Winter 2019

Hydrogeography of Salt Lake Valley, Utah

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CE 413: GIS IN WATER RESOURCES

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Introduction

Salt Lake City is the capital of Utah and holds a majority of the state's population. The valley is nestled at the base of the Wasatch Mountains, where most of the water comes from. In 2012, Salt Lake County obtained 57% of total water from surface waters such as streams and reservoirs (Sowby 2014)(Figure 1).

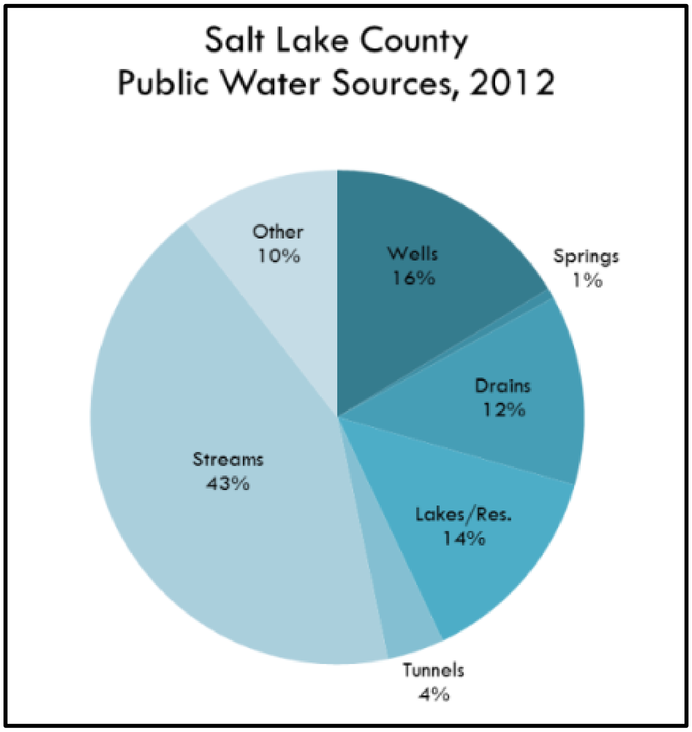

Figure 1. Break down of water sources in Salt Lake County

Big Cottonwood and Little Cottonwood canyon are both subwatersheds that supply a large portion of drinking water to the valley. Because of this, recreation and land use are heavily monitored. The Jordan River flows down the center of the valley and spans from Utah Lake (south), to the Great Salt Lake (North-West). This allows for a lot of pollution to get in the water. When the water reaches the Great Salt Lake, the salinity is too high for it to be useful anymore.

This project should serve as an opportunity to educate the general population about where their water comes from. This can also create a greater respect for the quality of our water, as most of it comes straight from the mountains. This should also be considered when thinking about the future of water as climate change becomes more apparent. ArcMap 10.5 will be used to identify the subbasin, subwatersheds, look at mean annual flow for the streams and rivers, create a point feature class of stream gauges, and analyze soil information.

Project Overview

Objective

The objective of this project was to better understand where water comes from and how it moves through the Salt Lake Valley. This was done first by using watershed boundary and stream data from National Hydrography Dataset Plus to set up the bounds of the study area. Next, flowlines were assessed and re-quantified by mean annual flow. Third, a feature dataset of stream gauge locations using latitude and longitude was created. Finally, soil data from the SSURGO soil database was assessed to figure out the available water storage.

Site Description

The population of Salt Lake County is around 1.14 million people, so this water is heavily used by the time it reaches the Great Salt Lake. Because there are so many sources of water, it is important to know how this water will flow, and by what volume. With this information, people can better understand the pollutants that get into the water. This is especially important as the population continues to grow. Having a base dataset will also allow us to understand how changes in water flow might impact the people and environment of the valley. The Jordan River Watershed is roughly the same area as Salt Lake County and is synonymous with the Salt Lake Valley. The drainage area is roughly 3,805 square miles (Jordan River Watershed n.d). This provides a unique situation because water management can be done on a county level. It has a drainage area of over 3,800 square miles. The elevation ranges from the high points of the Wasatch Mountains of 11,900 feet to the Salt Lake Valley at 4,200 feet. The valley is very flat, so most of the topography comes from the mountain range the wraps the valley in a horseshoe shape, as can be seen in figure 2. This water is heavily reliant on the snow and rain that comes down as runoff from the mountains. Average rainfall in the valley is 18 inches, and the average snowfall is 62 inches per year. Snow in the mountains will be much higher than this, around 500 inches a year. Water management is very important in this area because it is a high desert region, and with the larger population, many people do not consider how much water they are using. Many of the plants are used for aesthetic purposes and are not native to this land or compatible with the amount of water that is available here.

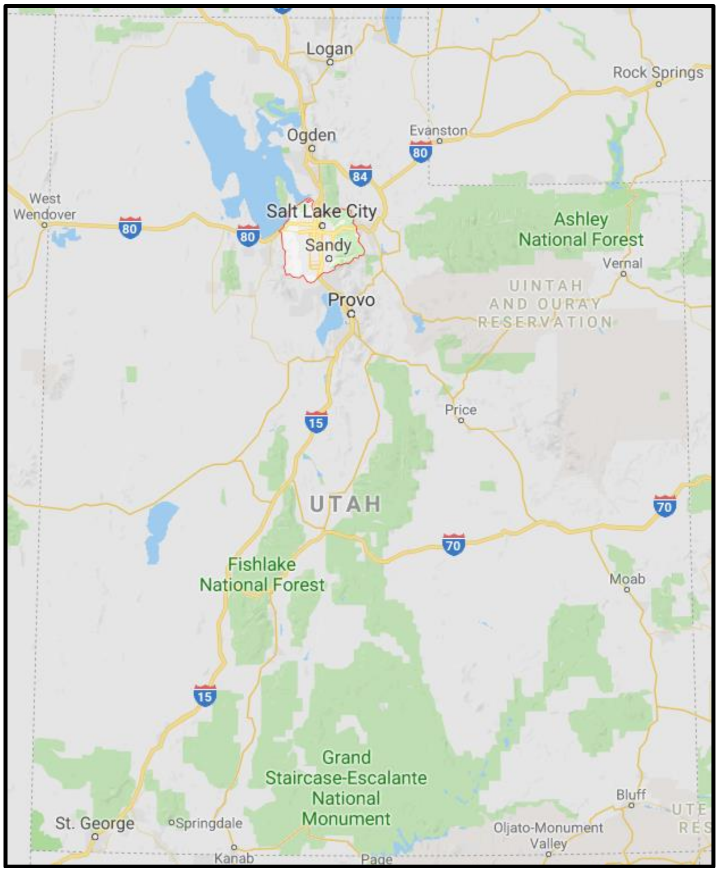

Figure 2. Salt Lake County in relation to the state of Utah

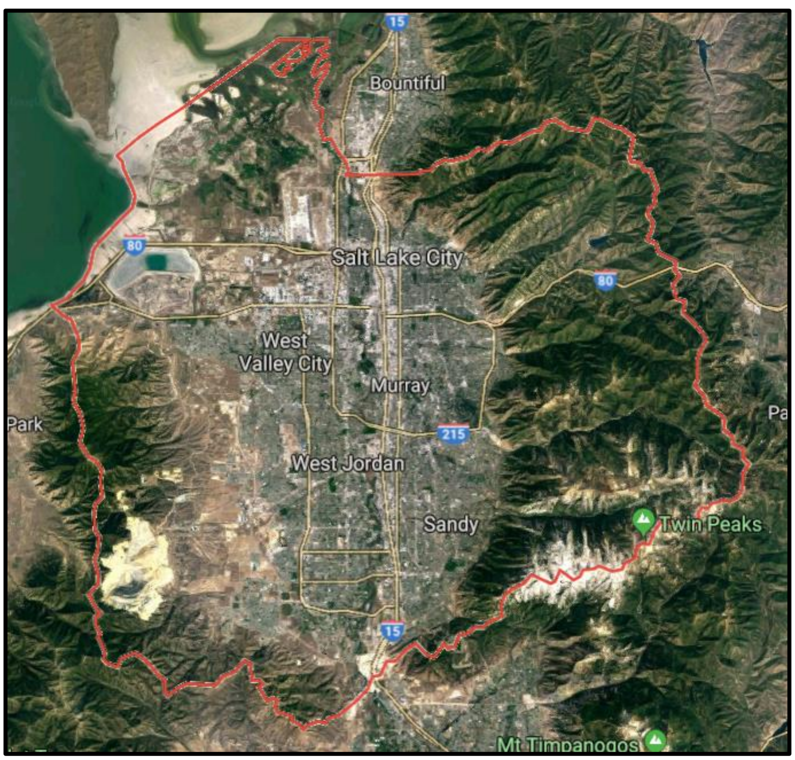

Figure 3: Aerial image of Salt Lake County

Methodology

Data Acquisition

The Jordan River Watershed is in the Great Basin Water resource region 16. More specifically, it is in 16b, the Great Salt Lake Basin. The datasets that were downloaded are from the National Hydrography Dataset Plus (NHDPlus) and included NHDSnapshot, NHDPlusAttributes, WBDSnapshot, and EROMExtension. These datasets are in vector format and include layers such as watershed boundaries, held in polygons, and flowlines, held as lines. These data sets are not projected but have a Geographic Coordinate System of GCS_North_American_1983.

Well data was obtained from USGS National Water Information System. Five water gauges were selected and archived in an excel spreadsheet by the provided latitude and longitude. These values were converted to decimal degrees so that they could be inserted into ArcMap as points. Along with these points is information about the drainage area in square miles.

Soil data was obtained from the SSURGO data downloader. The initial data shows the different soil classes in the subbasin, along with the subbasin boundary. There are many other fields that can be displayed to convey information. This data is in vector polygon format. The projected coordinate system of this data is WGS 1984 Web Mercator Auxiliary Sphere.

Data Processing

<u>Setting up the base data</u>

The analysis began by creating a geodatabase that held all information of this project. Within that geodatabase, a new feature dataset was created that held feature class base data that was generated throughout the analysis process. After adding the data, the Watershed Boundary Dataset was used to zoom into the Jordan River Watershed. This watershed has a HUC-8 value of 16020204. Using the tool select by attributes, all HUC-8s with is value were selected; then, these polygons were exported to a new layer, ensuring that they were all saved in the geodatabase as a new feature class. Symbology was then used to give each of the HUC-10 watersheds a different color (Figure 4).

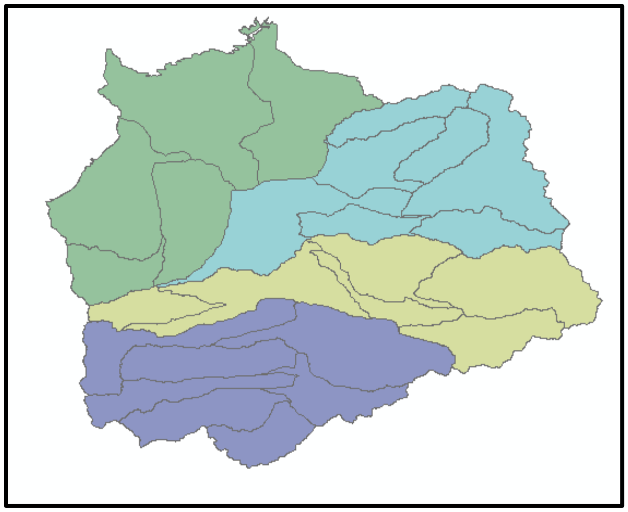

Figure 4. HUC-10 watersheds displayed by different colors

From the image, there are four HUC-10 watersheds, and 25 HUC-12 subwatersheds within the HUC-8 subbasin. From here, a subbasin boundary line was created using the dissolve (data management) tool. HUC-8 was used as the Dissolve field, so that all watersheds with the same HUC-8 number will merge. All that will be left is the total subbasin.

<u>Flowlines</u>

Going from the base data created in the first section, the flowline layer titles nhdflowline (Figure 5) were added. To clip the flowlines to only include those within the study site, the select by location tool was used. When those lines were selected, the data was exported into a new feature class and saved in a feature database. To get the result below, the symbology of the watershed layer was changed to be hollow with only outline color.

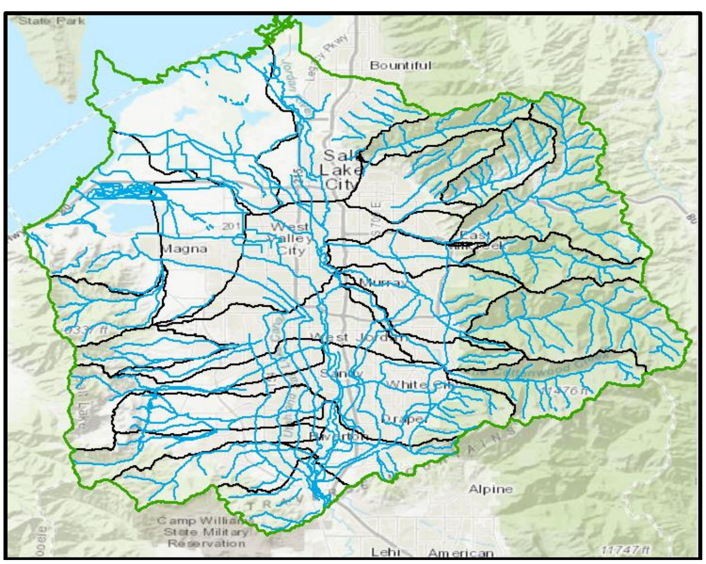

Figure 5. Flowlines in the subbasin.

To add attributes to these flowlines, the join function can be used to bring in more information. Two joins were performed to obtain the correct mean annual flow values. The table PlusFlowlineVAA was joined by reach code and joined again to Extended Runoff Method table by COMID. By doing this, only commonalities will be maintained, so many of the flowlines will be dropped out. Within the flowlines layer attribute table, field titled mean_annual_flow was added as type double. This field was calculated to be equal to EROM_MA0001.Q0001E, which is the mean annual flow of this table. When all joins were removed, mean annual flow remained in the flowline attribute table. The symbology was then changed to graduated symbols; figure 6 reflects the mean annual flow values.

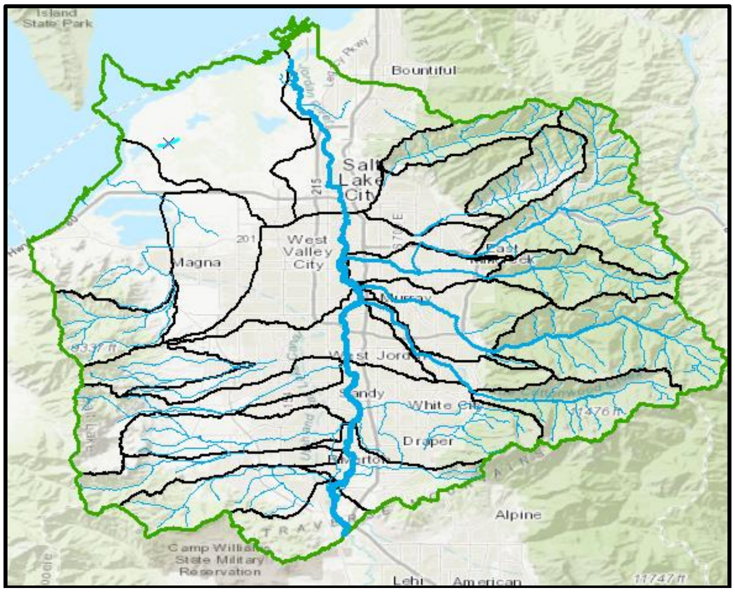

Figure 6. Flowlines symbolized by graduated mean annual flow

Stream gauge

After locating the stream gauges and placing them in an excel sheet (figure 7), the point feature class was created. To do this, the file was uploaded into ArcMap, which then caused it to display XY data. These points were then exported to the feature dataset. The points were then resized and labeled.

SiteID	SiteName	Latitude	Longitude	LatDD	Long	LongDD	DASqMile	MAFlow
10172200	RED BUTTE CREEK AT FORT DOUGLAS	40°46'48"	111°48'19"	40.78	111.805278	-111.805278	7.25	<Null>
10168300	TAILRACE AT STAIRS PLANT NEAR SALT LAKE CITY	40°37'26"	111°45'05"	40.623889	111.751389	-111.751389	49.2	<Null>
10167800	LITTLE COTTONWOOD CREEK @ CRESTWOOD PARK @ SLC	40°36'52"	111°50'32"	40.614444	111.842222	-111.842222	37	<Null>
10168000	LITTLE COTTONWOOD CREEK @ JORDAN RIVER NR SLC	40°39'51.5"	111°53'55.9"	40.664306	111.898861	-111.898861	46	<Null>
10171000	JORDAN RIVER @ 1700 SOUTH @ SALT LAKE CITY, UT	40°44'01"	111°55'21"	40.733611	111.9225	-111.9225	3438	<Null>

Figure 7. Excel spreadsheet for stream gauge data.

Soils

This data began as soil classifications, as shown in the image below. With the soils data downloaded, the clip (analysis) tool was used to clip the data down to only what is in the subbasin. This new feature class was then placed in the feature dataset.

With a reclassification of the symbology to graduated colors, the available water storage across the entire watershed was able to be seen.

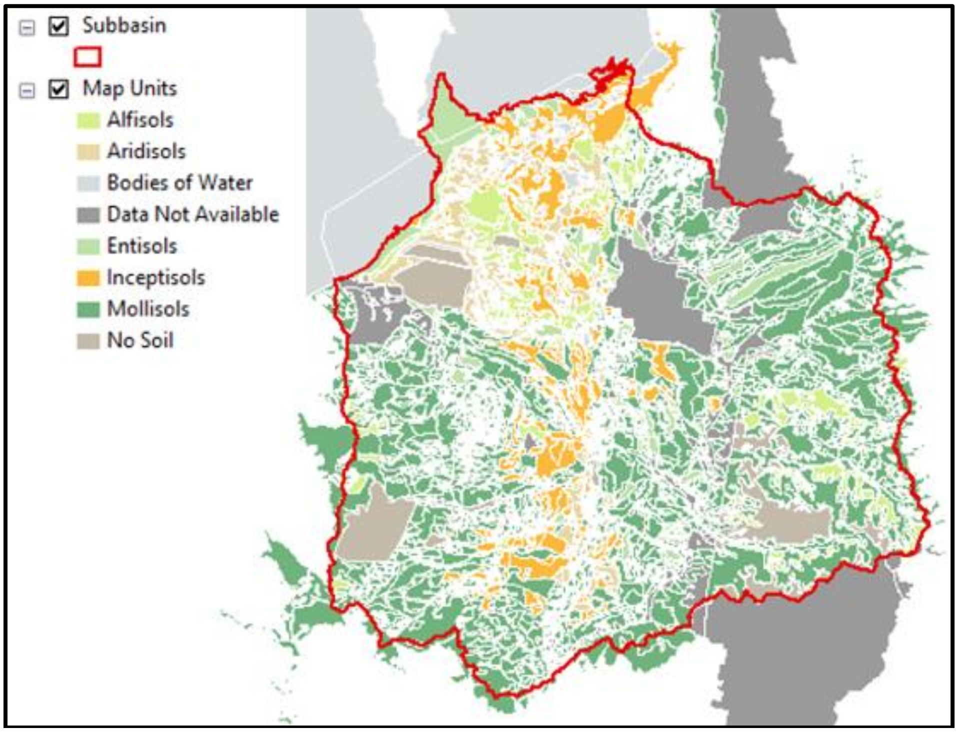

Figure 8. Soil Classes

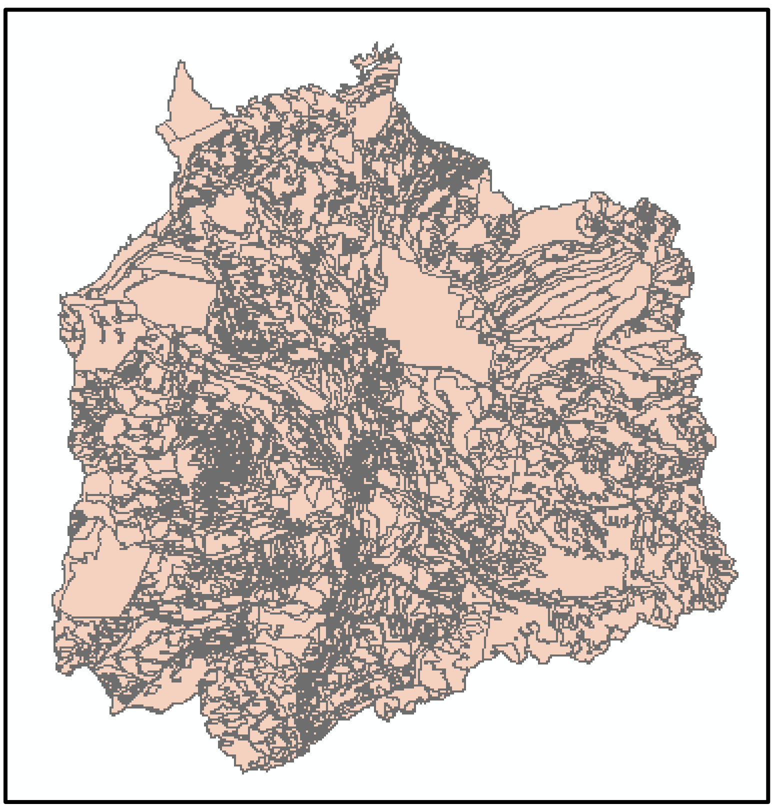

Figure 9. Soil base information

Shown below is the outline of the steps that were taken throughout the project process. This workflow should present two results conveying important hydrological information. The first should include the background knowledge of each HUC used, the flowlines symbolized by mean annual flow, and the stream gauge locations. The second map should show the soil data symbolized by the available water storage in the top 1 meter of soil throughout the valley.

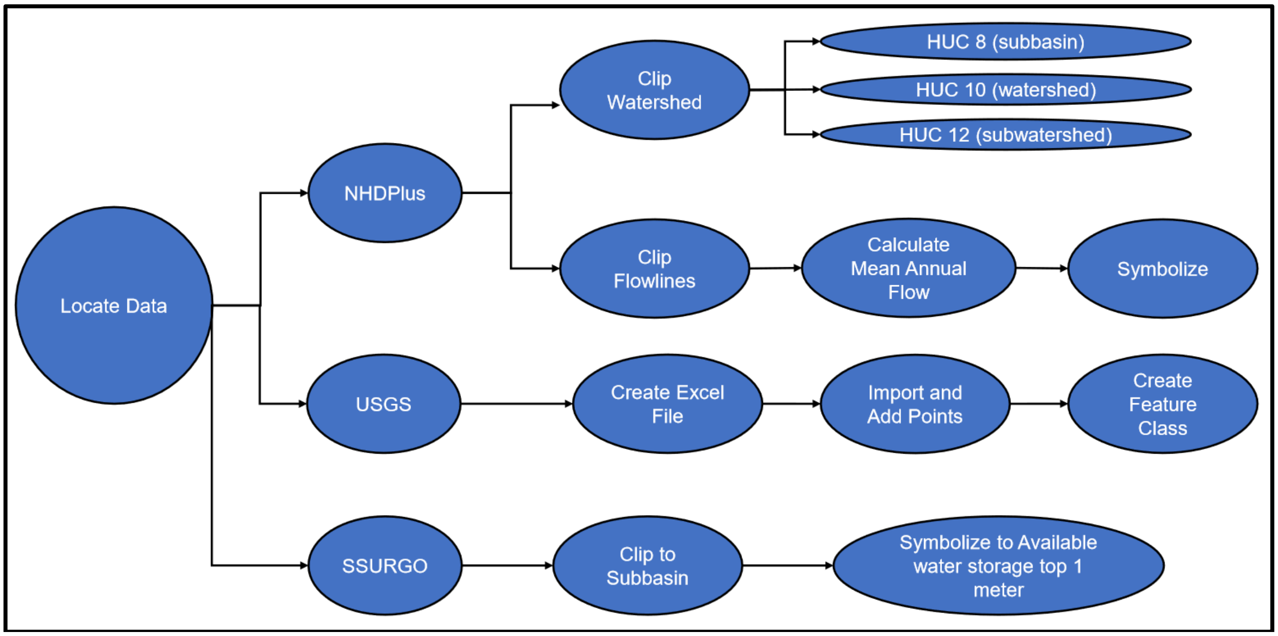

Figure 10. Flow chart showing major steps for this project

Results and Discussion

Result 1

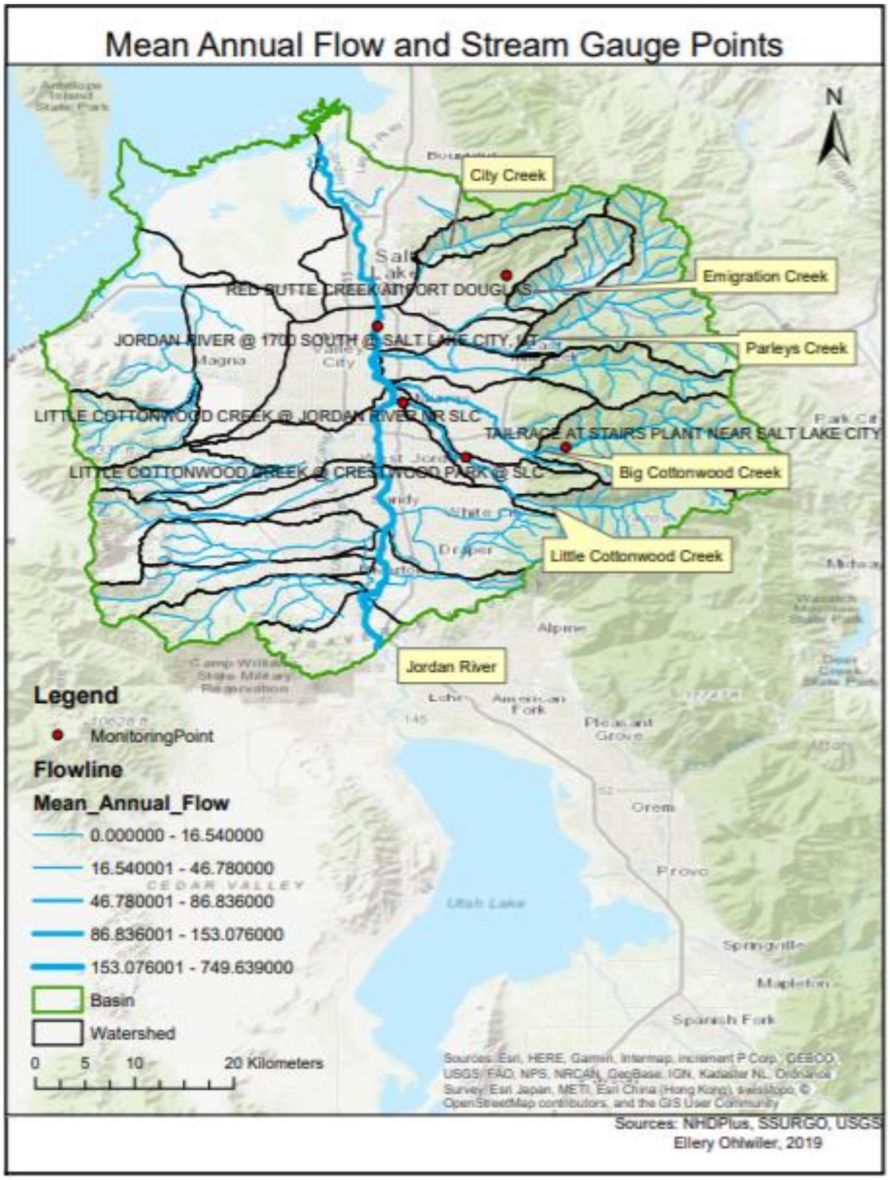

Figure 11. Flowline map for mean annual flow with major streams and monitoring points

Through this section of work, it is very important to make sure that the geodatabase and feature dataset are saved in an area that is easily found. The subbasin and watersheds are also important to understand, as they are going to be used as a foundation for each of the steps. One problem that arose when joining the tables to the flowline data. Many of the flowlines were dropped out, primarily the ones in developed areas. With the remaining flowlines, drainage density can be calculated by the total length of all rivers divided by the total area of the drainage basin. The result is 862.939/1850.8596 = 0.46624 1/km (figures 12 & 13).

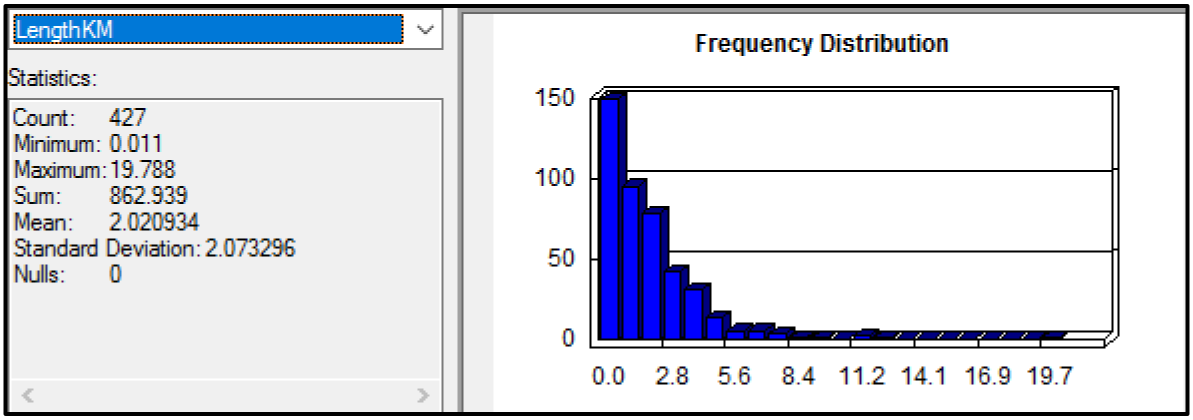

Figure 12. Total length of flowlines in kilometers

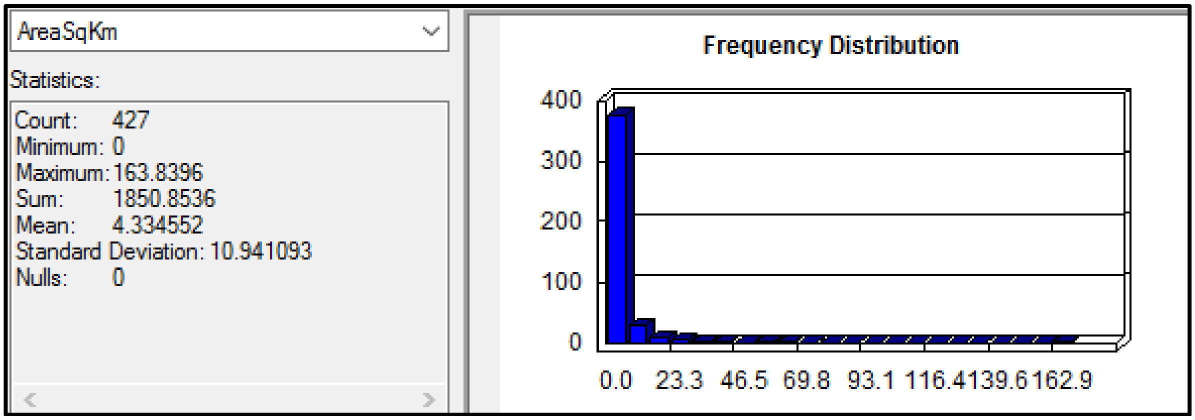

Figure 13. Total area of drainage basin in square kilometers

Most of the incoming streams are from the Wasatch Mountains, aside from the Jordan River. There were not many stream monitoring points through the valley; the ones that were picked were the ones that had the highest relationship with the high mean annual flow streams. Major streams in the mountains correlate to each of the 6 canyons that surround the valley. Both Big Cottonwood and Little Cottonwood canyon provide a lot of the water that is used in the valley. Because of this, dogs are not allowed up the canyons to maintain clean water. The lakes and reservoirs are not used for recreation of any type. Another important aspect to consider is the water that is coming in from the neighboring subbasins, such as Utah Lake.

The take away of this map emphasizes the importance of water management in the canyons. Many of the people on the east side of the valley get the benefit of first access to the fresh mountain water, while the people in the west side may get water that requires filtration and treatment. To further explore this, it would be interesting to look at the demographics of the valley and see how distribution of people correlate to the quality of the water.

Result 2

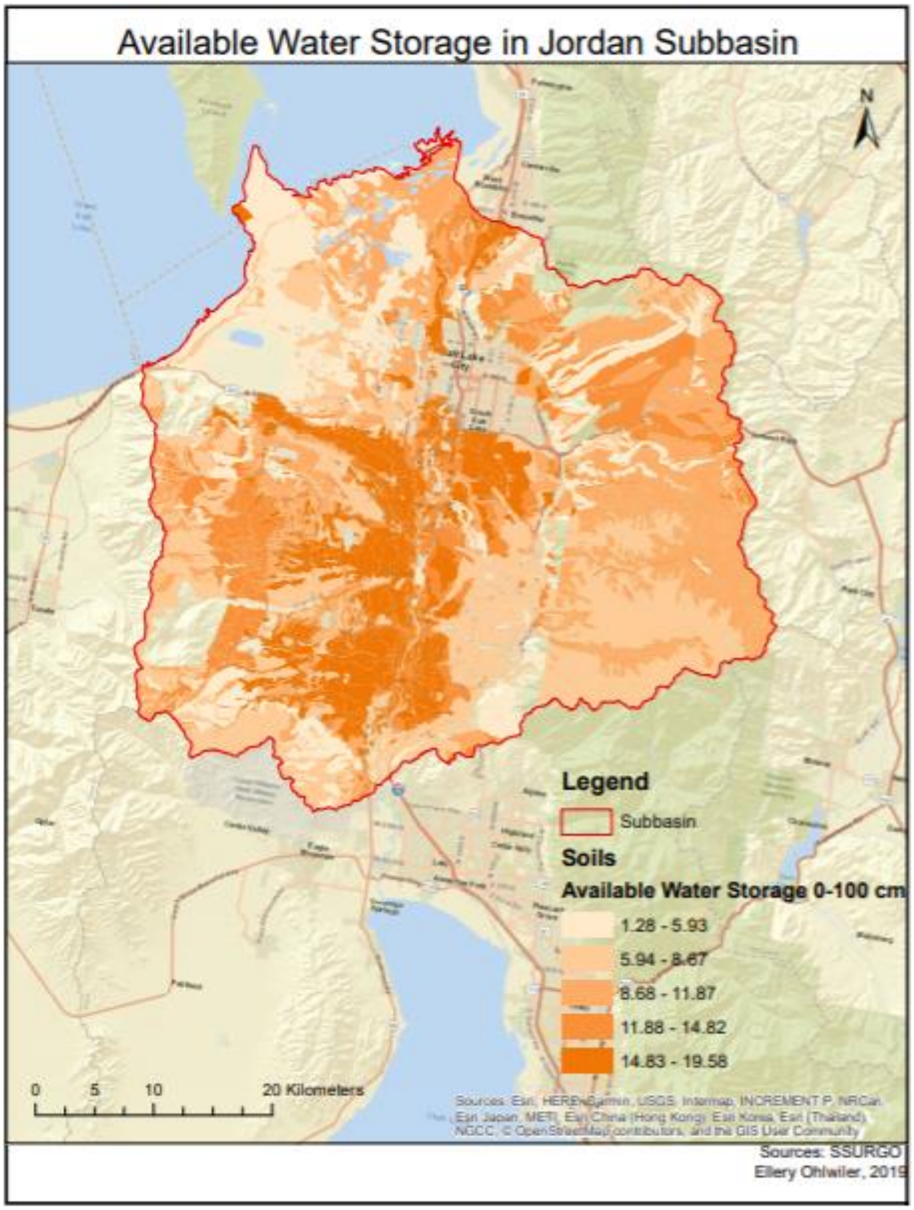

Figure 14. Soil map for available water storage

The area that has the most available water storage is at the bottom of the valley, along the Jordan River. These soils are comprised of mostly inceptisols, which are freely draining soils. The areas with moderate water storage are primarily mollisols, which are dark, nutrient-rich soils. The important thing to keep in mind with these results is the high amount of development in the valley. Development increases the chances of runoff. The total available water storage in the first meter of soil is 28525.48 cm^3.

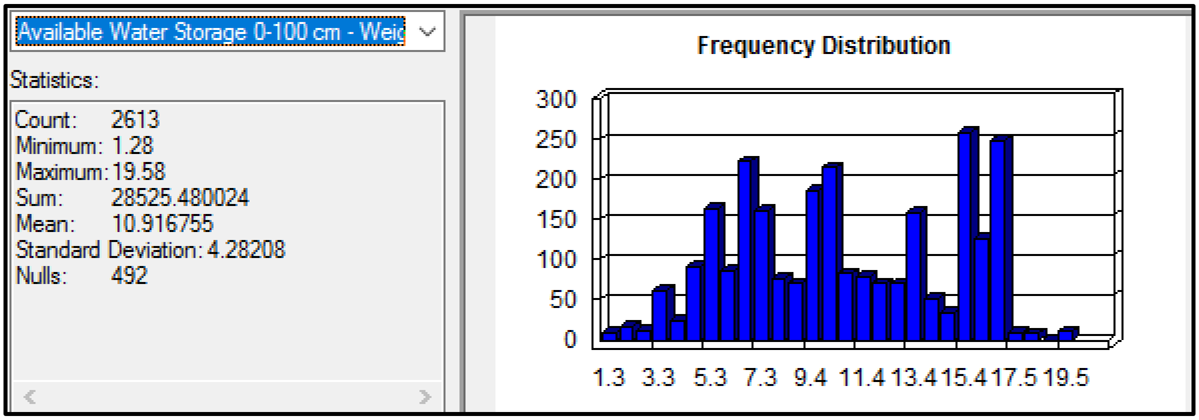

Figure 15. List of statistics for the available water storage in the first meter of soil

With further research, observing how development interacts with the available water storage in the valley and how the growing population will impact that is recommended. It is also recommended to view maps of different fields in the soils attribute table, such as floods, drainage, and water table depth.

Conclusion

The future of water in the Salt Lake valley is unknown. With climate change increasing average temperatures, it is anticipated that there will be less snow in the winter (Utah River Council 2012). Because snowpack is a slower release of water, storage is not a big concern. If the snow turns to rain, there is no plan to store that water for long term use. Along with that, the summers will be warmer and drier. This combination could be detrimental if management isn't emphasized now. By making the public aware of what the future could look like, this could bring in more stress to policymakers. The future water stress will also increase as the population continues to grow. This project emphasizes the importance of knowing where your water comes from and how it will change in the coming years.

References

"Jordan River Watershed." (n.d.). *Salt Lake County*, Watershed Planning and Restoration, <https://slco.org/watershed/know-your-local-waters/jordan-river-watershed/> (Mar. 17, 2019).

Sowby, R. (2014). "Where does Utah get its water?" *Wasatch Water Review*, <http://www.wasatchwater.org/utah-water-sources/> (Mar. 17, 2019).

Utah Rivers Council. (2012). "Crossroads Utah -- Utah's Climate Future." *Utah Rivers* , Utah River Council, <http://utahrivers.org/climate-change> (Mar. 17, 2019).