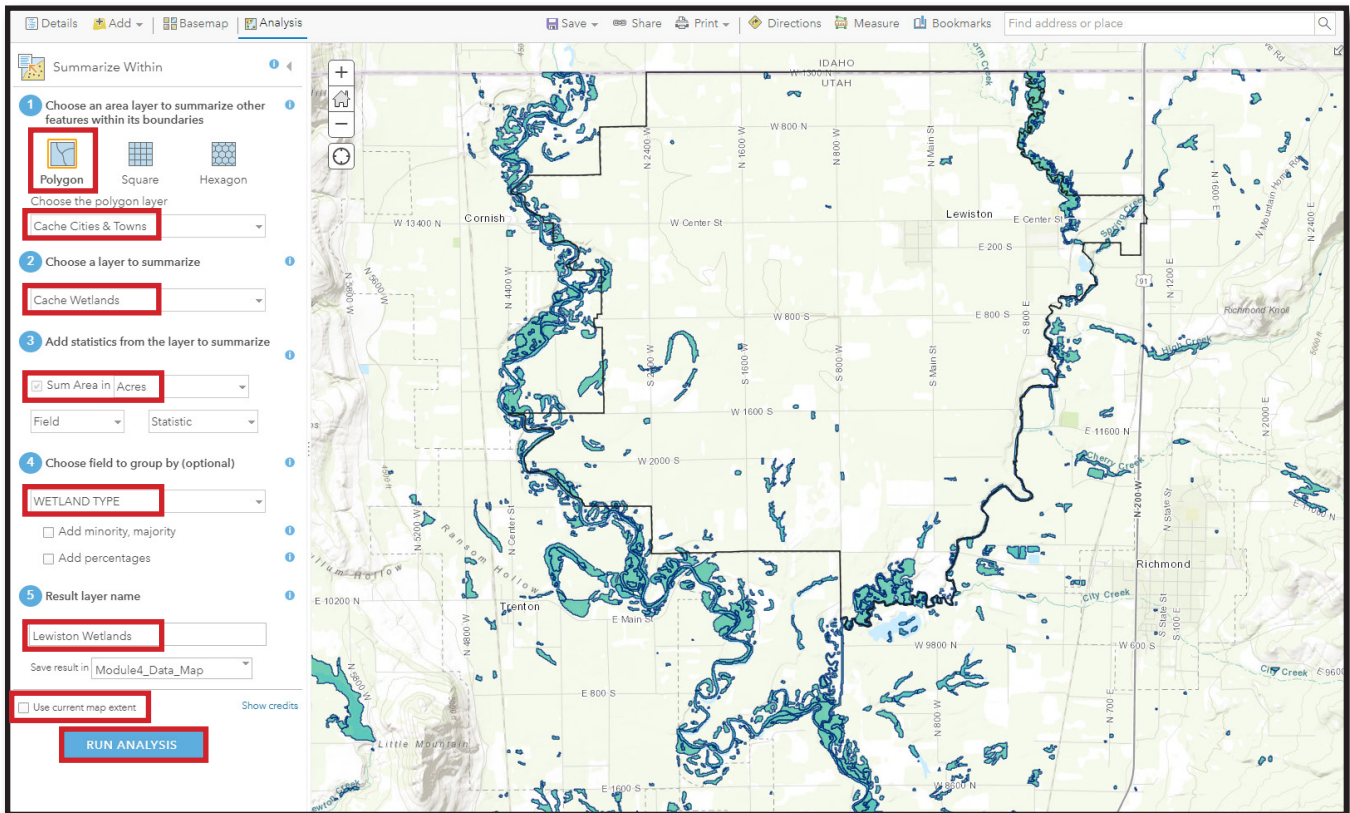
With Lewiston City selected, you can now summarize the area of wetlands within the city boundary. To summarize the area of wetlands, click on the *Analysis* button. Under *Perform Analysis*, click on *Summarize Data*, and then select *Summarize Within*.



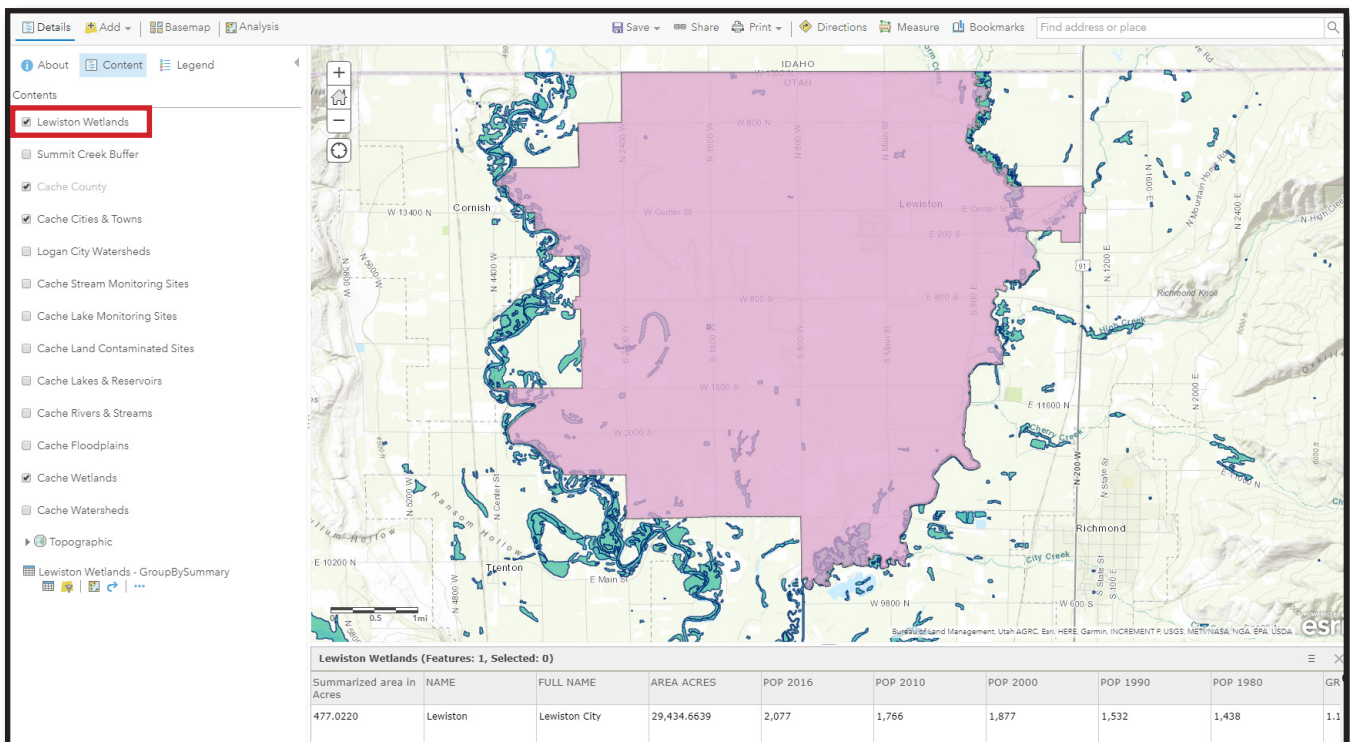
In the *Summarize Within* tool, there are five steps that must be completed to calculate the area of wetlands within Lewiston City. Below (1) Choose an area layer to summarize other features within its boundaries, select the *Polygon* option. Under *Choose the polygon layer*, select the *Cache Cities & Towns* data layer. Since a filter has been applied that has selected Lewiston City from the data layer, the analysis will only be performed for that city.

Below (2) Choose a layer to summarize, click the dropdown menu and select *Cache Wetlands*. Below (3) Add statistics from the layer to summarize, next to *Sum Area*, click the dropdown menu and select *Acres*. You can leave the default settings for the *Field* and *Statistic* fields.

Below (4) Choose field to group by (optional), click the dropdown menu and select WETLAND TYPE. Below (5) Result layer name, click in the first box and give the new data layer a name called *Lewiston Wetlands*. Uncheck the box next to *Use current map extent*. Click **RUN ANALYSIS**. This analysis will take several minutes to run.



After the analysis has been completed, you will see that there is a new polygon feature that represents Lewiston City, called *Lewiston Wetlands*. The information that you need to know about wetlands in Lewiston is located within the attribute table. Open the attribute table by clicking the *Show Table* button.



The attribute table for the *Lewiston Wetlands* data layer appears to only have one record. The first column, named *Summarized area in Acres*, reveals the total area of wetlands within Lewiston City. This analysis indicates that there are 477.02 acres of wetlands in Lewiston City. While this field tells you how many acres of wetlands are located within the city, it does not tell you the area of different wetland types within the city. This is because ArcGIS Online has created an additional table with all of the wetland information. In order to view this table, use the scroll bar at the bottom of the attribute table and scroll all the way to the right. Under the last column, named *groupBySummary*, click on *Show*.

PROJ 2040	WEBSITE	THUMBNAIL	Shape Area	Shape Length	AREA (SQUARE MILES)	2016 POPULATION DENSITY	JOIN ID	groupBySummary
2,751	http://www.lewiston-ut.org/	https://usonline.maps.arcgis.com/sharing/rest/content/items/883fe66fd39a4dad958d5a71c4f5f875/data	119,117,858.5781	68,009.7067	45.9917		1	(6) Show

A new table will appear with the additional wetland information. This table contains the summarized wetland information for Lewiston City, including the area of different wetland types. ArcGIS Online also added this table to the content list. It is named *Lewiston Wetlands - GroupBySummary*. You can also access this information by directly opening the table by clicking the *Show Table* button.

JOIN ID	OBJECTID	Join ID	TYPE	Summarized area in Acres
1	1	1	Herbaceous	167.30152748
	2	1	Playa	6.29598215
	3	1	Riverine	48.63351202
	4	1	Shore	17.18635321
	5	1	Waterbody	103.42493779
	6	1	Wooded	134.17972731

With this information, planners and administrators can begin developing wetland inventories that promote wetland protection. This process can be used to develop wetland inventories for other cities and towns.

Before proceeding, the filter needs to be removed from the *Cache Cities & Towns* data layer. To remove the filter, hover over the *Cache Cities & Towns* data layer, click the *Filter* button, and click *REMOVE FILTER*.

Remember to save a copy of the map to your ArcGIS Online account. You can name it *Module 4 Map*.

INVESTIGATION

In this module, you assessed the locations of critical water features as they relate to urban development. You learned that watersheds are an appropriate geographic extent for studying water resources and that they play an important role in water quantity. You learned how to develop spatial queries, filter spatial data, buffer features, and symbolize your maps in greater detail. Using the skills you learned in this module, please answer the following questions:

1. The size of a watershed can frequently indicate the amount of water that is collectively discharged from a topographic area. Planners and administrators can use this information to estimate how much water may be available for various uses, such as drinking water, irrigation, wildlife, and recreation. Also, by knowing the location of a watershed in relation to urban development, planners and administrators can account for several environmental concerns, such as water quality and water quantity.

By using the *Logan City Watersheds* data layer that you created in this module, identify the largest of the four watersheds that intersects with Logan City. You will need to open up the attribute table and sort the column *AREA_ACRES*.

What is the name of the largest watershed that intersects with Logan City?

What is the area (in acres) of this watershed?

By using the *Cache Watersheds* data layer that you created in this module, identify the watershed that the town of Paradise is located within. You can identify this watershed by visually examining the data or by developing a spatial query.

What is the name of the watershed that intersects with the town of Paradise?

What is the area (in acres) of this watershed?

2. Clean rivers and streams are critical components of healthy thriving communities. Not only do clean rivers and streams provide safe drinking water, they are also critically important for wildlife, recreation, and irrigation. However, as urban and industrial development expands, clean rivers and streams may become polluted from improper use and management. The impacts of urban and industrial development on rivers and streams can be minimized by creating riparian buffers. Riparian buffers can limit the pollution that enters waterways and they can reduce flood-related damage.

Using the skills that you learned from the Summit Creek exercise, select the Little Bear River from the *Cache Rivers & Streams* data layer and place a 200-foot buffer around it. You will need to use the *Filter* tool to select the Little Bear River from the *Cache Rivers & Streams* data layer. You will then need to use the *Create Buffers* tool to place a 200-foot buffer around the Little Bear River.

What is the length (in miles) of the Little Bear River?

What is the total area (in square miles) of the 200-foot buffer that surrounds the Little Bear River?

3. Wetlands are important aquatic features that provide a range of benefits for both humans and wildlife. They provide critical wildlife habitat, they filter pollution, they provide storm and flood water control, and they provide scenic and recreational opportunities. Due to significant losses of wetlands in the United States, it is important for counties and cities to create wetland inventories.

Using the *Cache Wetlands* data layer, identify the total area of riverine wetlands and herbaceous wetlands in Cache County. You will need to review the attribute table associated with the *Cache Wetlands* data layer.

What is the total area (in acres) of riverine wetlands in Cache County?

What is the total area (in acres) of herbaceous wetlands in Cache County?

4. The town of Trenton is interested in asking the State of Utah for some funds to improve and establish playa wetlands to attract nesting snowy plovers (<https://www.audubon.org/field-guide/bird/snowy-plover>). Populations of snowy plovers have declined in some regions due to human disturbance and lack of high-quality nesting habitat. The town of Trenton would like to improve their local economy by developing a bird-watching tourism and bird conservation program.

If the town of Trenton is interested in eventually managing a total of 200 acres of playa wetlands, how much playa wetland do they need to establish to meet this goal? In order to determine this, you will need to use the skills that you learned from the Lewiston City exercise. You will need to use the *Filter* tool to select the town of Trenton from the *Cache Cities & Towns* data layer, and then you will need to use the *Summarize Within* tool to calculate the area of different wetland types in Trenton. You can name the new data layer *Trenton Wetlands*. Once you have identified the area (in acres) of playa wetlands in the town of Trenton, you will want to subtract that value from 200 acres.

What is the total area (in acres) of wetlands within the town of Trenton?

What is the total area (in acres) of playa wetlands in the town of Trenton?

How many acres of playa wetlands would the town of Trenton need to establish to meet their goal of 200 acres?