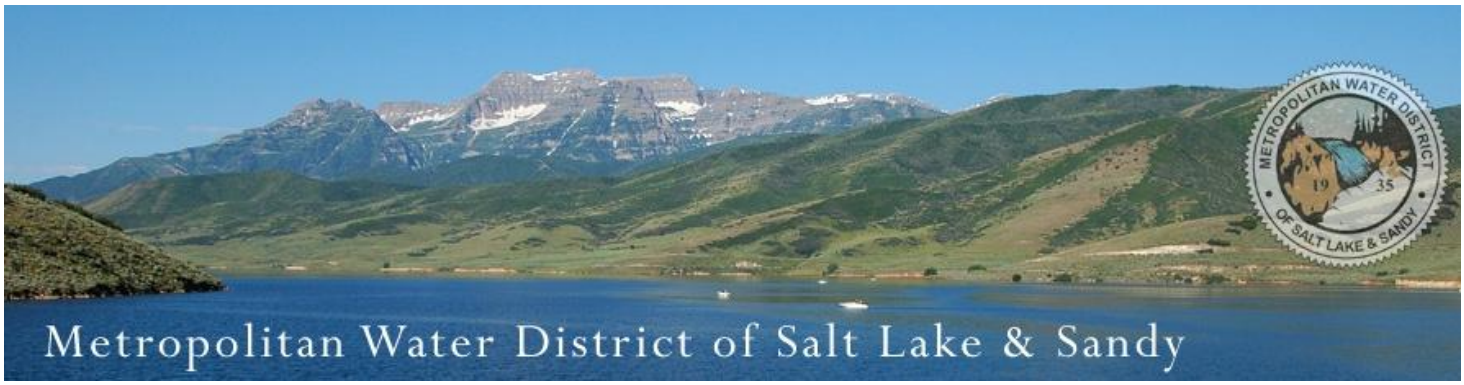


Analysis of Metropolitan Water District of Salt Lake and Sandy Water Resources

Daniel Ethington

CEE 6440 : ArcGIS for Water Resources

Final Report

Background

Metropolitan Water District of Salt Lake and Sandy was established in 1935 by the Salt Lake City Commission. Salt Lake City if the founding member and Sandy City joined the District in 1990. The District's primary function is to create a firm water supply for its member cities. The District also provides water to other outside agencies and entities on a surplus basis.

The District's Mission Statement States "The District is dedicated to providing high quality water and reliable services to our customers in a safe, timely, economical, and environmentally sensitive manner. We promote the wise, long term and sustainable use of water resources. We accomplish this by effectively managing valuable resources, utilizing practical technologies and providing employees with opportunities for growth and achievement."

Facilities

The District owns and operates two potable water treatment facilities. These facilities are summarized as follows:

I. Little Cottonwood Water Treatment Plant
- Location: Cottonwood Heights, Utah
- Year Built: 1960
- Treatment Design Capacity = 150 Million Gallons per Day (MGD)
- Method of Treatment: Conventional (sand filters) with primary treatment achieved with Ozone

II. Point of the Mountain Water Treatment Plant
- Location: Draper, Utah
- Year Built: 2006
- Treatment Design Capacity = 70 Million Gallons per Day (MGD)
- Method of Treatment: Conventional (sand filters) with primary treatment achieved with Ozone

Aside from the water treatment plants the District also operates the Salt Lake Aqueduct. This aqueduct supplies the majority of the District's raw water. Some of its features are as follows:

I. Design Capacity = 113 Million Gallons per Day (MGD)
II. 33 miles of untreated water conveyance
III. 9 miles of treated water conveyance
IV. 72 - 69 inch steel mortar lined and concrete pipe

The District also own and operates various other facilities that are described as follows:

I. Terminal Reservoir : 2 - 20 Million Gallon concrete potable water storage reservoirs
- Serves Salt Lake City
- Built in 1951 and currently being rebuilt with an addition of 8.7 MG storage

II. 15000 South Pipeline
- Design Capacity = 33 MGD (Gravity)
= 84 MGD (POMA Sleeve Valves)
- District owns 50%

III. Jordan Valley Water Treatment Plant
- Design Capacity = 180 MGD
- District Owns 2/7 = 51 MGD

Water Resources

I. Little Cottonwood Creek

- Avg. Supply per Year = 20,318 acre feet (ac-ft)

II. Little Dell Reservoir

- Avg. Supply per Year = 4,830 acre feet (ac-ft)

III. Deer Creek Reservoir

- Avg. Supply per Year = 41,416 acre feet (ac-ft)

IV. Jordanelle Reservoir

- Avg. Supply per Year = 20,000 acre feet (ac-ft)

Project Purpose & Objectives

The purpose of this project is to analyze the Districts water resources in the following four stages:

1) Analysis of Metro's current water resources in order to delineate the watersheds and accompanying areas and flows to these water bodies.

2) Analysis of land cover and land cover change in these watersheds in order to determine the effect of these changes with regard to water quality.

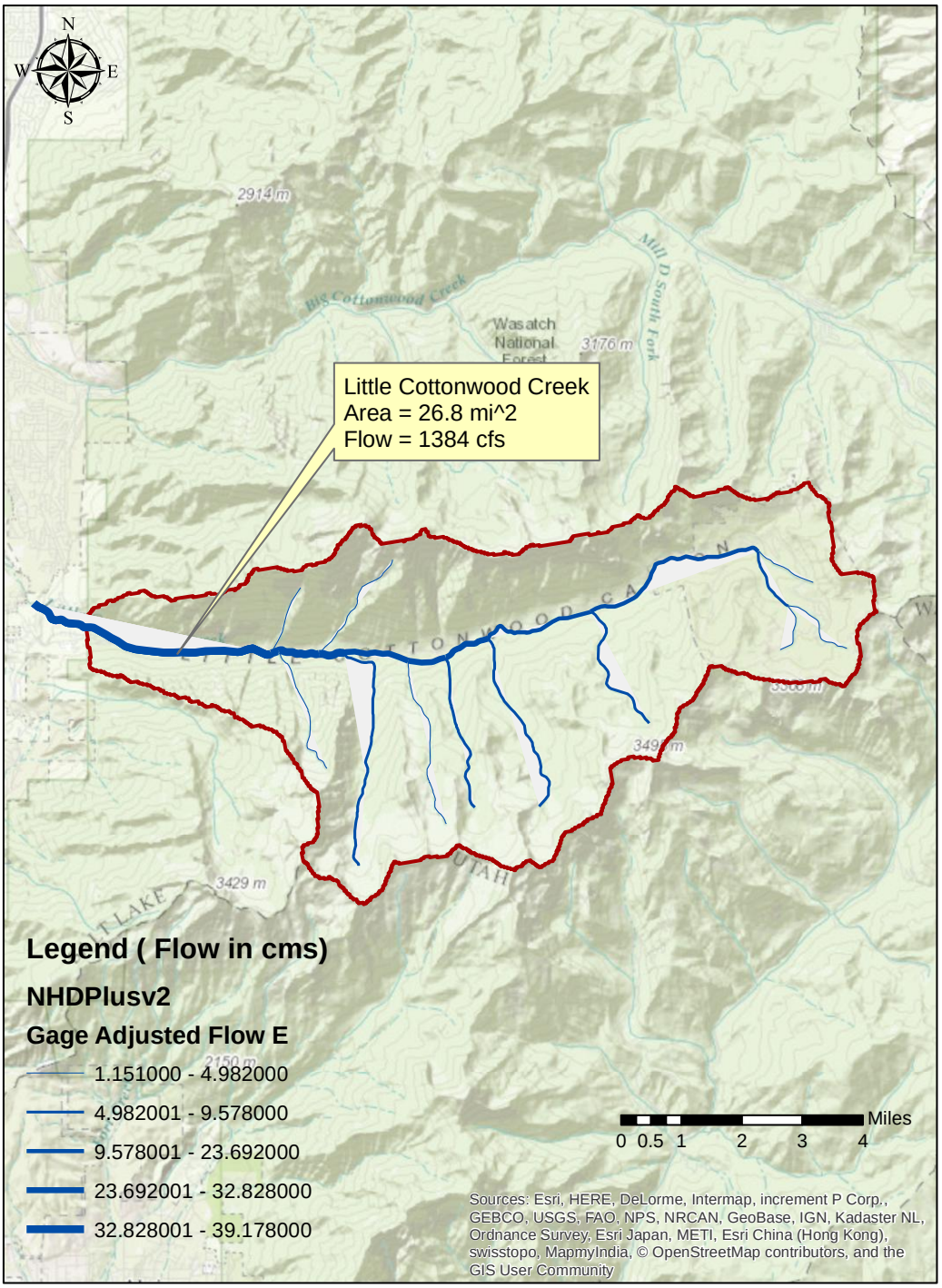
3) Analysis of growth patterns for member cities in order to determine water resource demands.

4) Determination if current Metro holdings are adequate to meet current demand and how long those resources are projected to be adequate.

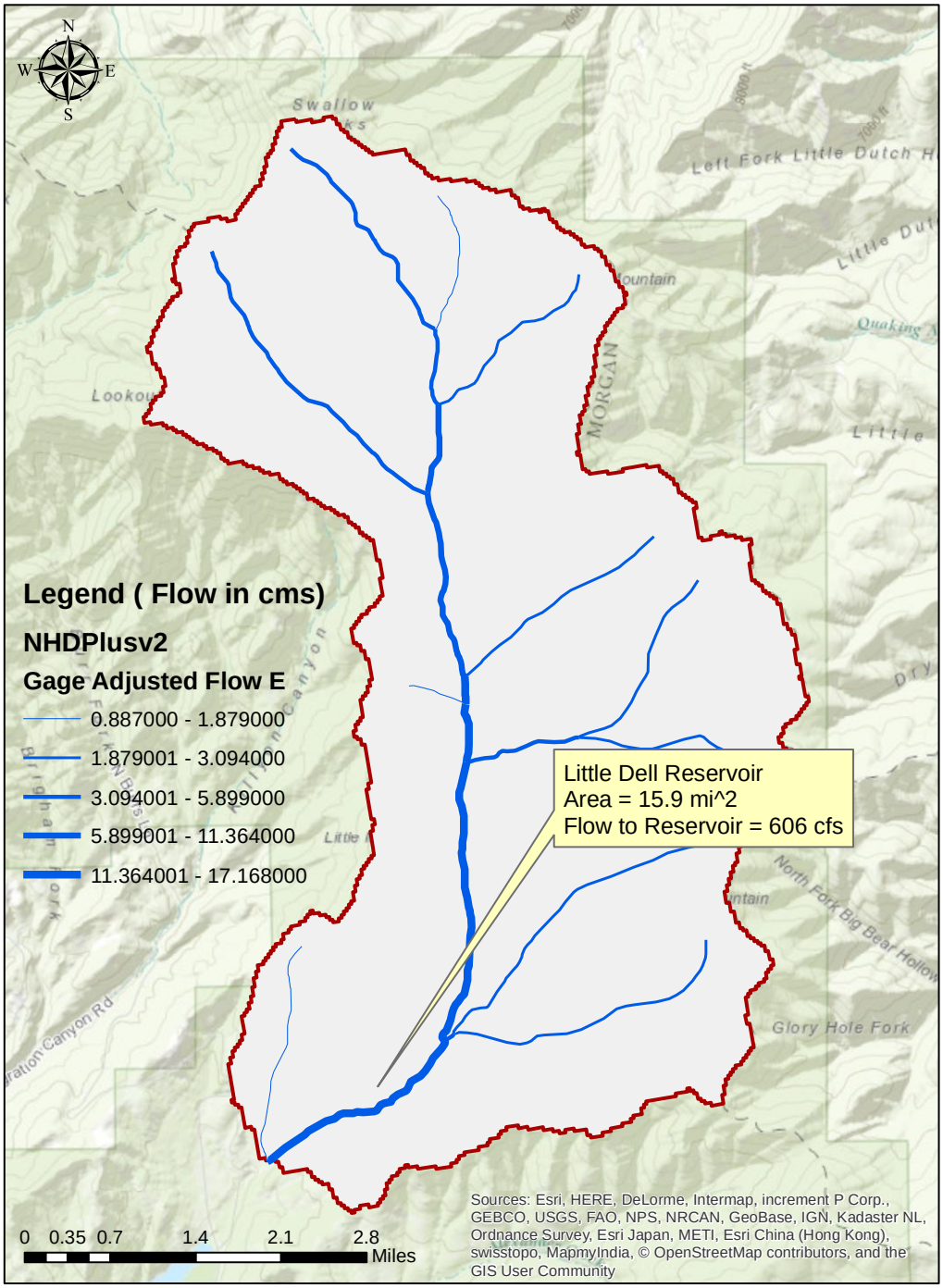
Stage 1 : Watershed Delineation

Through the utilization of ArcGIS the watersheds for each corresponding water source were delineated with its accompanying area. Also through the use of NHDPlus raster data set available in ArcGIS the stream flows for and to these water bodies were obtained.

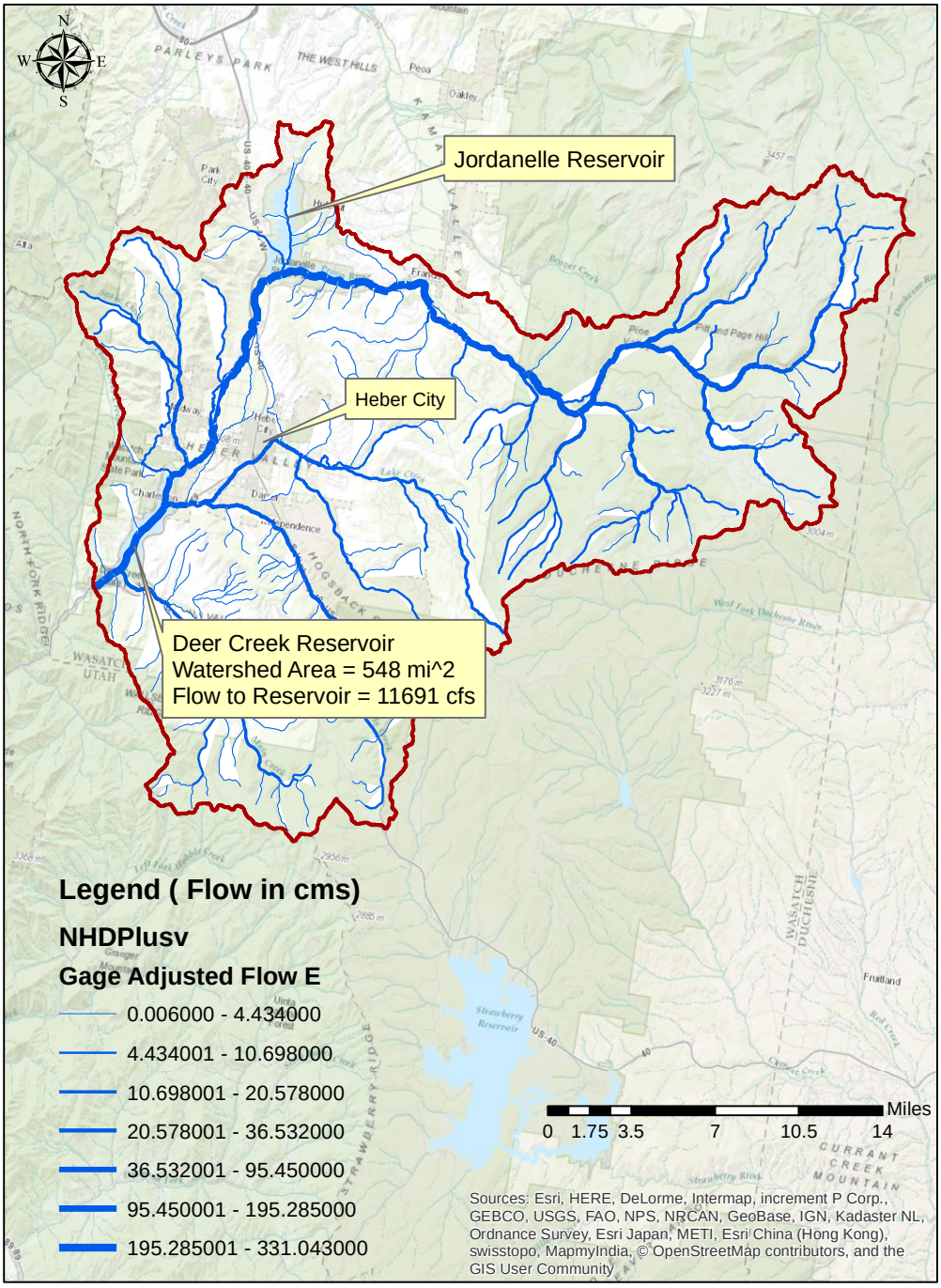
1) Little Cottonwood Creek Watershed



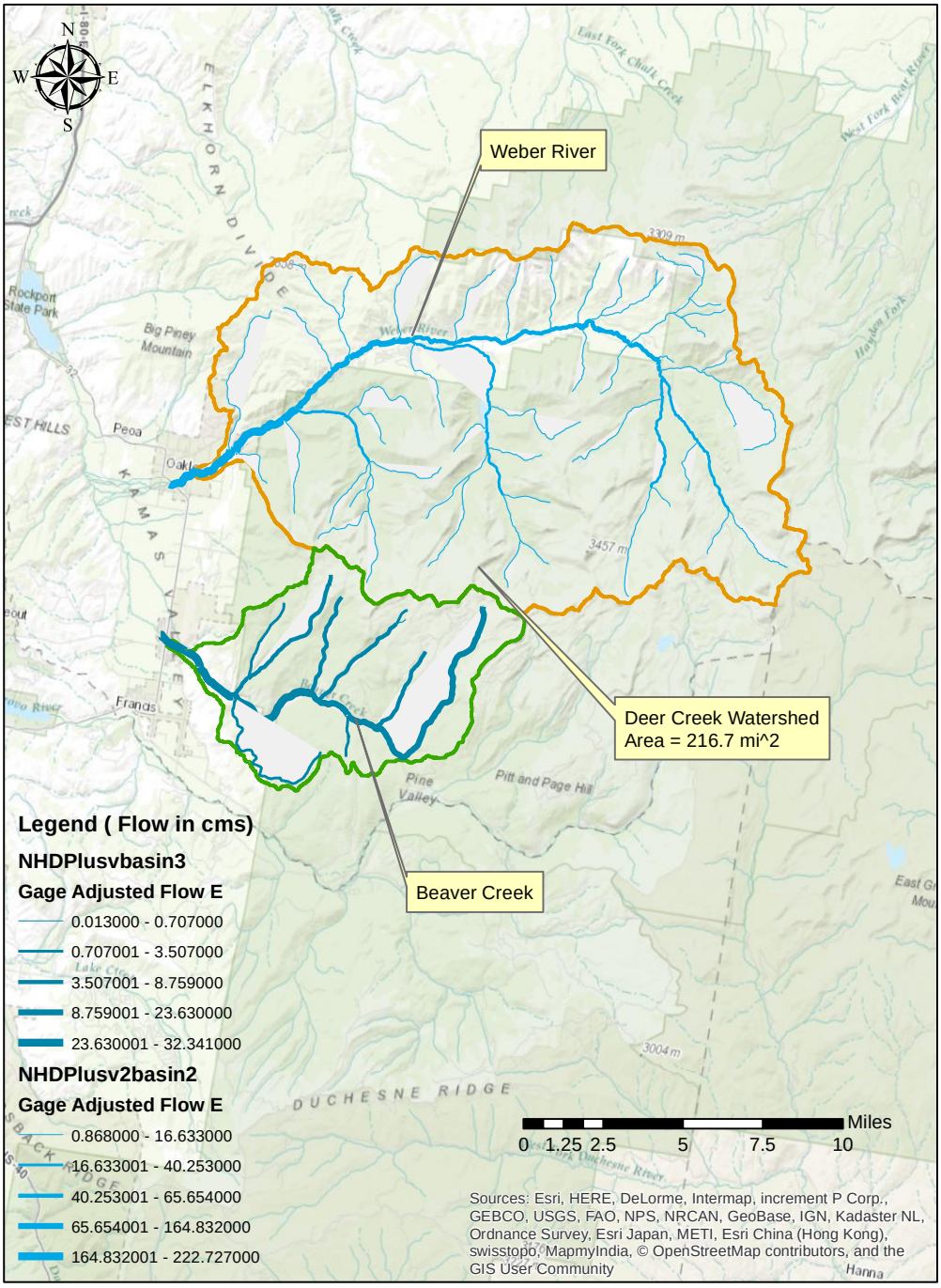
2) Little Dell Reservoir Watershed



3) Deer Creek Reservoir Watershed



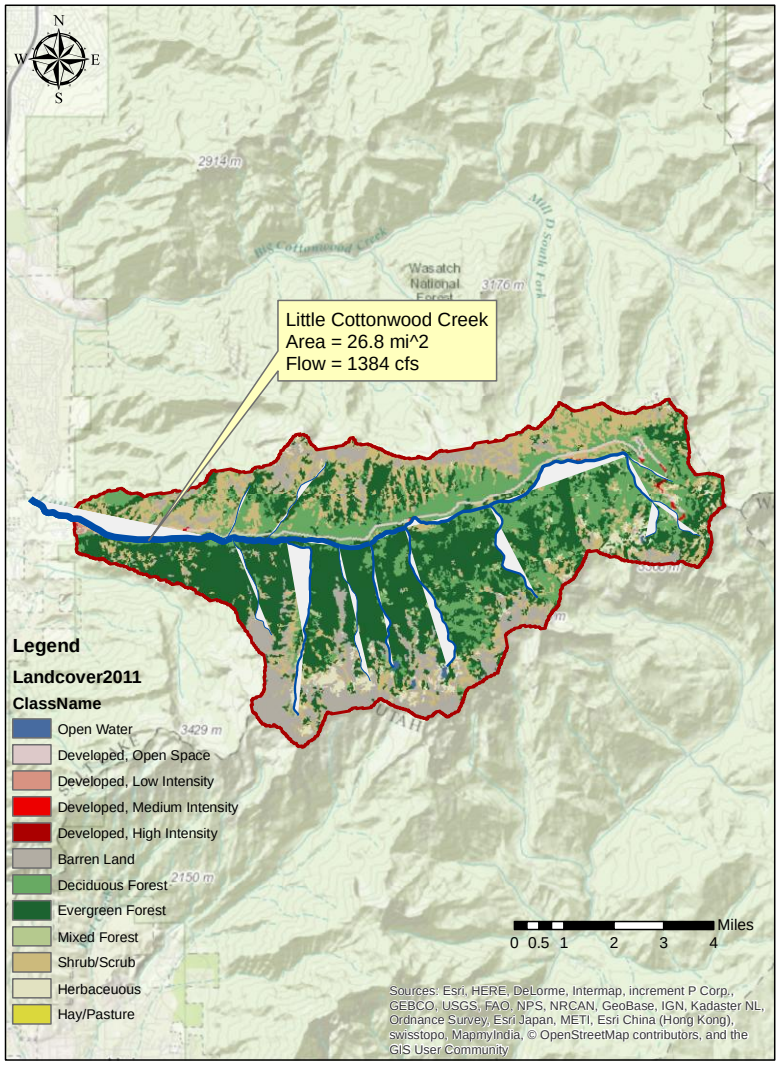
4) Jordanelle Reservoir Watershed



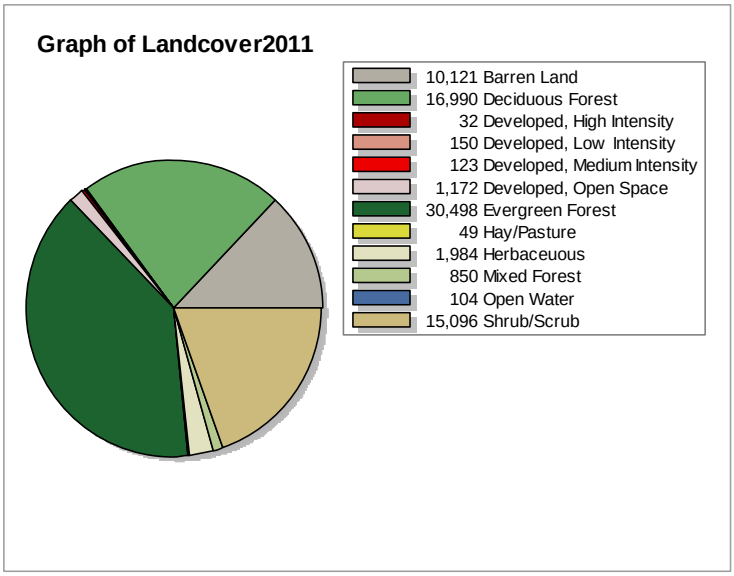
Stage 2 : Land Cover Effects

The land cover for each watershed was obtained through the National Land Cover Data set available through services within ArcGIS. This data was obtained so that the effects of land cover and its changes can be determined if they have any effect on the quality of water that is provided to the District. As part of the NHDPLus data set reported impairments from the Environmental Protection Agency (EPA) of water bodies are included. Along with this and reports from Utah's Division of Water the type and frequency of these impairments can be made.

1) Little Cottonwood Creek Watershed



Land Cover Analysis



Land Cover	Count	% of total
Open Water	104	0.13
Developed, Open Space	1172	1.52
Developed, Low Intensity	150	0.19
Developed, Medium Intensity	123	0.16
Developed, High Intensity	32	0.04
Barren Land	10121	13.12
Deciduous Forest	16990	22.02
Evergreen Forest	30498	39.52
Mixed Forest	850	1.10
Shrub/Scrub	15096	19.56
Herbaceuous	1984	2.57
Hay/Pasture	49	0.06
Total	77169	

From the obtained data one can see that the Little Cottonwood Creek watershed is mostly some type of forest whether that be evergreen, deciduous, or both. There is some development in this watershed. This is due to the two ski resorts that reside within the watershed (Alta and Snowbird Ski Resorts). The development mostly consists of low to medium intensity development such as large hotels, lodging complexes and skiing facilities. There were no appreciable changes in the land cover from the year 2006 to 2011.

Water Quality Analysis

Through the EPA and Utah Division of Water's websites it was determined that the waters of Little Cottonwood Creek contained trace pollutants

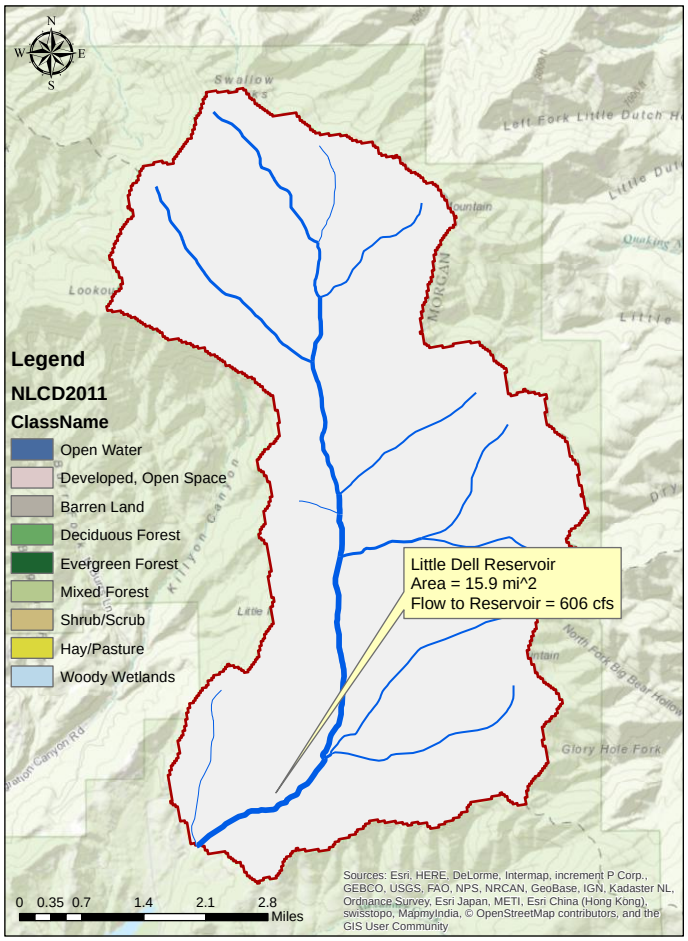
Causes of Impairment for Reporting Year 2014

Description of this table

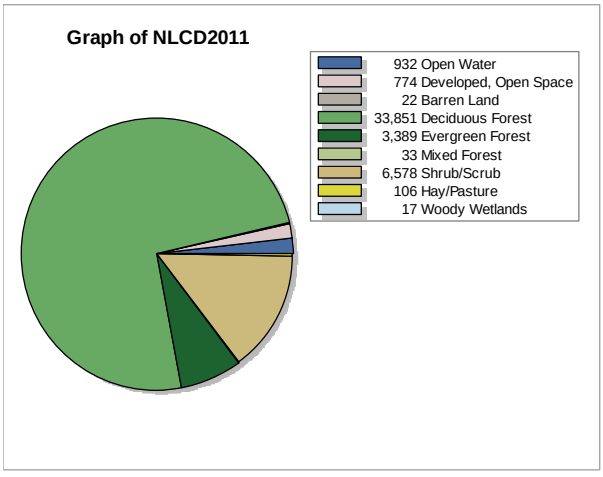
Cause of Impairment	Cause of Impairment Group	State TMDL Development Status
Cadmium	Metals (other than Mercury)	TMDL needed
Copper	Metals (other than Mercury)	TMDL needed
pH	pH/Acidity/Caustic Conditions	TMDL needed

Because of the trace nature of these impairments and it was deemed that these waters were relatively clean and no further investigation need be done.

2) Little Dell Reservoir Watershed



Land Cover Analysis



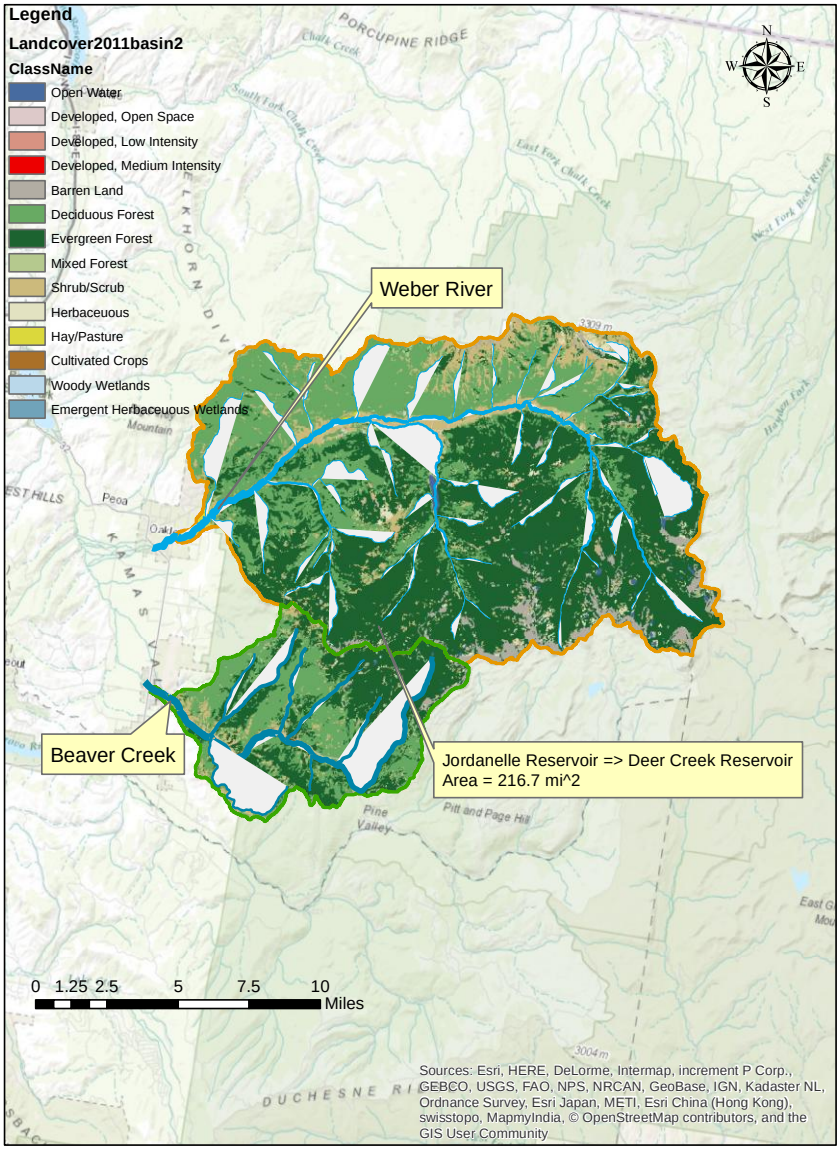
Land Cover	Count	% of total
Open Water	932	2.04
Developed, Open Space	774	1.69
Barren Land	22	0.05
Deciduous Forest	33851	74.07
Evergreen Forest	3389	7.42
Mixed Forest	33	0.07
Shrub/Scrub	6578	14.39
Hay/Pasture	106	0.23
Woody Wetlands	17	0.04
Total	45702	

From the obtained data one can see that the Little Dell Reservoir watershed is by the vast majority comprised of deciduous forest. There is some developed open space that comprises 1.6% of the total land. Other than this slight amount of developed open space this watershed has been kept untouched. . There were no appreciable changes in the land cover from the year 2006 to 2011. A contributing factor in the untouched state of this watershed is that it lies within the Wasatch Forest Reserve and such is stringently managed.

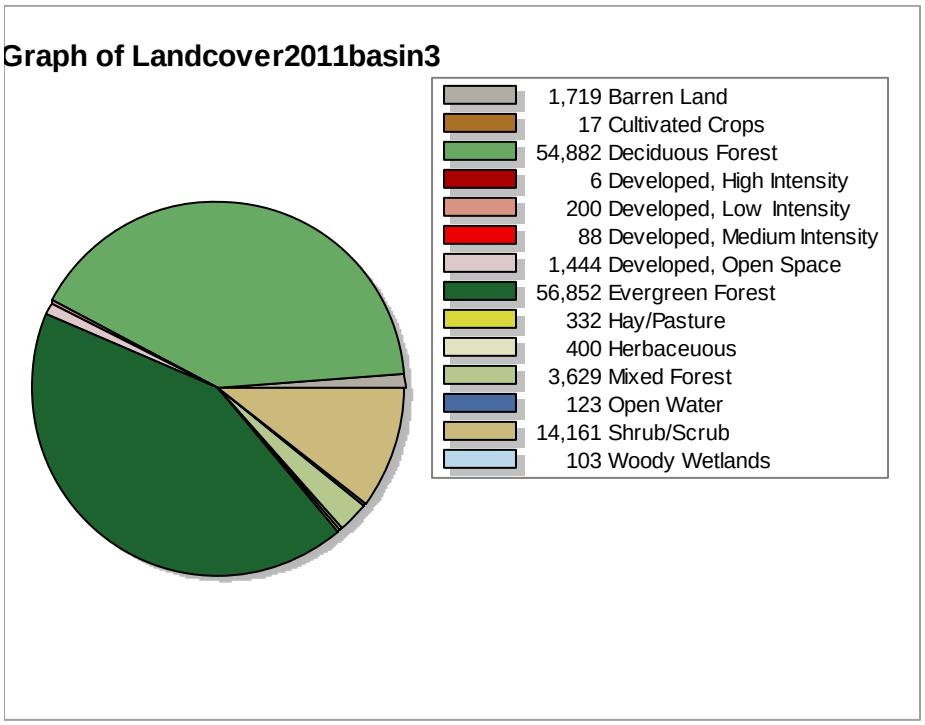
Water Quality Analysis

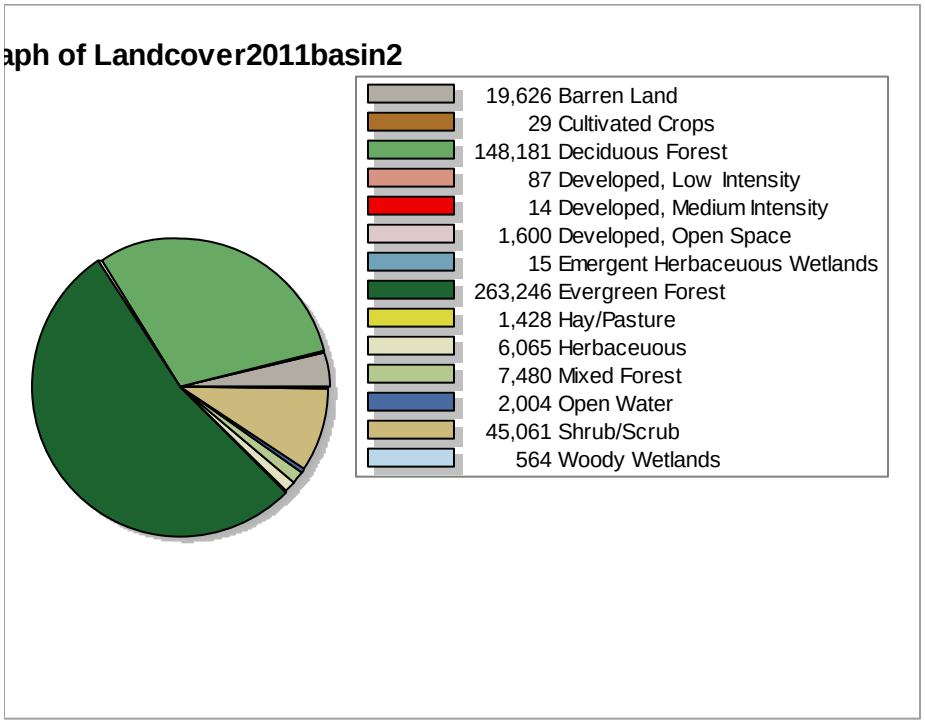
There were no historical or current reported impairments for this water body. Because of the lack of any recorded impairments and the lack of any development in the watershed this water can be considered pristine and no further investigation need be done.

3) Jordanelle Reservoir Watershed



Land Cover Analysis





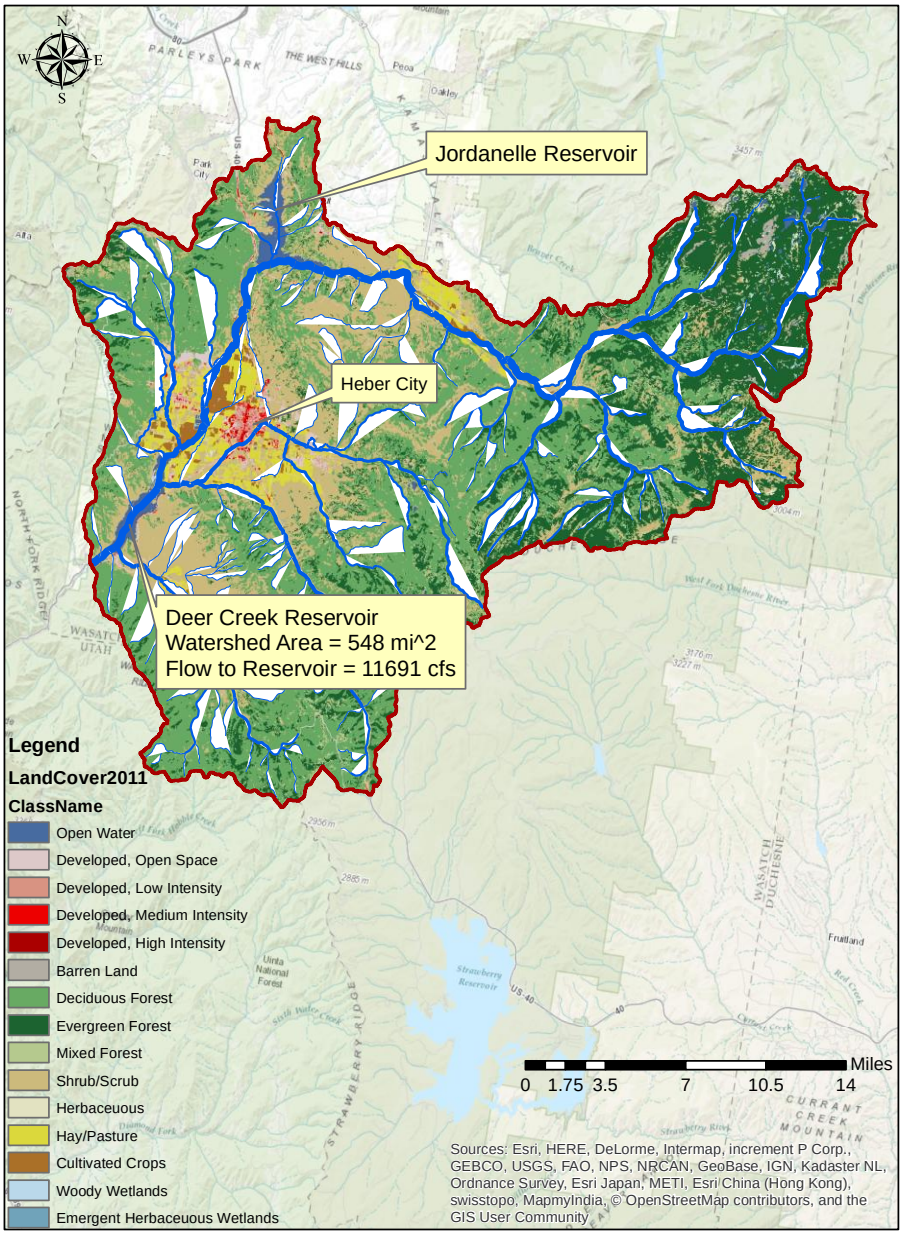
Land Cover	Count	% of total
Open Water	2127	0.34
Developed, Open Space	3044	0.48
Developed, Low Intensity	1800	0.29
Developed, Medium Intensity	102	0.02
Developed, High Intensity	6	0.00
Barren Land	21345	3.38
Deciduous Forest	203063	32.19
Evergreen Forest	320098	50.74
Mixed Forest	11109	1.76
Shrub/Scrub	59222	9.39
Herbaceuous	6465	1.02
Hay/Pasture	1760	0.28
Woody Wetlands	667	0.11
Cultivated Crops	46	0.01
Total	630854	

From the obtained data one can see that the Jordanelle Reservoir Watershed is mostly comprised of either deciduous or evergreen forests. There are some developed areas that indicate the presence of small towns. For the most part this watershed has remained untouched. There were no appreciable changes in the land cover from the year 2006 to 2011.

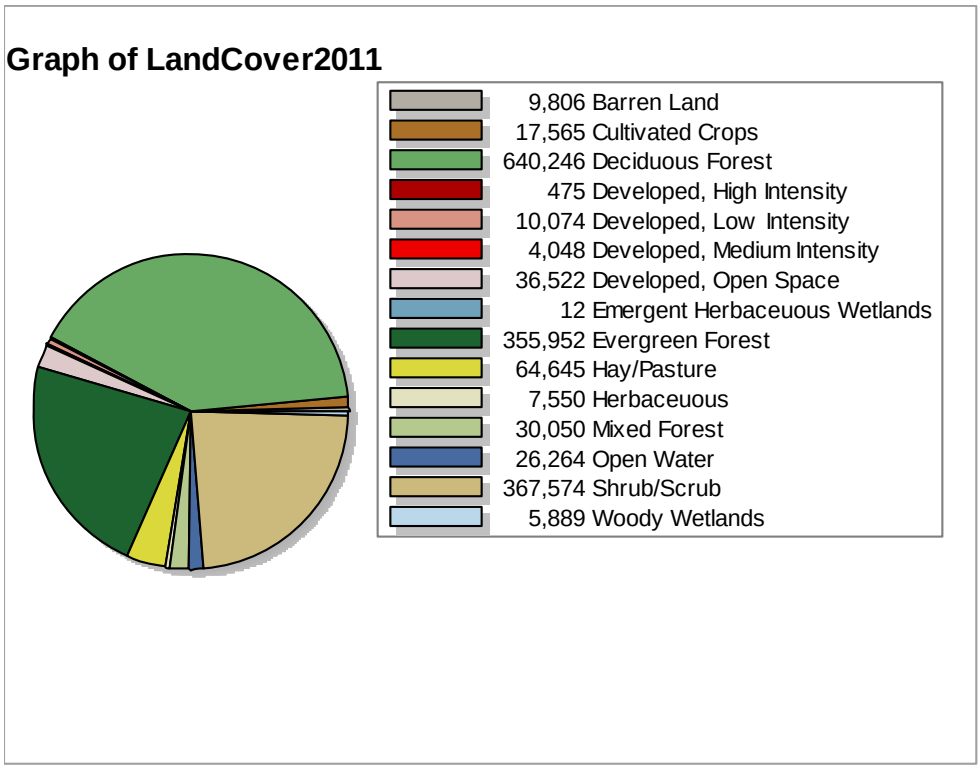
Water Quality Analysis

There were no historical or current reported impairments for this water body. Because of the lack of any recorded impairments and the lack of any development in the watershed this water can be considered pristine or near to and no further investigation need be done.

4) Deer Creek Reservoir Watershed



Land Cover Analysis



Land Cover	Count	% of total
Open Water	26264	1.67
Developed, Open Space	36522	2.32
Developed, Low Intensity	10074	0.64
Developed, Medium Intensity	4048	0.26
Developed, High Intensity	475	0.03
Barren Land	9806	0.62
Deciduous Forest	640246	40.61
Evergreen Forest	355952	22.58
Mixed Forest	30050	1.91
Shrub/Scrub	367574	23.31
Herbaceous	7550	0.48
Hay/Pasture	64645	4.10
Woody Wetlands	5889	0.37
Cultivated Crops	17565	1.11
Emergent Wetlands	12	0.00
Total	1576672	

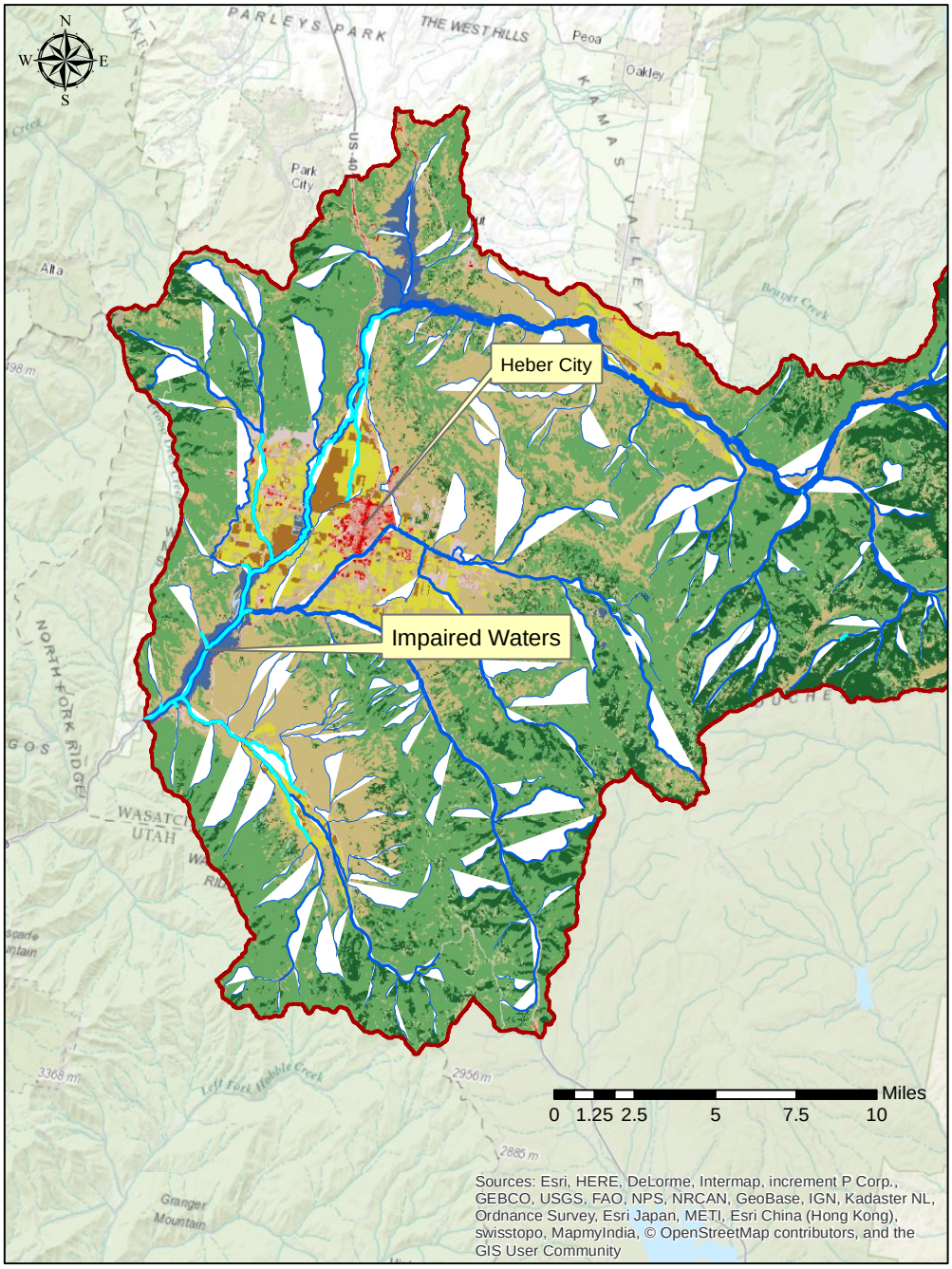
From the obtained data one can see that there is a shift in land cover for the Deer Creek Reservoir watershed versus the previous watersheds. Although the vast majority of the land cover is forest there is a more prevalent presence of development and agriculture. Developed spaces account for approximately 3.5% of the land cover. This is due to the presence of larger towns and cities such as Heber city and Midway within the Heber Valley. Heber Valley in the last year has seen an extraordinarily rapid expansion as the population has nearly doubled in the last ten years alone. This is due to the development of higher end homes and communities around mainly Heber city. The local of Heber valley makes it ideal for those who enjoy the temperate climate, beautiful scenery and convenient distance to Salt Lake City. Also with the Deer Creek Reservoir watershed there is a larger presence of agriculture. Agriculture lands account for approximately 5.25% of the land cover.

Unlike the other watersheds that influence the Districts water resources Deer Creek Reservoir watershed has seen a significant change in land cover. As stated before the Heber Valley in the last ten years has seen a dramatic increase in development and population. More and more land is being developed and from the year 2006 to 2011 this watershed saw a 0.63% change in land cover when compared to the total area of the watershed. The vast majority of the land cover change occurred because of low to medium intensity development in and around Heber City.

Water Quality Analysis

The Deer Creek has approximately 445 stream reaches. Out of those reaches there are currently reported impairments in 41 stream reaches. These stream reaches have various reported impairments some of which are listed below:

- Mercury
- pH
- Temperature
- Metals other than Mercury
- E. Coli
- Pathogens
- Nutrients
- Phosphorous


Heber City
Impaired Waters
Miles
0 1.25 2.5 5 7.5 10
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Causes of Impairment for Reporting Year 2010

Description of this table

Cause of Impairment	Cause of Impairment Group	State TMDL Development Status
Arsenic	Metals (other than Mercury)	TMDL needed
Escherichia Coli (E. Coli)	Pathogens	TMDL needed

Causes of Impairment for Reporting Year 2014

Description of this table

Cause of Impairment	Cause of Impairment Group	State TMDL Development Status
Phosphorus, Total	Nutrients	TMDL needed
pH	pH/Acidity/Caustic Conditions	TMDL needed

Phosphorous and other nutrients such as nitrogen are of particular interest to the District. These nutrients accumulate within water bodies such as Deer Creek Reservoir. When these nutrients are withdrawn through the Salt Lake Aqueduct they will interact with microorganisms within the raw water. These microorganisms will in turn form a biofilm within the aqueduct. This biofilm will decrease the capacity of the aqueduct in turn costing the District resources in combating this biofilm and revenue as they have to supplement this loss with other means.

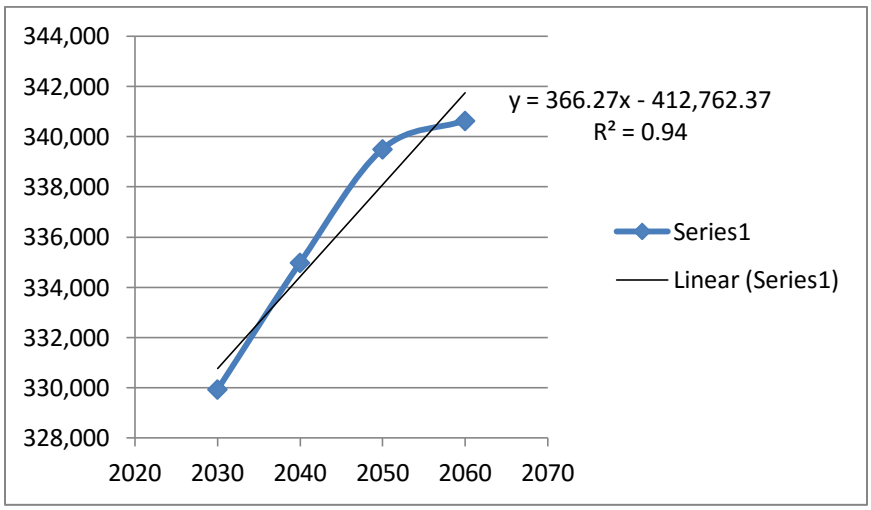
The location of these impairments is worth noting. These instances occurred within or just downstream of an area that is predominately agriculturally developed. This is a common phenomena throughout the world. The close proximity of these agricultural lands to a water body allows these pollutants to easily enter these water bodies. These pollutants can enter the water by various means such as application of fertilizer, grazing of animals and mining activities past or present.

Stage 3 & 4 : Water Resource Demand and Forecasting

In order to determine the water demand on the District's resources a forecasting model had to be developed. To start a population growth trend had to be determined. In order to develop this trend the State of Utah Governor's Office population projections for the member cities was

utilized. This projection is carried out the year 2060. The Governor's Office will only project out 50 years due to the ambiguity of any further projection. The trend to project further was established by using the last 40 years of their projection. This was done because these projections form a more consistent growth pattern.

By means of linear regression within excel an equation with which population forecasting can be conducted.



The corresponding high value of R^2 means that this equation is highly correlated to the population data.

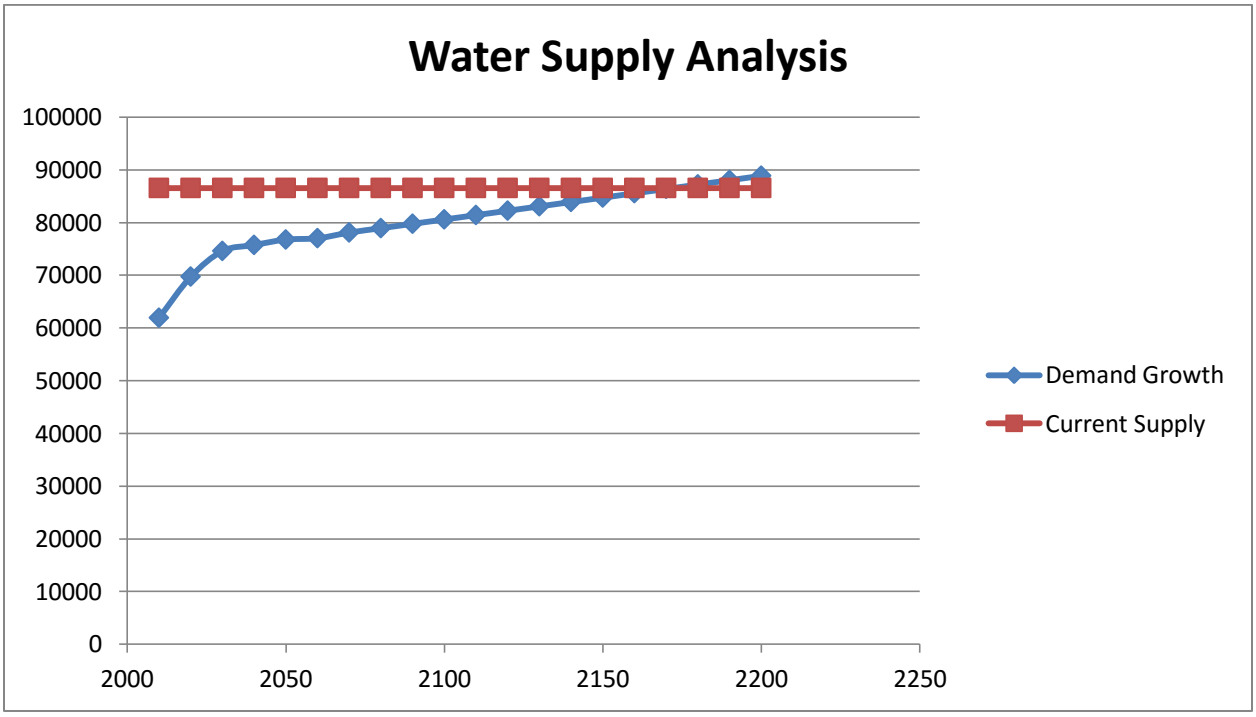
Using reported data of water supply and demand from the member cities from the District a demand forecasting was determined. This reported demand from the District was then reduced to a per person basis so that this forecast can be determined by population alone.

	Sandy City	Salt Lake City	Total
Avg. Demand per year (ac-ft)	16432	45513	61945

Demand (ac-ft) /pers./yr	total demand/ total pop.	0.226

City	2010	2020	2030	2040	2050	2060
SLC	186,440	210,592	227,824	229,985	233,031	234,704
% growth	-	12.954	8.183	0.948	1.324	0.718
Sandy	87,461	97,826	102,107	104,993	106,471	105,929
% growth	-	11.851	4.377	2.826	1.407	-0.509
Total Pop.	273,901	308,417	329,932	334,978	339,502	340,633
% growth		12.602	6.976	1.530	1.350	0.333
Demand (ac-ft)	61945	69751	74617	75758	76781	77037

With this forecasting the adequacy and time with which these water resources will last can then be determined. The results are shown as follows:



As these results show that with the District's current average yearly water supply of 86,564 acre feet, these water resources will be adequate until approximately the year **2170**.

Closing Comments

Suffice it to say the Metropolitan Water District of Salt Lake and Sandy has more than ample supply of water currently and for the distant future. This can be attributed to any number of reasons. The most prevalent reasons that the District has managed their water well and that through their acquisition of water rights has comfortably secured the Districts future for well over the next century. In a state that is one of the driest it is reassuring to see that entities such as the District know the importance of water in societies grounded in arid regions and that they can respond in turn by planning accordingly to secure the future for sustained growth of the communities it serves.