2017 SALT LAKE COUNTY WATER QUALITY ANNUAL REPORT

A summary of the health and quality of streams in Salt Lake County

Prepared by:
Salt Lake County Watershed Planning & Restoration Program
2001 South State Street, Suite N3-120, Salt Lake City UT 84190
https://slco.org/watershed/

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ABSTRACT

This Salt Lake County Watershed Planning and Restoration (WPRP) report aims to quantify and explain the functionality of the Jordan River Watershed and sub-basins within Salt Lake County jurisdiction. The 2009 Salt Lake Countywide Water Quality Stewardship Plan (WaQSP) identified data gaps when trying to determine overall watershed health. These data gaps lead to continued monitoring of the Jordan River Watershed in an effort to track how ecosystems respond to water availability, management practices, and restoration efforts.

In the 2017 water year (October 1, 2016 - September 30, 2017) WPRP collected nearly 650 samples from over 100 locations within the Jordan River Watershed. WPRP Staff will continue to monitor water quality in the Jordan River Watershed with an aim to determine where/why degradation occurs, and provide solutions to preserve the chemical, physical, and biological integrity of the watershed.

The Jordan River Watershed and its sub-basins drain over 800 square miles (515,600 acres) of land with a terminus at the Great Salt Lake. For the purposes of this document the Watershed follows the political boundary of Salt Lake County. Its boundaries are created by the surrounding Wasatch Mountains to the East, the Traverse Mountains to the South, and the Oquirrh Mountains to the West. There are ten major streams from the Wasatch Mountains and seven streams from the Oquirrh Mountains. Major streams range in size from less than three miles to 26 miles in length and have unique flow and water quality conditions. In addition to ecological, water quality, and social functions, these streams are identified as countywide facilities for flood control purposes and are often used to convey stormwater discharge to either the Jordan River or the Great Salt Lake. The Jordan River Watershed pairs together a dynamic topographic environment with a variety of resource interests. In order to properly highlight trends in water quality, this document takes a subwatershed approach to provide an analysis of each component of the larger watershed. Overall watershed characteristics will be considered in a summary following subwatershed information.

The methodologies used in this study are the same as the data collection protocols outlined in the Sampling and Analysis Plan (SAP) for Salt Lake County. To summarize, four major categories were assessed in this study: field parameters, bacteria, macroinvertebrate health, and stream channel stability sampling. Field parameters relate to water chemistry and are collected with every bacteria sample and macroinvertebrate sample. Bacteria samples are collected monthly using the EPA approved Colilert method. Macroinvertebrate samples are collected three out of every five years, to determine ecosystem health via the Karr-BIBI and Biological Condition Gradient (BCG) scores. In an attempt to collect data related to channel stability on all major waterways throughout Salt Lake County, WPRP walks rivers and streams from their headwaters to terminus determining different reaches based on stream type and change to overall stability. Stream stability was sampled independently of this report and began in 2009.

Data for each sampling location can be found in the 2017 site Data Appendix that accompanies document.

Although the streams of Salt Lake County all have unique characteristics and differing results, there are some watershed-wide patterns that have been observed. 2017 was a slightly above average year regarding snowpack, which increased flows in the higher elevation subwatersheds for one to two months. After snowmelt runoff, high summer air temperatures settled in and baseflow levels were quickly reached. This can be seen in the bacteria and field parameters data with dilution of parameters during runoff and increases in stream temperature once baseflow is reached. The most apparent trend is a decrease in stream function as soon as streams meet urban areas. This loss in function is seen in both stream stability and ecosystem health. Stream stability shows a reduction of stable channel types

and negative stability scores in urban areas. Ecosystem heath is shown with the rapid decline in macroinvertebrate scores in all urban areas. Even in the urban sections that are still are steep and confined with little change in field parameter values, macroinvertebrate scores indicate loss of ecosystem health. This could be related to the increase in urbanization, storm water runoff, and channel over-widening, as well as a reduction of sinuosity, floodplains, and canopy cover. Another common watershed-wide trend is the relationship between intermittent flow and negative scores on all data collected. There are stream channels that are naturally dry seasonally and some where this occurs because of management practices. In both cases low scores are achieved for both macroinvertebrates (if data can be collected) and stream stability. Specifically, Big Cottonwood Creek and Little Cottonwood Creek could benefit from the addition of baseflow year-round by changing water management practices.

INTRODUCTION

With completion of the Area-Wide Water Quality Management Plan in 1978, Salt Lake County Government was designated the regional water quality planning authority. Since then, the program has developed into the Salt Lake County Watershed Planning and Restoration Program (WPRP). Although the name and the scope of work have changed over time, the focus to provide "a continuous planning process directed toward achieving the policy of restoring and maintaining the chemical, physical and biological integrity of the waters of Salt Lake County" (Area-Wide Water Quality Management Plan 1978) remains the same. This WPRP report aims to quantify and explain the functionality of the Jordan River Watershed and sub-basins within Salt Lake County jurisdiction. The 2009 Salt Lake Countywide Water Quality Stewardship Plan (WaQSP) identified data gaps when trying to determine overall watershed health. These data gaps lead to continued monitoring of the Jordan River Watershed in an effort to track how ecosystems respond to water availability, management practices, and restoration efforts.

In the 2017 water year (October 1, 2016-September 30, 2017) WPRP collected nearly 650 samples from over 100 locations within the Jordan River Watershed. A variety of parameters were tested including Temperature (°C), pH, Dissolved Oxygen (% and mg/L), Conductivity (mS/cm), Turbidity (NTU), Total Flow (CFS), Coliform Bacteria (MPN), Coliform E. coli (MPN), and Macroinvertebrate Health (BCG & KARR-Bibi). The data from these collection points aid in painting a picture of overall watershed health throughout the Jordan River Watershed and its sub-basins. Salt Lake County WPRP will continue to monitor water quality in the Jordan River Watershed with an aim to determine where/why degradation occurs, and provide solutions to preserve the chemical, physical and biological integrity of the watershed.

WPRP staff would like to thank Salt Lake County Flood Control and Engineering for continued support. This document includes invaluable data and expertise from many individuals and organizations including The Utah Division of Water Quality, Salt Lake County Gauging Program, University of Utah Environmental and Sustainability Program, and Bob Wisseman with Aquatic Biology Associates.

WATERSHED DESCRIPTION

The Jordan River Watershed (the Watershed) and its sub-basins drain over 800 square miles (515,600 acres) of land with a terminus at the Great Salt Lake. Its boundaries are created by the surrounding Wasatch Mountains to the east, the Traverse Mountains to the south, and the Oquirrh Mountains to the west. Nearly half (46%) of the Watershed is mountainous terrain and largely undeveloped. Watershed management concerns vary greatly including source water protection and recharge, wilderness management, dispersed recreation concerns, urban stormwater runoff, and urban flood prevention. There are ten major streams, or subwatersheds, that discharge into the Jordan River from the Wasatch Mountains. These account for most of the water coming into the Jordan River and are driven primarily by snowpack. The Oquirrh Mountains have seven streams that discharge into the Jordan River. They vary from intermittent to ephemeral and contribute to the Watershed mostly through rainfall and agricultural return flows. The Traverse Mountains act as a border to the south separating Utah Lake from the Jordan River. Technically the Jordan River Watershed is a subwatershed of the larger Great Salt Lake Watershed which includes Utah Lake. For the purposes of this document the Watershed follows the political boundary of Salt Lake County.

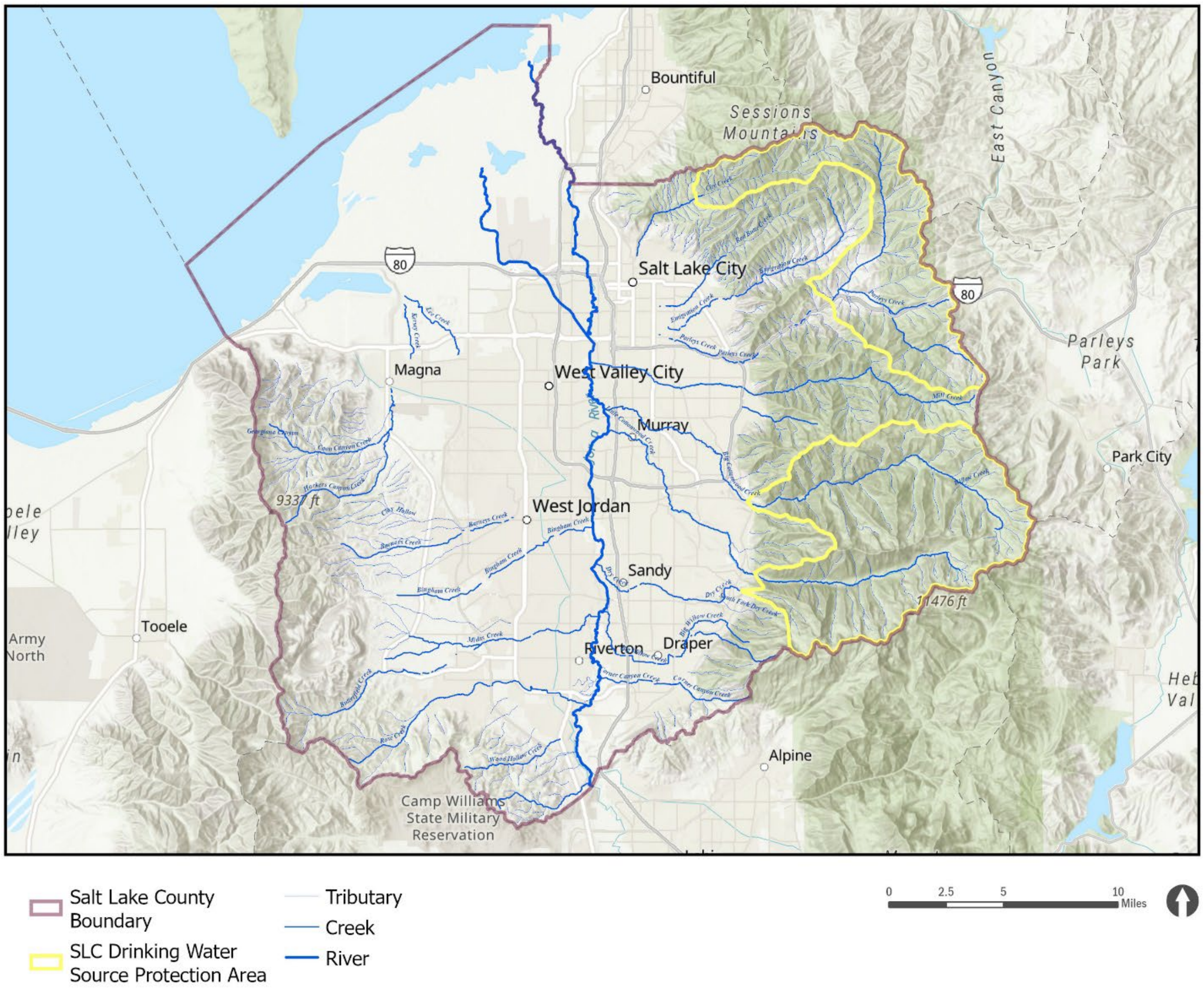


Figure 1. Salt Lake County Watershed

Like many watersheds containing mountainous areas and valley systems, there is drastic change in topography. The highest point is the Broad's Fork Twin Peaks in the Wasatch Range, with an elevation of 11,329 feet. Much of the upper elevation areas are found in the Wasatch Mountains, although the Oquirrh Mountains have peaks that exceed 10,000 feet (Flat Top Mountain 10,613 feet). These upper elevations receive snowpack in the winter that can exceed 600 inches and drive much of the Jordan River Watershed's hydrologic cycle. Moving toward the valley floor from the Wasatch and Oquirrh Mountains are a series of benches and alluvial fans, which often coincide with increased residential development. Moving farther to the valley floor, land slopes decrease and urban/commercial lands increase. All the tributary rivers in the valley flow from the mountains to the Jordan River, which flows north between the Wasatch and Oquirrh Mountains. There are ten major streams that originate from the Wasatch Mountains and seven streams from the Oquirrh Mountains. Although waters from these streams eventually discharge into the Jordan River, many are conveyed through urban areas by underground pipes or canal systems. Major streams range in size from less than three miles to 26 miles in length and have unique flow and water quality conditions. In addition to ecological, water quality, and social functions, these streams are identified as countywide facilities for Salt Lake County's flood control purposes and are often used to convey stormwater discharge to either the Jordan River or the Great Salt Lake. The Jordan River is approximately 52 miles long flowing from Utah County, through Salt Lake County, and into the Great Salt Lake in Davis County. Much of the Jordan River and its tributaries along the valley floor have been straightened and down-cut, while residential and commercial development have reduced river sinuosity and floodplain availability. The terminus of the Jordan River, into the Great Salt Lake, is at roughly 4,200 feet although the lake level is prone to fluctuation.

The Jordan River Watershed pairs together a dynamic topographic environment with a variety of resource interests. In order to properly highlight trends in water quality, this document takes a subwatershed approach to provide an analysis of each component of the larger watershed. Overall watershed characteristics will be considered in a summary following subwatershed conclusions.

Weather within the county boundary varies greatly in many aspects. Seasonal extreme temperatures range from -30° F in the winter to 110° F in the summer. Water surface evaporation in the valley averages 42-inches per year. The average frost-free season for the valley area is approximately 200 days and usually occurs between the middle of April and the end of October. As is the case with many western watersheds, annual precipitation totals vary dramatically. As a result of large differences in elevation, average annual precipitation ranges from 12 inches in the lower valleys to 50+ inches in the highest mountain areas. Snow accumulation and melt is a very significant feature in terms of the annual hydrologic cycle.

Land use is an important factor contributing to existing and projected water quality conditions of surface waters. Analyzing existing and future land use data helps identify where predicted changes could threaten water quality the most. The most widely seen land use change is an increase of impervious surfaces and less open space, which can impact water quality in the following ways: (1) reduced groundwater recharge; (2) increased volume of stormwater discharges; (3) increased runoff into streams that could exacerbate flood potential and erosion, thereby affecting the aquatic habitat; and (4) increased urban pollutants discharged to streams by stormwater runoff. With the expansion of urban development into previously undeveloped areas and increasing population densities, Salt Lake County expects the amount of impervious surface area throughout the county to increase. This increase is expected to be seen less in the mountainous areas and more heavily in the transition of rural/agricultural into residential lands along the valley floor.

SUBWATERSHED DESCRIPTIONS

Salt Lake County's eastside creeks have their headwaters high in the Wasatch Range. The upper sections of these watersheds, generally from the canyon mouth up, are characterized by open spaces that are managed for forest land, recreation, and protection of water supply resources. Steep mountain canyons set the stage for high flows during the spring snowmelt season, which ranges from April through July depending on elevation and snowpack.

Originating in the Oquirrh Range the westside creeks featured in this report have perennial flow in short sections but are largely intermittent. The lack of streamflow in these creeks makes sampling difficult and only three creeks are continually monitored. Rose, Midas, and Bingham are the three creeks monitored in this report and will commonly be referred to as the westside tributaries. After years of stream modification, they are not entirely natural stream channels, but they resemble historic drainage ditches. They have dramatically increased in size, flow, and flow duration from human activities. These include conveyance of canal overflow and irrigation water to downstream water rights holders, and higher volumes of storm runoff from impervious surfaces (pavement, rooftops, etc.) as development continues. As a result, westside stream flows do not reflect the typical spring runoff/high flow scenario observed in streams of the Wasatch Range. Rather, they flow during irrigation season (mid-April through mid-October) and storm events, with peak flows occurring during summer downpours, not spring snow melt.

Bingham, Barneys, Coon, and Harkers Creeks are also found on the westside of Salt Lake County. None are tributaries of the Jordan River but are, of course, all part of the larger watershed.

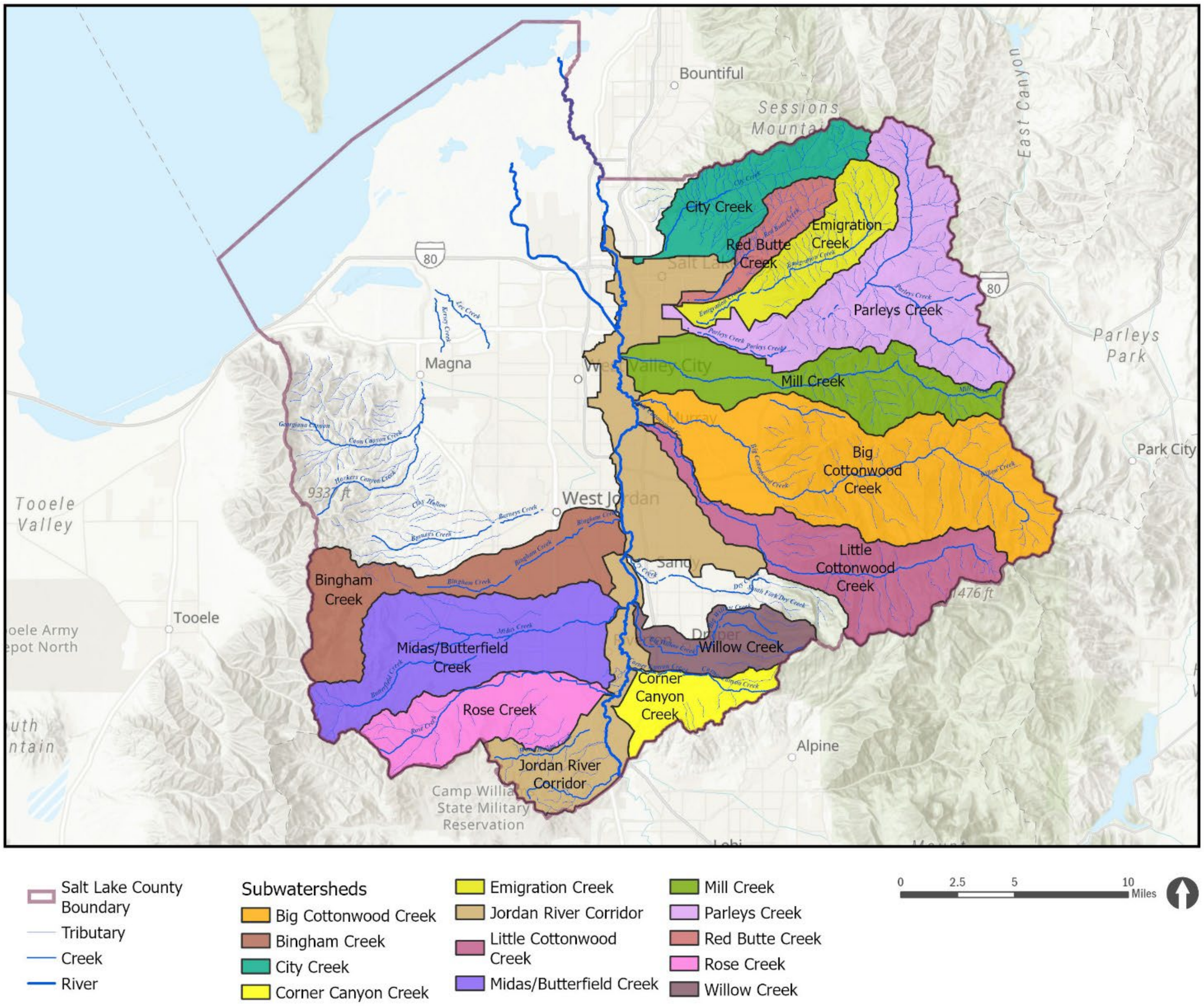
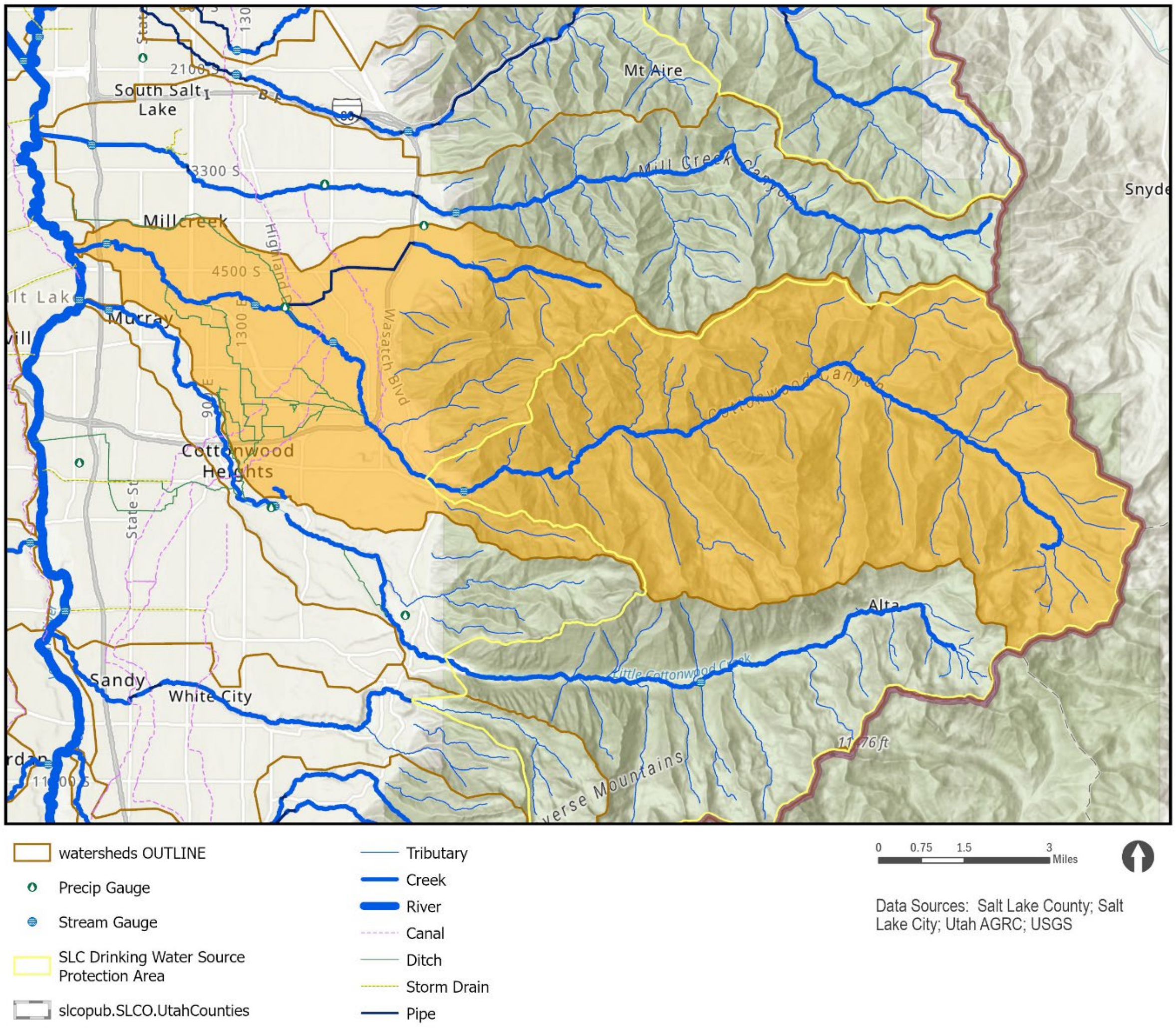


Figure 2. Salt Lake County Subwatersheds

Big Cottonwood Creek Subwatershed

Big Cottonwood Creek Watershed is located between Mill Creek and Little Cottonwood Creek Canyons and is highly used for recreational and culinary water purposes. The majority of upper Big Cottonwood Creek lies in unincorporated Salt Lake County, while much of the lower, urbanized stream runs through Cottonwood Heights, Murray, and Holladay cities. The upper watershed is 50 square miles with elevations ranging from 5,000 to 10,500 feet. The headwaters of the creek are located at approximately 9,600 feet in a broad, glaciated basin and the creek descends 24.3 miles before emptying into the Jordan River. With the largest flow of any adjacent Wasatch canyon stream, Big Cottonwood Creek provides the largest source of drinking water to Salt Lake City, which owns 99% of the water rights. As a result, the canyon is a regulated as a drinking water source protection area. Dogs and horses are strictly forbidden in protected watershed areas. Although most of the canyon is owned and managed by the U.S. Forest

Service, significant private landholdings exist near the headwaters. In addition to the Brighton and Solitude Ski areas, there are roughly 200 private residences in the Silver Fork area. The lower watershed drains 31.6 square miles with elevations ranging from 4,200 to 5,000 feet. Upper Big Cottonwood Canyon has a legacy of mining activity that, in some cases, can relate to water quality issues. Water quality sampling related to legacy mining activities is ongoing. In the lower portion of the watershed the stream ecosystem has been degraded by runoff from urban land uses, illegal discharges, and hydrologic modification. Increased recreation and urban development pressures stress the stream with higher levels of storm water pollution and have resulted in a reduced ability to recharge groundwater. Land use is primarily residential with some commercial and industrial development. Early claims to Big Cottonwood Creek water predate the growth of cities. Managing the water for modern needs has led to intricate exchange agreements between cities with junior rights and irrigators with senior rights. In exchange for its rights to lower quality Utah Lake water, Salt Lake City treats the higher quality stream water at a treatment plant at the mouth of the canyon for culinary use. This diversion seasonally dewaters four miles of the creek between the canyon mouth downstream to Cottonwood Lane. The city makes up the diverted flow with canal exchanges between April and October, but from November through March, 50% of the valley creek segment is dry. From Cottonwood Lane downstream, late Autumn-Winter instream flow originates, supporting a reproducing brown trout fishery. The source of this small flow is likely groundwater discharge.

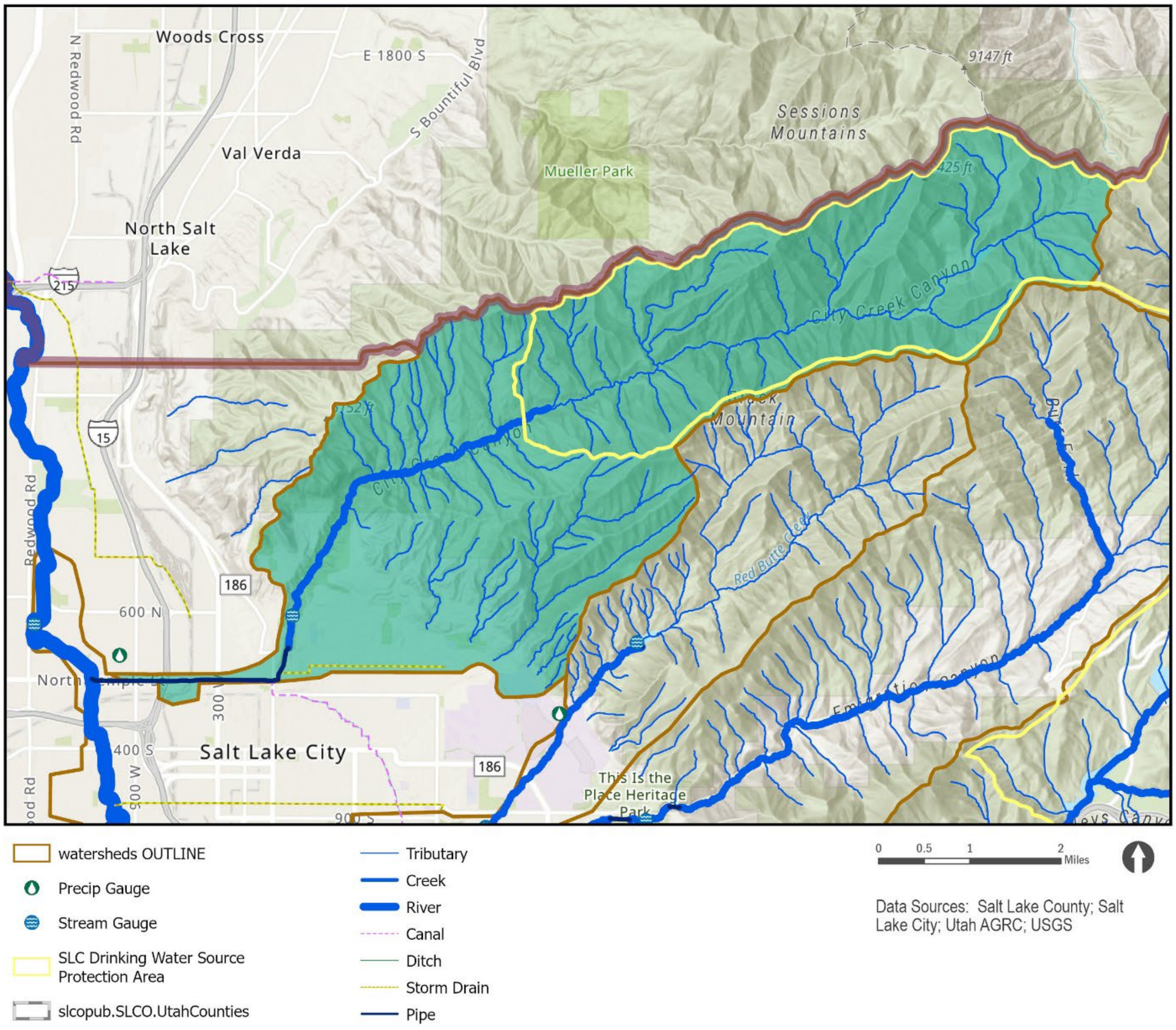


Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 3. Big Cottonwood Creek Subwatershed

City Creek Subwatershed

City Creek subwatershed is in the northeast corner of Salt Lake County in the Wasatch Mountains. The upper portion of the canyon has changed little since the first pioneers arrived in 1847. City Creek was Salt Lake City's first drinking water source and remains a major source of potable water today. The canyon is a protected watershed and is managed according to guidelines designed to protect and sustain water quality. Therefore, no dwellings or overnight camping are allowed in the canyon. City Creek watershed is a highly used and coveted recreational area. In 1985 the Salt Lake City Council adopted the City Creek Canyon Master Plan, which lead to its designation as a Nature Preserve and annexation of the entire canyon to Salt Lake City. Recreational activities such as picnicking, hiking, biking, and wildlife observation are enjoyed by canyon visitors. Dogs are permitted below Salt Lake City's water treatment plant; however, they must be on leash due to the high level of mixed-use recreation. In addition to City Creek Canyon, the lower City Creek watershed includes several undeveloped gulches and an urbanized residential neighborhood on the lower mountain/valley interface. City Creek enters a pipe below Memory Grove Park that has open channel sections in the median between Canyon Road and Canyon Side Road, as well as through City Park. City Creek then enters the North Temple Conduit to the Jordan River.

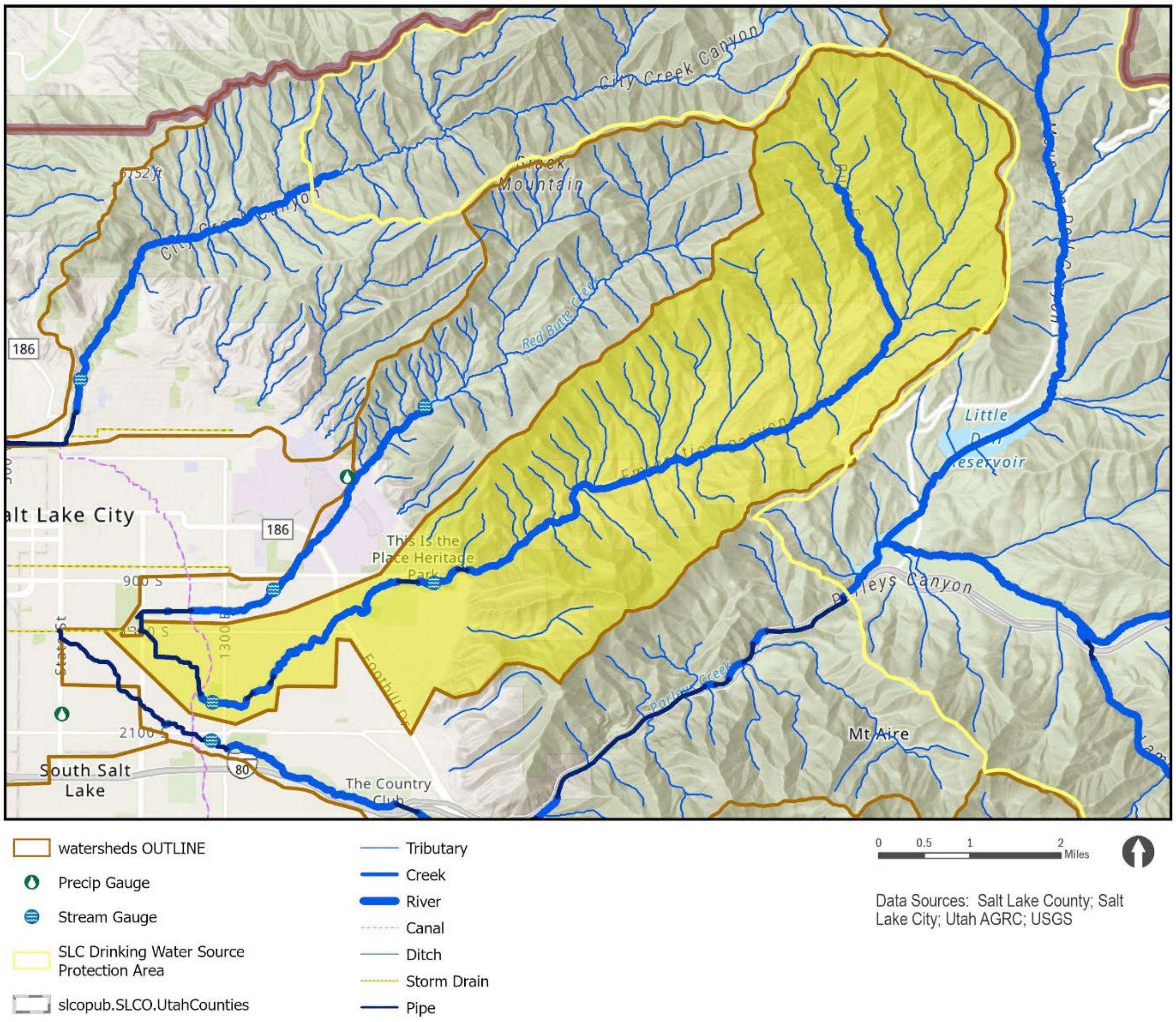


Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 4. City Creek Subwatershed

Emigration Creek Subwatershed

Emigration Creek is a perennial stream located in northeastern Salt Lake County in the Wasatch Mountains. Headwaters begin in a small open valley at an elevation of approximately 6,000 feet. The creek receives tributary flow from Killyons and Burr Fork canyons along with several mountain springs. The upper watershed (from the canyon mouth upstream) drains 18.2 square miles with moderately steep mountain slopes ranging from 5,000 to 8,900 feet. In 1846, the Donner-Reed Party cleared a trail in Emigration Canyon on its way to California. This was the primary route used by Pioneers to enter the Salt Lake Valley in 1847. The canyon was also part of the Federal Sheep Driveway used to drive sheep through to the Rio Grande Railroad station in Salt Lake City. A railroad line ran up the canyon, built in 1907, and was used for quarrying and transportation purposes until its closure in 1917. Today, the canyon is designated as a National Historic Place. Land use in the canyon includes primarily residential property, some National Forest land, Salt Lake County Open Space lands protected for high quality habitat (Killyon Canyon and Perkins Flat properties) and limited commercial properties. Unlike other Wasatch Front canyons in Salt Lake County, Emigration Canyon maintains a large residential population. The highway through the canyon carries considerable traffic and provides access to Parleys and East Canyons. The upper end of the canyon above Burr Fork is protected for drinking water by Salt Lake City's Department of Public Utilities. Residential development is primarily serviced by private wells and septic



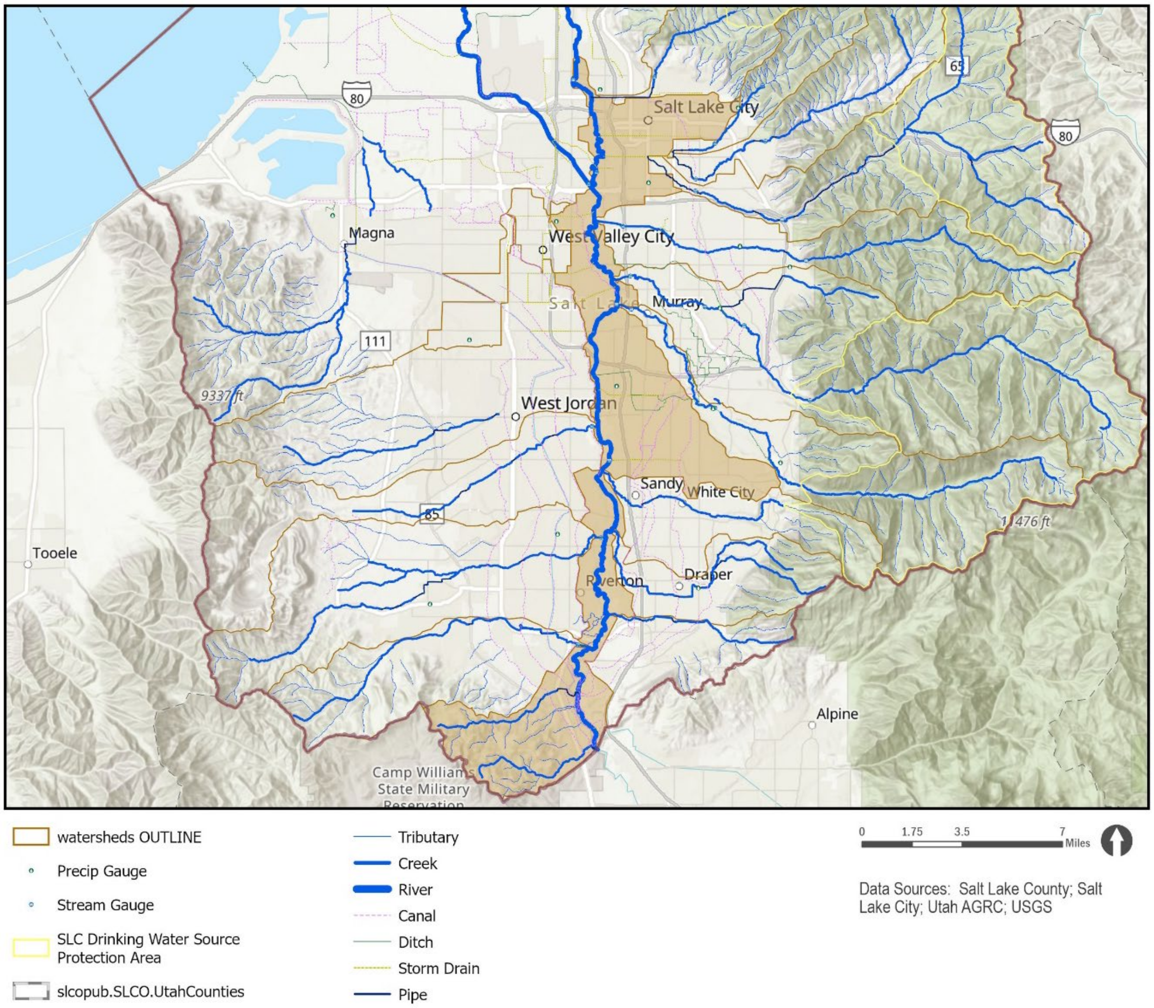
Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 5. Emigration Creek Subwatershed

systems and the canyon contains a groundwater recharge zone. The Utah Division of Wildlife Resources lists the creek as a good trout fishery, with native Bonneville cutthroat trout and introduced rainbow trout, although it is common for the creek to run dry between Camp Kostopulous and the Emigration Drain in Rotary Glen Park during certain times of the year. Streamside vegetation includes box elder, cottonwood, maple, scrub oak, dogwood, alder, river birch, willow, grasses, mustard, clover, and serviceberry. The lower watershed is primarily residential and commercial development. Consistent with other highly urbanized areas, much of the native vegetation has been displaced due to encroachment into the floodplain and riparian zone, although in some areas box elder, gamble oak, willows, and June grass can be seen. Just west of the Westminster College campus (at approximately 1100 East) the stream flows underground into a closed channel, daylights briefly in Liberty Park Pond and then continues down to the Jordan River via the1300 South storm drain.

Jordan River Corridor Subwatershed

The Jordan River Corridor subwatershed is the main water artery for the Salt Lake Valley. It flows 51 miles northward from Utah Lake to the Great Salt Lake through three counties and fifteen cities, including four of Utah's largest cities. The image pictured above only shows the direct drainage of the Jordan River after all tributaries have been removed. This river was once meandering river with a lush ecosystem that supported a diversity of terrestrial and aquatic life. It provided a source of livelihood for



Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 6. Jordan River Corridor Subwatershed

Native Americans and early settlers who established farms and settlements along the river. As the population of the valley increased, so did the demands on the river's water and impacts to the health of the river corridor. Dams and canals were built to satisfy increasing needs for irrigation and drinking water. Increasing development led to the river being straightened and channelized, ultimately causing it to become disconnected from its floodplain and vital wetlands. Due to the highly managed nature of the water in the Jordan River, flows vary widely throughout the year. While shallow groundwater and the tributaries do ensure some year-round flow, average high and low flows are controlled by the release of water through the gates of Utah lake. The gates are opened when the elevation of Utah Lake exceeds 4,489 feet above sea level, as per a lawsuit settles in 1985. This is known as the lake "compromise level".

Little Cottonwood Creek Subwatershed

Little Cottonwood Creek is the second largest surface water source used by Salt Lake City for culinary purposes. As a result, the canyon is protected and managed according to city guidelines designed to protect and sustain water quality, and no dogs or horses are allowed in the canyon. Historically, sustaining water quality was not such a high priority. Mining and smelting activities occurred along Little Cottonwood Creek, and these historic activities continue to impact water quality to this day. There were

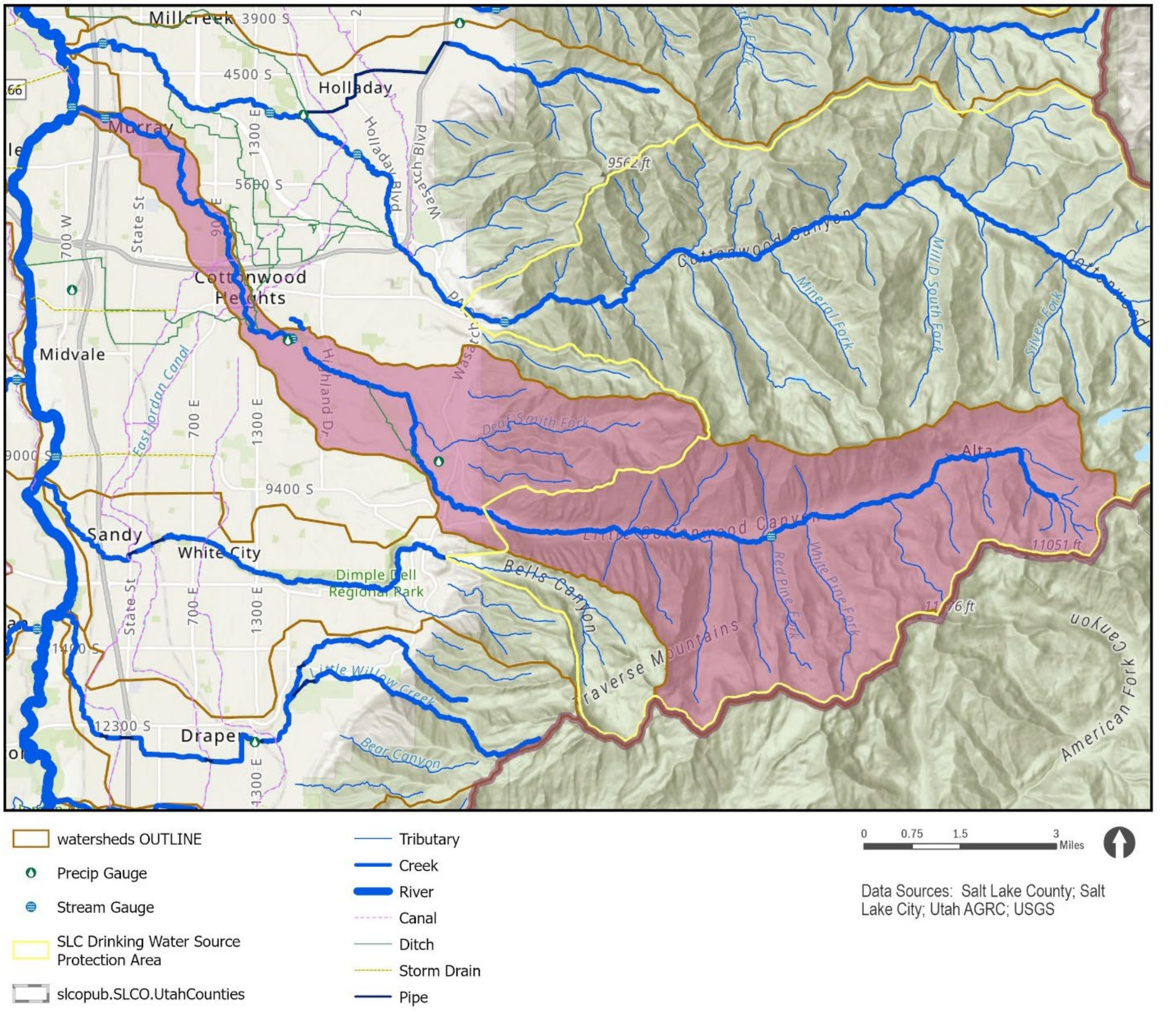
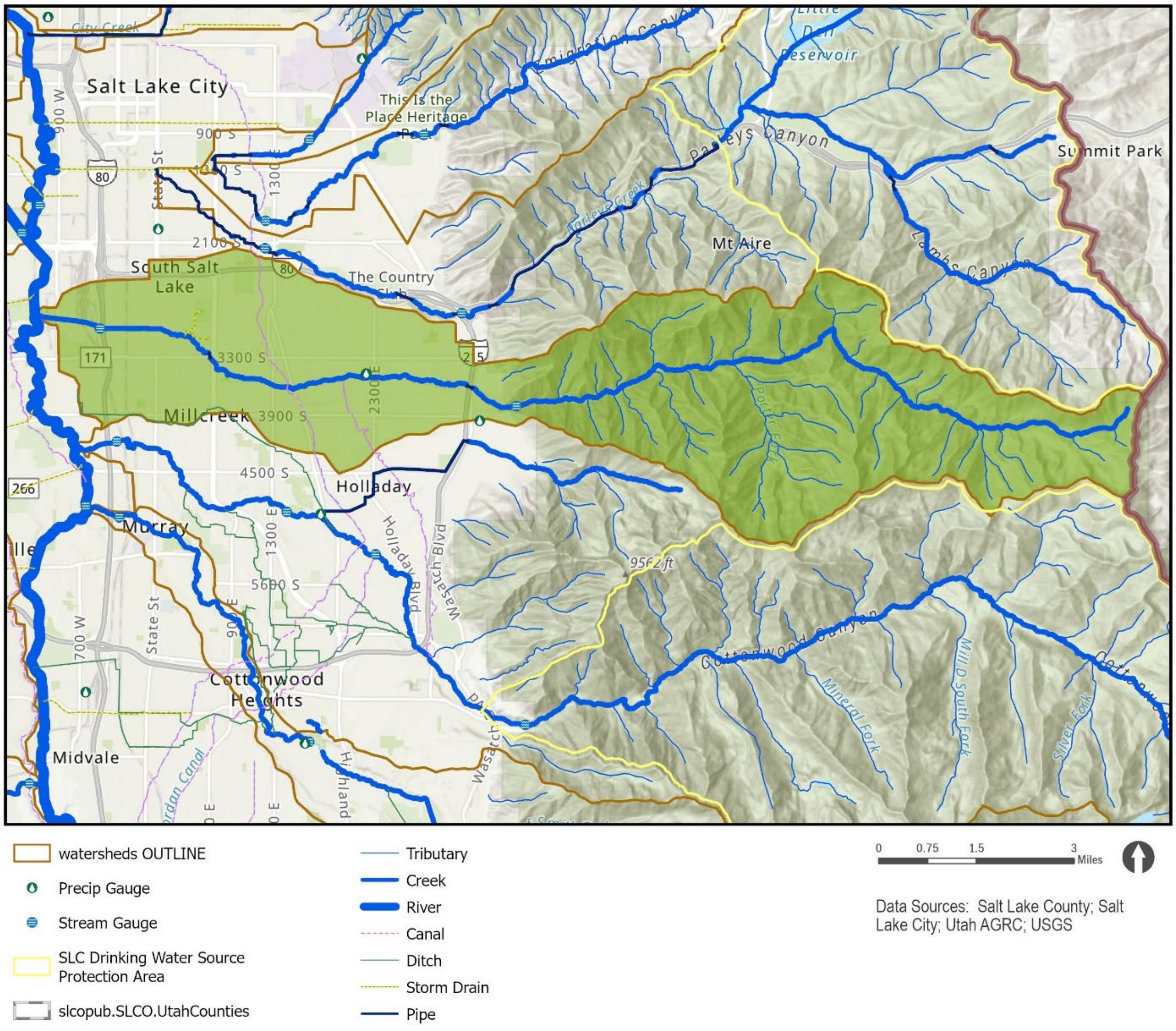


Figure 7. Little Cottonwood Creek Subwatershed

several hydropower operations over the years, and the stream still generates power for Murray City. Land and water managers deal with the historic mining and water rights legacies to this day. The upper watershed drains 27.2 square miles of steep canyon slopes with elevations ranging from 5,200 to 11,200 feet. The headwaters of the creek gather in Albion Basin at 9,800 feet, formed from intermittent creeks and outflow from Cecret Lake. From there the stream drops approximately 5,400 feet over 22 miles to its confluence with the Jordan River, a larger drop than any other Wasatch Front stream. It follows the canyon course carved by glaciers. Today, the primary land use is managed forest land for recreation—skiing, hiking, biking, climbing, camping, picnicking, fishing, and more. Other land uses include seasonal and year-round residences, the Town of Alta, two ski resorts, and resort-related commercial development. Upper Little Cottonwood Canyon has a legacy of mining activity that, in some cases, can relate to water quality issues. Water quality sampling related to legacy mining activities is ongoing. The lower watershed drains 12.7 square miles of a highly urbanized land, comprised of primarily residential and commercial development with increased commercial and industrial densities in the I-15 and I-215 corridors. Not unlike Salt Lake County's other urban streams, little, if any, of the natural channel remains as Little Cottonwood Creek makes its way down to the Jordan River. In fact, when the creek crosses I-215, it is carried above the highway in a concrete box culvert. From July through March the creek has little to no flow in the valley, due primarily to a stream diversion above the canyon mouth that pipes water out for culinary and hydropower uses. When flows are low enough, the diversion takes all the water. Some water is brought back into the stream in the Fort Union area (upper Jordan River water brought in via canal). Groundwater and storm drains also add to streamflow, but for the most part the aquatic ecosystem in the nine-mile stretch from the diversion to the Fort Union canal is seriously impacted.

Mill Creek Subwatershed

At one time Mill Creek had as many as 20 mills in operation. Today the canyon is a popular recreational destination for Salt Lake Valley residents including skiing, biking, hiking, and picnicking. From the canyon mouth upstream, the upper watershed is 21.7 square miles of steep canyon slopes ranging in elevation from 5,100 to 10,200 feet in the Wasatch Mountain Range. Millcreek Canyon is managed forest land for recreational use such as hiking, biking, picnicking, camping, fishing, and cross-country-skiing. In fact, more U.S. Forest Service picnic areas are found in this canyon than any other in the Salt Lake Valley. Currently, stream water is used for irrigation and not for culinary purposes and is therefore not regulated as a drinking water source protection area by Salt Lake City. As a result, dogs are allowed in the canyon. Prior to the 1990s, much of the canyon and the stream channel had been degraded, largely due to human activities. To address the damage from popular use, the U.S. Forest Service and Salt Lake County entered into an agreement to collect a fee for facilities repair and environmental improvement. Remediation has since been completed at several campground facilities and a fee station was installed. User fee revenues have been used for restoration and continued maintenance of the canyon and the creek's riparian zone. Porter Fork and Church Fork are the two major tributaries of Mill Creek. Porter Fork is likely named for long time farmer and logger Porter Rockwell. This narrow, north-facing canyon includes a neighborhood of private homes and an exceptional diversity of native riparian plants. Other development includes cabins above the Firs Picnic Area, two restaurants, and a Boy Scout camp. Otherwise, there is little commercial development in the canyon. The lower watershed drains 15.2 square miles of highly urbanized landscape. Increased commercial and industrial land uses are anticipated to occur on the east bench and closer to the Jordan River. High flows on Mill Creek usually come near the end of May through mid-June and rise 6-18 inches above base flow.



Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 8. Mill Creek Subwatershed

Parleys Creek Subwatershed

The Parleys Creek subwatershed is in northeastern Salt Lake County and the Wasatch Mountains. It is the largest mountain drainage near Salt Lake City. The watershed contains a total of 58.4 square miles. Initially named Big Canyon Creek by Brigham Young, the creek was renamed after Parley P. Pratt who explored the canyon for the purpose of building a toll road. Today, the canyon continues to be a major route into the Salt Lake Valley via Interstate 80. The majority (89%) of the Parleys Creek watershed is upstream from the mouth of the canyon. This upper watershed covers 51.9 square miles and is comprised of moderate to steep mountain slopes ranging from 4,800 to 9,400 feet in elevation. The headwaters are subdivided into Mountain Dell Canyon and Lambs Canyon. Much of the water from Parleys Creek is diverted and stored in Little Dell and Mountain Dell Reservoirs. These structures were initially constructed for water supply and flood control purposes and are currently managed by the Salt Lake City Department of Public Utilities. Stored water is utilized to meet potable water and recreation needs as well as cold water fishery habitat. Land in the upper watershed is a mix of private ownership and National Forest land. The canyon is primarily used as a transportation corridor for I-80, with homes in Mount Aire (Smith Fork) and Lambs Canyon, and developed recreational facilities for golf, cross country skiing, and picnicking. R.J. Harper has operated a quarry in the lower end of the canyon, adjacent to I-80 since the early 20th century. Parleys Creek water is used primarily for culinary purposes, and a large part of the upper Parleys Creek watershed is a protected drinking water source area for Salt Lake City. The treatment plant is located below Mountain Dell Reservoir. The dam is adjacent to Mountain Dell Golf Course, which is owned and operated by Salt Lake City. The lower watershed (downstream from the canyon mouth) is roughly 6.4 square miles of commercial development and residential neighborhoods, along with several local parks including Parleys Historic Nature Park and Sugarhouse Park.

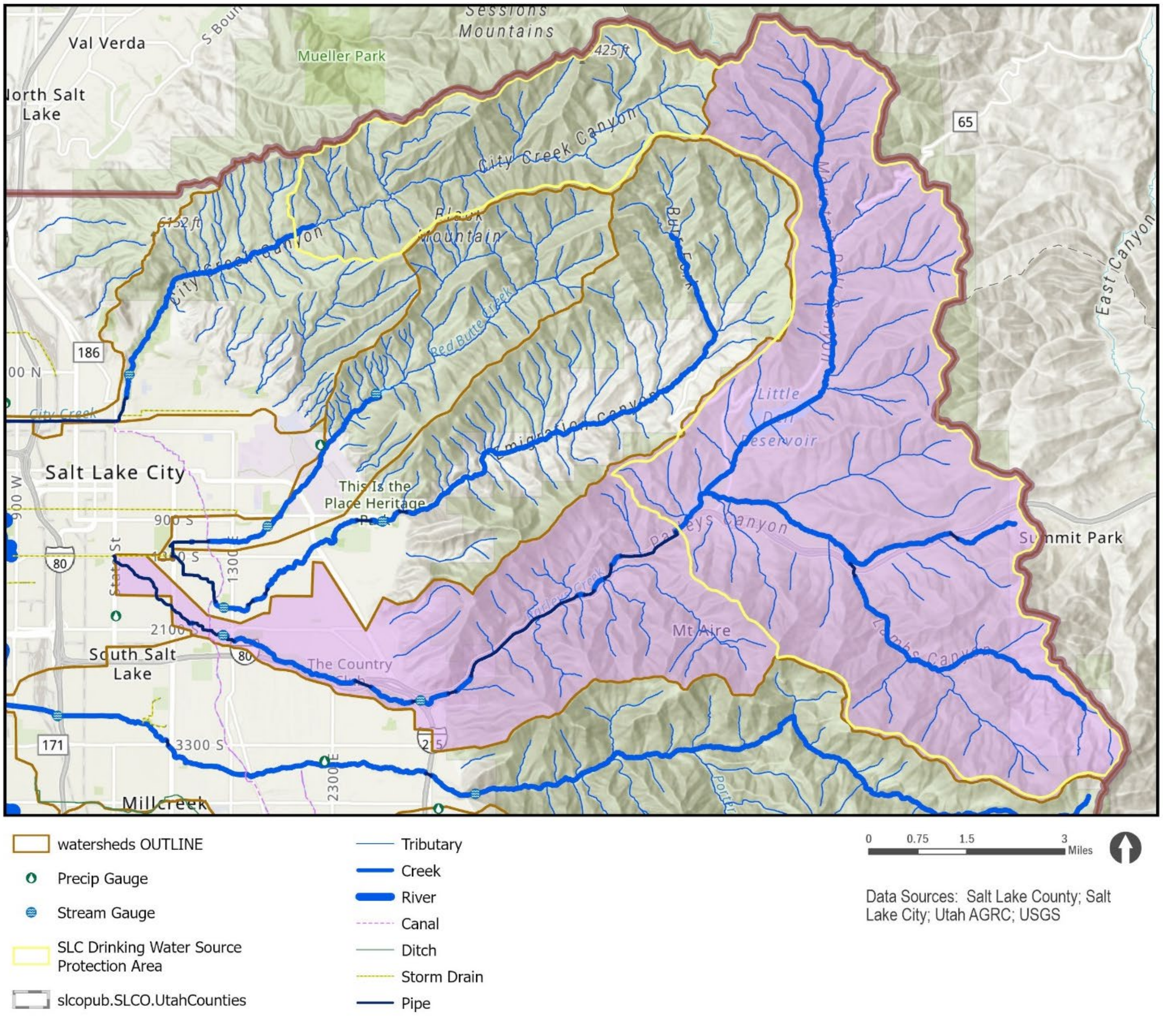
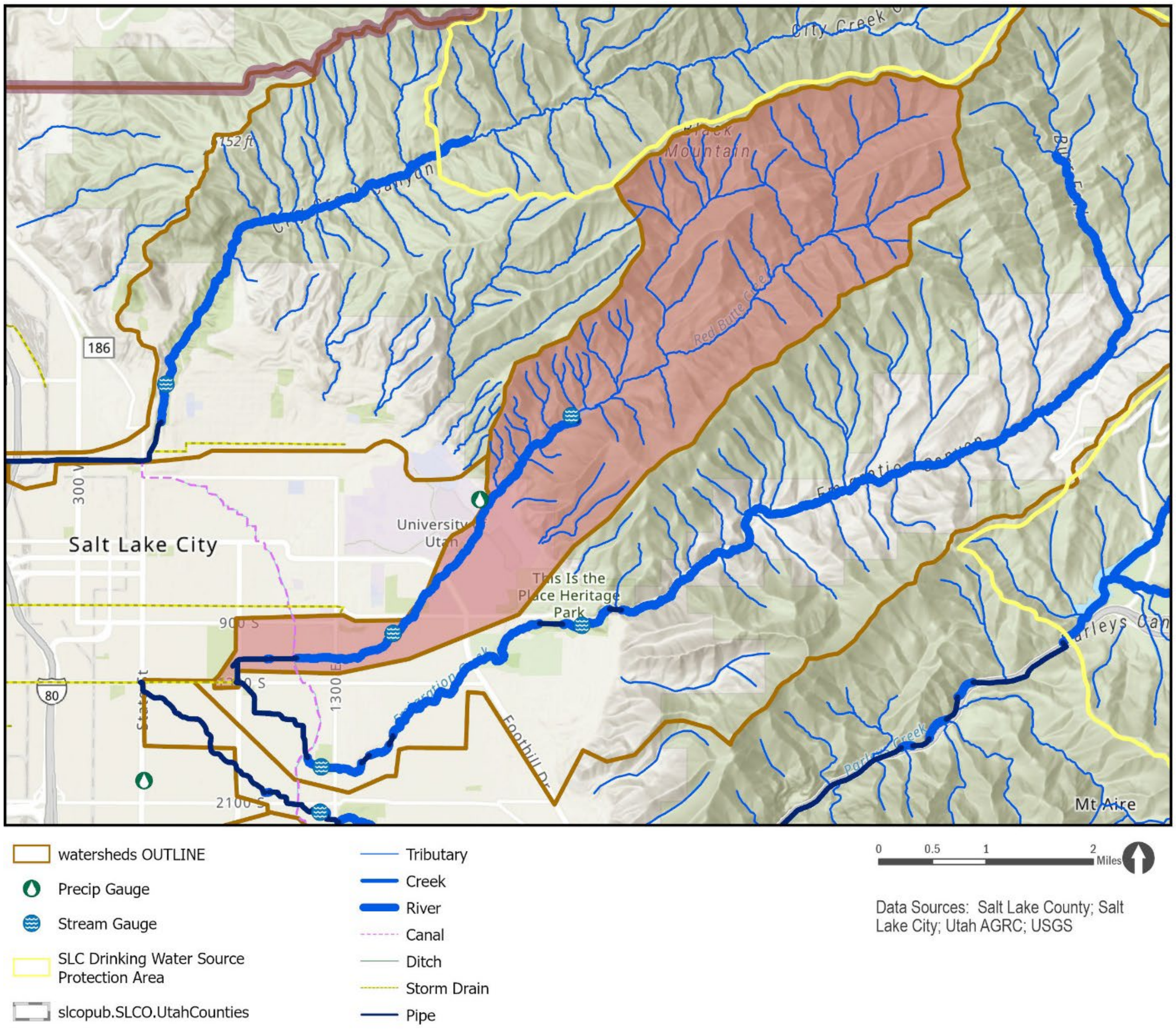


Figure 9. Parleys Creek Subwatershed

Red Butte Creek Subwatershed

Red Butte Creek subwatershed is located south of the City Creek subwatershed, with the Black Mountain ridgeline creating a border. In 1862 the United States Army established Fort Douglas at the mouth of Red Butte Canyon and utilized water from the creek. The canyon was also a source of red sandstone for building construction, and some of the historic sandstone buildings can still be seen today in the canyon and at Fort Douglas. The upper portion of the Red Butte Creek subwatershed has remained mostly undeveloped over time. It is comprised of moderately steep mountains ranging from 5,000 to 8,200 feet in elevation. Since the creek was the primary water source for Fort Douglas, development and use was limited in the canyon to preserve water quality. The Red Butte Reservoir was built in 1930 as a water supply for Fort Douglas, and eventually switched to the Salt Lake City municipal water supply in 1991. Ownership and management of the reservoir was transferred to the Central Utah Water Conservancy District in 2004, which has focused on providing long-term refuge for the June Sucker (an endangered fish). In 1969, the United States Forest Service assumed responsibility for about 83 percent of the upper Red Butte Creek subwatershed with the remainder owned by Salt Lake City, the University of Utah, and private landowners. The Forest Service designated much of the upper canyon



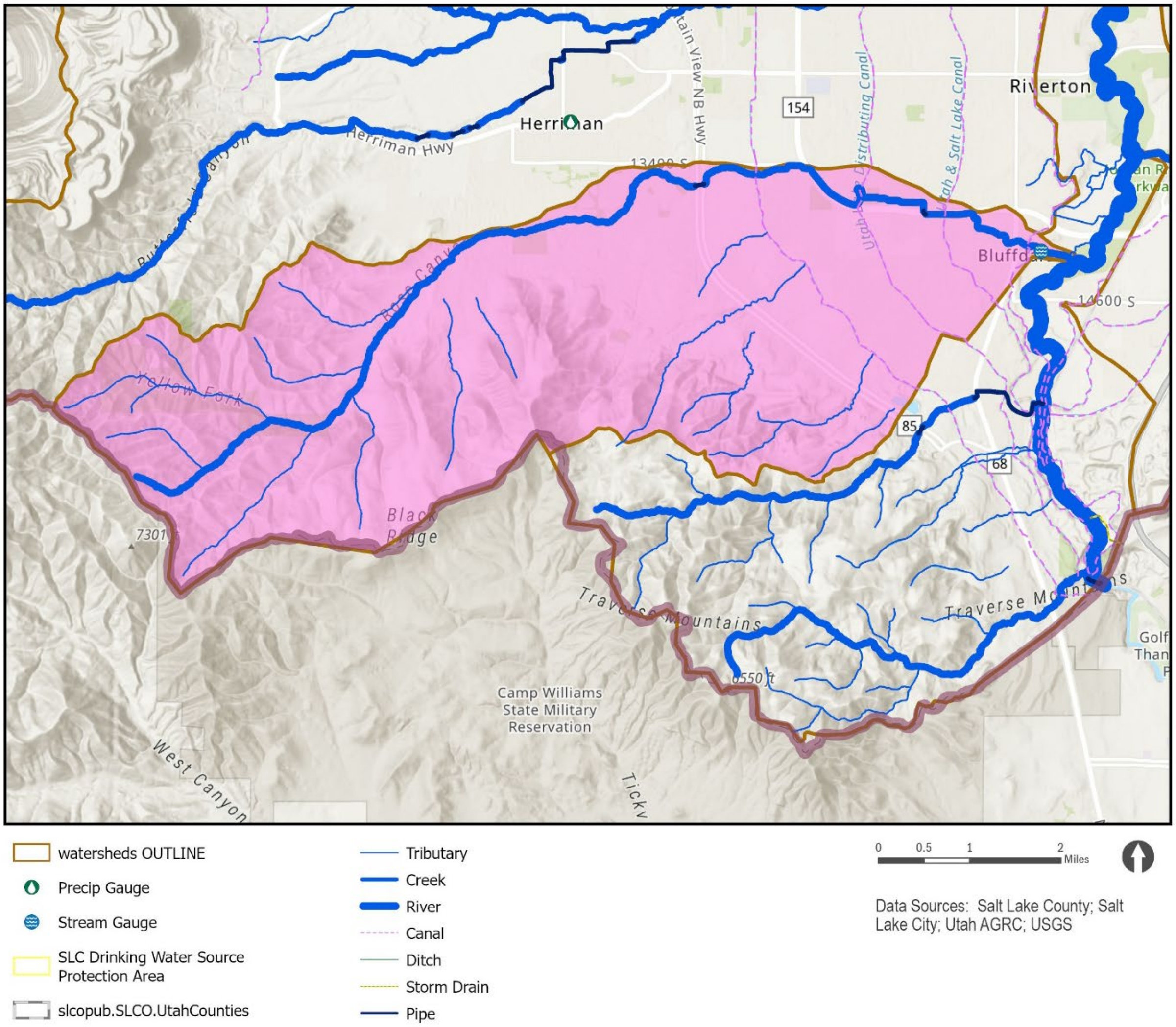
Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 10. Red Butte Creek Subwatershed

(5,370 acres) as the Red Butte Research Natural Area (RNA) in 1971, which is managed for research, observation, and study with public access limited to these purposes. This designation for the upper section of Red Butte is a reason for the lack of sample sites in this area. In 1983, the University of Utah dedicated 150 acres at the mouth of the canyon as a regional botanical garden, the Red Butte Garden & Arboretum. From the canyon mouth down to the Jordan River, the lower watershed drains 2.6 square miles of land comprised of the mountain/valley interface from the Wasatch Mountains. The University of Utah Campus/Research Park and residential properties are the primary land uses. At approximately 1100 east, the stream known as Red Butte Creek ceases to exist as an open channel. There it flows into a constructed underground closed system, daylighting briefly in Liberty Park Pond, then continuing along the 1300 South Storm Drain.

Rose Creek Subwatershed

Rose Creek drains a 27.58 square mile basin with headwaters flowing from the Oquirrh Mountains. The creek has year-round flows in the upper watershed where the land is managed for irrigation, water supply, wildlife and military use. Rose Canyon and Yellow Fork Canyon have long been recreation destinations for hikers, runners, mountain bikers, equestrian riders, and birders. The 1,681-acre Rose



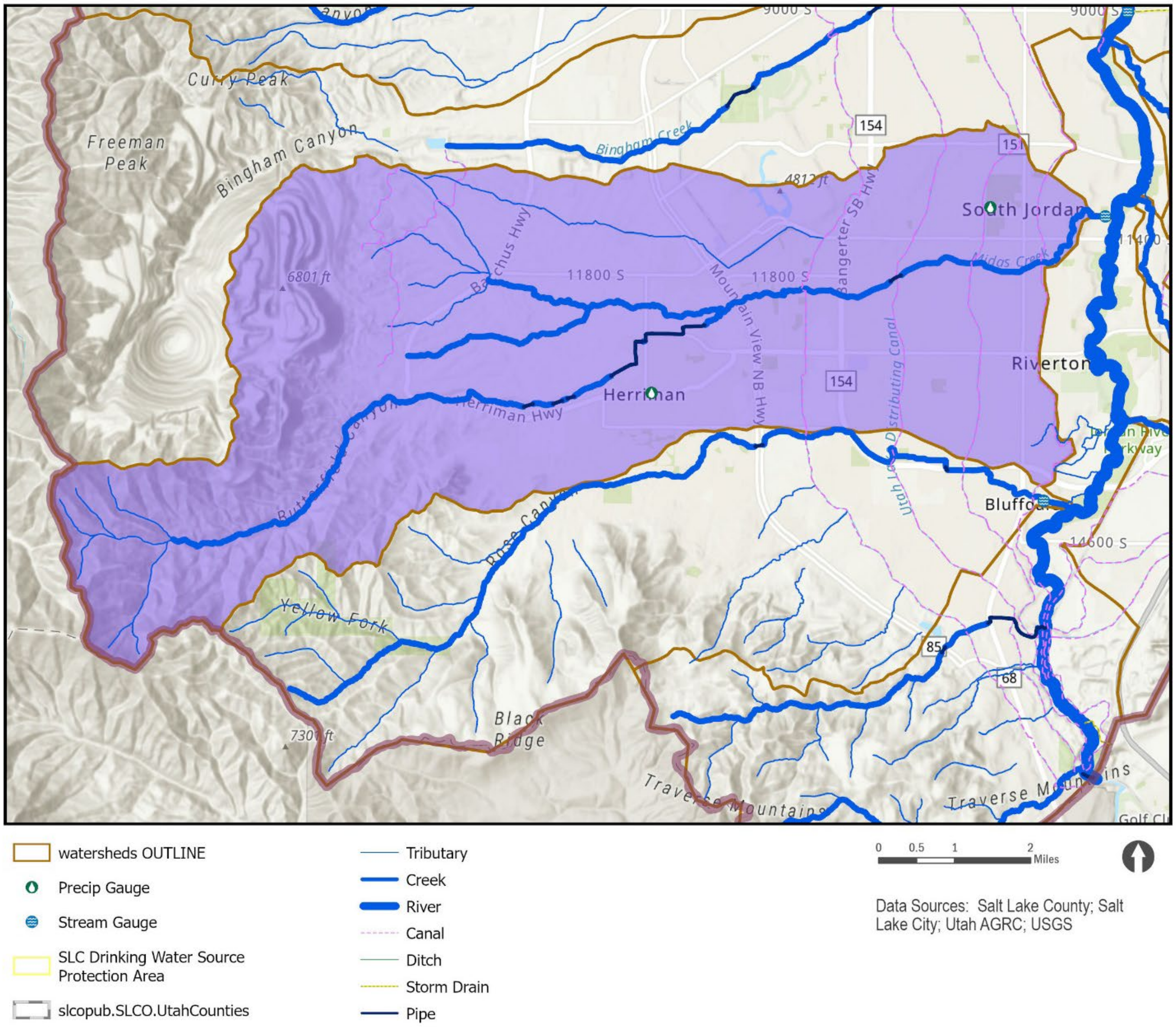
Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 11. Rose Creek Subwatershed

Canyon Ranch is protected open space in the foothills of the Oquirrhs, and Yellow Fork Canyon Park offers 800 acres of parkland. The lower watershed is rapidly urbanizing, transitioning from primarily agricultural land use to residential and commercial land uses. Creek flow is intermittent in the valley section of the creek causing WPRP to have minimal sample sites where ephemeral flow is found.

Midas Creek Subwatershed

Midas Creek drains a 50.3 square mile basin, which includes Butterfield Creek and several gulches. Butterfield Creek originates in the Oquirrh Mountains and converges with Midas Creek at approximately 5100 West 12120 South. Midas Creek once drained a larger basin. Prior to excavation of the Kennecott Copper Mine, the eastern portion of the mine originally had slopes that drained into Midas Creek. As the land surface has changed, drainage patterns have changed, resulting in tributary area being routed to Bingham Creek. High levels of lead and arsenic have been found in Bingham and Butterfield Creeks due to historic mining activities. The Environmental Protection Agency and Kennecott have participated in cleanup of contaminated soils along the creeks.

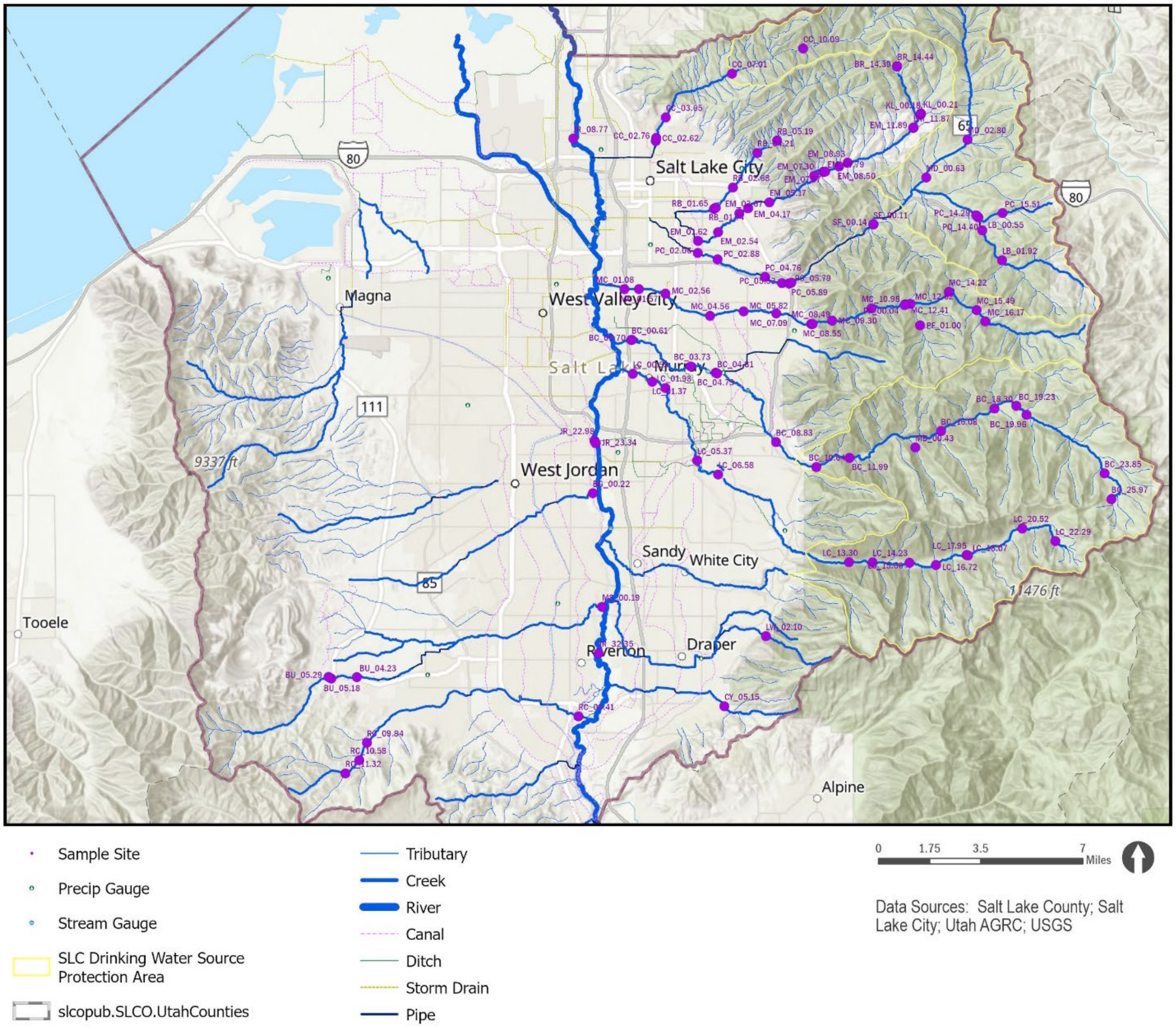


Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 12. Midas Creek Subwatershed

SAMPLE LOCATIONS

The sample locations assessed for this study include areas throughout the Jordan River Watershed and its surrounding mountains. For QA/QC purposes, WPRP developed a system for SiteID generation that allows for quick and accurate data conveyance. Data was collected at all sampling locations shown below. Sample locations were assigned codes based on their river mileage above stream terminus and preceded by a two-letter stream code. A site located 14.23 miles upstream from the confluence of Little Cottonwood Creek and the Jordan River is assigned the SiteID "LC_14.23". WPRP QA/QC protocols are carried out before data is published to ensure accuracy. For more information on QA/QC protocols and Standard Operating Procedures please contact WPRP staff with questions.



Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 13. 2017 Sample Locations

Table 1. List of 2017 Sample Locations

SiteID	Macro	Bacteria	Stream Name	Subwatershed	Latitude	Longitude
BC_00.61	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.681014	-111.899912
BC_00.70		✓	Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.681063	-111.899608
BC_03.73	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.668044	-111.86115
BC_04.73		✓	Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.664956	-111.844861
BC_04.81	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.664547	-111.843859
BC_08.83		✓	Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.630691	-111.805367
BC_10.64	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.618267	-111.779063
BC_11.99		✓	Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.622994	-111.757467
BC_16.08	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.636359	-111.697854
BC_18.30	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.647547	-111.66291
BC_19.23		✓	Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.648938	-111.648723
BC_19.96	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.644558	-111.642002
BC_23.85	✓		Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.615479	-111.591121
BC_25.97		✓	Big Cottonwood Creek	Big Cottonwood Creek Subwatershed	40.602739	-111.586641
BG_00.22		✓	Bingham Creek	Bingham Creek Subwatershed	40.604927	-111.92466
BR_14.39	✓		Burr Fork	Emigration Creek Subwatershed	40.817207	-111.726936
BR_14.44		✓	Burr Fork	Emigration Creek Subwatershed	40.81729	-111.726961
BU_04.23		✓	Butterfield Creek	Midas Creek Subwatershed	40.513018	-112.077541
BU_05.18	✓		Butterfield Creek	Midas Creek Subwatershed	40.512222	-112.094305
BU_05.29		✓	Butterfield Creek	Midas Creek Subwatershed	40.51297	-112.09604
CC_02.62		✓	City Creek	City Creek Subwatershed	40.779748	-111.884467
CC_02.76	✓		City Creek	City Creek Subwatershed	40.781342	-111.884355
CC_03.65	✓	✓	City Creek	City Creek Subwatershed	40.79158	-111.878068
CC_07.01	✓		City Creek	City Creek Subwatershed	40.813378	-111.834966
CC_10.09	✓		City Creek	City Creek Subwatershed	40.82593	-111.788507
CY_05.15	✓		Corner Canyon Creek	Corner Canyon Creek Subwatershed	40.499542	-111.838374
EM_01.62		✓	Emigration Creek	Emigration Creek Subwatershed	40.73031	-111.856664
EM_02.54		✓	Emigration Creek	Emigration Creek Subwatershed	40.734736	-111.843573
EM_03.67		✓	Emigration Creek	Emigration Creek Subwatershed	40.744088	-111.82981
EM_04.17	✓		Emigration Creek	Emigration Creek Subwatershed	40.746568	-111.824122
EM_05.17		✓	Emigration Creek	Emigration Creek Subwatershed	40.74958	-111.81012
EM_07.30		✓	Emigration Creek	Emigration Creek Subwatershed	40.762803	-111.781013
EM_07.79		✓	Emigration Creek	Emigration Creek Subwatershed	40.764776	-111.775199
EM_07.87	✓		Emigration Creek	Emigration Creek Subwatershed	40.76494	-111.773777
EM_08.93		✓	Emigration Creek	Emigration Creek Subwatershed	40.769411	-111.75906
EM_11.87		✓	Emigration Creek	Emigration Creek Subwatershed	40.786736	-111.716377
EM_11.89	✓		Emigration Creek	Emigration Creek Subwatershed	40.786973	-111.716159
JR_08.77	✓	✓	Jordan River	Jordan River Corridor Subwatershed	40.780855	-111.938376
JR_22.98	✓		Jordan River	Jordan River Corridor Subwatershed	40.631071	-111.9237
JR_23.34		✓	Jordan River	Jordan River Corridor Subwatershed	40.629748	-111.922822

SiteID	Macro	Bacteria	Stream Name	Subwatershed	Latitude	Longitude
JR_32.35	✓	✓	Jordan River	Jordan River Corridor Subwatershed	40.525538	-111.920265
KL_00.18	✓		Killyon Creek	Emigration Creek Subwatershed	40.793242	-111.711512
KL_00.21		✓	Killyon Creek	Emigration Creek Subwatershed	40.793962	-111.711463
LB_00.55		✓	Lambs Canyon Creek	Parleys Creek Subwatershed	40.735994	-111.671165
LB_01.92	✓		Lambs Canyon Creek	Parleys Creek Subwatershed	40.721131	-111.658184
LC_00.53	✓	✓	Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.664243	-111.898836
LC_01.37	✓		Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.660345	-111.886232
LC_01.98		✓	Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.657228	-111.87758
LC_05.37	✓		Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.621382	-111.856751
LC_06.58		✓	Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.614461	-111.842906
LC_13.30	✓		Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.571229	-111.757544
LC_14.23		✓	Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.571145	-111.742131
LC_15.66	✓		Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.570922	-111.718199
LC_16.72		✓	Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.56993	-111.700826
LC_18.07	✓		Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.574644	-111.680049
LC_20.52		✓	Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.588116	-111.644599
LC_22.29	✓		Little Cottonwood Creek	Little Cottonwood Creek Subwatersh.	40.581845	-111.623065
LW_02.10	✓		Little Willow Creek	Willow Creek Subwatershed	40.534332	-111.811533
MB_00.43	✓		Mill B South Fork	Big Cottonwood Creek Subwatershed	40.628159	-111.714489
MC_01.08		✓	Mill Creek	Mill Creek Subwatershed	40.706232	-111.904637
MC_01.57	✓		Mill Creek	Mill Creek Subwatershed	40.706253	-111.895101
MC_02.56		✓	Mill Creek	Mill Creek Subwatershed	40.704101	-111.877849
MC_04.56		✓	Mill Creek	Mill Creek Subwatershed	40.693112	-111.848659
MC_05.82	✓		Mill Creek	Mill Creek Subwatershed	40.695463	-111.826732
MC_07.09		✓	Mill Creek	Mill Creek Subwatershed	40.694523	-111.805464
MC_08.49		✓	Mill Creek	Mill Creek Subwatershed	40.689301	-111.782733
MC_08.55	✓		Mill Creek	Mill Creek Subwatershed	40.689328	-111.781688
MC_09.30	✓		Mill Creek	Mill Creek Subwatershed	40.690993	-111.769003
MC_12.41		✓	Mill Creek	Mill Creek Subwatershed	40.69914	-111.721405
MC_12.62	✓		Mill Creek	Mill Creek Subwatershed	40.699438	-111.71779
MC_14.22	✓		Mill Creek	Mill Creek Subwatershed	40.705384	-111.692844
MD_00.63	✓	✓	Dell Fork	Parleys Creek Subwatershed	40.762168	-111.707843
MD_02.80	✓		Dell Fork	Parleys Creek Subwatershed	40.781006	-111.680937
MS_00.19		✓	Midas Creek	Midas Creek Subwatershed	40.548516	-111.918232
PC_02.06		✓	Parleys Creek	Parleys Creek Subwatershed	40.724382	-111.856896
PC_02.88		✓	Parleys Creek	Parleys Creek Subwatershed	40.72121	-111.843889
PC_04.76	✓	✓	Parleys Creek	Parleys Creek Subwatershed	40.712577	-111.812842
PC_05.53		✓	Parleys Creek	Parleys Creek Subwatershed	40.709552	-111.801762
PC_05.79		✓	Parleys Creek	Parleys Creek Subwatershed	40.70935	-111.797217
PC_05.89	✓		Parleys Creek	Parleys Creek Subwatershed	40.70981	-111.795714
PC_14.29	✓		Parleys Creek	Parleys Creek Subwatershed	40.743456	-111.675006

SiteID	Macro	Bacteria	Stream Name	Subwatershed	Latitude	Longitude
PC_14.40		✓	Parleys Creek	Parleys Creek Subwatershed	40.742406	-111.673698
PC_15.51	✓		Parleys Creek	Parleys Creek Subwatershed	40.744601	-111.657959
PF_00.04		✓	Porter Fork	Mill Creek Subwatershed	40.698831	-111.721691
PF_01.00	✓		Porter Fork	Mill Creek Subwatershed	40.688811	-111.711597
RB_01.65		✓	Red Butte Creek	Red Butte Creek Subwatershed	40.746225	-111.846378
RB_01.74	✓		Red Butte Creek	Red Butte Creek Subwatershed	40.74688	-111.845133
RB_02.68	✓		Red Butte Creek	Red Butte Creek Subwatershed	40.756902	-111.834073
RB_04.21		✓	Red Butte Creek	Red Butte Creek Subwatershed	40.774139	-111.818237
RB_05.19	✓		Red Butte Creek	Red Butte Creek Subwatershed	40.780201	-111.805293
RC_00.41		✓	Rose Creek	Rose Creek Subwatershed	40.494198	-111.933315
RC_09.84	✓		Rose Creek	Rose Creek Subwatershed	40.480518	-112.070846
RC_10.58		✓	Rose Creek	Rose Creek Subwatershed	40.47178	-112.07568
RC_11.32		✓	Rose Creek	Rose Creek Subwatershed	40.465234	-112.084725
SF_00.11		✓	Smith Fork	Parleys Creek Subwatershed	40.73877	-111.742325
SF_00.14	✓		Smith Fork	Parleys Creek Subwatershed	40.73887	-111.742215

METHODOLOGIES

The methodologies used in this study match those of the data collection protocols outlined in Sampling and Analysis Plan (SAP) for Salt Lake County. To summarize, there were four major categories assessed in this study:

1) Field parameters
    - pH
    - dissolved oxygen (DO)
    - conductivity (ms/cm)
    - turbidity (NTU)
    - temperature (°C)
2) Bacteria [*E. coli* MPN]
3) Aquatic macroinvertebrate health [Karr-BIBI and BCG]
4) Stream stability sampling [stream type and Pfankuch score].

After measurements are taken in the field, the information is entered into digital data collection forms (built with Esri’s Survey123) that populate the Salt Lake County WPRP GIS database. When the information goes through the QA/QC process outlined in the SAP, the “QA/QC Complete” status in the database is changed to “yes” (sample data submitted via Survey123 is initially assigned a default value of “no”). Any data that does not meet QA/QC requirements is removed from the database and not included in this report; thus, the graphs are occasionally missing data from specific months due to the unreliability of that piece of data.

Field Parameters Sampling

Field parameters relate to water chemistry and were assessed using the Oakton pHTestr 50, Lovibond TB250 Turbidimeter, and the YSI ProDO Meter. These devices are used simultaneously to measure five different water quality parameters. Technical information including device precision can be found in Salt Lake County's SAP. Field parameters are collected with every bacteria sample and macroinvertebrate sample. All data relating to field parameters is graphed to show trends from the 2017 water year. Each of these graphs features an "average" for that parameter displayed. This average is made from all data from the 2017 Water Year. The purpose is to see if the new sample data deviates from the average.

The **pH** of surface water can affect the rate of chemical solubility, toxicity of the water and the diversity of biological organisms. The standard range set by the Utah Division of Environmental Quality is 6.5 standard units (displayed as '6.5 pH') to 9.0 standard units for waters in the county. Lower or higher pH readings can indicate that conditions are present to mobilize toxic constituents, which can harm aquatic species. Arid climates commonly have pH ranges above neutral (7.0 pH) averaging in the range of 8.0-8.5. Arid climates with variable source rock geochemistry including limestone can have high alkalinity as well, which tends to resist changes to the pH level. If pH levels are observed to drop in certain locations, it can be an indicator of significant water chemistry change. Known sources that can drive the pH of streams up or down are mine drainage, concrete spills, illicit dumping, and industrial discharge.

Dissolved oxygen (DO) is an indicator of the amount of oxygen available in streams to support macroinvertebrates and fish populations. Low DO conditions can harm aquatic habitat by limiting the amount of oxygen available to aquatic organisms. Low DO conditions can be caused by excessive algae growth, high levels of nutrients, high oxygen demand or the decay of submerged plants. The reference value of 4.5 mg/L was used by the County for comparative purposes for all subwatersheds. The state water quality standard for minimum DO for various aquatic wildlife beneficial uses us established by UAC R317-2 and ranges between 4.0 and 9.5. No observations were made detailing Coarse Particulate Organic Matter (COPM), Fine Particulate Organic Matter (FPOM), Organic Nutrients or Inorganic Nutrients thus no statements about speciation of consumption/depletion of DO in the water column as a result of those processes can be made here.

Water temperature (℃) is an important indicator because it can affect biological activity and species diversity and populations as well as water chemistry processes. Water temperature often dictates healthy conditions for cold-water and warm-water fish, and water temperatures affect aquatic diversity, metabolism, growth, and reproduction. The rate of chemical solubility and reactions generally increase with higher temperatures. A reference value of 20 degrees Celsius (°C) was used by Salt Lake County and was met for most subwatershed creeks for most of the year. The state water quality temperature standard is set at 20°C for cold-water aquatic wildlife, with the water quality temperature standard at 27°C for warm-water and other aquatic wildlife.

Turbidity (NTU) measures how much suspended solid is present in the water being tested. Higher levels indicate sediment entering the system through erosion, mass wasting, disturbance of the substrate, point or non-point sources or construction related activities. In natural systems streams should show low turbidity levels during low flows and high values during runoff events.

Conductivity (ms/cm) values, like most rivers in the arid west, should have higher natural values during the spring months and lower values in the later summer, fall and winter months. Although these values are more dependent on water chemistry than flow, chemical and mechanical weathering of the rocks can also play a role in the stream's conductivity. In the urban sections of the watershed, conductivity is much more a product of pollutants added to the water than natural decomposition. Spring flow dominated streams will also have higher conductivity as well; especially if the source rock of the streams in marlaceous limestone as is the case for a few of the eastern valley streams.

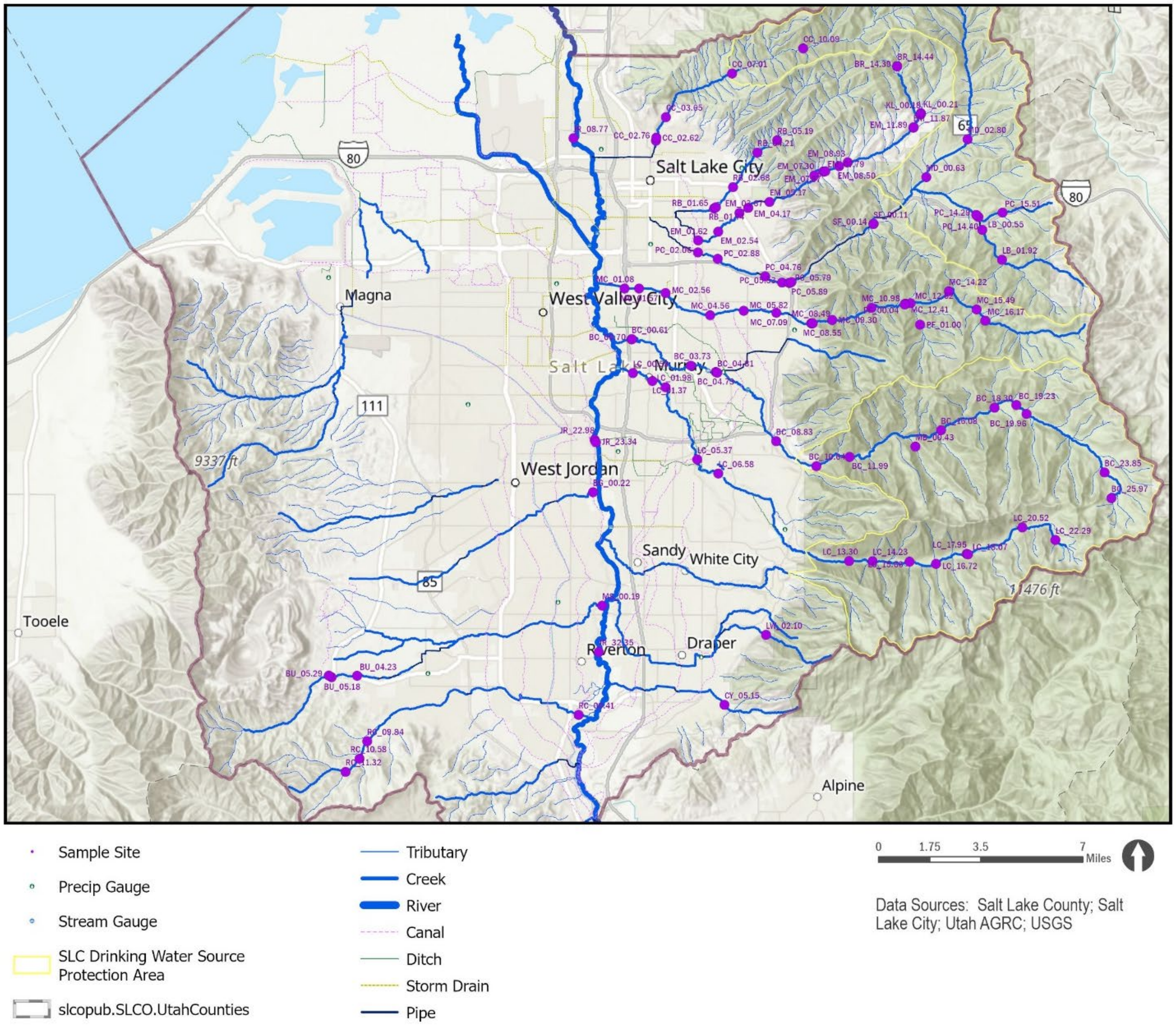
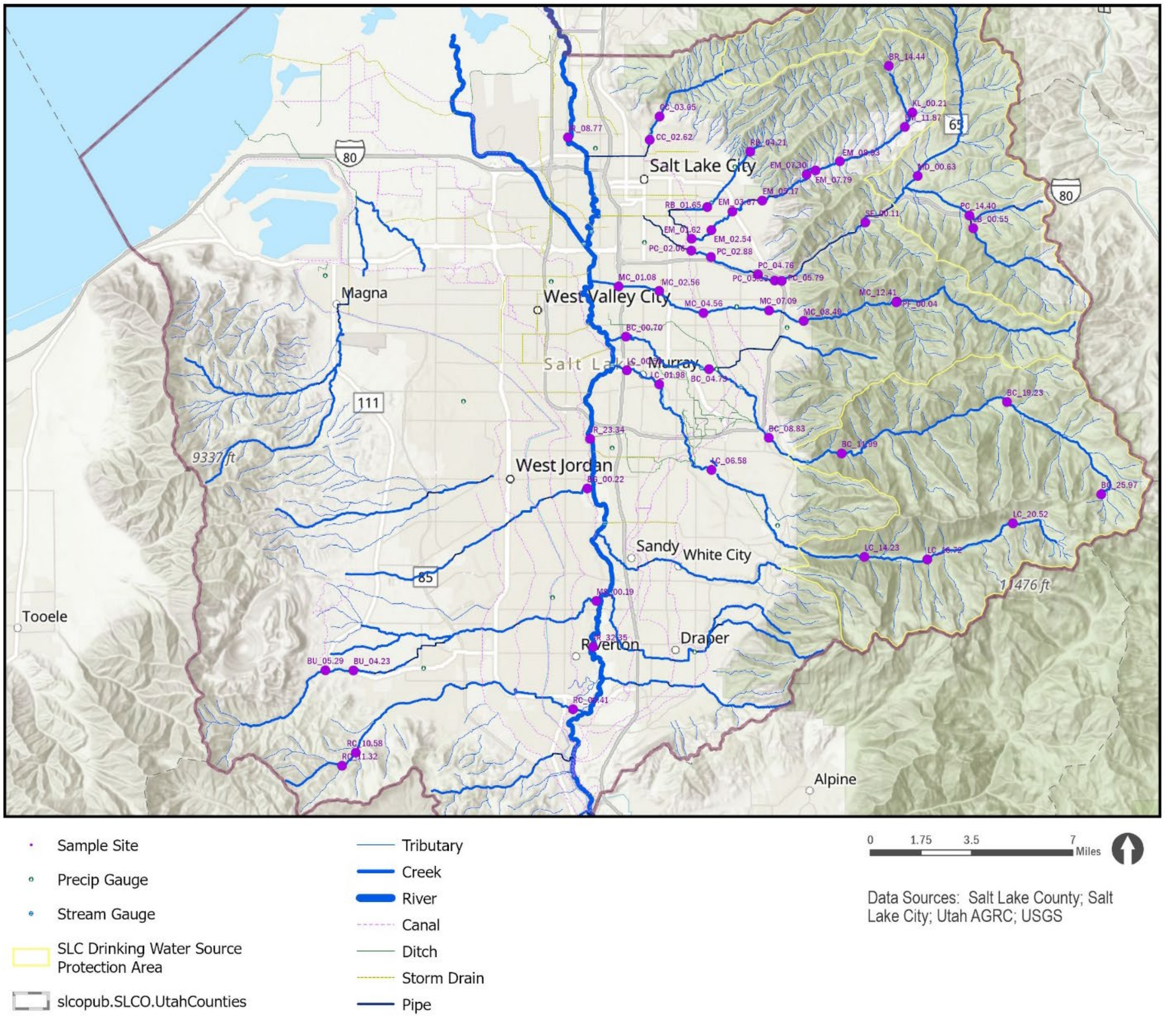


Figure 14. 2017 Field Parameter Sampling Locations

Bacteria (*E. coli*) Sampling

Bacteria samples are collected monthly using the EPA approved Colilert method. This method requires samplers to access the stream and pull a 100 ml sample of stream water into a sterile 120 ml vessel. A reagent is then added, and samples are incubated for 24-28 hours until they are read. A Most Probable Number (MPN) or likely concentration of *E. coli* organisms per 100 ml of stream water is generated by enumerating the colored cells in the reagent trays. If triplicate samples are pulled all three are entered into our database. For this report the values from triplicate samples were averaged so long as there were no major outlying values. A field blank is collected during each sampling day for QA/QC purposes. Technical information is available in Salt Lake County's SAP.

E. coli **(MPN)** is a type of bacteria found in the intestines and feces of warm-blooded mammals. The measurement of *E. coli* in a waterbody is an indication of the presence of human and/or animal waste contamination and possible harmful bacteria in surface waters. Although there are multiple methods for determining the amount of *E. coli*, the County conducted the *E. coli* analysis using the IDEXX MPN method which is followed by the Utah Division of Environmental Quality. Standards for *E. coli* are MPN=206 as a chronic limit and MPN=668 as an acute limit. Higher levels of *E. coli* typically mean there is a greater risk to human health when in contact with water. This does not mean that water with a low *E. coli* MPN is safe, but it is used as a common parameter by public health professionals. The IDEXX MPN generator shows a maximum value of MPN=<2419.6 and minimum value of MPN=>1. For database development reasons WPRP displays the maximum value as MPN=2420 and minimum value of MPN=0.



Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 15. 2017 Bacteria Sampling Locations

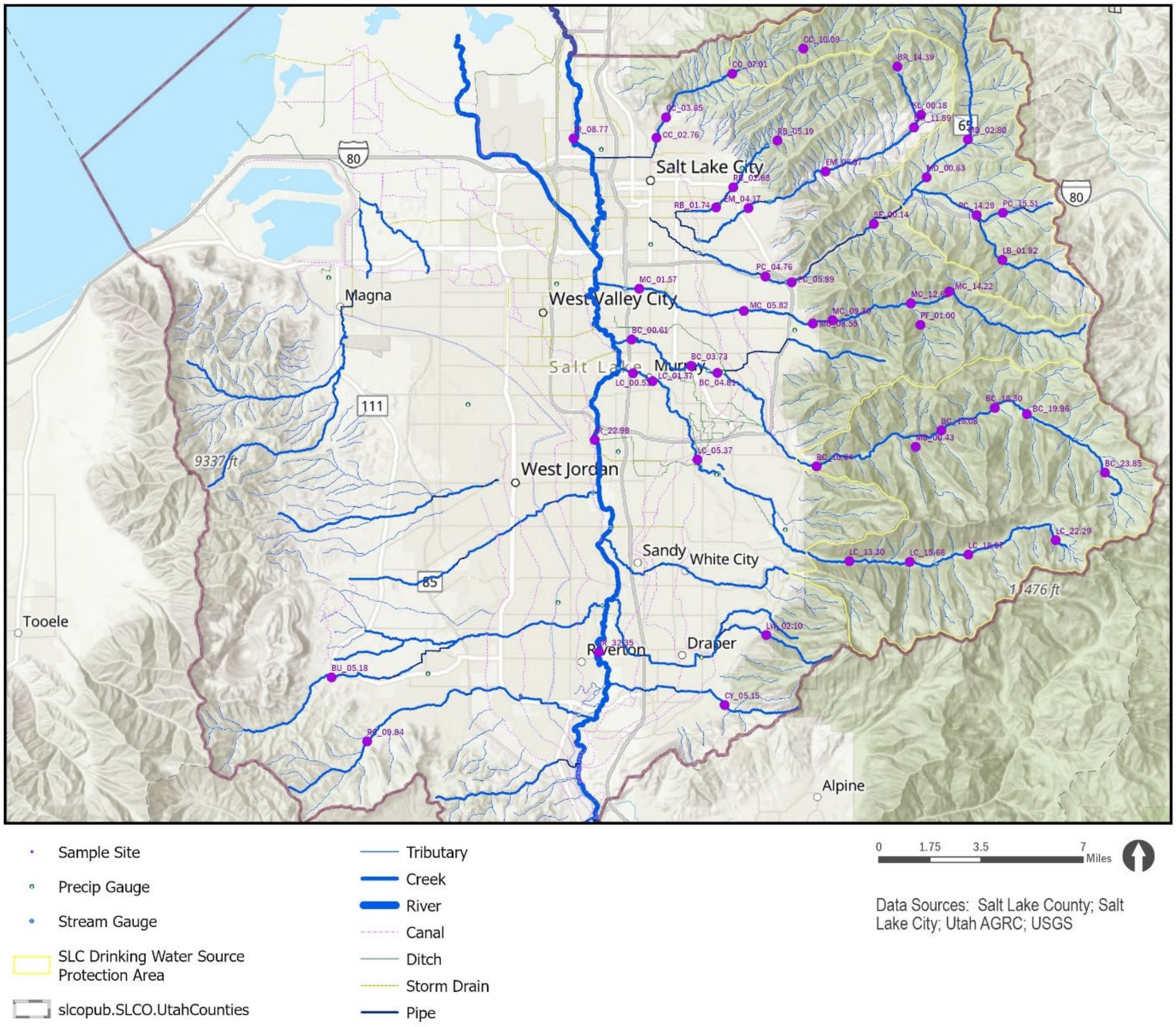
Macroinvertebrate Sampling

Aquatic macroinvertebrates are an especially helpful tool, as the presence and/or absence of certain species provides a clear picture of the overall health of the stream ecosystem. Unlike fish and other more mobile animals, aquatic macroinvertebrates (a.k.a. bugs) cannot move away from polluted waters.

Most have an annual life cycle, but some larger species can spend up to five years as larvae living under water. By taking one sample of a macroinvertebrate community, biologists are potentially compiling at least a year’s worth of water quality data. Among the different species there is a wide range of tolerance to pollutants; some are very sensitive and cannot survive changes in their environment, while others can adapt more easily. Through ongoing monitoring, changes in the aquatic bug community can determine if pollutants are widespread in the waterbody, as well as what those pollutants might be.

Macroinvertebrate samples are collected 3 out of every 5 years by WPRP. These samples target multiple riffle stream sections in a given reach and disturb the substrate upstream of a 500-micron net. The net allows the water to pass through but capture debris (vegetation, macroinvertebrates, and sediment) which is then bottled and preserved using 95% denatured alcohol. The samples are sent to Aquatic Biology Associates Inc. for processing. Results from these samples take anywhere from 5-12 months to receive and generate a number of different ratios and figures.

Macroinvertebrate samples have been broken down into two parameters, **Karr-BIBI** and **Biological Condition Gradient (BCG)**. These two scales use different indicator species and relationships to look at water quality and ecosystem integrity at a given sampling location. Karr-BIBI ranges from 10-50 with 10 being the lowest value and 50 being the highest. BCG ranges from 6- to 1+, with 6- as the lowest value and 1+ being the highest.



Data Sources: Salt Lake County; Salt Lake City; Utah AGRC; USGS

Figure 16. 2017 Macroinvertebrate Sampling Locations

Stream Channel Stability Survey

Streams are dynamic. In a healthy stream system, stream banks move as erosive forces shape and reshape the channel and floodplain. Stream bank and bed mobility are natural phenomenon. A stream is considered stable when the water flow and sediments carried by the channel do not cause excessive changes to the width, depth, cross-sectional area, and slope of the stream. The difference between stable and unstable streams is primarily marked by the rate of bank and bed mobility. The expected rate of change for a particular stream varies by stream type, which is based on steepness of the streambed and surrounding landscape, the surrounding geology, soil types, and other factors.

To evaluate channel stability, Watershed Program staff walk each stream to first delineate them into units called reaches, which are defined based on changes in geology and tributary influences. A variety of data is then collected for each reach using the Pfankuch Method, which provides a combined assessment of physical variables of the upper bank, lower bank, and stream bed. Each variable is assigned a score, some weighted based on level of importance, and a final combined score indicates whether the overall channel stability is “Good”, “Fair”, or “Poor”, based on stream type.

This system allows us to identify weak links and to discover what, if any, opportunities exist to correct the condition. Unnaturally high rates of stream bank erosion and bed mobility can have multiple causes. These range from small-scale local influences like unrestricted livestock access or streamside landscaping changes made by unsuspecting homeowners, to large-scale influences such development that increases impervious surfaces (paving, rooftops) that can dramatically increase stormwater and pollutant inputs into a stream.

Channel stability was sampled independently of this report by WPRP staff and began in 2009. The full report can be found by contacting WPRP staff. Results and conclusions from the stream stability survey are valuable to this annual report and will be referenced frequently. Moving forward WPRP plans to resample stream stability every 5 years looking for long-term trends.

In order to collect data related to channel stability on all major waterways throughout Salt Lake County the stream stability study was created. To collect this data WPRP employees walk rivers and streams from their headwaters to terminus determining different reaches based on stream type and change to overall stability. This generates a raw numerical value that is compared to stream type (also determined for each reach) and a condition of “Good”, “Fair” or “Poor” is determined according to the Pfankuch Stability Method. Some stream types are inherently less stable than others, because of this both the raw value and the condition are helpful.

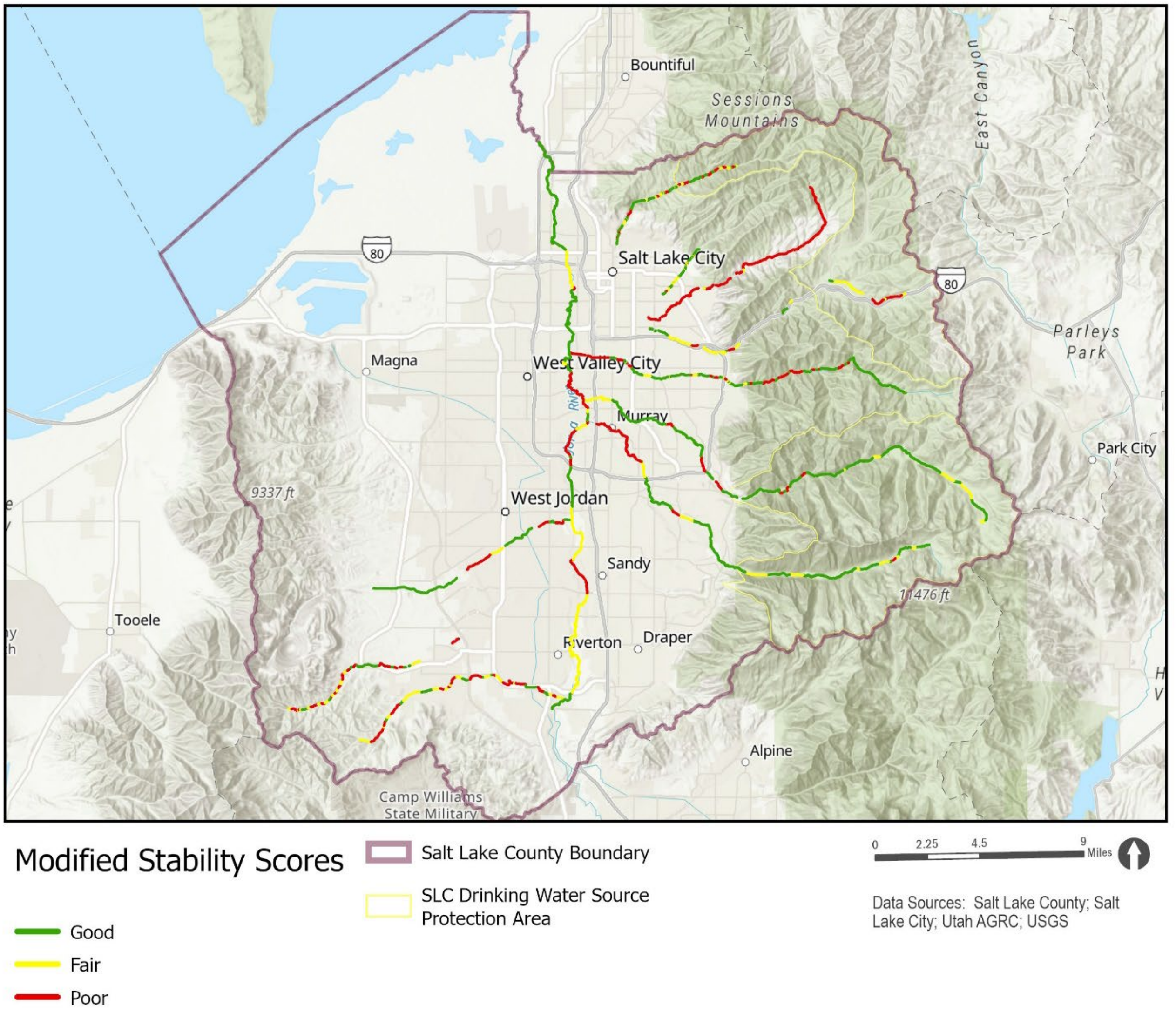


Figure 17. Stream Channel Stability Analysis

DATA

Data for each sample site can be found in the 2017 Site Data Appendix that accompanies this document. The Appendix also includes all the figures in this document. Each location graph contains all monthly sampling parameters at the listed locations. Macroinvertebrate data can also be found in the Appendix and will be included in the conclusions section of this document. Data from the Channel Stability Survey will only be included in the conclusion section of this document. A full copy of the stability survey can be found by contacting WPRP staff.

CONCLUSIONS

Watershed Summary

Although the streams of Salt Lake County all have unique characteristics and differing results, there are some watershed-wide patterns that have been observed. 2017 was slightly above average year regarding snowpack which provided elevated flows in the higher elevation subwatersheds for 2-3 months. After snowmelt runoff high summer air temperatures settled in and baseflow levels were quickly reached. This can be seen in the bacteria and field parameters with dilution of parameters during runoff and increases in stream temperature once baseflow is reached. The most apparent trend is a decrease in stream function as soon as the river meets urbanization. This loss in function is seen in both stream stability and ecosystem health. Stream stability shows a reduction of stable channel types and negative stability scores in urban areas. Ecosystem heath is shown with the rapid decline in macroinvertebrate scores in all urban areas. Even in the urban sections that are still are steep and confined with little change in field parameter values, macroinvertebrate scores have negative scores. This could be related to the increase in urbanization, storm water runoff, channel over-widening and reduction of sinuosity, floodplains, and canopy cover. Another common watershed wide trend is the relationship between intermittent flow and negative scores on all data collected. There are channels that are naturally dry seasonally and some where this occurs because of management practices. In both cases low scores are achieved for both macroinvertebrates (if data can be collected) and stream stability. Specifically, Big Cottonwood Creek and Little Cottonwood Creek could benefit from the addition of baseflow year-round by changing water management practices.

Big Cottonwood Creek Subwatershed

Bacteria and field parameter data was collected at six locations along Big Cottonwood Creek: three in the upper watershed, one below the mouth of the canyon, and two in the lower sections. One sample at the highest location site resulted in an *E. coli* value above the chronic limit, but other than that, all upper sampling locations had healthy *E. coli* results. The two lowest sampling locations show consistent high values for *E. coli*. This can be attributed to canal inputs and increased urbanization. Two of the top sampling site conductivity measurements show significantly higher levels than all other sampling locations. This could be due to constant low flow levels and large recreation related impervious surface runoff nearby. Other parameters fall into a normal range with increasing disturbance in the lower watershed. Macroinvertebrate samples were collected at nine locations in Big Cottonwood Creek: five in the upper watershed, one at the canyon mouth and three in the lower watershed. The upper sites show ranges from very good to fair. The fair site is one point away from good and is located between two heavy recreation access nodes. The very good site had the highest score of all samples in SLCo in 2017. This could be related to a long stretch of perennial, unaltered flow to the channel. Upstream from the sample are a series of beaver ponds that create wetland habitat and catch fine sediment. The middle sample is in the fair range but very close to the poor range. This sample is collected in Big Cottonwood at the same point where heavy modification begins. All lower samples are in the very poor range. Channel stability is healthy in the upper canyon with some disruption where creeks meet mountain development areas. Scores drop quickly as soon as the creek enters the valley and it subject to human bank-alterations. The lack of water due to resource management in lower reaches of the stream make it difficult for any riparian corridor to exist and further disrupt stream stability.

City Creek Subwatershed

Bacteria and field parameter data was collected at two locations in the lower sections of the City Creek subwatershed. Overall water quality in this creek is good. There is a trend found in many of the parameters (*E. coli*, pH, Conductivity and Turbidity) showing increased stress on the watershed as land use/management changes from forest to urban areas. Four macroinvertebrate samples were collected along City Creek: two in the upper watershed and two in the lower watershed. Upper sampling site locations (CC_10.09 & CC_07.01) display good and fair scores for Karr-BIBI and the Biological Condition Gradient (BCG). The lower sampling sites (CC_03.65 & CC_02.76) display poor and very poor scores for Karr-BIBI and BCG. Common macroinvertebrate stressors found in sites through the lower reaches of City Creek are thermal and fine sediment substrate embedding. The WPRP Stability Report states upper watershed conditions are generally good and that most of the lower and middle sections of City Creek have man-made stabilization structures present (riprap and gabion baskets). The presence of these structures decreases stream function by reducing flood plains and increasing width/depth ratios. Scores in the lower watershed are generally fair.

Emigration Creek Subwatershed

Bacteria and field parameter data was collected at 11 sites along Emigration Creek: six upper, one middle and four lower watershed locations. 2017 data shows only slight changes among most parameters through the watershed, but there is still a trend of increased stress observed moving downstream with conductivity. Emigration Creek also shows a specific seasonal relationship to *E. coli* values, most predominately in the upper watershed but not unseen downstream. Warmer months (July, August, September) show high *E. coli* values for all upper sites. Macroinvertebrate samples were collected at four locations, with two in the upper watershed, on in the middle reaches, and one in the lower urban section. This data shows all values in the fair, poor and very poor range for both Karr-BIBI and BCG. Macroinvertebrate stressors include fine sediment embedment for all samples. Although scores are reasonably low throughout the creek there is a strong trend of decreasing ecosystem health moving downstream. The stability report for Emigration Creek states that reaches "remain poor for nearly the entire length" of the creek. Low stream stability can be attributed to rapid downcutting and near-stream development.

Jordan River Corridor Subwatershed

Bacteria and field parameter data was collected at three locations along the Jordan River: one upper, one middle and one lower watershed location. Although the Jordan River sees input from many different streams in Salt Lake County, it does not show a lot of variation from upstream to downstream sections regarding water quality samples. This is, in part, because most of the major tributaries to the Jordan River see return flows from canals and irrigation. This means that by the time most tributaries reach the Jordan River, they are already mixed with water from the Jordan River and Utah Lake. *E. coli* samples at the two upper sampling locations resulted in multiple samples above the chronic limit. The lowest sampling site registered no samples above the chronic limit. Temperature shows a strong seasonal trend with warmer temperatures in the summer. On average the Jordan River is warmer than all other streams in Salt Lake County. Dissolved Oxygen shows a few low values at the upper and lower sites. The Jordan River is impaired for low Dissolved Oxygen, and samples collected by WPRP staff may not fully convey this point. Dissolved oxygen reaches its lowest value during the night, when some plants are still taking in oxygen, but none are producing it. For this reason, WPRP has placed long-deploy water quality sondes that will log data on 15-minute intervals. Turbidity is higher, on average, in the Jordan River than any other tributary in Salt Lake County. There is also a strong correlation of increased turbidity and irrigation season in the two upper sampling locations. Three macroinvertebrate samples were collected along the Jordan River, one upper, one middle and one lower sample. All samples fell into the very poor range. The Jordan river is highly modified and has little to no ecological integrity. The main species found in the Jordan river are Asiatic mussels (non-native) and New-Zealand Mud Snails (invasive). With regards to stability, the Jordan River has undergone hydrologic alteration to the point that the river has no natural reaches remaining in the County. Stability is generally poor throughout the river corridor. Many of the banks have been hardened and will show good stability in the upper parts of a cross section but the lower reaches are so over widened that there is little to no ability for the river to move sediment. This results in ongoing dredging projects as needed.

Little Cottonwood Creek Subwatershed

Bacteria and field parameter data was collected at six locations in Little Cottonwood Creek: three upper and three lower watershed sample sites. Most parameters show little change from site to site except for the two lowest sampling sites. These locations show increases in bacteria, temperature, and turbidity. This can be attributed to the input of stormwater and irrigation return flows. Macroinvertebrate samples were collected at seven locations: four in the upper watershed and three lower urban sites. The upper watershed samples all fell in the good range and were similar to each other. Of the three lower sampling sites, data was not collected at one location because the creek is dewatered. The two lowest sampling locations showed scores in the very poor range. Stability in Little Cottonwood Creek shows that the upper canyon is healthy, with some disruption along where mountain development areas meet the creek. Scores drop quickly as soon as the creek enters the valley, and it is subjected to human bank-alterations. Lack of water dur to resource management in the lower reaches of the stream make it difficult for any riparian corridor to exist and further disrupt stream stability. The dewatering of this creek also plays a role in the lack of water quality and macroinvertebrate data collection.

Mill Creek Subwatershed

Bacteria and field parameter data was collected at seven sites along Mill Creek: four upper and three lower watershed locations. The watershed shows common trends to other areas with diminished water quality in urban areas and seasonal trends in many parameters. Among the three lower sampling locations high *E. coli* values are found in the summer months. This could be related to higher urban use and canal input at lower sections of the creek. Conductivity measurements are higher in the Porter Fork tributary but can be attributed to specific differences in geochemistry. Macroinvertebrate samples were collected at seven locations: three upper sites, two middle sites, and one lower urban site. The two highest sites on Mill Creek showed the best ecosystem health with scores in the good range. The third upper site is located along the Porter Fork tributary and showed a score in the fair range. This subwatershed is developed with residential cabins and the stream has been altered near the sample location. The middle sampling sites both show fair and poor scores, although the downstream location shows a better score than one that is upstream a short distance. Overall, the lower middle scores can be related to upstream development with campgrounds, picnic areas and scout camps. The odd relationship between the healthier downstream sample can also be attributed to the development. The sample with a lower score is immediately downstream of Camp Tracy, which sees degraded stream banks and increased sedimentation in the creek. The lowest sampling site shows very poor ecosystem health. Channel stability in Mill Creek was noted to decrease "near development including trailheads, campgrounds, picnic areas, scouting activity (Camp Tracy) and trail nodes" (Salt Lake County Stream Stability Analysis). Over widening of streams and loss of riparian habitat are seen extensively in the areas with poor stability and are believed to be related. Overall channel stability in Mill Creek is good in the upper reaches and decreases as urbanization increases. This canyon experiences high recreational use at specific nodes but, these hardened access nodes, keep use to specific areas and protect riparian corridors in other areas.

Parleys Creek Subwatershed

Bacteria and field parameter data was collected at eight sites along Parley's Creek: four upper and four lower watershed locations. Tributaries along Parley's creek show low conductivity numbers while the mainstem creek shows higher values consistently. This is due to geologic differences in the channel. At the lowest site (PC_02.06) turbidity numbers increase in the winter months because of a dredging project upstream. No other parameters showed abnormal trends. There are six macroinvertebrate sampling sites in the Parley's subwatershed: five upper sites along parleys and tributaries, one along a middle tributary, and two lower watershed locations. Results from upper watershed samples vary greatly. Samples on the mainstem of Parley's Creek are in the good/very good range where there is perennial flow. At the most upstream site flow is seasonal resulting in poor macroinvertebrate health; this site also experienced flood flows that modified and reshaped the channel. Along the tributaries scores also show high values where perennial flow is found. One site (MD_00.63) shows poor macroinvertebrate scores. This site is located between Mountain Dell and Little Dell Reservoirs, an area which rarely has perennial flow and is determined by reservoir management. Macroinvertebrate stressors in the upper watershed are fine sediment embedding and, in some places, thermal stressors were seen as well. Scores in the lower watershed show poor and very poor values for macroinvertebrate health. Macroinvertebrate stressors in the lower watershed include, thermal, toxins and fine sediment embedment. Stability scores along Parley's Creek are difficult to determine because Parley's is "possibly the most altered creek in Salt Lake County" according to the WPRP Stability Report. Most of the creek is underground while it parallels I-80. The upper reaches are choked with woody debris and headcuts giving unstable stream types and low stability scores. Lower reaches also show low stability scores due to sediment aggradation, denuded streambanks, and human bank alteration.

Red Butte Creek Subwatershed

Bacteria and field parameter data was collected at two locations in the Red Butte Creek subwatershed in 2017. The upstream site is below the Forest Service research area, before urban development occurs along the creek. The second site is in Miller Park, one of the lowest sites along the creek where access is possible before Red Butte Creek is channelized underground to Liberty Park. Most water quality parameters show little difference between upstream and downstream locations, but many show seasonal changes related to water temperature differences in the winter/summer. *E. coli* values are much higher at the lower sampling location, this is common through urban streams and can be attributed to increased urbanization, stormwater input and reduction of active floodplains. Macroinvertebrate samples were collected at three locations along Red Butte Creek: one upper, one middle, and one lower watershed sample. Like most creeks throughout the County, ecosystem health is poor in the lower reaches of the stream. Uniquely, Red Butte Creek still only scores in the "Fair" range in its upper reaches. Stressors related to macroinvertebrate health are thermal and fine sediment substrate embedding. Extremely low flows could be related to low macroinvertebrate scores in the lower reaches as well. Stream stability was not performed in the upper reaches of Red Butte Creek. From the research area downstream data was collected in 2011. The stability scores are overall low which could be related to the cleanup of the creek after the oil spill through the creek in 2010. Even with the overall low scores Red Butte Creek shows a degradation in stream stability moving downstream.

West Side Tributaries—Rose Creek, Midas Creek, and Bingham Creek Subwatersheds

The west side tributaries to Salt Lake County include Rose, Midas, Butterfield, and Bingham Creeks. A large portion of these creeks only see ephemeral flow and they have been grouped for this reason. Bacteria and field parameter data was collected at seven locations: four upper and three lower watershed sites. Upper watershed *E. coli* and turbidity samples show a strong seasonal trend with increased values in the summer. This likely corresponds to higher temperature and increased recreation. Lower watershed samples show high values for *E. coli* year-round. This could be related to perennial flow from irrigation return. There were only two macroinvertebrate samples collected along the west side tributaries in Salt Lake County. This is because they are mostly intermittent streams, and it is difficult to find sampling locations. Even though the two samples were collected in sections with perennial flow they both resulted in the poor range. These streams see very low flows, high sedimentation, and thermal stressors much of the year, all hurting the biological integrity of the stream. The west side tributaries generally have poor stability and have been restricted to tighter channel corridors by development activity. Where man-made stability structures have been placed sections display good stability, but generally are unstable stream types and have little to no ecological health. The western watersheds to Salt Lake County are in the midst of a development boom and will see a rapid increase in the amount of impervious surface area. This will result in more frequent flood flows with a shorter, but more intense, duration. Events like this will impair stability in any sections of the river that are currently not stable.